Leituras de Teoria Ator-Rede

para uma Sociologia da Tecnologia

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CAPA: Detalhe da cortina em foto de Bruno Latour por Iorgis Matyassy, publicada no site *La Croix* em 08/02/2020
<https://www.la-croix.com/Bruno-Latour-Nous-devons-savoir-quoi-nous-tenons-2020-02-08-1101077044>).

SUMÁRIO

CALLON, Michel; LATOUR, Bruno. 1981. Unscrewing the big Leviathan: how actors macro-structure reality and how sociologists help them to do so. In: K. Knorr-Cetina; A.V. Cicourel (eds.). Advances in social theory and methodology: toward and integration of micro- and macro-Sociologies. Boston: Routledge; Kegan Paul, pp.277-303.

sequence. However, the development of social integration is by no means synonymous with a sequential decrease in social exploitation.

From an evolutionary perspective, the type of social integration that is tied to the kinship system and that, in conflict situations, is maintained through preconventional legal sanctions belongs to a lower stage of development than the type that involves political rule and that, in conflict situations, is maintained through conventional legal practices. Yet, from the vantage-point of moral standards applicable to both primitive and civilized societies, the form of exploitation necessarily practised in class societies must be judged as a regression in comparison with the moderate social inequalities possible in kinship systems. This explains why class societies are structurally unable to satisfy the need for legitimation that they produce. This is the key to the recurring class struggles in postkinship societies.

Note

1 Compare Klaus Eder, *Zur Entstehung staatlich organisierter Gesellschaften* (Frankfurt-Main: Suhrkamp, 1976).

10 Unscrewing the big Leviathan: how actors macro-structure reality and how sociologists help them to do so

Michel Callon and *Bruno Latour**

Canst thou fill his skin with barbed irons? . . . Lay thine hand upon him remember the battle, do no more . . . . None is so fierce that dare stir him up: who then is able to stand before me?

Job 41:7,8,10

[*Like Habermas, Callon and Latour conceive of micro-macro relations in dynamic terms, but they do not conceive of them in evolutionary terms. The process they have in mind is not a process in which forms of social integration become replaced by new forms on the basis of social learning, but rather a process* by which micro-actors successfully grow to macro-size.

Callon and Latour consider the macro-order to consist of macro-actors who have successfully 'translated' other actors' wills into a single will for which they speak. This enrolment of other actors allows them to act like a single will which is, however, extremely powerful because of the forces on which it can rely. How do micro-actors grow to such formidable sizes like that of big multinational corporations? Callon and Latour say that unlike baboons, human actors are able to rely not only on symbolic relations, but also on more 'durable' materials, for which they provide examples. It is this difference which allows the human society to produce macro-actors and which forces the baboon society to enact all its relations on a micro-level of symbolic practice.

The present chapter is the contribution to the book which most forcefully reminds us of a possible correlation between power and the macro-level. It is also the chapter whose conception of macro-actors is perhaps most similar to Harré's notion of structured collectivities to which he attributes causal powers (see chapter

* Authors in alphabetical order. We especially thank John Law, Shirley Strum, Karin Knorr, Lucien Karpik and Luc Boltanski for their sharp criticism which we failed, most of the time, to answer.

4), and which has some overlap with Cicourel's focus on the summarizing procedures through which the macro is generated within micro-social action (see chapter 1 and section 5 of the Introduction). In a sense it can be seen as the macro-counterpart of the last mentioned micro-conceptions.]

1 Hobbes's paradox

Given: a multitude of equal, egoistic men living without any law in a merciless state of nature that has been described as, 'the war of every one against every one'.[1] How can this state be brought to an end? Everyone knows Hobbes's reply: through a contract that every man makes with every other and which gives one man, or a group of men bound to none other, the right to speak on behalf of all. They become: the 'actor' of which the multitude linked by contracts are the 'authors'.[2] Thus 'authorized',[3] the sovereign becomes the *person* who says what the others are, what they want and what they are worth, accountant of all debts, guarantor of all laws, recorder of property registers, supreme measurer of ranks, opinions, judgments and currency. In short the sovereign becomes the Leviathan: 'that Mortal God, to which we owe under the Immortal God, our peace and defense'.[4]

The solution proposed by Hobbes is of interest to political philosophy and of major importance to sociology, formulating clearly as it does for the first time the relationship between micro-actors and macro-actors. Hobbes sees no difference of level or size between the micro-actors and the Leviathan *which is not the result of a transaction*. The multitude, says Hobbes, is at the same time the Form and the Matter of the body politic. The construction of this artificial body is calculated in such a way that the absolute sovereign is nothing other than the sum of the multitude's wishes. Though the expression 'Leviathan' is usually considered synonymous with 'totalitarian monster', in Hobbes the sovereign says nothing on his own authority. He says nothing without having been authorized by the multitude, whose spokesman, mask-bearer and amplifier he is.[5] The sovereign is not *above* the people, either by nature or by function, nor is he higher, or greater, or of different substance. He is the people itself in another state – as we speak of a gaseous or a solid state.

This point seems to us of capital importance, and in this paper we

should like to examine all its consequences. Hobbes states that there is no difference between the actors which is *inherent in their nature*. All differences in level, size and scope are the result of a battle or a negotiation. We cannot distinguish between macro-actors (institutions, organizations, social classes, parties, states) and micro-actors (individuals, groups, families) on the basis of their dimensions, since they are all, we might say, the 'same size', or rather since size is what is primarily at stake in their struggles it is also, therefore, their most important result. For Hobbes – and for us too – it is not a question of classifying macro- and micro-actors, or reconciling what we know of the former and what we know of the latter, but posing anew the old question: how does a micro-actor become a macro-actor? How can men act 'like one man'?

The originality of the problem posed by Hobbes is partly concealed by his solution – the social contract – which history, anthropology and now ethology have proved impossible. The contract, however, is merely a specific instance of a more general phenomenon, that of translation.[6] By translation we understand all the negotiations, intrigues, calculations, acts of persuasion and violence,[7] thanks to which an actor or force takes, or causes to be conferred on itself, authority to speak or act on behalf of another actor or force:[8] 'Our interests are the same', 'do what I want', 'you cannot succeed without going through me'. Whenever an actor speaks of 'us', s/he is translating other actors into a single will, of which s/he becomes spirit and spokesman. S/he begins to act for several, no longer for one alone. S/he becomes stronger. S/he grows. The social contract displays in legal terms, at society's very beginnings, in a once-and-for-all, all-or-nothing ceremony, what processes of translation display in an empirical and a reversible way, in multiple, detailed, everyday negotiations. The contract need only be replaced by processes of translation and the Leviathan will begin to grow, thus restoring to Hobbes's solution all its originality.

The aim of this article is to show what sociology becomes if we maintain Hobbes's central hypothesis – provided we replace the contract by a general law of translation. How can we describe society, if our aim is the analysis of the construction of differences in size between micro- and macro-actors?

The methodological constraints we impose for describing the Leviathan should not be misunderstood. We should miss the point completely, if we distinguish between 'individuals' and 'institutions'; if we supposed that the first fell within the sphere of psychology, and the second of economic history.[9] *There are* of course macro-actors and micro-actors, but the difference between them is brought about by power relations and the constructions of networks that will *elude analysis* if we presume *a priori* that macro-actors are bigger than or superior to micro-actors. These power relations and translation processes reappear more clearly if we follow Hobbes in his strange assumption that all actors are isomorphic.[10] Isomorphic does not mean that all actors have the *same* size but that *a priori* there is no way to decide the size since it is the consequence of a long struggle. The best way to understand this is to consider actors as networks. Two networks may have the same shape although one is almost limited to a point and the other extends all over the country, exactly like the sovereign can be one among the others and the personification of all the others. The financier's office is no larger than the cobbler's shop; neither is his brain, his culture, his network of friends nor his world. The latter is 'merely' a man; the former is, as we say, a 'great man'.

Too often sociologists – just like politicians or the man in the street – *change their framework of analysis* depending on whether they are tackling a macro-actor or a micro-actor, the Leviathan or a social interaction, the culture or individual roles. By changing the framework of analysis while this is under way they confirm the power relations, giving aid to the winner and giving the losers the 'vae victis'.

This problem has become urgent – as the contributors to this volume suggest – because no sociologists at present examine macro-actors and micro-actors using the same tools and the same arguments. They take it for granted that there are differences in level between micro-sociological analysis and macro-sociological analysis, though they may still want to reconcile them in a broad synthesis.[11]

It seems to us that sociologists are too often on the wrong foot. Either, believing that macro-actors really do exist, they anticipate the actors' strength by helping them to grow more vigorous.[12] Or else they deny their existence, once they really do exist, and will not even allow us the right to study them.[13] These two alternate but symmetrical errors stem from the same presupposition: the acceptance as a given fact that actors can be of different or of equal size. As soon as we reject this presupposition, we are once again faced with Hobbes's paradox: no actor is bigger than another except by means of a transaction (a translation) which must be examined. We show in this article that if one remains faithful to Hobbes's paradox, one avoids the symmetrical errors and understands how the Leviathan grows.

In section 2 we attempt to resolve the following paradox: if all actors are isomorphic and none is by nature bigger or smaller than any other, how is it that they eventually end up as macro-actors or individuals? In section 3 we shall examine how actors wax and wane, and how the methods we propose enable us to follow them through their variations in size, without having to alter the framework for analysis. Lastly, in the conclusion, we consider in more detail the role of sociologists in such variations in relative size.

2 Baboons, or the impossible Leviathan

Let us leave Hobbes's myth of the Leviathan and take another myth: the impossible Monkey-Leviathan or the difficulty of building up macro-actors in a herd of baboons living in the wild.[14] Hobbes believed that society only emerged with man.[15] This was believed for a long time, until gatherings of animals were observed closely enough for it to become clear that theories about the emergence of societies were pertinent for primates, ants, the Canidae, as well as for men.

This 'disordered' herd of brute beasts – eating, mating, howling, playing and fighting one another in a chaos of hair and fangs – surely tallies closely with the 'state of nature' postulated by Hobbes. Without any doubt at all the life of a baboon is 'poor, nasty, brutish and short'.[16] This image of total disorder enabled a contrast to be made, right from the beginning, between human society and bestiality, between social order and chaos. At least this is how animals were imagined before people actually went and studied them.

When, before the Second World War, but more intensively since the 1950s, people began to study baboons, each observer reconstructed Hobbes's Leviathan on his own account.[17] The baboons no longer live in disordered bands. They started living in rigid cohorts where the females and their young are surrounded by dominant males organized according to a strict hierarchy. In the 1970s, the image of a pyramid-shaped society of monkeys has gradually come to be used as a foil for human societies which have been said to be more flexible, freer and more complex. Over 30 years, the study of primates has thus been used as a projective test: first, bestial chaos was observed, then a rigid, almost totalitarian system. Baboons have been obliged to restructure the Leviathan and to move from the war of all against all to absolute obedience.

Despite this, observers closer to the monkeys have gradually worked out a different Leviathan. The baboons do indeed have organization: not everything is equally possible in it. One animal does not go close to just any other; an animal does not cover or groom another by chance; nor does it move aside just at random; animals cannot go just where they wish. However, this organization is never rigid enough to constitute an integrated system. As the observers have come to know their baboons better, the hierarchies of dominance have become more flexible, finally dissolving – at least in the case of the males.[18] Primary aggressiveness has become rarer: it has been seen to be consistently channelled and socialized until finally the groups of baboons have become surprisingly 'civil'. The famous elementary impulses which fuel the war of all against all – eating, copulating, domination, reproduction – have been observed to be constantly suspended, halted and diffracted by the play of social interactions. There is no chaos, but no rigid system either. Now the baboons live in units, none of which is rigid, but none of which is flexible. In addition to differences of size, sex and age, social links, are the family, clan and friendship networks, or even habits due to traditions and customs. None of these categories is clearly defined since they all come into play together, and can break apart again. Observers now construct the baboon society as one whose texture is much stronger than was imagined by those who thought it a chaos of brute beasts, but infinitely more flexible than postwar observers thought.

For a society of baboons to be at the same time so flexible and yet so close-knit, an amazing hypothesis had to be advanced: more and more extensive social skills had to be bestowed on the monkeys in order to make them competent to repair, accomplish and ceaselessly consolidate the fabric of such a complex society.[19]

A baboon's life is not easy in the new society that has been forged for it and is no less difficult than our life as revealed by ethnomethodological works. He must constantly determine who is who, who is superior and who inferior, who leads the group and who follows, and who must stand back to let him pass. And all he has to help him are fuzzy sets whose logic is fashioned to evaluate hundreds of elements. Each time it is necessary, as the ethnomethodologists say, to repair indexicality. Who is calling? What is it intending to say? No marks, no costumes, no discreet signs. Of course, many signs, growls and hints exist, but none of them is unambiguous enough. Only the context will tell, but simplifying and evaluating the context is a constant headache. Hence the strange impression these animals give today. Living as they do in the heart of the bush, all they should be thinking about is eating and mating. But all they care about is to stabilize their relations, or, as Hobbes would say, durably to attach bodies with bodies. As much as we do they build up a society which is their surroundings, shelter, task, luxury, game and destiny.

To simplify we might say that baboons are 'social animals'. The word 'social' derives, we know, from 'socius', which is akin to 'sequi', to follow. First of all to follow, then to form an alliance or to enlist, then to have something in common, to share. Several act like a single entity, the social link is there. Baboons are social like all social animals in the sense that they follow each other, enrol each other, form alliances, share certain links and territories. But they are social, too, in that they can maintain and fortify their alliances, links and partitions only with the tools and procedures that ethnomethodologists grant us to repair indexicality. They are constantly stabilizing the links between bodies by acting on other bodies.[20]

Only among the baboons are the living bodies alone, as Hobbes requires, at the same time the Form and the Matter of the Leviathan. But what happens when this is the case? There is no Leviathan. We must now formulate the central question: if the baboons realize Hobbes's conditions and offer us the spectacle of a society made with no solid Leviathan or durable macro-actor, how are the solid, durable macro-actors which we see forming everywhere in human societies, actually constructed?

Hobbes thought the Leviathan could be built with bodies, but then he was only talking about baboons. His Leviathan could never have been built if bodies had been the Form *and* Matter of the social body. Although in order to stabilize society everyone – monkeys as well as men – need to bring into play associations *that last longer than the interactions that formed them*, the strategies and resources may vary between societies of baboons or of men. For instance, instead of acting straight upon the bodies of colleagues, parents and friends, like baboons, one might turn to more solid and less variable materials in order to act in a more durable way upon the bodies of our colleagues, parents and friends. In the state of nature, no one is strong enough to hold out against every coalition.[21] But if you transform the state of nature, replacing unsettled alliances as much as you can with walls and written contracts, the ranks with uniforms and tattoos and reversible friendships with names and signs, then you will obtain a Leviathan: 'His scales are his pride, shut up together as with a close seal. One is so near to another that no air can come between them. They are joined one to another; they stick together that they cannot be sundered' (Job 41:15–17).

A difference in relative size is obtained when a micro-actor can, in addition to enlisting bodies, also enlist the greatest number of durable materials. He or she thus creates greatness and longevity making the others small and provisional in comparison. The secret of the difference between micro-actors and macro-actors lies precisely in what analysis often neglects to consider. The primatologists omit to say that, to stabilize their world, the baboons do not have at their disposal any of the human instruments manipulated by the observer. Hobbes omits to say that no promise, however solemn, could frighten the contracting parties enough to force them to obey. He omits to say that what makes the sovereign formidable and the contract solemn are the palace from which he speaks, the well-equipped armies that surround him, the scribes and the recording equipment that serve him.[22] The ethnomethodologists forget to include in their analyses the fact that ambiguity of context in human societies is partially removed by a whole gamut of tools, regulations, walls and objects of which they analyse only a part. We must now gather up what their analysis leaves out and examine with the same method the strategies which enlist bodies, materials, discourses, techniques, feelings, laws, organizations. Instead of dividing the subject with the social/technical, or with the human/animal, or with the micro/macro dichotomies, we will only retain for the analysis *gradients of resistivity* and consider only the *variations in relative solidity and durability of different sorts of materials.*

By associating materials of different durability, a set of practices is placed in a hierarchy in such a way that some become stable and need no longer be considered. Only thus can one 'grow'. In order to build the Leviathan it is necessary to enrol a *little more* than relationships, alliances and friendships. An actor grows with the number of relations he or she can put, as we say, in black boxes. A black box contains that which no longer needs to be reconsidered, those things whose contents have become a matter of indifference. The more elements one can place in black boxes – modes of thoughts, habits, forces and objects – the broader the construction one can raise. Of course, black boxes never remain fully closed or properly fastened – as it is particularly the case among the baboons – but macro-actors can do *as if* they were closed and dark. Although, as ethnomethodologists have shown, we are all constantly struggling for closing leaky black boxes, macro-actors, to say the least, do not have to negotiate with *equal intensity* everything. They can go on and count on a force while negotiating for another. If they were not successful at that, they could not simplify the social world. In mechanical terms, they could not make a machine, that is hide the continued exercise of a will to give the impression of forces that move by themselves. In logical terms, they could not make chains of arguments, that is stabilize discussion of certain premises to allow deductions or establish order between different elements.

If the expression 'black box' is too rigid to describe the forces which shut off the stacks of boxes, and keep them hermetically sealed and obscure, another metaphor is possible, one Hobbes might have used had he read Waddington.[23] In the first moments of fertilization, all cells are alike. But soon an epigenetic landscape takes form where courses are cut out which tend to be irreversible; these are called 'chreods'. Then cellular differentiation begins. Whether we speak of black boxes or chreods, we are dealing with the creation of asymmetries. Let us then imagine a body where differentiation is never fully irreversible, where each cell attempts to compel the others to become irreversibly specialized, and where many organs are permanently claiming to be the head of the programme. If we imagine such a *monster* we shall have a fairly clear idea of the Leviathan's body, which we can at any moment see growing before our very eyes.

The paradox with which we ended the introduction has now been resolved. We end up with actors of different size even though they are all isomorphic, because some have been able to put into black boxes more elements durably to alter their relative size. The question of method is also resolved. How can we examine macro-actors and micro-actors, we were wondering, without confirming differences in size? Reply: by directing our attention not to the social but towards the processes by which an actor creates lasting asymmetries. That among these processes some lead to associations which are sometimes called 'social' (associations of bodies), and that some of the others are sometimes called 'technical' (associations of materials), need *not* concern us further. Only the differences between what can be put in black boxes and what remain open for future negotiations are now relevant for us.

To summarize, macro-actors are micro-actors seated on top of many (leaky) black boxes. They are neither larger, nor more complex than micro-actors; on the contrary, they are of the same size and, as we shall see, they are in fact simpler than micro-actors. We are able, now, to consider how the Leviathan is structured, since we know that we do not need to be impressed by the relative size of the masters, or to be frightened by the darkness of the black boxes.

3 Essay in teratology

In this section, we leave Hobbes's barbarous, juridical Leviathan, as well as the 'bush and savannah' Leviathan we saw in action among the baboons. We shall follow up one detail of the huge, mythical monster in a modern context: the way in which two actors – Electricity of France (EDF) and Renault – varied their relative dimensions in the course of a struggle that took place between them during the 1970s.[24]

To replace the usual divisions (macro/micro; human/animal; social/technical), which we have shown to be unprofitable, we need terms in keeping with the methodological principles stated above. What is an 'actor'? Any element which bends space around itself, makes other elements dependent upon itself and translates their will into a language of its own. An actor makes changes in the set of elements and concepts habitually used to describe the social and the natural worlds. By stating what belongs to the past, and of what the future consists, by defining what comes before and what comes after, by building up balance sheets, by drawing up chronologies, it imposes its own space and time. It defines space and its organization, sizes and their measures, values and standards, the stakes and rules of the game – the very existence of the game itself. Or else it allows another, more powerful than itself, to lay them down. This struggle for what is essential has often been described but few have tried to find out how an actor can make these asymmetries last, can lay down a temporality and a space that is imposed on the others. And yet the answer to this question is in principle quite simple: by capturing more durable elements which are substituted for the provisional differences in level s/he has managed to establish. Weak, reversible interactions, are replaced by strong interactions. Before, the elements dominated by the actor could escape in any direction, but now this is no longer possible. Instead of swarms of possibilities, we find lines of force, obligatory passing points, directions and deductions.[25]

3.1 Electricity of France and Renault: hybrids and chimera

Let us take the case of the Electricity of France (EDF) which, in the early 1970s, was struggling to launch an electric vehicle. EDF ventures out onto a terrain that is new to it, with the aim of bringing the ideal electric vehicle into existence. It does this by redefining the totality of a world from which it will cut out what is natural and what is technical. EDF places the evolution of industrial societies as a whole in a black box and enrols it for its own advantage. According to the ideologists within this public enterprise, the all-out consumption characteristic of the postwar years is doomed. Henceforth, the direction of future production must take into consideration man's happiness and the quality of life. With this vision of our future societies, the ideologists deduce that the petrol-driven car – which best symbolizes the successes and deadlocks of growth for its own sake – must now be doomed. EDF proposes to draw the conclusions from this 'ineluctable' social and economic evolution, gradually replacing the internal combustion engine with its electric vehicle.

Having defined the evolution of the social world, EDF next determines evolution of techniques, this being carefully distinguished from that of the social world: a new black box that is indisputable and ineluctable. EDF chooses to consider the VEL (Electric Vehicle) as a problem concerned with generators. Once these premises have been laid down, EDF marks out possible choices – which it evocatively calls 'channels'. Associated – always ineluctably – with each channel are a set of procedures, a set of laboratories and industrialists and – most important of all – a chronology. Lead accumulators, providing they are properly developed by this or that firm, could be used until

1982; the years 1982–90 will be the years of zinc-nickel accumulators and the zinc-air circulation generator; from 1990 onwards, fuel cells will be ready for use. These sequences of choices are made up of scattered elements taken from different contexts, gleaned by EDF's engineers, leaders and ideologists wherever they are available. From these scattered parts EDF creates a network of channels and regulated sequences.

Not content with making parallel connections between overall social development and technical channels, EDF begins to translate into simple language the products which industrialists cannot fail to want to produce, and the needs which clients and consumers cannot fail to feel. EDF foresees a huge market for lead accumulators, that of light commercial vehicles. Zinc accumulators cannot fail to be preferred for use in electric taxis, whilst fuel cells are certain to conquer the private car market as a whole.

In the space of a few years, and by dint of organizing channels, branches and developments, EDF begins to translate the deep desires, the technical knowledge and the needs and aptitudes of a large number of actors. EDF thus structures a reality by building up a gigantic organizational chart in which each black box, each carefully demarcated islet, is linked to other boxes by a set of arrows. The islets are shut off, and the arrows are unequivocal. Thus is the Leviathan structured. The actor tells you what you want, what you will be able to do in 5, 10 or 15 years, in which order you will do it, what you will be glad to possess, and of what you will be capable. And *you really believe this*, you identify with the actor and will help him or her with all your strength, irresistibly attracted by the differences in level he or she has created. What Hobbes described as an exchange of words during a period of universal warfare should be described more subtly in the following way: an actor says what I want, what I know, what I can do, marks out what is possible and what impossible, what is social and what technical, their parallel developments and the emergence of a market for zinc taxis and electric mail vans. How could I possibly resist when that is exactly what I want, when that is the correct translation of my unformulated wishes?

An actor like EDF clearly displays how the Leviathan is built up in practice – and not juridically. It insinuates itself into each element, making no distinction between what is from the realm of nature (catalysis, texture of grids in the fuel cell), what is from the realm of

the economy (cost of cars with an internal combustion engine, the market for buses) and what comes from the realm of culture (urban life, Homo automobilis, fear of pollution). It ties together all these scattered elements into a chain in which they are all indissociably linked. One is forced to go through them just as if a line of reasoning was being unfolded, a system developed or a law applied. This chain or sequence traces a chreod or a set of chreods which thus define the margin for manoeuvre enjoyed by the other actors, their positions, desires, knowledge and abilities. What they will want and be able to do is channelled. Thus the EDF, like every Leviathan, gradually deposits interactions. There now exists something resembling contents, and something resembling a container, the contents fluid and the container stable. Our wills flow into the EDF's canals and networks. We rush towards the electric engine just as the river water rushes towards the Seine along the stone and concrete pipes designed by the hydraulic engineers. Contrary to what Hobbes states, thanks to this preliminary mineralization, certain actors became the Form of the Leviathan's body and certain others its Matter.

And yet, as we have already stated, an actor is never alone, despite everything it has. In vain does it saturate the social world, totalize history and the state of wills, it can never be alone since all the actors are isomorphic and those it enrols can desert it. One actor, for example, had its role redefined by EDF in the course of this vast connecting-up of necessities. Renault, which then produced petrol-driven cars, seemed to have a brilliant future ahead of it, and symbolized industrial success in France. EDF changed its destiny, taking away its future. Now Renault symbolizes industries doomed because of city congestion, pollution and the future of industrial societies. It must now – like the others – make changes in its intended production. Now Renault would like to make the chassis for the electric vehicles planned by EDF. This modest role suits the company well, and corresponds to what it cannot but want. So Renault goes along with what EDF wants, just like the rest of France, moving towards an all-electric future.

So far we have not said whether for EDF this is a question of something dreamed up by engineers, or a reality. In fact no one can make this distinction *a priori*, for it is the very basis of the struggle between the actors. The electric vehicle is thus 'real'. The actors that EDF has approached and mobilized to play the role of a firm foundation – designed for them by EDF – thus adhere to the differences in level which the public enterprise has laid out. But now something happens which will help us understand what we have been seeking to explain since the beginning of this chapter, that is how relative dimensions are changed.

In a few years' time Renault will disappear as an autonomous actor. Together with the petrol engine, it is doomed, and has no option but to reorientate its activities – unless the landscape which EDF projects before and around itself can be remodelled. But can this be done? During the first few years Renault is unable to fight its way back against the EDF's predictions. Everyone agrees that the private car is doomed.

How can this black box be opened? As all sociologists agree, no one will want a private car any more. How can the situation be reversed? Who can reveal technical ignorance in the scenario of an enterprise which has a monopoly of production and distribution of electricity? In these circumstances the only possible conclusion is that Renault will fail, and one must begin as best one can to adapt to the new landscape, one without the thermal car. And yet Renault has no wish to disappear; Renault wants to remain autonomous and indivisible, itself deciding what will be the social and technical future of the industrial world. What EDF so firmly associates, Renault would dearly like to dissociate. So Renault begins the work of undermining the edifice, probes the walls, makes up lost ground, seeks allies. How can Renault transform into fiction what will – if it is not careful – become the reality of tomorrow? How can it force EDF to remain, as we say, 'on the drawing board'?

EDF stated that no one would want a thermal car any more. And yet, despite increases in petrol prices, demand for cars is growing all the time. These two elements, which EDF links together in a strong interaction, prove dissociable in practice. Oil prices can rise concurrently with demand for cars, concurrently with the fight against pollution and with city congestion. Renault's hopes rise once more, and it begins to translate consumer desires differently: now they want the traditional private car at any price. As a result the future is altered yet again: the electric car has no natural market. The word is out. The natural laws as interpreted by the EDF Leviathan are not the same as for Renault. The consumer, by his or her very nature, demands performances with regard to speed, comfort and acceleration that the

electric car will never approach. Already one of EDF's premises has been upset, a difference in level flattened out or filled in and one of the black boxes opened and profaned. Renault becomes bolder. If EDF's interpretation of social evolution can be thrown out of joint, perhaps the same is true of its knowledge of electrochemistry? Perhaps the technical demands could be altered?

Renault sets out on the long task of dissociating the associations made by EDF. Each interaction is tested, every calculation redone, every black box opened. The engineers are requestioned, the laboratories revisited, the records re-examined, the state of electrochemistry called into question. EDF had chosen to simplify certain information and to incorporate masses of figures which Renault now considers contradictory. As a consequence the chronology is disturbed. For EDF the internal combustion engine was a dead-end. Renault discovers that, by using electronics, it can be perfected so as to be unbeatable for several decades. Conversely, EDF had mentioned channels with regard to zinc accumulators. Renault does the sums again, assesses the estimates, gets another expert opinion from the experts, and shelves the zinc accumulator technically so that, at the very best, it would be suitable to equip a few tip-lorries much later than planned by EDF. Similarly, what EDF called the fuel cell 'channel' was for Renault a cul-de-sac. Instead of being the chreod through which flowed the wills of the engineers, it became just a rut. Into it fell only those laboratories which backed the wrong technical revolution and placed all their hopes in the study of catalysis. Like the rivers in China which sometimes suddenly change their course, demands and technical channels are thus diverted. The industrial society was running towards an all-electric future. Now it continues its majestic course towards the private car with an improved thermal engine. As Renault grows larger its future looks more rosy than it ever seemed before this confrontation. EDF shrinks in proportion. Instead of defining transport and reducing Renault to the role of subordinate, EDF has had to retire from the field, withdraw its troops and transform the world which it was building out of an engineer's dream.

3.2 The rules of sociological method

This confrontation clearly displays how the Leviathan is structured, making no *a priori* distinction between the size of actors, between the real and the unreal, between what is necessary and what contingent, between the technical and the social. Everything is involved in these primordial struggles through which Leviathans are structured: the state of techniques, the nature of the social system, the evolution of history, the dimensions of the actors and logics itself. As soon as sociological language avoids the assumption that there is an *a priori* distinction between actors, these combats are revealed as the fundamental principle underlying the Leviathan. Sociological analysis is nevertheless involved, since it follows the associations and dissociations, but it follows them wherever they are produced by the actors. The actors can bond together in a block comprising millions of individuals, they can enter alliances with iron, with grains of sand, neurons, words, opinions and affects. All this is of little importance, providing they can be followed with the same freedom as they themselves practise. We cannot analyse the Leviathan if we give precedence to a certain type of association, for example associations of men with men, iron with iron, neurons with neurons, or a specific size of factors. Sociology is only lively and productive when it examines *all associations with at least the same daring as the actors who make them.*

In the primordial conflicts we have just described, there are indeed winners and losers – at least for a while. The only interest of our method is that it enables these variations to be measured and the winners to be designated. This is why we stress so strongly that they must be looked at in the same way, and dealt with using similar concepts. What concept will enable us to follow the actors in all their associations and dissociations and to explain their victories and defeats, though without our admitting belief in the necessities of every kind which they claim? An actor, as we have seen, becomes stronger to the extent that he or she can firmly associate a large number of elements – and, of course, dissociate as speedily as possible elements enrolled by other actors. Strength thus resides in the power to break off and to bind together.[26] More generally, strength is *inter*vention, *inter*ruption, *inter*pretation and *inter*est, as Serres has so convincingly shown.[27] An actor is strong in so far as he or she is able to intervene. But what is intervention? Let us go back to the Leviathan: You want peace, so do I. Let us make a contract. Let us return to the baboons: Sara is eating a nut. Beth appears, supplants her, takes her place and her nut. Let us return to EDF: a laboratory is studying the fuel cell. The engineers are questioned, their knowledge simplified and summed up: 'we shall have a fuel cell in 15 years'. The Leviathan once more: we have made a contract, but a third party appears who respects nothing and steals from us both. The baboons once more: Sara yelps, this attracts her faithful friend Brian. He is now enrolled, he approaches and supplants Beth. The nut falls to the ground and Brian grabs it. The EDF once more: the Renault engineers read through the literature again and alter their conclusions: 'There will be no fuel cell in 15 years.' All this is still 'the war of all against all'. Who will *win in the end?* The one who is able to stabilize a particular state of power relations by associating the largest number of irreversibly linked elements. What do we mean by 'associate'? We return again to the Leviathan. Two actors can only be made indissociable if they are one. For this their wills must become equivalent. He or she who holds the equivalences holds the secret of power. Through the interplay of equivalences, hitherto scattered elements can be incorporated into a whole, and thus help to stabilize other elements.

3.3 'None is so fierce that dare stir him up: who then is able to stand before me?' (Job: 41,10)

By comparison with the Leviathan revealed by the sociologist, the one Hobbes describes is a pleasant idealization:

> Art goes yet further, imitating that Rational and most excellent work of Nature, *man*. For by Art is created that great LEVIATHAN called a Commonwealth, or a State which is but an artificial Man; though of greater stature and strength than the Natural, for whose protection and defence it was intended; and in which the Sovereignty is an Artificial Soul, as giving life and motion to the whole body; the Magistrates and other officers of Judicature and Execution, artificial joints.[28]

For the Leviathan is a body, itself designed in the image of a machine. There is a single structural principle – an engineer's plan – and a homogeneous metaphor which orders the whole, that of an automaton. The true Leviathan is far more monstrous than this. Is the Leviathan a machine? It is, but what is a machine without an operator? Nothing more than a broken-down heap of iron. So the metaphor of the automaton is not valid. If the machine can move, build and repair itself, it must be a living thing. Let us move on to biology. What is a body? A machine once again, but there are many kinds: thermal, hydraulic, cybernetic, data-processing – from which the operator is again absent. Shall we say finally that it is a set of chemical exchanges and physical interactions? Can we compare it with the interest of a market or an exchange system? In the field of the economy with what is it comparable? Once again with chemical interactions. And these in their turn may be compared with a field of struggling forces. The Leviathan is such a monster that its essential being cannot be stabilized in any of the great metaphors we usually employ. It is at the same time machine, market, code, body, and war. Sometimes, forces are transmitted as in a machine, sometimes operating charts come into place in the same way as cybernetic feedbacks. Sometimes there is a contract, sometimes automatic translation. But one can never describe the whole set of elements using only one of these metaphors. As in the case of Aristotle's categories, we jump from one metaphor to another whenever we try to express the meaning of one of them.

Monstrous is the Leviathan in yet another way. This is because, as we have seen, there is not just *one* Leviathan but many, interlocked one into another like chimera, each one claiming to represent the reality of all, the programme of the whole. Sometimes some of them manage to distort the others so horribly that for a while they seem the only soul in this artificial body. The Leviathan is monstrous too because Hobbes built it using only contracts and the bodies of ideal, supposedly naked, men. But since the actors triumph by associating with themselves other elements than the bodies of men, the result is terrifying. Steel plates, palaces, rituals and hardened habits float on the surface of a viscous-like gelatinous mass which functions at the same time like the mechanism of a machine, the exchanges in a market and the clattering of a teleprinter. Sometimes whole elements from factory or technical systems are redissolved and dismembered by forces never previously seen in action. These forces then in turn produce a rough outline of a chimera that others immediately hasten to dismember. Neither Job on his dunghill, nor the teratologists in their laboratories have observed such dreadful monsters.

Impossible not to be terrified by this primordial combat which concerns everything that political philosophy, history and sociology consider indisputable frameworks for description. Impossible not to

be terrified likewise by the flood of speeches Leviathans make about themselves. On some days and with some people they allow themselves to be sounded or dismantled (depending whether they choose that day to be body or machine). Sometimes they sham dead or pretend to be a ruin (metaphor of a building), a corpse (biological metaphor), or a huge heap of iron from some museum of industrial archeology. At other times they are inscrutable and delight in admitting themselves monstrous and unknowable. The next moment they change and, depending on their audience, stretch out on a couch and whisper their most secret thoughts or, crouching in the shadows of the confessional, admit their faults and repent of being so big or so small, so hard or so soft, so old or so new. We cannot even state that they are in a continuous state of metamorphoses, for they only change in patches and vary in size slowly, being encumbered and weighed down with the enormous technical devices they have secreted in order to grow and to restrict precisely this power to metamorphose.

These imbricated Leviathans more resemble a never-ending building-site in some great metropolis. There is no overall architect to guide it, and no design, however unreflected. Each town hall and each promotor, each king and each visionary claim to possess the overall plan and to understand the meaning of the story. Whole districts are laid out and roads opened up on the basis of these overall plans, which other struggles and other wills soon restrict to the egoistic and specific expression of a period or an individual. Constantly – but never everywhere at the same time – streets are opened, houses razed to the ground, watercourses covered over. Districts previously thought out-of-date or dangerous are rehabilitated; other modern buildings become out of fashion, and are destroyed. We fight about what constitutes our heritage, about methods of transport and itineraries to be followed. Consumers die and are replaced by others, circuits by degrees compel their recognition, enabling information to run along the wires. Here and there one retires within oneself, accepting the fate decided by others. Or else one agrees to define oneself as an individual actor who will alter nothing more than the partitions in the apartment or the wallpaper in the bedroom. At other times actors who had always defined themselves and had always been defined as micro-actors ally themselves together around a threatened district, march to the town hall and enrol dissident architects. By their action they manage to have a radial road diverted or a tower that a macro-actor had built pulled down. Or again, as in the case of the famous 'trou des Halles' in central Paris, they put forward 600 alternative projects, in addition to the hundreds the Paris Town Hall had already considered. A tiny actor becomes a macro-actor, just like in the French nursery rhyme: 'The cat knocks over the pot, the pot knocks over the table, the table knocks over the room, the room knocks over the house, the house knocks over the street, the street knocks over Paris: Paris, Paris, Paris has fallen!' We cannot know who is big and who is small, who is hard and who is soft, who is hot and who is cold. The effect of these tongues which suddenly start to wag and these black boxes that suddenly snap shut is a city, uncountable Leviathans with the beauty of the beast or of the circles of hell.

Hobbes's Leviathan was indeed a paradise by comparison with what we have described here. As for the baboons' Leviathan, it is a dream of the unadulterated society amid the beauty of the still-wild savannah. The monster that we are, that we inhabit and that we fashion sings a quite different song. If Weber and his intellectual descendants found that this monster was becoming 'disenchanted', this was because they allowed themselves to be intimidated by techniques and macro-actors. This is what we shall now show.

4 Conclusion: the sociologist Leviathan

In order to grow we must enrol other wills by translating what they want and by reifying this translation in such a way that none of them can desire anything else any longer. Hobbes restricted this process of translation to what we now call 'political representation'. The scattered wills are recapitulated in the person of the sovereign who says what we want, and whose word has force of law and cannot be contradicted. And yet it is a very long time now since 'political representation' was alone sufficient to translate the desires of the multitude. After political science, the science of economics also claims to sound loins and coffers, and to be able to say not only what the goods, services and people making up the Leviathan desire, but also what they are worth. In this article we are not interested in political science or economics. We are interested in the latecomers, the sociologists, who also translate – using polls, quantitative and qualitative surveys – not only what the actors want, not only what they are worth,

but also *what they are*. On the basis of scattered information, replies to questionnaires, anecdotes, statistics and feelings, the sociologist interprets, sounds out, incorporates and states what the actors are (classes, categories, groups, cultures, etc.), what they want, what interests them and how they live. Self-designated and self-appointed, spokesmen of the people, they have, for more than a century now, taken over from Hobbes's sovereign: the voice that speaks in the mask is their own.

4.1 *The sociologist Leviathan*

We have followed through the creation of the political Leviathan on the basis of a contract, the formation of the monkey-Leviathan and, last, the construction of the monster-Leviathan. Now we shall see how the sociologist-Leviathan is built. We can already state as a matter of principle that Leviathans formed like sociologies or sociologies like Leviathans.

So what do sociologists do? Some say that there is a social system. This interpretation of the social credits translation processes with a coherence that they lack. To state that there is a system is to make an actor grow by disarming the forces which he or she 'systematizes' and 'unifies'. Of course, as we have seen, the Leviathan's arithmetic is very special: each system, each totality *is added* to the others without retrenching itself, thereby producing the hybrid monster with a thousand heads and a thousand systems. What else does the sociologist do? He or she interprets the Leviathan, saying for example that it is a cybernetic machine. So all associations between actors are described as circuits of an artificial intelligence, and translations are seen as 'integrations'. Here again the Leviathan is built up by this type of description: it is proud to be a machine and immediately, like any machine, starts to transmit forces and motions in a mechanical way. Of course this interpretation is added to all the others and struggles against them. For the Leviathan is – sometimes and in some places – a traditional and not a cybernetic machine, likewise a body, a market, a text, a game, etc. Since all interpretations act upon it simultaneously, per*forming* and trans*forming* forces according to whether they are machines, codes, bodies or markets, the result is this same monster again, at one and the same time machine, beast, god, word and town. What else can sociologists do? They can say, for example, that they 'restrict themselves to the study of the social'. They then divide the Leviathan into 'reality levels' leaving aside, for example, the economic, political, technical and cultural aspects in order to restrict themselves to what is 'social'. The black boxes that contain these factors are thus sealed up and no sociologist can open them without stepping outside the field. The Leviathans purr with relief, for their structure disappears from view, whilst they allow their social parts to be sounded. Of course, as we know (see the EDF), no actor is so powerful that its decisions and associations as a whole will be finally and definitely considered as technical reality. The other actors, helped by sociologists, push back and trace anew the boundaries between what is technical, economic, cultural and social. The result is that here again the Leviathans are hacked about by conflicting teams of sociologists, and are covered with scars like Frankenstein. What else do sociologists do? Like everyone else, they never stop working to define who acts and who speaks. They tape the recollections of a workman, a prostitute or an old Mexican; they interview; they hand out open and closed questionnaires on every subject under the sun; they unceasingly sound out the opinions of the masses. Each time they interpret their surveys they inform the Leviathan, transforming and performing it. Each time they construct a unity, define a group, attribute an identity, a will or a project;[29] each time they explain what is happening, the sociologist, sovereign and author – as Hobbes used the term – add to the struggling Leviathans new identities, definitions and wills which enable other authors to grow or shrink, hide away or reveal themselves, expand or contract.

Like all the others, and for the same reason, sociologists work on the Leviathan. Their work is to define the nature of the Leviathan whether it is unique or whether there are more than one, what they want and how they transform themselves and evolve. This specific task is in no way unusual. There is no 'metadiscourse' – to speak archaically – about the Leviathan. Every time they write sociologists grow or shrink, become macro-actors – or do not – expand, like Lazarsfeld, to the scale of a multinational,[30] or shrink to a restricted sector of the market. What makes them grow or shrink? The other actors whose interests, desires and forces they translate more or less successfully, and with whom they ally or quarrel. Depending on the period, the strategies, the institutions and the demands, the sociologist's work can expand until it becomes what everyone is saying

about the Leviathan, or shrink to what three PhD students think about themselves in some British university. The sociologists' language has no privileged relationship with the Leviathan. They act upon it. Suppose they state that the Leviathan is unique and systematic, suppose they create cybernetic, hierarchically integrated subsystems: either this will be accepted, or not, will spread, or not, will be used as resources by others – or will not. The success of this definition of the Leviathan proves nothing about the latter's own nature. An empire is born, that of Parsons, and that is all. Conversely, the fact that ethnomethodologists might manage to convince their colleagues that macro-actors do not exist proves nothing about their non-existence. Sociologists are neither better nor worse than any other actors. Neither are they more external nor more internal, more nor less scientific.[31] Common, too common.

4.2 *How to slip between two mistakes*

A macro-actor, as we have seen, is a micro-actor seated on black boxes, a force capable of associating so many other forces that it acts like a 'single man'. The result is that a macro-actor is by definition no more difficult to examine than a micro-actor. Growth is only possible if one can associate long lasting forces with oneself and thereby simplify existence. Hence a macro-actor is at least as simple as a micro-actor *since otherwise it could not have become bigger*. We do not draw closer to social reality by descending to micro-negotiations or by rising towards the macro-actors. We must leave behind the preconceptions which lead us to believe that macro-actors are more complicated than micro-actors. The opposite might be true as the example of the baboons showed us. A macro-actor can only grow if it simplifies itself. As it simplifies its existence, it simplifies the work of the sociologist. It is no more difficult to send tanks into Kabul than to dial 999. It is no more difficult to describe Renault than the secretary who takes telephone calls at the Houston police station. If it were much more difficult the tanks would not move and Renault would not exist. There would be no macro-actors. By claiming that macro-actors are more complex than micro-actors sociologists discourage analysis, and hamstring investigators. And they prevent the secret of the macro-actors' growth from being revealed: making operations childishly simple. The king is not only naked, he is a child playing with (leaky) black boxes.

The other preconception, too often shared by sociologists, is that individual micro-negotiations are truer and more real than the abstract, distant structures of the macro-actors. Here again, nothing could be further from the truth for almost every resource is utilized in the huge task of structuring macro-actors. Only a residue is left for the individuals. What the sociologist too hastily studies is the diminished, anaemic being, trying hard to occupy the shrinking skin left to it. In a world already structured by macro-actors, nothing could be poorer and more abstract than individual social interaction. The dreamers who would like to restructure macro-actors on the basis of the individual will arrive at an even more monstrous body for they must leave out all the hard parts which have enabled the macro-actors to simplify their lives and to take over all the space.

4.3 More than a monster, a monster and a half

What then is a sociologist? Someone who studies associations and dissociations, that is all, as the word 'social' itself implies. Associations between men? Not solely, since for a long time now associations between men have been expanded and extended through other allies: words, rituals, iron, wood, seeds and rain. The sociologist studies all associations, but in particular the transformation of weak interactions into strong ones and vice versa. This is of special interest because here the relative dimensions of the actors are altered. When we use the word 'study' we must make clear there is of course no suggestion of knowledge. All information is transformation, an emergency operation on and in the Leviathan's body.

When we slip between two mistakes, we do not intend to withdraw to some distant planet. What is valid for the others is valid for us too. We too work on the Leviathan, we too aim to sell our concepts, we too seek allies and associates and decide who it is we want to please or displease. By taking for granted differences in level and size between actors, the sociologist ratifies past, present and future winners, whoever they may be, finding favour with the powerful because they make them look reasonable. By agreeing to restrict the study of associations to the residual social, the sociologist affixes seals onto the black boxes, and once again guarantees that the strong will be secure and the cemeteries peaceful – filled with lines of hermetically closed black boxes crawling with worms.

For the sociologist then the question of method boils down to knowing where to place oneself. Like Hobbes himself, he or she sits just at the point where the contract is made, just where forces are translated, and the difference between the technical and the social is fought out, just where the irreversible becomes reversible and where the chreods reverse their slopes. There, only a tiny amount of energy is necessary to drag a maximum of information about its growth from the newborn monster.

The sociologists who choose these places are no longer anyone's lackey or ward. They no longer need dissect the corpses of Leviathans already rejected by others. They no longer fear the great black boxes which dominate the whole of the 'social world' where they no more wander like ghosts, cold as vampires, with wooden tongues, seeking the 'social' before it coagulates. The sociologists – teratologists – are in the *warm, light* places, the places where black boxes open up, where the irreversible is reversed and techniques return to life; the places that give birth to uncertainty as to what is large and what is small, what is social and what technical. They inhabit the blessed place where the betrayed and translated voices of authors – Matter of the social body – become the voice of the sovereign actor described by Hobbes – the Form of the social body.

Notes

1 T. Hobbes, *The Leviathan* (1651) (London: Pelican Books, 1978), p. 185. All quotations are from that edition.
2 Ibid., p. 218.
3 Ibid., p. 219.
4 Ibid., p. 227.
5 Ibid., p. 217.
6 Concept developed by Michel Serres, *La Traduction, Hermès III* (Paris: Ed. de Minuit, 1974), and then applied to sociology by M. Callon 'L' Opération de traduction', in M. Roqueplo (ed.), *Incidence des rapports sociaux sur le développement scientifique et technique* (Paris: CNRS, 1975).
7 Even the sacrificial victim of R. Girard, *Des Choses cachées depuis la fondation du monde* (Paris: Grasset, 1978), is nothing but a more solemn and cruel form of contract and a particular case of translation. It cannot be made the foundation of the other forms.
8 By the term 'actor' we mean, from now on, the semiotic definition by A. Greimas in *Dictionnaire de sémiotique* (Paris: Hachette, 1979): 'whatever unit

of discourse is invested of a role', like the notion of force, it is no way limited to 'human'.

9 See the devastating criticism of psychoanalysis made by G. Deleuze and F. Guattari, *L'Anti-Oedipe, capitalisme et schizophrénie* (Paris: Ed. de Minuit, 1972). For them there is no difference of size between a child's dreams and a conqueror's empire or between the family life story and the political story. The unconscious, anyway, is not 'individual', so that in our innermost dreams we still act inside the whole body politic and vice versa.

10 On this point, like on most, C. B. Macpherson, *The Political Theory of Possessive Individualism: Hobbes to Locke* (Oxford: Clarendon Press, 1962), missed Hobbes's originality. It is not Marxism that helps interpret what is beneath Hobbes's theory; it is, on the contrary, the latter that might explain what is beneath the former.

11 See R. Collins (this volume) and P. Bourdieu (this volume).

12 See the conclusion of this chapter.

13 For instance A. Cicourel, *Method and Measurement in Sociology* (New York: Free Press, 1964), as an example of the requirements that tie the observer's hands. Ethnomethodologists have since much increased the constraints on what can be said about society.

14 This part is based on an ongoing study on the sociology of primatology by one of us (B.L.). Most of this chapter is inspired by the work of Shirley Strum. She is in no way responsible for the awkward situation in which we put her baboons, but only for the new and revolutionary way she understands animal sociology. For direct references see S. Strum, 'Life with the Pumphous-Gang', *National Geographic*, May (1975), pp. 672–791; 'Interim Report on the Development of a Tradition in a Troop of Olive Baboons', *Science* 187 (1975), pp. 755–7; 'Agonistic Dominance in Male Baboons – An Alternate View' (forthcoming). For an analysis of the link between primatology and political philosophy, see Donna Haraway, 'Animal Sociology and a Natural Economy of the Body Politic', *Signs*, 4/1 (1978), pp. 21–60.

15 Except insects, of course, Hobbes, *The Leviathan*, p. 225.

16 Ibid., p. 186.

17 For two general presentations, see H. Kummer, *Primate Societies* (New York: Aldine, 1973); and T. Rowell, *Social Behaviour of Monkeys* (London: Penguin, 1972). For a historical background see Donna Haraway, 'Animal Sociology and a Natural Economy of the Body Politic', and 'Signs of Dominance: From a Physiology to a Cybernetics of Primate Societies, C. R. Carpenter 1930–1970' (forthcoming).

18 S. Strum, 'Agonistic Dominance in Male Baboons – An Alternate View'.

19 This was already visible in H. Kummer, 'Social Organization of Hamadryas Baboons' (Chicago: Aldine, 1968), and very clear in H. Kummer, 'On the Value of Social Relationships to Non-Human Primates. A Heuristic Scheme', *Social Science Information*, 17 (1978), pp. 687–707.

20 This is the case either in the sort of Bourdieu sociology that Kummer used to describe his baboons ('On the Value of Social Relationships'), or in the sociobiological myth of defence of investments.

21 Hobbes, *The Leviathan*, p. 183, for human, and Strum, 'Agonistic Dominance in Male Baboons – An Alternate View', for baboons.

22 In his *Myth of the Machine* (New York: Harcourt, 1966), Lewis Mumford tries to integrate different sorts of materials, but he makes two major mistakes: first, he sticks to the metaphor of the machine, instead of dissolving it; second, he takes for granted the size of the megamachine instead of tracing its genealogy. The same thing can be said of A. Leroi-Gourhan, *La Geste et la parole* (Paris: Albin Michel, 1964), although he tries very hard to blur the limits between technics and culture, but favours, nevertheless, one sort of division and one sort of determinism.

23 C. H. Waddington, *Tools for Thought* (London: Paladin, 1977).

24 Michel Callon, *De Problèmes en problèmes: itinéraire d'un laboratoire universitaire saisi par l'aventure technologique* (Paris: CORDES, 1978); and *Rapport sur le véhicule électrique* (Paris: CORDES, 1978).

25 For more complete descriptions, see F. Nietzsche, *The Will to Power* (New York: Garden Press, 1974); G. Deleuze and F. Guattari, *Mille Plateaux* (Paris: Ed. de Minuit, 1979); B. Latour, *Irréductions: précis de Philosophie* (Paris: Chèloteur, 1981).

26 Hobbes, *The Leviathan*, p. 150.

27 Michel Serres, *Le Parasite* (Paris: Grasset, 1980).

28 Hobbes, *The Leviathan*, p. 18.

29 For instance, see Luc Boltanski, 'Taxinomie sociale et lutte de classe', *Actes de la recherche en sciences sociales*, 29 (1979), pp. 75–110.

30 Michael Pollak, 'Paul Lazarsfeld, une Multinationale des Sciences Sociales', *Actes de la recherche en sciences sociales*, 25 (1979), pp. 45–60.

31 The lack of distinction between soft and hard sciences is shown in B. Latour and S. Woolgar, *Laboratory Life: The Social Construction of Scientific Facts* (London: Sage, 1979).

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« Les “vues” de l’esprit » Une introduction à l’anthropologie des sciences et des techniques

Bruno Latour

Nous voudrions bien comprendre ce qui fait la différence entre les sciences et les autres activités, entre nos sociétés scientifiques et celles, préscientifiques, qui les ont précédées. Mais nous souhaiterions aussi trouver des explications qui soient les plus légères possibles. En appeler à des changement dans le cerveau, ou dans l’esprit, ou dans les relations sociales, ou dans les infrastructure économiques, voilà qui est trop lourd ; c’est prendre un bulldozer pour dépoter un géranium. Un homme nouveau n’a pas émergé au début du XVI[e] siècle et ceux qui travaillent dans leurs laboratoires ne sont pas des mutants au grand front. Un esprit plus rationnel, une méthode scientifique plus contraignante qui émergeraient ainsi de l’obscurité et du chaos, voilà une hypothèse trop compliquée[1].

Je l’admets, il s’agit là d’une position *a priori* mais ce préjugé est une étape nécessaire. Il nous permet de dégager le terrain de toute distinction préalable entre l’activité scientifique et les autres. Selon l’expression consacrée, le grand partage avec ses divisions hautaines et radicales doit être remplacé par de nombreux « petits partages » aux emplacements imprévus [Goody, 1979]. En procédant ainsi, nous nous débarrassons des divisions imposées par d’autres auteurs, celle de Lévi-Strauss entre « science » et « bricolage » [Levi-Strauss, 1962], de Garfinkel entre raisonnement quotidien

1. Originellement publié comme introduction au numéro 14 de *Culture Technique* Les « Vues » de l’Esprit, sous la direction de Bruno Latour & Jocelyn de Noblet (sous la direction de), Juin 1985 pp. 4-30 ; republié dans Daniel Bougnoux (sous la direction de) *Sciences de l’information et de la communication*, Paris, Larousse, 1993 pp. 572-596.

et raisonnement scientifique [Garfinkel, 1967], de Bachelard entre esprit préscientifique et esprit scientifique [Bachelard, 1934, 1967], ou même de Horton entre refus des contradictions et acceptation des contradictions [Horton, 1967, 1990]. Toutes ces « coupures épistémologiques » ne peuvent être administrées que par un autre préjugé qui traite différemment les deux côtés de la frontière. Dès qu'on laisse la frontière ouverte, les aptitudes intellectuelles sautent de tous côtés, les sorciers deviennent des popperiens de stricte obédience, les ingénieurs deviennent des bricoleurs – bricoleurs qui deviennent à leur tour tout à fait rationnels[2]. Ces renversements sont si rapides qu'ils prouvent assez que nous avons affaire à une frontière artificielle, comme celle qui sépare la France de la Wallonie. Elle peut être maintenue avec des douaniers, des barbelés et des bureaucrates, mais elle ne souligne rien de naturel. La notion de « coupure épistémologique » est utile pour faire des discours, pour remonter le moral des troupes, mais loin d'expliquer quoi que ce soit, elle est au contraire une manie que l'anthropologie devrait expliquer [Latour, 1983].

1. Connaître de vue

a. Sombrer ou flotter sur le relativisme

Pourtant, il nous faut admettre qu'il y a de bonnes raisons pour maintenir ces dichotomies en dépit du fait qu'elles sont contredites par l'expérience quotidienne. La position relativiste à laquelle on arrive en les rejetant semble à première vue grotesque. Il est impossible de mettre sur le même pied l'intellectuel de brousse décrit par Goody [Goody, 1979] et Galilée dans son studiolo ; l'ethnobotanique et la botanique du Muséum d'histoire naturelle ; l'interrogation méticuleuse d'un cadavre en Côte-d'Ivoire et l'interrogation d'un gène par une sonde d'ADN dans un laboratoire californien ; un mythe d'origine en Thaïlande et le Big Bang ; les calculs hésitants d'un gamin dans le laboratoire de Piaget et ceux d'un mathématicien récompensé par la médaille Fields ; une abaque japonaise et le Cray I. Il y a une telle différence dans les *effets* qu'il semble légitime de se mettre à la recherche d'énormes *causes*. Ainsi, même si chacun admet en privé que les « coupures épistémologiques » sont extravagantes, contradictoires, contraires à l'expérience, tous les acceptent néanmoins afin d'éviter les conséquences absurdes du relativisme. « La botanique, se disent-ils, doit dépendre de quelque chose qui est *radicalement* différent de l'ethnobotanique ; nous ne savons pas quoi mais si la notion de « rationalité » nous permet de colmater la voie d'eau et de ne pas sombrer dans le relativisme, elle est bonne à prendre. »

2. [Augé, 1975] ; [Hutchins, 1980] ; [Knorr, 1981] ; [Latour, 1981]

Nous allons essayer de flotter sur le relativisme au lieu d’y sombrer et d’expliquer les énormes différences dans les effets, que personne ne peut contester, grâce à un tout petit nombre de causes très humbles, très simples et que nous pourrons étudier empiriquement. Il s’agit donc, dans cette recension de la littérature disponible, de maintenir l’échelle des effets mais de diminuer celle des causes.

Ne risquons-nous pas de tomber alors sur un autre problème? Lorsque les chercheurs évitent d’expliquer le développement des sciences par des facteurs intellectuels, c’est pour en appeler, d’habitude, à des facteurs matériels. Des mouvements gigantesques dans le mode de production capitaliste expliqueraient, après de nombreuses réflexions, distorsions et autres médiations, certains changements dans les façons de croire, d’arguer et de prouver. Malheureusement de telles explications ont toujours semblé assez ridicules dès lors qu’on s’intéresse non à la science en général mais à telle équation, tel peptide du cerveau, tel moteur Diesel. Il y a une telle distance entre la petite bourgeoisie et la structure chimique du benzène que les explications sociologiques font toujours rire. Il y a plus grave. Afin de croire aux explications matérialistes des sciences, il faut capituler en face de l’une de ces sciences, l’économie. C’est pourquoi les explications matérialistes ressemblent tellement aux explications intellectualistes ; dans les deux cas, le chercheur (historien, philosophe, ethnologue ou économiste) demeure caché et nous n’apprenons rien sur les pratiques artisanales qui lui permettent d’expliquer et de savoir. Nous allons donc éviter les explications « mentales » aussi bien que les « matérielles » ; nous allons rechercher les causes les plus petites possibles capables de générer les vastes effets attribués aux sciences et aux techniques.

b. Attention à ce qui est écrit

Les explications les plus fortes, c’est-à-dire celles qui engendrent le plus à partir du moins, sont, d’après moi, celles qui attirent notre attention sur les pratiques d’écriture et d’imagerie. Ces pratiques sont si simples, si répandues, si efficaces que c’est à peine si nous sommes encore capables de les éprouver. Chacune d’elles permet pourtant de dégonfler d’immenses et flatteuses baudruches et c’est cette opération qui donne à beaucoup d’auteurs, que tout sépare par ailleurs, le même style ironique et rafraîchissant.

Lorsque Goody [Goody, 1979] s’intéresse au grand partage qui séparerait la « pensée sauvage » de la « pensée domestiquée », il n’accorde à Lévi-Strauss aucune des grandes coupures que celui-ci se plaît à aiguiser : « Durant les quelques années que j’ai passées chez les gens des « autres cultures », je n’ai jamais rencontré ce genre d’hiatus dans la communication auquel on aurait dû s’attendre si eux et moi avions eu du monde physique des approches de sens opposé. » (*Ibid*., p. 46.)

Il y a bien sûr un grand nombre de petites différences, mais elles ne se situent pas pour Goody entre le « chaud » et le « froid », l’ingénieur et le bricoleur ; il faut les rechercher dans les moyens d'inscription, par exemple dans le dressage d'une simple liste : « La liste implique discontinuité et non continuité. Elle suppose un certain agencement matériel, une certaine disposition spatiale ; elle peut être lue en différents sens, latéralement et verticalement, de haut en bas comme de gauche à droite, ou inversement, elle a un commencement et une fin marqués, une limite, un bord, tout comme une pièce d'étoffe. Elle facilite, c'est le plus important, la mise en ordre des articles par leur numérotation, par le son initial ou par catégories. Et ces limites, tant externes qu'internes, rendent les catégories plus visibles et en même temps plus abstraites. » (*Ibid.*, p. 150.)

Que se passe-t-il si la pensée sauvage s'applique à une liste au lieu d'écouter un récit? Elle se domestique sans qu'il soit nécessaire, pour Goody, de faire appel à d'autres miracles. Comme Walter Ong [Ong, 1982], Jack Goody finit sa longue enquête à travers les procédés scriptovisuels par ces mots : « Si l'on accepte de parler d'une "pensée sauvage", voilà ce que furent les instruments de sa domestication. » (*Id.*, p. 267.)

L'aptitude à raisonner par syllogismes est souvent prise, dans les sondages de psychologie, comme le meilleur critère de classement [Vygotsky, 1978]. Qu'est-ce qui est classé, demandent Cole et Scribner [Cole, Michael, 1974] ? Les capacités cognitives des paysans russes, des chasseurs mandingues et des enfants de cinq ans? Non, le nombre d'années d'école. C'est le « métier » d'élève et d'enseignant qu'il faut étudier si l'on s'intéresse aux syllogismes, et si l'on veut comprendre pourquoi si peu de gens sont capables de répondre à la question « tous les A sont B, x appartient à A, est-ce que x appartient à B ? » Lorsque Luria demande à un paysan russe : « Dans le Nord tous les ours sont blancs, la ville de Minsk est dans le Nord, quelle couleur ont les ours à Minsk ? », il répond : « Comment le saurais-je, demandez à votre collègue, c'est lui qui a été à Minsk, moi je n'y ai jamais été… » Il faut deux à trois ans d'école pour que des cercles tracés sur le papier blanc, et des éléments x inscrits dans ces cercles permettent aux fils de paysans de donner une réponse adéquate. Accèdent-ils à l'abstraction comme les psychologues se plaisent souvent à le dire? Non, d'après Cole et Scribner, ils acquièrent par dressage et discipline le « métier » d'écolier. Une énorme division (abstrait/concret ; logique/illogique) se trouve ramenée à de modestes distinctions de métier. « La conclusion la plus solide et la plus importante à laquelle nous sommes arrivés aujourd'hui c'est qu'il n'y a aucune preuve que différentes espèces de raisonnement existent ; nous ne pouvons pas mettre en évidence une "pensée primitive". » (1974, p. 170.)

Facile, dira le sceptique, il ne s'agit là que de capacités cognitives minimales, ce serait bien autre chose si nous abor-dions les sciences. Pourtant, le même travail a été fait par Elizabeth Eisenstein pour la révolution copernicienne [Einsenstein, 1980]. « Les "conséquences radicales" qui suivirent le travail "modeste et non révolutionnaire" de Copernic sembleraient bien moins étranges si les pouvoirs nouveaux de la presse à imprimerie étaient pris en considération. » (p. 614.) Avant l'imprimerie une version complète de l'*Almageste* de Ptolémée se trouvait rarement disponible dans une bibliothèque (p. 623). Il était encore plus rare d'en posséder plusieurs : « Il y a une grande différence entre posséder un traité complet lorsque l'on dessine des diagrammes ou que l'on compile des tables (astronomiques) et se débrouiller avec un compte rendu du livre ; cette différence vaut qu'on s'y arrête. » (p. 623.)

L'imprimerie d'Eisenstein joue le même rôle que les listes de Goody. Ces techniques d'inscription et d'enregistrement permettent aux mêmes esprits de produire des effets différents. Que cherche à faire Copernic? À établir enfin une version correcte et complète de Ptolémée. Le même vieux travail s'applique cette fois-ci à un grand nombre de versions toutes simultanément présentes. Les contradictions sautent enfin aux yeux de Copernic au fur et à mesure qu'il rassemble le texte : « Lorsque Kepler était étudiant à Tübingen les astronomes avaient à décider entre trois théories différentes. Un siècle plus tôt, à Cracovie, les étudiants avaient de la chance lorsqu'ils pouvaient prendre connaissance d'une seule. » (p. 629.)

En faisant attention à ces techniques d'inscription, Eisenstein n'a pas de peine à critiquer Kuhn. Copernic ne rompt pas avec des siècles de « science normale » ; il ne propose pas un nouveau paradigme à la place de l'ancien. Il cherche seulement à rendre systématique le puzzle épars des textes adultérés de l'*Almageste*. En cinquante ans, entre les mains de Copernic, les textes de Ptolémée deviennent enfin un système et, pour les mêmes raisons, s'effondrent...

Cette manie d'attribuer à l'esprit des mutations qui appartiennent à d'autres instances se retrouve en tous les points de la psychologie. C'est ce que montre la critique méticuleuse que Perret-Clermont fait des tests de Piaget [Perret-Clermont, 1979]. Les tests de celui-ci sont tellement épurés de tout leur contexte social et matériel, qu'il ne reste plus que les structures de l'esprit pour expliquer les modifications du comportement des enfants. Mais lorsque Perret-Clermont ajoute à la situation de test quelques éléments « sociaux », les structures mentales se trouvent modifiées en quelques minutes, ce qui est un défaut mortel pour une structure ! Un enfant non conservant, par exemple, peut devenir conservant après quelques minutes d'interaction avec un enfant plus âgé qui s'est *opposé* à lui : « Au vu de ces résultats nous serions tentés d'affirmer que si l'échange collectif peut certainement faciliter le travail cognitif et la formation des opérations, le *conflit sociocognitif peut lui*, dans certaines conditions et à un moment donné du développement de l'individu, *les susciter*. » (1979, p. 206.)

L'enfant n'est jamais seul avec le monde et le principe de réalité, c'est souvent les autres. Ne pas faire attention à ce contexte c'est abstraire le travail d'abstraction et idéaliser le travail d'idéalisation.

C'est sur ce contexte et sur ces techniques d'inscription que l'ethnographie des laboratoires a attiré depuis quelque temps l'attention [Latour et Woolgar, 1979]. L'esprit scientifique a bon dos. En appliquant les mêmes méthodes ethnographiques aux esprits scientifiques et aux esprits préscientifiques l'« esprit » se dissout peu à peu et les coûteuses et locales circonstances apparaissent en pleine lumière. Penser est un travail des mains et ce travail ne semble insaisissable qu'aussi longtemps qu'il n'est pas étudié [Lynch, 1985c] [Pinch, 1985a]. Il en est de même de la « pensée technique » [Ferguson, 1985]. « C'est la pensée non verbale qui a fixé les grandes lignes de tout le monde matériel qui nous entoure et qui en a élaboré les détails. Les pyramides, les cathédrales, les fusées n'existent pas à cause de la géométrie, de la résistance des matériaux ou de la thermodynamique ; elles existent parce qu'elles furent d'abord une image – littéralement une vision – dans l'esprit de ceux qui les construisirent. » [Ferguson, 1977], p. 835.)

Si j'indique brièvement ces travaux différents c'est pour indiquer la direction de nos efforts. Au lieu de nous précipiter dans l'esprit, pourquoi ne pas regarder d'abord les mains, les yeux et le contexte matériel de ceux qui savent. « Matériel », on le voit, ne nous renvoie pas à des infrastructures mystérieuses que seul l'économiste connaîtrait, ou à des agencements de neurones que seul le neurobiologiste connaîtrait, ou à des capacités cognitives que seul le psychologue connaîtrait, ou à des paradigmes que seul l'historien des sciences connaîtrait. L'adjectif « matériel » nous renvoie à des pratiques simples par lesquelles toutes choses sont connues, *y compris* les économies, les cerveaux, l'esprit et les paradigmes.

Il est nécessaire de s'attaquer en même temps à toute cette littérature parce qu'il n'y a, au fond, qu'un seul préjugé, qu'un seul grand partage, que les différentes disciplines ne font que souligner à plaisir. C'est la même division que l'on emploie pour diviser les sauvages des civilisés, les profanes des experts, les techniciens des ingénieurs, l'esprit de finesse de l'esprit de géométrie, le monde précopernicien du monde copernicien, les pseudo-sciences des sciences, les enfants des adultes, les autres civilisations de l'Occident. La force du grand partage c'est qu'il semble invincible puisqu'il partage tant de choses. Sans lui notre culture s'effondrerait, c'est ce que laissent entendre les rationalistes ; il serait impossible de distinguer le passé du présent, le haut et le bas, le bien et le mal, l'enfantin et le profond, le primitif et le moderne. Le chaos du relativisme nous menacerait. Rejetez le grand partage et le ciel vous tombera sur la tête !

Heureusement pour nous, cette universalité du grand partage est aussi sa grande faiblesse. C'est un seul préjugé, répété à temps et à contretemps et imposé par force à chaque domaine d'étude, par Lévi-Strauss aux sauvages, par Bachelard aux sciences, par Piaget aux enfants. Dès que des travaux empiriques permettent de mettre en doute l'un des partages, les autres viennent à la rescousse. Mais les autres c'est le même ; c'est la même ritournelle fondatrice de l'épistémologie, la même tautologie : la pensée rationnelle est la pensée rationnelle [Latour, 1984]. Pour se convaincre que l'épistémologie est un tigre de papier il suffit de débusquer son unique préjugé partout à la fois.

C'est ce que je m'efforce de faire dans cet article et qui explique à la fois la diversité de ses sources et son unité.

II. Mise au point d'une visée binoculaire

Notre premier pas est de rejeter *a priori* tout grand partage *a priori* ; le second est de rassembler les études qui expliquent les vastes effets des sciences par des pratiques simples d'inscription, d'enregistrement, de visualisation. À la place du grand partage nous avons maintenant une multiplicité de petites distinctions qui sont pour la plupart imprévues et très modestes.

Ce double mouvement nous amène pourtant à une impasse. S'intéresser aux techniques d'inscription est à la fois évident – à la limite c'est un lieu commun – et insuffisant pour expliquer les sciences et les techniques. Tout lecteur admettra volontiers que les pratiques d'inscription et de visualisation sont des causes nécessaires des révolutions scientifiques ; mais de là à en faire les causes suffisantes, il y a un pas que nul n'est prêt à effectuer. Ce n'est vraiment pas la peine, dira le sceptique, de vous être débarrassé de la mystique du grand partage pour retomber dans une mystique pire encore, celle des icônes et de nous faire croire à la puissance du signe isolé de tout le reste.

Nous ne pouvons prendre cette objection à la légère parce que l'immense littérature sur ces questions peut nous offrir aussi bien des clichés que des explications nouvelles. Les diagrammes, les listes, les formules, les archives, les dossiers, le dessin technique, les équations, les dictionnaires, les collections, selon la façon dont on les introduit, peuvent expliquer presque tout ou rien du tout. C'est trop facile d'enfiler comme des perles sur un fil les arguments de Havelock sur l'alphabet grec [Havelock, 1981], de Walter Ong sur les tables de Ramus [Ong, 2005], jusqu'à McLuhan [McLuhan, 2003] en passant par les idéogrammes chinois, les livres de comptes en partie double, sans oublier la Bible et la grammatologie de Derrida [Derrida, 1967]. Tout le monde est bien d'accord que les techniques scriptovisuelles sont présentes partout, mais quel poids leur accorder ? Combien d'aptitudes cognitives peuvent être non seulement facilitées mais expliquées complètement en ayant recours à l'écriture ? Lorsque nous abordons ces questions, nous avons l'impression tantôt de nous embourber dans une vieille ornière, tantôt de marcher sur un terrain neuf et ferme. Pour faciliter le débat, il s'agit de *mettre au point* l'image floue que nous donne cette littérature sur les images.

La première chose à faire est de spécifier dans quelles situations une modification des techniques d'inscription pourra introduire une différence quelconque dans les façons d'arguer et de convaincre. Sans cette étape préliminaire, nous risquons d'attribuer trop de poids aux phénomènes rassemblés dans ces pages, ou pas assez. Pour situer le problème, il convient de rappeler quelques résultats de l'anthropologie dessciences. Un fait est un énoncé qui est répété par quelqu'un d'autre sans qualification pour être utilisé sans contestation comme prémisse d'un raisonnement. « L'ADN a la forme d'une double hélice » est un fait lorsqu'il est repris dans la phrase suivante : « *Puisque* l'ADN a la forme d'une double hélice, il est possible d'imaginer un mécanisme simple pour la réplication des gènes. » Ce cas de reprise sans discussion est rare. La plupart du temps, les énoncés que nous proposons ne sont repris par personne, ou s'ils le sont, c'est pour être disputés. Ainsi Chargaff, dans les années 50, pouvait dire de l'énoncé précédent : « Deux ignorants au Cavendish s'obstinent à penser sans aucune preuve que l'ADN a la forme d'une double hélice. » C'est bien le même énoncé, mais modalisé, dépecé, situé dans le temps et l'espace, mis en doute. Chargaff, au lieu d'être un conducteur fidèle de l'énoncé, l'interrompt et le dévie. Selon le rapport des forces parmi les collègues, le même énoncé deviendra davantage un fait ou davantage une fiction. C'est le passage progressif et réversible du fait à l'artefact, et c'est le sort collectif des faits scientifiques qui établissent la possibilité d'une anthropologie des sciences [Latour, 1987] ; [Callon, *et al.*, 1986].

Bien que les combinaisons de la rhétorique scientifique soient sans fin, il est possible de dégager pour l'instant quelques règles pratiques.

1) Un énoncé ne se déplace jamais par lui-même d'un locuteur à un autre, il n'y a pas de force d'inertie qui expliquerait son mouvement.
2) Pour cette raison, le sort d'un énoncé est donc entièrement entre les mains des autres locuteurs qu'il doit intéresser ; sa destinée est, par définition, collective ; vous pouvez avoir prouvé sans conteste que la lune est un fromage, cet énoncé ne sera fait que si d'autres le répètent et le croient.
3) À cause de 1) et de 2), chaque locuteur se saisira d'un énoncé pour des raisons qui lui seront propres ; il agit comme un *multiconducteur* : il peut être indifférent, hostile, il peut trahir l'énoncé, l'incorporer avec un autre, le déformer de toutes sortes de façon ou même, dans certains cas, le passer à un autre sans discussion.
4) À cause de cette traduction continue, l'énoncé va changer en passant de main en main ; chaque fois qu'il sera transféré il sera transformé et, selon toute probabilité, il sera difficile de lui attribuer un auteur bien identifié.
5) Si l'on part de cette situation agonistique, il est possible de définir, dans l'ensemble des jeux de langages, le cas le plus rare : celui d'un énoncé cru par chaque membre du collectif sans autre dispute, et passé de main en main sans autre déformation ; cas encore plus rare, : le propriétaire de cet énoncé stable et répandu reste bien identifié et est reconnu comme tel par tout le monde : « Crick et Watson ont découvert que l'ADN avait la forme d'une double hélice. »

L'énoncé à la fois accepté, stable, répandu et approprié est une rareté. Comment le rendre plus fréquent? Il faut à la fois intéresser un plus grand nombre de gens à sa construction, pour que l'énoncé se répande, et rendre le comportement de ceux qui le saisissent entièrement prévisible, pour qu'il ne soit pas déformé ou trahi. Ces deux conditions sont évidemment contradictoires : si l'on intéresse beaucoup de gens, c'est en s'approchant au plus près de leurs lubies, passions et croyances ; il sera donc d'autant plus difficile d'empêcher qu'ils ne transforment ou discutent profondément l'énoncé. D'un autre côté, si personne n'est intéressé ou enrôlé, l'énoncé ne bougera pas d'un centimètre, demeurant dans la tête de son locuteur un rêve, une lubie, une folie. La difficulté deviendra presque insoluble si le locuteur veut convaincre d'un fait nouveau qui va contre l'intérêt et les croyances d'un grand nombre de gens.

Pour résoudre cette tension, il faut durcir le fait, passer des faits souples et mous qui se négocient aisément aux faits durs (*hard facts*). Pour cela, il faut accompagner l'énoncé de tellement d'éléments qu'il soit impossible pour ceux qui s'en emparent de le déformer. Qui va gagner dans ces controverses parfois vives ? Celui qui est capable de rassembler en un point le plus grand nombre d'alliés fidèles et disciplinés. Cette définition de la victoire, dira-t-on, est commune à la guerre, à la politique, au droit. En effet, et je vais montrer qu'elle est aussi commune aux sciences et aux techniques ou, plutôt, que nous avons fini par appeler « science et technique » ce rassemblement disproportionné de forces en un point.

Il nous est possible de revenir maintenant au problème des images et des inscriptions. La thèse que je voudrais illustrer est la suivante : les inscriptions par elles-mêmes ne suffisent pas à expliquer le développement cognitif des sciences et des techniques ; elles le peuvent seulement lorsqu'elles améliorent d'une façon ou d'une autre la position du locuteur dans ses efforts pour convaincre. Nous n'allons donc pas nous intéresser à toute l'anthropologie de l'écriture [Leroi-Gourhan, 1964], mais seulement aux techniques d'écriture qui permettent d'accroître soit la mobilisation, soit la présentation, soit la fidélité, soit la discipline des alliés dont la présence est nécessaire pour convaincre. Un exemple fera comprendre cette approche. Dans un célèbre passage de son journal de bord, La Pérouse relate comment, ayant abordé à Sakhaline, un groupe de Chinois lui enseigna la géographie de l'île ou de la presqu'île. La Pérouse est très surpris parce que les Chinois sont parfaitement capables de dessiner sur le sable leur île en projection. Voyant que la marée efface la carte, un Chinois plus jeune prend le carnet de La Pérouse et la redessine. Le reste de la journée se passe à échanger des connaissances nautiques[Latour, 1983] p. 226-231.

Pour analyser cet exemple, il est inutile de rameuter de grands partages entre esprit préscientifique et esprit scientifique, entre une géographie implicite et concrète – celle des natifs – et une géographie explicite et abstraite – celle des visiteurs. L'aptitude à inscrire et à visualiser ne fait pas de différence non plus puisque les Chinois et La Pérouse se comprennent fort bien et que le jeune Chinois utilise de la même façon le même carnet. Est-ce à dire qu'il n'y a pas de différence et que, toutes les géographies étant nées libres et égales, le relativisme a raison ? Non, parce que La Pérouse va faire quelque chose qui va *créer* une énorme différence entre lui et les natifs. Ce qui pour ces derniers est un dessin sans importance que la mer peut effacer, un simple *intermédiaire* qu'ils peuvent redessiner à volonté, est pour La Pérouse le seul but de sa mission. Garder la trace de la carte est inutile pour le Chinois, puisqu'il peut la refaire, qu'il est né dans ces lieux et qu'il y mourra. Mais La Pérouse ne fait que passer, il n'y est pas né et il ne compte pas y mourir. Pourquoi est-il là ? Afin de rapporter à Versailles un nombre suffisant de preuves qui décideront si Sakhaline est une île ou une presqu'île. Comment rapporter ces preuves ? En les inscrivant toutes dans le même langage, selon la longitude et la latitude. Ce qui pour le natif est l'intermédiaire consommé dans l'échange devient pour l'autre le but ultime de tout son déplacement. Un intermédiaire est devenu la seule chose digne d'être *capitalisée*. Si la carte est effacée, peu importe au Chinois ; mais si La Pérouse perd son carnet de bord, tout son voyage est perdu. Inversement, s'il disparaît, mais que ses notes aient pu parvenir à Versailles, son voyage se trouvera justifié [Stafford, 1984].

Pour comprendre cette obsession pour la trace inscrite, il convient de prendre en compte à la fois le déplacement de La Pérouse – envoyé par Versailles, il doit y revenir pour convaincre de la forme qu'il donne au Pacifique – et les techniques d'inscriptions. Sans le premier, aucune technique ne serait suffisante pour expliquer la création en quelques dizaines d'années d'une nouvelle géographie. Sans les secondes, aucun « esprit capitaliste », aucune « soif de connaissance », aucun « appât du gain », aucun « impérialisme » ne serait suffisant pour expliquer la capitalisation, en quelques points du globe, de tout le globe terrestre.

C'est seulement en considérant à la fois le mouvement pour convaincre et les techniques qui favorisent la mobilisation des ressources, que nous pouvons avoir une vision vraiment « binoculaire » des rapports entre visualisation et capacités cognitives. Nous ne trouvons pas convaincante n'importe quelle explication des sciences qui parlent d'inscription, de reliure, de physiographe, d'instrument, de diagrammes ; mais seulement celles qui rattachent ces pratiques au mouvement de mobilisation. Inversement, nous ne trouvons pas également convaincantes toutes les explications – et Dieu sait s'il y en a – en terme de groupes, d'intérêts, de classes, de cycle économique ; mais seulement celles qui proposent en même temps un mécanisme précis pour que ces groupes, intérêts, classes et cycles soient additionnés quelque part grâce à certaines techniques nouvelles d'inscription.

III. Des mobiles immuables

Ce n'est pas à un problème de perception que nous nous trouvons confrontés, mais à un problème de mobilisation. Si vous souhaitez convaincre un grand nombre de gens de choses inhabituelles, c'est vous qui devez d'abord sortir de vos habi-tuels chemins ; vous reviendrez, accompagnés d'un grand nombre d'alliés imprévus et nouveaux, et vous convaincrez, c'est-à-dire que vous vaincrez tous ensemble. Encore faut-il que vous soyez capables de revenir avec les choses. Si vous en êtes incapables, vos mouvements seront perdus. Il faut donc que les choses puissent supporter le voyage sans se corrom-pre. Il faut aussi que toutes ces choses puissent être présentées à ceux que vous souhaitez convaincre et qui n'ont pas été là-bas. Pour résumer, il faut que vous inventiez des objets qui soient *mobiles, immuables, présentables, lisibles et combinables*. J'ai la conviction que ceux qui ont étudié les nombreuses relations entre les inscriptions et l'esprit scientifique ont fait, à leur manière, l'histoire de ces mobiles immuables.

a. Les chemins de la perspective

La révolution scientifique, pour William Ivins, ne vient pas de l'esprit, de la philosophie ou même de l'œil. Elle vient de la vision [Ivins, William M., 1985]. L'esprit va devenir scientifique en voyant le monde en perspective. Pourquoi la perspective, inventée à la fois par les géomètres, les peintres et les graveurs, a-t-elle autant d'importance ? « Normalement, ce sont les relations extérieures des objets… qui se transforment lorsqu'ils changent de lieux, ou alors ce sont leurs relations internes qui se déforment… » La perspective joue un rôle crucial « parce qu'elle reconstruit logiquement les invariances internes à travers toutes les transformations produites par les déplacements dans l'espace ». Dans la perspective linéaire, un objet peut apparaître à n'importe quelle distance et sous n'importe quel angle ; il sera néanmoins possible de le *déplacer* sous un autre angle et à une autre distance sans qu'il ait subi de déformation. Grâce à la perspective, les formes vont devenir immuables malgré leur mobilité. Cette immuabilité, d'après Ivins, a pour conséquence de créer des « allers et retours » entre les objets et leurs images. L'image d'une église romaine peut être déplacée à Paris, mais peut aussi revenir à Rome, comparée au modèle, et remaniée. Grâce à la perspective, c'est l'ensemble des objets du monde qui peut être cartographié par longitude et latitude, transporté sur des rouleaux de papier, amendé et corrigé lorsque d'autres voyageurs reviennent aux modèles. Comme le dit Ivins, des avenues à double voie relient le monde et ses images, avenues qui permettent la circulation et la collaboration : « La science et la technologie ont progressé en relation directe avec la capacité de l'homme à inventer des méthodes grâce auxquelles des phénomènes qu'on ne pourrait sans cela connaître que par les sens du toucher, du goût et de l'odorat, ont pu être visuellement reconnus et mesurés. »

Ce que permet la perspective, c'est d'offrir une « cohérence optique » à toutes les images. Tous les autres sens sont abandonnés, la vue seule permet enfin de penser. Avantage capital, il est enfin possible de capitaliser en quelques points tous les autres points du globe. Personne ne peut écouter, toucher ou sentir l'île Sakhaline, mais tout le monde peut lire à Versailles la carte de l'île et décider sur pièces l'itinéraire de la prochaine mission. Ils se disputent peut-être, mais entourés par les choses elles-mêmes, absentes et présentes à la fois. Comme autrefois, dira-t-on ! Non, parce que ces images calibrées peuvent supporter autant de voyages aller et retour que l'on voudra. Du local au global, pour parler comme Michel Serres, un chemin est frayé. Grâce à des inventions graphiques et géométriques (le quadrillage, le point de fuite, la projection de Mercator, l'eau-forte), la forme des choses a survécu aux déplacements continuels. On a bien inventé des mobiles immuables.

Il y a un autre avantage offert par la perspective, bien illustré par Samuel Edgerton [Edgerton, 1980]. Grâce à elle, il est possible d'offrir la même cohérence optique à des objets venus du monde et à des objets venus de la fiction ou de la croyance. Des utopies, des scènes mythologiques, des épiphanies religieuses, des créations humaines ou des objets naturels, tous se retrouvent dans le même *lieu commun*, l'espace homogène de la perspective : « En Occident, même si le sujet d'un texte imprimé n'était pas scientifique, l'image imprimée présentait une forme rationnelle établie selon les lois universelles de la géométrie. En ce sens, la révolution scientifique doit probablement plus à Dürer qu'à Vinci. » (p. 190.)

Bien sûr, ce n'est pas le lieu commun par lui-même qui est intéressant. Ce sont les *échanges* qu'il permet. Les éléments les plus hétérogènes peuvent s'éparpiller en morceaux, en pièces détachées, et se recombiner librement dans l'espace blanc du papier. Commentant les planches d'Agricola, Edgerton attire notre attention sur cette nouvelle liberté : « Curieusement, la perspective linéaire et le clair-obscur qui permettent aux images d'acquérir une solidité géométri-que permettent aussi au spectateur d'échapper provisoire-ment à sa dépendance envers la gravitation. Avec un peu d'habitude, le spectateur imagine des volumes solides qui flottent librement dans l'espace comme s'ils étaient les pièces déta-chées d'un même engin. » (*Idem*, p. 193.)

Lorsque de tels échanges se font, toutes les images se recombinent, créant sur le papier des hybrides. C'est là tout l'intérêt du langage de la perspective. Il ne permet pas seulement de décrire, il permet de voir la nature comme une fiction et la fiction comme une nature. Le monde peut être battu comme un jeu de cartes. De nouvelles donnes sont possibles sans aller chercher bien loin dans l'esprit : « Le *Saint Jérôme* d'Antonello est le meilleur exemple qui soit de cette nouvelle conscience du monde à laquelle parvint, vers la fin du XVIe siècle, l'intelligentsia d'Occident. Cette conscience se manifeste dans les œuvres d'artistes comme Léonard de Vinci, Francesco di Giorgio Martini, Albrecht Dürer, Hans Holbein et bien d'autres. Tous, ils avaient développé une grammaire et une syntaxe très complexes pour quantifier les phénomènes naturels dans des images. Entre leurs mains, la construction des images devint un langage pictural qui, avec un peu d’habitude, pouvait communiquer plus d’informations, plus rapidement et à beau-coup plus de gens, qu’aucun autre langage au cours de l’histoire humaine. » (*Idem* p. 189.)

Ce langage pictural permet au même esprit d’avoir d’autres visions. Il lui permet de combiner en quelques points la totalité de ce qui avait été imaginé, visité, vu et projeté : des machines, mais aussi des villes, des monstres, des planches anatomiques, des Vierges Maries, des saints et des cieux. L’histoire de la perspective illustre à merveille la double ligne d’arguments que j’ai présentée dans la section précédente : les inventions dans le graphisme sont capitales, mais seulement parce qu’elles permettent d’accélérer la mobilité des images, d’accroître leur immutabilité, ou d’amplifier leurs recombinaisons.

b. Les cultures de l’œil

Si nous voulons considérer à la fois la mobilisation du monde et les inventions picturales, il nous faut étudier la culture de l’œil [Baxandall, 1972], ou ce que Svetlana Alpers appelle, après Foucault, l’« art de décrire » (*the art of describing*) [Alpers, 1983]. Alpers nous explique que les Hollandais ne peignent pas à la manière italienne de grandes scènes historiques auxquelles le spectateur assiste comme à travers une fenêtre. Ils utilisent la surface même du tableau – prise comme l’équivalent d’une rétine – pour y laisser le monde s’inscrire directement. L’astuce de la camera obscura est de transformer de grands volumes en une surface réduite autour de laquelle le spectateur peut tourner à volonté. Quand une telle capture d’images a réussi, il n’y a plus pour le spectateur de site privilégié, de même qu’il n’y a plus pour l’image de cadre nécessaire. « Les artistes du Nord, de façon caractéristique, cherchèrent à représenter, en transportant l’étendue de la vue sur leur surface de travail, plate et petite (...) C’est cette capacité de la surface à contenir une telle illusion du monde – c’est-à-dire une combinaison de vues différentes – qui est typique de la plupart des images du Nord. » (p. 51.)

Au lieu de faire allusion au monde à travers des symboles dramatisés, à la manière italienne, les Hollandais transfèrent le monde « à même » l’image. De là une série de traits bien connus : l’échelle des tableaux se trouve modifiée (p. 84), l’artiste n’est plus nulle part, l’image devient plus horizontale que verticale ressemblant souvent à une carte (chapitre IV), le cadre devient une limite arbitraire, de nombreux aspects du même objet peuvent être simultanément présents (p. 91), les thèmes apparaissent dérisoires (églises vides, citrons pelés, lettres lues...). Le grand intérêt pour nous du livre d’Alpers est qu’il ne porte pas seulement sur les images mais sur l’ensemble de la culture visuelle d’un pays et d’une époque. Cette culture comprend à la fois certaines images, mais aussi des sciences nouvelles, des théories de l’optique, une certaine organisation des arts et des métiers, et surtout une économie. On parle souvent de « vues du monde » sans comprendre que cette métaphore doit toujours être prise littéralement. Alpers la prend très au sérieux : comment une culture *voit le monde* ? Comment le rend-elle *visible* ? Une nouvelle « vue du monde » redéfinit ce que c'est que voir et ce qu'il y a à voir.

Avant les Hollandais, tout le monde bien sûr avait regardé des huîtres, des nuages, des fleurs ou des églises. Personne pourtant avant eux n'avait regardé ces images particulières dessinées pour transporter les objets du monde, les capitaliser en Hollande, les étiqueter à même le tableau avec des légendes, les combiner à d'autres images et à des textes. Alpers donne un sens concret à la notion encore intellectuelle de Foucault : celle d'*épistémê*. Elle s'efforce d'expliquer comment les mêmes yeux se mettent soudainement à voir les mêmes représentations. Elle va plus loin encore que le « panoptique » [Foucault, 1975], parce que c'est une certaine façon de mettre en scène le monde qui définit en même temps une science, un art et ce que c'est que d'avoir une « économie-monde ». Loin d'expliquer des images en ayant recours à une infrastructure économique, elle présente un nouveau régime des images qui établissent une nouvelle économie. Pour utiliser mes termes : les Pays Bas deviennent puissants grâce à un petit nombre d'inventions qui accélèrent la mobilité et augmentent l'immutabilité d'un plus grand nombre d'inscriptions. Le monde littéralement s'accumule dans ce petit pays, comme Diderot le disait si joliment.

Tous les aspects de la vie sont touchés par cet « art de décrire toute chose » : l'obsession pour les lettres, pour les miroirs, les lentilles, pour les perspectives, les inventaires, les dictionnaires, pour les cartes ethnographiques, pour les microscopes et les télescopes. La principale qualité de ce nouvel espace visuel n'est pas d'être plus « objectif », c'est de posséder cette « cohérence optique » étudiée par Ivins, cohérence qui permet à des éléments *à première vue* éloignés, d'échanger leurs caractéristiques : cartes, livres de comptes, descriptions de voyages, missives, théories de l'œil. Un ensemble très hétérogène d'innovations sont sélectionnées afin de « voir secrètement et sans qu'on le sache ce qui se passe en des lieux très éloignés » (cité p. 201) !

c. Rassembler l'espace et le temps

L'invention de l'imprimerie et ses effets sur la connaissance sont un cliché aussi vieux que l'imprimerie elle-même. Personne n'a renouvelé ce vieil argument autant qu'Elizabeth Eisenstein dans son livre capital [Einsenstein, 1980]. Elle considère en effet les nombreuses inventions du système technique « presse à imprimer » comme un moyen d'améliorer à la fois la mobilisation et l'immutabilité des écrits et des images. Eisenstein ne cherche pas comme tant d'autres une seule cause à la révolution scientifique ; elle ne cherche pas non plus à accumuler dans le désordre un grand nombre de petites causes. Elle cherche une cause seconde qui, par sa nature, permettrait à toutes les petites causes signalées par les auteurs d'agir comme une seule cause efficiente. L'invention de l'imprimerie est évidemment la réponse. Comme pour Ivins, Ferguson, Edgerton et pour Mukerji[3], c'est la combinaison du texte imprimé et des gravures à l'eau-forte dessinées selon les règles de la perspective, qui *fait* vraiment *la différence*. Le monde peut enfin se cumuler en quelques places et être synoptiquement présenté. Mieux encore, ces éléments une fois assemblés, amendés et corrigés peuvent être déplacés à nouveau partout sans autre modification.

Après avoir critiqué des historiens qui proposent, pour expliquer le développement de l'astronomie, un grand nombre de facteurs contradictoires, Eisenstein explique : « Que l'astronome du XVIe siècle soit confronté à des textes du IVe siècle avant Jésus-Christ ou récemment composés au cours du XIVe siècle après Jésus-Christ, qu'il soit plus réceptif à des courants de pensée scolastiques ou humanistes, tout cela semble avoir moins de signification dans ce contexte que le fait que toutes sortes de matériaux divers soient vus au cours d'une vie par la même paire d'yeux. Pour Copernic comme pour Tycho Brahe, le résultat était le même : ils étaient beaucoup plus conscients et beaucoup moins satisfaits des contradictions présentes dans les données. » (p. 602.)

La conscience des contradictions dépend de la présence synoptique des données diverses venues de siècles différents. Sans cela, l'esprit ne voit rigoureusement rien, aussi « scientifique » soit-il. Avec une ironie charmante, Eisenstein déplace l'attention de l'esprit vers ce qu'il voit : « John Locke écrit que "pour découvrir la vérité d'une proposition d'Euclide, il n'est pas besoin ou nécessaire d'attendre une révélation, puisque Dieu nous a procuré des moyens naturels et plus sûrs de parvenir à les connaître". Au XIe siècle pourtant, Dieu n'avait pas procuré aux érudits de l'Occident un moyen naturel et sûr de comprendre un théorème d'Euclide. Bien au contraire, les plus savants hommes de la chrétienté étaient engagés dans une recherche désespérée pour comprendre ce qu'Euclide pouvait bien vouloir dire par angles rentrants. » (p. 649.)

Il n'est pas, pour Eisenstein, de question sur la Réforme ou la révolution scientifique ou l'économie capitaliste, qui ne puisse être renouvelée en devenant attentif à la mobilisation et à l'immutabilité permise par la presse à imprimer. Après Ivins [Ivins, Williams M., 1953], elle explique par exemple le décalage de centaines d'années entre l'apparition de la presse et le début des images « exactes », décalage qui est souvent utilisé afin de dénier à l'imprimerie tout pouvoir sur l'intellect. Les premiers livres imprimés reproduisent des herbiers, des planches ana-tomiques, des schémas géométriques, des cartes comme on le faisait depuis deux mille ans et « sans aucun. d'exactitude ». Si nous considérions la seule perception, cela serait, bien sûr, étonnant ; en nous attachant à la structure discutée plus haut, nous pouvons y voir, au contraire, l'illustration de notre thèse : le déplacement des mobiles immuables est premier ;

3. [Ivins, William M., 1985] ; [Ferguson, 1985] ; [Edgerton, 1985] ; [Mukerji, 1983]

de vieux textes vénérables sont répandus partout dans la forme adultérée où le dernier copiste les a laissés. Seulement, les contradictions entre les vieux textes ainsi répandus deviennent *visibles*, au sens littéral du terme, ainsi que les contradictions entre ces textes et les innombrables lieux où ils se trouvent assemblés : d'autres fleurs, d'autres noms d'organes, d'autres montagnes et caps, d'autres taux d'échange... Ces contre-exemples, maintenant visibles, peuvent être ajoutés aux vieux textes et seront à leur tour, aussi faux soient-ils, reproduits et répandus. Comme pour le code génétique, les erreurs sont reproduites exactement et multipliées, mais les corrections le sont aussi, si bien qu'après quelques dizaines d'années, l'exactitude glisse *du médium vers le message*. Ce nouvel intérêt pour une information exacte ne vient pas d'un nouvel esprit, mais du même esprit s'appliquant à un objet nouveau qui mobilise différemment l'espace et le temps.

La preuve qu'il ne s'agit point là de pensée ou de méthode, c'est que le même mécanisme a sur la croyance religieuse un effet exactement inverse. La précision mécanique du médium jette le doute sur le message à partir du moment où toutes les versions du texte sacré se trouvent présentes à la vue. Plus les réformés veulent retrouver le texte primitif, plus les contradictions sautent aux yeux. Là encore, les effets de vérité ou de doute sont obtenus par contamination à partir d'un médium qui mobilise en certains points toutes les versions possibles. La notion de « contexte » change avec le texte et les adultérations continues de la Bible, normales jusqu'ici, deviennent autant de scandales [Latour, 1983].

L'avantage du mécanisme mis en évidence par Eisenstein, c'est d'expliquer l'accumulation irréversible de l'exactitude, trait particulier à la fois aux sciences et au capital. Là encore, il faut en revenir aux conditions particulières de l'argumentation. Aucune des sciences nouvelles ne peut décrire par un texte ce dont elle parle : elle doit le montrer par l'image. Dès que quelqu'un commence à accompagner son texte d'un certain nombre d'images du monde, fidèles et bien alignées, le seul moyen de disputer l'argument est de présenter d'autres images, plus nombreuses, plus fidèles et mieux alignées [Mukerji, 1985]. Les planches anatomiques se multiplient et deviennent de plus en plus nombreuses, détaillées et exactes, simplement à cause de la pression agonistique et de la nécessité d'augmenter sans cesse le « coût de la preuve ». Une fois que Tycho Brahe commence à inonder l'Europe de tables imprimées et calibrées pour y noter les observations du ciel, il devient beaucoup plus difficile aux autres astronomes de s'en passer. Ou bien ils abandonnent le combat, ou bien ils reviennent avec encore plus de « preuves » visuelles. La course aux preuves obéit au même mouvement que la course aux armements et pour les mêmes raisons.

Cette course, commencée à l'époque décrite par Eisenstein, continue aujourd'hui dans tous les laboratoires. N'importe quelle invention qui accélérera la mobilité des traces, ou qui améliorera leur immutabilité, ou leur lisibilité, ou leur combinaison, sera aussitôt sélectionnée par des chercheurs passionnés : une nouvelle manière de colorer les microbes, un nouveau radiotélescope, un nouveau programme pour dessiner des diagrammes, une nouvelle chambre à bulle, un nouveau produit pour mouler les fossiles, un nouveau satellite, un nouveau scanner… Tout sera choisi, construit, acheté, qui permet à quelqu’un d’accumuler localement des images du monde lisibles et combinables pour rendre plus fort son argument. La pensée sauvage est toujours en train d’être domestiquée.

IV. Des avantages qu’il y a à inscrire

Pourquoi les inscriptions de toutes sortes sont-elles aussi importantes pour les chercheurs, les ingénieurs, les architectes, tous ceux qui pensent avec leurs yeux et leurs mains ? Parce qu’elles offrent un avantage unique lors des discussions : « Vous doutez de ce que je dis ?… Vous allez voir, je vais vous montrer ! » et sans remuer de plus de quelques centimètres, l’orateur déploie devant les yeux de ses critiques autant de figures, diagrammes, planches, silhouettes qu’il en faudra pour convaincre. Aussi médiates que soient ces inscriptions, aussi lointaines que soient les choses dont on parle, des chemins à double voie s’établissent. L’objecteur se trouve dominé par le nombre de choses dont parle l’orateur, toutes présentes dans la salle. Il peut douter de chacune d’elles, mais toutes ensemble, elles composent une formidable preuve[4]. Nous sommes tellement habitués à recourir à ces alliés, que nous avons oublié ce que c’est que penser sans index, sans bibliographies, sans dictionnaires, sans fiches bristol, sans physiographes, sans cartes, sans diagrammes…

a. « La voie sûre d’une science »

Dans de très beaux livres[5], François Dagognet a montré ce que c’était que de penser, par exemple la chimie, sans cette iconographie cohérente. Un fouillis de corps et de recettes, de réactions et de tours de main, ne devient un savoir scientifique que lorsque tout commence à s’écrire dans des termes optique-ment cohérents. Bien qu’il aborde le sujet par un tout autre biais, Dagognet parle du symbole chimique comme Goody parle de ses listes et tableaux à double entrée : « Nous avons beau traiter d’infimes détails (un léger changement de plan pour un chlore) : ce sont ceux qui, paradoxalement, détiennent les forces du monde moderne. » (1969, 199.) En effet, la chimie écrite et visualisée va pouvoir se recombiner sur le papier autant que dans les cornues. L’attention du chimiste se perd dans le laboratoire, mais se concentre à nouveau sur la surface même du papier. Comme l’intellectuel de brousse décrit par Goody,

4. [Lynch, 1985b] ; [Lynch, 1985c] ; [Latour et Bastide, 1983] ; [Callon, *et al.*, 1986]
5. [Dagognet, 1969] ; [Dagognet, 1973] ; [Dagognet, 1984]

Mendeleïev apprend de son tableau plus qu'il n'y a mis : « Qu'on le veuille ou non, pour qui sait voir et lire le tableau périodique final, les propriétés des éléments et celles de leurs diverses combinaisons découlent directement, entièrement, de leur emplacement. C'est ainsi (...) il faut bien le souligner contre les iconoclastes. » (*Id.*, 213.)

Les iconoclastes sont ceux qui veulent que l'esprit pense à Dieu, aux trous noirs, au benzène ou à la balance des paiements, sans voir aucune image de ces êtres. Cette présence des icônes est si importante pour Dagognet qu'elle fait dire à cet épistémologue des phrases qu'un sociologue ne renierait pas : « Autre notion que Lavoisier nous a léguée : le pouvoir du vocabulaire, la valeur des échanges et de la communication. On ne s'en étonne pas de la part de ce sociologue (chimiste malgré lui) et même de ce physiocrate qui souhaitait la circulation des signes, comme la liberté du commerce et des marchandises. » (*Id.*, 209.)

Je vous le disais bien : il ne s'agit pas de perception seulement, mais de mobilité, de combinaison, d'accélération, de thésaurisation : « La chimie a dû son statut et son essor moins aux chimistes qu'à un collecteur d'impôts et à un organisateur social. » (*Id.*) Ce lien si fondamental entre ce que l'esprit peut voir et l'organisation de ce qu'il doit voir, c'est bien sûr Michel Foucault qui l'a développé le plus loin, du moins pour les sciences humaines. En médecine, ce n'est pas l'esprit qui va changer, qui va devenir plus sceptique, plus scientifique, plus expérimental, c'est le *regard* [Foucault, 1963]. Et ce regard lui-même, pourquoi change-t-il ? Mais parce qu'il s'applique, dans l'intérieur de l'hôpital, à un nouveau régime d'inscriptions et de traces. Le corps est invisible ; chaque malade est particulier. Il n'en est pas de même de l'accumulation des planches anatomiques, des dossiers homogènes où se trouvent enregistrées avec soin les réponses à des examens identiques. Les fièvres s'agencent autrement si, au lieu de voir un malade enfiévré, puis un autre, c'est cent fièvres décrites qu'on inspecte d'un regard. Dans *Surveiller et punir*, Foucault précise quel est ce regard logé dans une institution construite pour lui. La prison ou l'école deviennent des laboratoires et ceux-ci sont des « panoptiques » : le seul moyen de voir la totalité est d'organiser, à la fois, les murs, les rondes, les dossiers et les instruments pour présenter synoptiquement les phénomènes. L'esprit changera sans autre révolution et comme par surcroît : « Les procédures d'examen ont été tout de suite accompagnées d'un système d'enregistrement intense et de cumul documentaire. Un "pouvoir d'écriture" se constitue comme une pièce essentielle dans les rouages de la discipline. Sur bien des points, il se modèle sur les méthodes tradition-nelles de la documentation administrative. » (1975, 191)

Dans tous ses livres, Foucault suit la transformation de savoirs en sciences plus ou moins exactes, et rapporte ce surcroît d'exactitude à un dispositif d'inscription. L'avantage de son analyse c'est d'attirer notre attention non pas sur la perception – ce qui serait, nous le savons, insuffisant – mais sur l'ensemble du dispositif qui mobilise, enregistre et assemble. Le « panoptique » procure aux savants et surveillants la « cohérence optique » dont parlait Ivins, cohérence sans laquelle le pouvoir exercé sur une grande échelle serait impossible (voir dernière section).

L'expression de « révolution copernicienne » sert à Kant pour décrire ce passage des savoirs obscurs, tournant autour des choses sans les comprendre, à ces sciences devenues exactes parce qu'elles font tourner le monde autour d'elles. Chaque savoir entre à son tour dans la « voie sûre d'une science ». Cette inversion des rapports n'est pas un problème théorique ; c'est une question pratique : il y faut des chemins et des voies. C'est un problème de Ponts et Chaussées ou de navigation. Rudwick a par exemple étudié l'entrée de la géologie dans cette voie assurée [Rudwick, Martin, 1976]. Ou bien les voyageurs se promènent à travers le monde et regardent les sols et les mines mais reviennent à Paris ou à Londres les mains vides ; ou bien ils sont capables de rapporter les profils, les strates et les fossiles avec eux. La première situation est précopernicienne, la seconde copernicienne. Comment passer de l'une à l'autre? Là encore, le médiateur obligé est un langage visuel, un protocole de descriptions des couches et des azimuts, un ensemble de conventions de couleurs et de tracés. La « voie sûre d'une science » c'est toujours l'invention d'un nouveau mobile immuable capable de rassembler les choses en quelques points. Comme Lagardère, le géologiste s'écrie : « Si tu ne vas pas à la Terre, la Terre ira à toi. » Ce transport de la Terre se fait par des véhicules trop humbles pour intéresser Kant : des carottes, des carnets, des relevés, des grisés, des hachures… Pourtant ce sont eux qui assurent le surcroît de certitude gagné par les géologues : ces images peuvent se combiner, se superposer, se redessiner. Le regard du géologue devient scientifique rien qu'à les regarder.

Pour se convaincre de l'importance de ces inscriptions il suffit de descendre en nous-mêmes et de mesurer combien peu nous savons dès qu'on nous en prive. Dans un livre pas-sionnant, François Fourquet a décrit la construction de cet autre panoptique, l'INSEE, qui nous permet de dire quelque chose de l'économie française [Fourquet, 1980]. Vous ne pouvez pas parler de l'économie française en « la » regardant. « Elle » est totalement invisible autant que la chimie, la maladie ou la terre. Jusqu'à la guerre de 40, les économistes interrogés par Fourquet avouent qu'ils ne savaient pas grand-chose de l'économie française. Ils regardaient les cours de la Bourse, seul indicateur mesurable de l'état « des affaires ». Il faut pour la rendre visible cette économie, des milliers d'inspecteurs, d'enquêteurs, de clavistes, d'économistes, d'ordinateurs, de programmeurs. L'INSEE, malgré sa taille, est un grand laboratoire qui procure aux activités innombrables de la France une cohérence optique. Cela ne suffit pas, car la simple accumulation des traces au bout des imprimantes suffirait déjà à noyer les économistes les plus courageux. Il faut donc d'autres ordinateurs, d'autres analystes, d'autres dessinateurs, qui, partant de ce monde de papier, en tirent quelques diagrammes très simples : le taux d'inflation, la balance des paiements, le produit national brut. L'« économie » est le produit de ce gigantesque et coûteux instrument au même titre que les radiosources sont le produit des coûteux radiotélescopes. On comprend pourquoi j'ai refusé, dès le début de cette présentation, de recourir aux « explications » économiques. Ce sont elles, au contraire (les infrastructures, les économies-mondes), qu'il convient d'expliquer…

Nous savons tous, surtout en France, à quel point les « théories » informent notre vision des choses. Aucun de nous n'est plus d'un empirisme naïf. Pourtant, ces « pouvoirs d'écriture » nous échappent, qui ne sont ni de l'ordre de la perception empirique, ni de l'ordre des théories et des paradigmes. Il s'agit plutôt d'organisation, de régime, de mouvement et nous ne nous en rendons pas compte tant ces pouvoirs sont évidents. Dans un livre très suggestif, Johannès Fabian a étudié la façon dont nous composions par exemple l'anthropologie [Fabian, 1983]. L'idée de « culture » et surtout de cultures « closes » est pour Fabian un artefact de l'anthropologie comme sciences : Comme Bourdieu avant lui [Bourdieu, 1972], et comme Goody, Fabian reprend la critique de l'anthropologie. « Nous » visualisons « leurs » cultures. Nos anthropologues voyagent à travers le monde et ne reviennent pas les mains vides. Ils rapportent des cartes, des inventaires, des chronologies, des généalogies, des herbiers, des photos, des totems, des masques, des récits de mythes. Tous ces éléments, même s'ils supportent bien le voyage, subissent à Paris, Londres, Berlin ou New York une transformation fondamentale : ils deviennent synoptiquement visibles. Les contradictions se multiplient alors entre les généalogies malaises et les botaniques andines, entre les rites iroquois et les initiations bantoues. Le seul moyen de résoudre ces contradictions c'est de faire de chaque culture une totalité close et immobile qui comprend le monde à sa façon, symbolique et bizarre, pendant que « nous », qui les *voyons toutes ensemble*, considérons à la fois le monde tel qu'il est et les visions déformées que les « autres » cultures en ont.

Fabian prétend que cette transformation est à la fois petite et radicale, qu'elle nous interdit à « nous » de rien dire sur « eux ». Là n'est pas la question. Pour convaincre nos collègues ethnologues, pour leur faire changer d'avis, il nous faut bien aller dans le monde et revenir avec autant d'images des choses que possible, images combinables et présentables. Respecter les autres cultures ne pourrait signifier que trois choses : ne pas y aller ; y rester ; revenir les mains vides. Si l'on veut revenir et « savoir », il faut transporter tous les aspects des peuples traversés en mobiles immuables, enregistrer, filmer, remplir des questionnaires, noter les mythes, garder les masques et les calebasses. Tout ce qui sert *d'intermédiaires* aux peuples traversés devient à la fois la fin et le début d'un cycle indéfini de *capitalisation*. Les « faits » qu'il faut produire à Berlin, Paris ou Londres sont à ce prix.

b. Simplifier les jugements perceptifs

Ce qui est en question dans ce virage des sciences n'est pas qu'elles soient exactes ou humaines. L'obsession pour les inscriptions est la même qu'il s'agisse d'un économiste, d'un géologue, d'un ethnographe ou d'un astronome. Ce qui est en question, c'est le bénéfice à attendre d'une inscription pour convaincre des collègues. Si les scientifiques *regardaient* la Terre, les économies, les organes ou les étoiles, ils ne *verraient* strictement rien. Cette « évidence », si l'on peut dire, est souvent utilisée pour critiquer l'empirisme et pour prouver que les chercheurs *voient* avec les yeux de l'esprit dans un ciel baigné d'une lumière platonicienne un peu analogue à celle du néon. La rupture totale avec la vision commune est même considérée par Bachelard comme une conversion nécessaire pour « entrer en science ». La critique de l'empirisme n'oblige pourtant pas à tomber dans ces « vues de l'esprit » et à croire aux « coupures épistémologiques ». L'esprit du savant ne quitte à aucun moment ses yeux et ses mains. Mais ce qu'il voit change en effet. Il ne regarde pas les étoiles, mais l'image en couleur artificielle que l'ordinateur a recomposée à partir de l'image optique ; il ne regarde pas les économies, mais les statistiques de l'INSEE. L'opposition entre empirisme et théorie, entre perception et paradigme, oublie ce petit décalage qui permet d'aller *d'images complexes à des images plus simples*.

Tycho Brahe par exemple dans son observatoire commence à discerner de nombreuses contradictions dans les savoirs anciens. Est-ce parce qu'il a rompu avec le « paradigme » qui le précède. Eisenstein en doute : « Ce n'est pas parce qu'il observait le ciel nocturne au lieu de vieux grimoires que Tycho Brahe différait des astrologues du passé. Ce n'est pas non plus, je crois, parce qu'il faisait plus attention aux "faits têtus" et aux mesures précises que les Alexandrins ou les Arabes avant lui. Mais il est vrai qu'il avait à sa disposition ce que peu de gens avaient eu avant lui, à savoir deux ensembles distincts de computations établies à partir de théories différentes et compilées à plusieurs siècles de distance qu'il pouvait comparer l'une à l'autre. » (1979, 624.)

Les hagiographes font de Tycho Brahe l'un des premiers qui regarda le ciel l'esprit libre de préjugés d'un autre âge. C'est pourquoi, disent-ils, il s'aperçut enfin de contradictions qui lui sautèrent aux yeux. Pourtant, les contradictions ne sont pas des puces, fussent-elles dialectiques. Elles apparaissent seulement *entre* des colonnes de chiffres : « L'observateur danois ne fut pas seulement le dernier qui fit des observations à l'œil nu ; il fut aussi le premier qui profita pleinement des nouvelles possibilités offertes par la presse à imprimer ; possibilités de détecter des anomalies dans d'anciennes compilations, de repérer précisément et d'enregistrer dans des catalogues la position de chaque étoile ; d'enrôler des collaborateurs dans de nombreuses régions, de fixer chaque nouvelle observation dans une forme permanente et de les corriger, si nécessaire, au cours des éditions suivantes. » (*Id.*, p. 625.)

Ce scepticisme, cette falsification, cet amour des contradictions, l'esprit scientifique se les attribue un peu vite. Il n'y a pas de contradiction en dehors d'un système d'écriture et d'enregistrement synoptique. L'esprit scientifique est mauvais joueur ; il doit partager ses mérites avec les humbles colonnes, listes, et inventaires.

Les chercheurs commencent à voir quelque chose et à parler avec autorité quand ils arrêtent de regarder la nature – les critiques de l'empirisme ont jusque-là raison – et qu'ils collent leur œil obstinément à des inscriptions plus simples – c'est là que les amoureux de la théorie se trompent. Eh oui, plus simples... Des objets lointains en trois dimensions, rien ne peut être dit. On ne peut parler sérieusement, c'est-à-dire être cru par d'autres, que si l'on commence à se pencher sur des objets aplatis, écrits dans le même langage et qui se peuvent combiner l'un l'autre. Cette simplicité des images est toujours oubliée et frappe les observateurs qui s' intéressent aux sciences en venant des sciences du langage[6]. La polémique propre à chaque science marque toujours la même tendance : les premières images sont toujours trop compliquées, il faut revenir quelques années et quelques centaines de milliers (ou de millions) de francs plus tard avec des images plus simples. Plus simples ne signifie pas qu'elles sont faciles à lire pour un non-initié, mais que le *jugement perceptif* demandé à l'objecteur en fin de polémique se résume à des termes enfantins : « ça monte, ça descend, c'est différent, c'est superposé. » Les dinosaures ont-ils disparu écrasés par un météorite de 10 km de large ? Les aérosols sont-ils en train d'éliminer la couche d'ozone qui nous protège des radiations ? L'univers est-il en train de s'épandre ou au contraire de se contracter ? Avons-nous détecté la particule W ? Ces questions, si compliquées qu'elles soient, si énormes soient les enjeux, se ramènent à lire des diagrammes aussi simples que les publicités à la télévision pour ou contre une lessive qui lave plus blanc... Cette simplicité surprend tellement les vulgarisateurs qu'ils illustrent toujours les sciences par des dessins *plus compliqués* sous prétexte de les faire comprendre [Jacobi, 1984]. On demande à des enfants de concevoir ce que c'est qu'une « année-lumière » alors que le chercheur mesure avec un double-décimètre une carte du ciel. Les enfants bien sûr ne parviennent pas à concevoir l'année-lumière ; mais le chercheur non plus n'y parviendrait pas ; c'est bien pourquoi il a rusé avec le ciel pour transformer ces distances en quelque chose d'assez plat et familier pour qu'un double-décimètre s'y applique.

Bien sûr, pour « ramener » ainsi le débat à cette pierre de touche, à ce jugement enfantin, il faut se donner beaucoup de mal. Encore une fois, ce n'est pas la perception seule qu'il faut considérer, mais le mouvement de conviction qui force à mobiliser un grand nombre de ressources : alors, et alors seulement, des inscriptions toujours plus simples, toujours plus faciles à lire, peuvent faire la différence et emporter la conviction. Le phénomène à étudier n'est pas tant celui des images scientifiques que celle d'une *cascade d'images* toujours plus simples afin de mobiliser en un point le plus grand nombre d'alliés.

N'oublions pas le principe formulé dans la deuxième section : les auditeurs peuvent à tout moment se comporter comme des multiconducteurs et refuser de croire ; pour

6. [Lynch, 1985c] ; [Jacobi, 1984] ; [Bastide, 1985]

les tenir en lisière, il faut constamment accumuler de nouvelles traces et simplifier continuellement le jugement final qui doit décider de tout. Rapporter de tous les coins du monde des collections de fossiles, c'est bien, mais bientôt les milliers de rochers s'accumulent en désordre dans les caves et les greniers. Il faut donc *partir* des rochers et en extraire un nouvel ordre exactement comme on a extrait ces fossiles de la confusion des couches d'anthracite ou de calcaires. Des années de travail mettent de l'ordre dans les collections du Muséum d'histoire naturelle ; chaque pièce est étiquetée. Même le fichier est encore trop vaste pour qu'un esprit s'y retrouve. Il faut donc le sommer, le simplifier encore, inventer des diagrammes qui décrivent les fossiles sur le papier. À la fin de cette cascade d'inscriptions sommées par d'autres, l'esprit du paléontologue commencera à discerner quelque chose. S'il est privé, pour une raison ou pour une autre, de cet empilement de traces, si des fiches ont été mélangées, si un fossile a été déplacé, l'obscurité la plus profonde régnera à nouveau[7].

La dynamique des instruments scientifiques permet souvent de prendre conscience de cette cascade d'inscriptions. L'analyse de séquences d'ADN, dans les années 70, nécessitait la lecture et l'interprétation de subtiles nuances de gris sur les bandes d'un chromatographe. En 1985 c'est la séquence écrite en lettres qu'il suffit de lire au sortir de l'imprimante. On pouvait discuter de la nuance des gris, il fallait de l'entraînement pour en décider ; on ne peut plus discuter de la différence entre les lettres « ATGCCTTCCGGTTA » – un enfant de cinq ans en déciderait pour vous.

En pratique, les premières images sont toujours trop riches pour emporter la décision. Une photo du ciel est encore trop confuse ; il faut inventer un laser qui puisse compter et mesurer les points de la photo. L'astronome ne regardera ni le ciel ni la photo ; il lira le nombre des étoiles classées par dimension sur un grand tableau sorti de l'imprimante. Nous oublions toujours l'importance des inscriptions, de leurs strates successives et leur « mise en instrument » alors que nous parlons pourtant d'êtres qui ne sont visibles qu'ainsi. Les trous noirs, les chromosomes, les microbes, l'inflation, les leptons, les rites baoulés ne sont ni des êtres de raison inspectés seulement par l'esprit, ni des objets qui tombent sous le sens : ce sont les effets d'une scénographie compliquée ; ce sont des êtres de papier produits par la « phénoménotechnique », selon le mot de Bachelard. Cette scénographie se retrouve pour la pompe à vide de Boyle [Shapin, 1979], pour les neutrinos du soleil [Pinch, 1986], comme pour les microbes de Pasteur [Latour, 1984]. Les décorateurs et les metteurs en scène savent bien que tous les détails comptent ; il en est de même pour ce « théâtre de la preuve » : un nouveau mordant pour une culture de microbes, et c'est un nouvel objet qui se colore au microscope ; un nouveau programme pour donner aux images du scanner des couleurs artificielles, et c'est tout l'éclairage du cerveau qui s'en trouve modifié ; un nouvel amplificateur

7. [Pinch, 1985a] ; [Latour et Woolgar, 1979]

pour le physiographe et ce sont des signaux plus subtils qui se détachent en pics majestueux sur le bruit de fond... Des détails? Oui, bien sûr, pour ceux qui croient que le monde se voit à l' œil nu ou devient l'objet d'une contemplation appelée théorie. Mais les chercheurs, comme les décorateurs, les éclairagistes et les peintres savent combien ils sont tous gens de l'image. Ce n'est pas à l'œil nu que l'on voit leur monde mais à l' œil *habillé*.

V. L'accélération des mobiles immuables

Dans les sections précédentes, j'ai essayé de montrer où se trouvaient les vues de l'esprit : à mi-chemin du monde et de notre cerveau, dans des inscriptions étalées sur la table d'un laboratoire, discutées par quelques collègues. Ces deux objets : le monde réel et l'esprit scientifique (se reflétant l'un l'autre), sont des images virtuelles produites par les humbles pratiques d'écriture et d'enregistrement. L'ethnographie des laboratoires ou l'anthropologie des sciences et des techniques peuvent décrire certaines de ces humbles pratiques. En voici sept que nous rencontrons le long des chemins de la référence.

a. Les sept travaux des chercheurs

1. *Mobiliser :* il faut pouvoir transporter des états quelconques du monde en quelques lieux ; qu'il s'agisse du Big Bang ou de la fin du monde ; qu'il s'agisse des animaux du crétacé ou des gènes d'*E. Coli* ; tous doivent être rassemblés quelque part et se mettre en chemin pour ce recensement universel.
2. *Fixer immuablement les formes :* la plupart des mobilisations entraînent une déformation, une corruption, voire une disparition des traces. Tout sera donc fait pour réduire la déformation, ne prélever que des traces, et conserver la forme à travers le mouvement. Les spécimens seront chloroformés, les colonies microbiennes seront fixées dans la gélatine, les fossiles dans la résine époxy, la perspective sera inventée et continûment améliorée. Surtout, à force de ruses, on gardera des traces de tous les états successifs du même phénomène. La chronophotographie de Marey, par exemple, maintient synoptiquement toutes les étapes d'un mouvement[8]. Grâce à ces deux procédés, la nature de l'espace-temps se trouve complètement modifiée : tous les états du monde s'accumulent en un point ; des chemins à double voie mènent de ce point à tous les autres ; le temps devient un espace inspecté par le regard.

8. [Marey, 2002] ; [Frizot, 1984] ; [Dagognet, 1987]

3. *Aplatir :* il n'y a rien que l'homme soit capable de vraiment dominer : tout est tout de suite trop grand ou trop petit pour lui, trop mélangé ou composé de couches successives qui dissimulent au regard ce qu'il voudrait observer. Si ! Pourtant, une chose et une seule se domine du regard : c'est une feuille de papier étalée sur une table ou punaisée sur un mur. L'histoire des sciences et des techniques est pour une large part celle des ruses permettant d'amener le monde sur cette surface de papier. Alors, oui, l'esprit le domine et le voit. Rien ne peut se cacher, s'obscurcir, se dissimuler. Feuilleter le monde, folio après folio, tel est le rêve du chercheur. La question ethnographique est donc celle-ci : comment faire de la nature le livre de la nature, ou si l'on veut l'atlas, le dictionnaire, le listing, le fichier, la banque de données de la nature?
4. *Varier l'échelle :* cette pratique est ce qui permet de vraiment dominer l'infiniment petit et l'infiniment grand. C'est tellement simple que personne ne s'en aperçoit. L'esprit ne commence à voir quelque chose qu'à partir du moment où le phénomène occupe un ou deux mètres carrés et se compose d'une centaine de signes (c'est aux psychologues de la cognition de nous donner la limite précise). Les milliards de galaxies, au moment où l'astronome vous en parle avec autorité, n'occupent jamais plus de place que la carte du génome d'*E. Coli*, au moment où le biologiste parle à ses collègues ; les tableaux d'échange industriel occupent à peu près la même place que ceux des particules élémentaires ; le modèle réduit d'une raffinerie ne dépasse jamais de beaucoup la taille d'un modèle en plastique de la molécule d'hémoglobuline… Laissons le vertige pascalien pour les moments où les chercheurs délirent en public sur l'infiniment grand ou l'infiniment petit. Quand ils ne délirent pas, ils dominent, en privé, des phénomènes qui ont quelques mètres carrés. Au-delà, la confusion renaît et, quelle que soit notre discipline, nous nous mettons tous à balbutier. Ces deux pratiques expliquent déjà une grande partie de la supériorité des sciences accordée un peu vite à l'esprit. Il est rare que nous dominions ainsi les phénomènes dont nous parlons, que nous les inspections du dessus et en manipulions les traces et modèles à la main. À ce titre la « vie courante » peut se distinguer assez facilement des laboratoires. On n'y est pas plus bête, mais les objets n'y sont ni aplatis ni homogénéisés.
5. *Recombiner et superposer les traces :* l'avantage énorme des inscriptions assemblées, fixées, aplaties, et ramenées à la même échelle, c'est de pouvoir être battues comme un jeu de cartes, recombinées à loisir et surtout *superposées* l'une à l'autre. À première vue, il paraît impossible d'établir une liaison entre la géologie et l'économie ; mais superposer une carte géologique et les cours de la Bourse, voilà une opération qui peut se faire sur un bureau, qui ne demande que du papier et une bonne documentation. Le déplacement paraissait énorme : il est de quelques centimètres.

Découvrir les structures de tous les mythes de la planète paraît insensé ; quel est le cerveau capable d'un tel exploit ? Il faut d'abord un bon *fichier*. Sous les yeux de Lévi-Strauss, à même son bureau, des connexions vont s'établir qui n'ont rien à voir avec le cerveau (et probablement peu avec la pensée sauvage).

La plupart des coups de génie, des éclairs d'intuition que l'on impute soit aux neurones des chercheurs, soit à la « cognition » peuvent s'expliquer par cette proximité, sur les tables du laboratoire, de traces recombinées. C'est bien des modèles en carton des bases que Watson manipule au moment décisif de la construction de la double hélice [Watson, 1999]. Le chemin de l'analogie et de la métaphore est fait, lui aussi, de ces humbles véhicules qui déplacent littéralement les montagnes sur quelques centimètres carrés. Des objets « sans rapport » se trouvent brusquement « mis en rapport ». La plupart de ces objets appelés « structure », « pattern », « lois » émergent avant tout comme les effets visuels d'une certaine disposition de traces. Bertin le sait bien qui apprend aux chercheurs à créer à la fois les inscriptions et leurs structures [Bertin, 1973]. Curieusement cette évidence échappe même aux observateurs les plus astucieux. Dans un très bel article Carlo Ginzburg parle du « paradigme de la trace » [Ginzburg, 1980]. Il retrace – justement – l'obsession de notre culture pour les indices et symptômes depuis la médecine grecque jusqu'aux lapsus de Freud et à la détection des fraudes. Va-t-il parler aussi de la physique, des mathématiques, ou de la géologie? Pensez-vous ! Il met en dehors de son paradigme les sciences exactes sous l'amusant prétexte qu'elles sont fondées sur des phénomènes « abstraits et universels » ! Mais comment devenir abstrait et universel sans cartes, sans photographies, sans physiographes et sans télémètres ? L'aveuglement de Ginzburg nous donne la mesure du préjugé épistémologique ; dans les laboratoires où crépitent de toutes parts des centaines de stylets, d'imprimantes, d'aiguilles, de marguerites et de rosaces, les traces ne seraient pas intéressantes? C'est devant de tels préjugés que l'on mesure la distance entre l'épistémologie et l'ethnographie des sciences.

6. *Incorporer l'inscription dans un texte :* cet avantage énorme distingue la littérature scientifique de toutes les autres ; elle est la seule dont le référent soit présent à l'intérieur même du texte qui le commente. Le texte n'est pas seulement « illustré » par des images, il est le développement de celles-ci. Cette exégèse particulière, qui permet d'offrir aux objets du monde, aux écrits déjà imprimés et au commentaire, la même cohérence optique ainsi que la même homogénéité sémiotique, explique bien sûr pourquoi la littérature scientifique est aussi exacte et convaincante.
7. *Fusionner avec les mathématiques :* nous l'avons vu avec la perspective [Ivins, Williams M., 1953], le trait principal de ces nouvelles images c'est de s'immerger

dans l’espace de la géométrie [Latour, 1991a]. Le blanc du papier, au lieu d’être simplement blanc, devient un espace significatif. De ce fait, chaque trait d’une machine, d’une construction, d’un fossile ou d’une carte, peut être étudié à nouveau avec des règles et des compas. Il est ainsi possible de *partir* de la surface du papier pour y trouver autre chose que ce qu’on y avait mis[9]. C’est là ce qui permet la cascade d’inscriptions dont j’ai parlé plus haut. Les images deviennent formes géométriques, puis diagrammes, histogrammes, chiffres, colonnes, équations… En fin de parcours, quelques équations permettent de *tenir* un grand nombre d’inscriptions primaires, secondaires, tertiaires, etc., jusqu’aux perceptions les plus complexes et les plus floues. Aucune de ces étapes ne reproduit seulement l’étape précédente, elle la concentre, la résume, la silhouette, l’idéalise. Chaque inscription offre une plus-value au chercheur : la carte rend cent fois plus d’informations que celles qu’on y avait mises. En fin de parcours, il est possible en effet de *capitaliser* sur une grande échelle toutes ces plus-values.

Les épistémologues – et les savants – s’étonnent souvent que les mathématiques s’appliquent au monde sensible. Cet étonnement les honore mais ne remplace pas une bonne étude ethnographique des procédés d’inscriptions par lesquels ils font écrire la nature en courbes sur du papier millimétré. L’application des mathématiques au papier millimétré sorti d’un physiographe est déjà beaucoup moins miraculeuse…

Ces sept ruses ne doivent pas être isolées l’une de l’autre ; ce sont toutes ensemble qu’elles accroissent la mobilisation, la fidélité et la combinaison des traces. Autrement dit, toute innovation, si petite soit-elle, qui permettra d’améliorer l’une de ces sept ruses, sera aussitôt sélectionnée, mise au point et conservée : une nouvelle pellicule, de nouveaux colorants, une nouvelle notation mathématique, un nouveau système de classement, une nouvelle interface, un nouveau chauffage pour garder les spécimens plus longtemps, un nouveau stylet… Quand on aura fait l’histoire de ces innova-tions et de ces ruses, alors il sera possible de voir ce qu’il reste à étudier dans l’esprit, les mentalités, les idées et les vues du monde ; à mon avis, peu de chose, la part de l’esprit dans l’histoire des sciences a été terriblement exagérée, comme celle de la providence dans l’histoire telle qu’on la faisait avant le XIXe siècle, ou celle de la pensée sauvage dans l’étude des sociétés non scientifiques.

b. Donnez-moi des représentants qui ne soient pas des potiches…

La pensée quotidienne, l’introspection, les croyances populaires, les certitudes magiques, l’émotion, tout cela est sûrement trop difficile à étudier. Par contraste, la pensée des savants est *plus facile* à étudier tant ils se donnent de peine pour *simplifier*

9. [Dagognet, 1973] ; [Edgerton, 1976] ; [Ferguson, 1985]

leur champ de vision et pour *matérialiser* leurs procédures dans des textes et des laboratoires. Le travail de la pensée scientifique peut se suivre littéralement « à la trace » en utilisant à la fois la psychologie et l'anthropologie cognitives [Lave, 1988] et la microsociologie des laboratoires[10] : le chercheur doit se déplacer, reproduire, capter des images, recueillir et conserver des inscriptions, trouver des emplacements qui permettent au monde de s'étaler à la vue ; il doit améliorer le rendu des traits, silhouetter les graphismes pour que ceux-ci puissent se combiner plus aisément [Dagognet, 1973] ; il doit conspirer avec les formes qui ressemblent déjà à un texte ou à un schéma [Lynch, 1985a]. Si l'on veut comprendre comment il pense il ne faudra pas se concentrer sur la tête (qu'il a dit-on fort grosse) et sur ses idées, mais le suivre dans ses déplacements, regarder ses mains et ses yeux.

On objectera qu'il ne s'agit pas là de pensée, mais d'arrière-cuisine, qu'il ne s'agit pas là de théorie mais d'empirisme. L'ethnographie, dira-t-on, peut s'appliquer peut-être à ces chercheurs qui ont besoin d'instruments, mais pas à ceux qui pensent dans leur bureau avec un papier et un crayon. Selon cette objection, il n'y aurait pas d'ethnographie possible du travail de pure formalisation.

Il est indéniable que cette ethnographie n'existe pas, malgré quelques tentatives[11]. Cela ne veut pas dire pour autant qu'elle est impossible ou même plus difficile que celle des « instrumentistes ». Au contraire, j'aurais tendance à croire qu'elle est beaucoup plus facile encore, et que seule la timidité nous a empêché de la tenter. En passant de l'empirique au théorique, on ne passe pas du matériel à l'intellectuel, de l'accessible à l'inaccessible, on passe *de mobiles immuables* à d'autres encore *plus mobiles*, encore *mieux combinables* et toujours *plus immuables*. Ce qui change – car quelque chose change en effet – c'est *l'accélération des déplacements sans transformation*.

Le travail d'abstraction n'est pas lui-même abstrait, mais concret bien sûr et plus simple, malgré les apparences, que tout ce qui le précède. La nécessité d'abstraire vient d'un problème très simple et presque trivial : chaque instrument, chaque campagne de fouille, chaque satellite, chaque passage d'un questionnaire, chaque interrogation de banques de données, chaque collection du Muséum, chaque console d'ordinateur vomit en quelques mois des masses d'inscriptions qui suffisent à noyer le plus intelligent chercheur. Plus il est habile à penser – au sens donné plus haut – plus il se retrouve en fin de compte Gros-Jean comme devant, écrasé sous les papiers comme il l'était avant par les perceptions confuses du monde. Il n'a qu'une seule solution : faire avec les papiers ce que ceux-ci faisaient avec le monde, c'est-à-dire trouver des chemins et des véhicules qui les déplacent sans les transformer, et qui permettent d'y revenir vite. Construire une théorie n'est jamais qu'une question de travaux publics

10. [Livingston, 1985] ; [Traweek, 1988] ; [Lestel, 1985]
11. [Derrida, 1967] ; [Bloor, 1982] ; [Ong, 2005]

et de mouvements rapides : comment tenir le maximum d’occurrences en perdant le minimum d’énergie et de temps ? C’est d’ailleurs toujours en terme de mouvement, de rapidité, de nombre de connexions, de régularité ou d’aisance, que les théories sont louées et que sont critiquées les simples collections de faits. L’idéal pour une théorie c’est, avec quelques éléments et quelques opérations, de retrouver tous les objets du monde, déformés aussi peu que possible.

C’est toujours autour des icônes qu’il faut chercher la réponse à cette « puissance » tant révérée dans les théories. Dans un article sur l’efficacité du travail de Galilée, Stillman Drake nous donne un bon exemple d’une telle icône [Drake, 1970]. Drake compare le travail de Galilée à celui de deux de ses collègues, Jordan et Stevin. Jordan lui aussi fait un diagramme, mais géométrique uniquement : « L’élément physique comme on peut le voir est rajouté après coup à la géométrie, de façon presque forcée. » (p. 163.) Avec Simon Stevin, c’est le contraire ; il dessine bien un diagramme, mais qui reproduit un phénomène physique, la forme géométrique ne pouvant s’y ajouter que par surcroît : « La géométrie, écrit Drake, est éliminée au profit d’une pure intuition mécanique. » (*Id.*) Tout se passe comme si les deux prédécesseurs de Galilée ne pouvaient littéralement *accommoder* sur la surface de papier et y voir à la fois le phénomène physique et la forme géométrique. Un léger changement dans la forme géométrique utilisée permet à Galilée de superposer physique et géométrie et d’accommoder enfin sa vision binoculaire sur le livre de la nature : « La façon dont Galilée fondit la géométrie et la physique (…) lui suggéra non seulement de nombreux corollaires mais des améliorations successives de sa preuve ainsi que de nouvelles applications physiques. » (p. 104.)

Cette possibilité de *partir du papier* sur lequel les phénomènes sont dessinés en formes géométriques, et de s’y tenir *malgré* le démenti des autres sens, de l’autorité, de la tradition et de l’Écriture, est l’un des traits le plus marquant des études sur Galilée. C’est ce qui permet à la physique d’exister. Les instruments capables de faire écrire les phénomènes en signes mathématiques n’existaient pas encore dans de vastes et coûteux laboratoires, mais Galilée en anticipe la création en inventant déjà leur « produit-papier », c’est-à-dire la courbe que dessinerait par exemple le glissement d’un grave sur un plan incliné. C’est d’ailleurs parce que Galilée anticipe les instruments que les historiens se battent sans pouvoir démontrer s’il fit ses expériences ou s’il les rêva. Peu importe, puisque, dans les deux cas, il en tira un diagramme bien dessiné. L’innovation capitale c’est que Galilée part de cette « bonne forme » pour la travailler, en quelque sorte, *à même* le papier. On peut parler comme Koyré [Kornhauser, 1962] de platonisme pour expliquer cette innovation, mais elle est à la fois plus matérielle, plus graphique et plus radicale : il faut donner aux phénomènes une forme qui soit telle que l’on puisse, en la retravaillant, gagner sur eux plus d’informations qu’on y a mis. Ce *supplément* de forces c’est celui que la géométrie a accumulé depuis 1 500 ans en travaillant sur les formes élémentaires. Encore faut-il qu’elle puisse venir au secours de la physique. Entre les mathématiques et le monde, la distance est trop grande, c'est ce que l'on savait avant Galilée. Il faut que celui-ci invente un « lieu commun » pour leur rencontre. La distance est déjà beaucoup plus petite entre les triangles de la chute d'un corps et le triangle. La loi de la chute des corps se lit à même le graphique et cette loi qui n'y était pas au moment du dessin est pourtant une loi physique[12].

Chose amusante, mais qui ne saurait nous étonner, Herbert Simon, en testant les aptitudes cognitives des novices et des experts, trouve le même recours aux diagrammes « accommodés » [Sigaut, 1984]. Il propose à ses sujets de petits problèmes de robinet, de pompes et de vases communicants. Novices aussi bien qu'experts, tous grattent du papier. Mais les novices font un grand nombre de dessins distincts alors que les experts n'en font qu'un seul : « La chose cruciale qui nous est apparue dans le comportement des experts était que la formulation initiale et finale du problème était assemblées de telle façon que les relations entre elles – et donc la réponse au problème – pouvaient pratiquement être lues directement sur le diagramme. » (p. 169.)

Ce que nous appelons « pensée rigoureuse » est probablement cette aptitude à construire des images qui peuvent être retravaillées au deuxième degré. En partant d'elles, d'autres choses sont découvertes si bien que les représentations finissent par avoir tout le pouvoir. La difficulté n'est pas dans la pensée, mais dans le fait de s'en tenir exclusivement au papier, quelles que soient les conséquences, les apories, les absurdités que l'on découvre, sans jamais chercher à faire appel du résultat à l'aide du « bon sens » ou des autres sens. Cette icônolatrie définit plus le mathématicien, le géologue, le physicien, le biologiste, que les méthodes ou les normes scientifiques.

Un charmant contre-exemple de cette aptitude nous est fourni par Edgerton [Edgerton, 1980]. Commentant les premiers traités chinois de mécanique occidentale, il remarque cette différence à la fois infime et énorme. Les dessinateurs chinois ont peu de confiance dans le graphisme technique et se servent des images comme illustrations. Tous les liens entre les rouages d'une pompe, par exemple, deviennent des décorations et, après quelques copies, se transforment en vagues sur un étang. Inutile de dire qu'il eût été impossible de partir de ces images ainsi redessinées pour penser une pompe, ou pour en construire une. Les Chinois ne dessinent pas moins bien et ne sont pas moins friands d'images que nous. Simplement, leurs représentations traditionnelles ne sont pas utilisables comme points de départ d'un nouveau travail qui, mobilisant les ressources millénaires de la géométrie, permet à celui qui accumule des traces de capitaliser en grand. Edgerton rejoint là Needham qui signale le même phénomène pour les idéogrammes : aussi nombreuses et bien tenues que soient les archives des mandarins chinois, il est impossible de partir des milliers d'idéogrammes pour produire des textes de textes. Le contexte doit rester présent ou du moins assez proche[13]. Autrement dit,

12. [Kornhauser, 1962] ; [Drake, 1970] ; [Wisan, 1984]
13. Voir aussi [Havelock, 1981]

comme les signes ne se déplacent pas très loin sans perdre leur sens, la mise en cascade est impossible. McNeill, dans son livre magistral [McNeil, 1982], y voit même la cause des limites toujours imposées à l'empire et au capitalisme chinois. L'image et l'idéogramme représentent bien sûr, mais ce ne sont pas des mobiles immuables que l'on peut travailler chez soi, à même le papier, en toute ignorance du contexte d'origine et en toute confiance dans l'écrivain rationnel qui les a d'abord rédigés. De ce fait, celui qui les accumule ne gagne pas un avantage décisif sur tous les autres.

Comme on le voit, c'est dans des termes classiques de pouvoir et de domination que l'on peut parler le plus simplement de forme et d'abstraction. Il s'agit de tenir le plus petit nombre de représentations et de transformer ces simulacres en une source nouvelle de pouvoir, inconnue de tous ceux qui s'en tiennent aux choses elles-mêmes. Dès que les inscriptions manquent, ou dès qu'il devient impossible de les retraiter au deuxième degré, le pouvoir se perd et la confusion renaît.

VI. Conclusion : des centres de calcul

Il y a deux façons de ne pas comprendre ce que j'ai présenté dans cet article. La première serait d'accorder à l'esprit scientifique ce qui dépend des mains et des yeux, des instruments et de la « guerre de position » faite par les chercheurs. Ce serait de l'iconoclastie. La seconde serait de s'occuper uniquement des signes et images, de la perception et du graphisme, en oubliant la mobilisation du monde dont ils ne sont que la pointe et le moyen. Ce serait de l'idolâtrie. Comme dans les querelles théologiques de jadis, les uns croient qu'ils penseraient mieux sans aucune image (alors que leur cerveau serait entièrement vide) ; les autres que les images suffisent à constituer le phénomène.

Pour le dire autrement, nous cherchons notre chemin entre deux erreurs : l'une qui constitue l'histoire « des sciences » ; l'autre qui constitue l'histoire « du capitalisme » (sans parler de la troisième qui voudrait comprendre les relations de « la science » et « du capitalisme »). L'un des moyens de se faufiler entre Fafner et Fasolt est de se demander comment il est possible de *capitaliser* quoi que ce soit. Dès que cette question est posée, on s'aperçoit que les réponses ne sont pas légions ; il faut faire venir le monde en certains points qui deviennent alors des centres ou des points de passage obligé. Très bien, mais sous quelle *forme* faire venir le monde pour que, d'une part, ce qui est loin, distant et périssable, s'y trouve assemblé, et que, d'autre part, le centre ainsi constitué ne soit pas un formidable embouteillage? Il faut inventer des dispositifs qui mobilisent les objets du monde, maintiennent leur forme et puissent s'inspecter du regard. Il faut surtout que toutes ces formes puissent se combiner à loisir et se retravailler de telle sorte que celui qui les accumule dispose d'un surcroît de pouvoir. Alors, et alors seulement, certains points deviennent des centres capables de dominer sur une grande échelle. Dans la suite des recherches, je ne parlerai plus des lieux où se cumulent les mobiles immuables que comme des centres de calcul, sans plus m'occuper de savoir à quels domaines ces calculs ressortissent. Il me semble qu'en reformulant ainsi le problème des « vues de l'esprit », il serait possible de sortir de l'impossible étreinte de Fafner et Fasolt et de comprendre pourquoi « la science » et « le capitalisme » font depuis toujours si bon ménage. Voici quelques pistes ouvertes par ce numéro.

a. Calculer les machines

S'il est un sujet que l'étude des inscriptions graphiques a renouvelé de fond en comble, c'est bien l'histoire des techniques. Peter J. Booker a retracé l'histoire du dessin technique [Booker, 1979], histoire reprise en France par Yves Deforges [Deforge, 1981] et qui a fait l'objet d'un des plus beaux livres de machine qui soit, celui de Ken Baynes et Francis Pugh [Baynes et Francis, 1981]. Quand on va des sciences aux machines, on ne va pas du monde des idées et des principes à celui du cambouis et des applications; on va des dessins à plus de dessins [Ferguson, 1985]. La notion même de techno-logie est indissociable, comme l'a montré Bertrand Gille pour les Alexandrins, du rassemblement des modèles réduits et des dessins de tous les mécanismes précédents [Gille, 1980]. Sans ce rassemblement, les techniques, affirme-t-il, évoluent presque avec la lenteur de l'évolution biologique [Leroi-Gourhan, 1964]. Pour qu'elles s'accélèrent, il faut qu'elles deviennent des êtres de papier présents tous ensemble à la vue du bibliothécaire.

Il faut aussi, nous le savons grâce à Ivins, que le dessin permette de les penser et de les voir. La perspective linéaire n'y suffit pas, car l'image qu'elle permet de tracer dépend encore du « point de vue » du spectateur. Une machine dessinée en perspective ne peut être déplacée, élargie et éclatée sans subir de graves déformations. Surtout, ses différentes parties se dissimulent l'une l'autre, à mesure qu'elle devient plus complexe. C'est, après Desargues, Monge qui permit au dessin technique d'obtenir enfin la mobilité et l'immuabilité qui lui manquait. En géométrie projective « (l'objet) peut être vu et photographié de n'importe quel angle – c'est-à-dire déformé – et pourtant le résultat final demeure vrai » (1979, p.35). « [Desargues et Monge] aidèrent à changer le "point de vue" ou la façon de concevoir les choses mentalement. À la place des lignes imaginaires – si malaisées à concevoir clai-rement – qui étaient le fondement de la perspective jusque là, la géométrie projective permit à la perspective d'être vue en terme de géométrie des solides[14]. »

14. [Booker, 1979] p. 34.14. [Booker, 1979] p. 34.

Les sept travaux du chercheur (voir section précédente) peuvent alors s'exécuter également à propos des machines qui deviennent pensables, calculables, combinables. Tous les avantages dont j'ai fait la liste plus haut se retrouvent ici. En y ajoutant les conventions de grisés, les cotes et quelques symboles, la mécanique se lit maintenant aussi facilement que la Terre sur une carte. Elle se domine du regard, quelle que soit la taille gigantesque du produit final. Chaque partie se détache des autres et s'y rattache – une fois acceptées les conventions permettant les vues éclatées.

Il va de soi que les machines elles-mêmes aussi bien que les machines-outils se couvrent d'instruments permettant aux phénomènes de se lire sur le papier[15]. Lorsque tous ces papiers convergent, comme ils sont tous superposables et combinables, des domaines qui paraissaient fort éloignés sont, littéralement, à quelques centimètres l'un de l'autre. La résistance des matériaux, la géométrie, l'économie politique, la mécanique et l'organisation du travail sont des domaines épars. Oui, tant qu'on les « idéalise ». Lorsqu'on les a tous transformés en papier, ils se superposent aisément : des cotes, des calculs, des numéros de code, des salaires horaires, des contrôles qualité, tout cela peut enfin se combiner. Là encore, la pensée technicienne doit peu à la pensée et beaucoup au montage de traces homogènes en tous lieux. Comme le montrent Booker [Booker, 1979] et Deforges [Deforge, 1981], il n'y a plus qu'à attendre que l'ordinateur ait digitalisé l'image, les tolérances, les règlements, les calculs et les ordres, pour brasser tout cet ensemble dans un *centre de calcul* devenu enfin tout-puissant. On l'aura compris, la nature des calculs importe moins que leur présence simultanée en un lieu devenu centre. L'anthropologie des techniques peut étudier librement ces centres de calculs, aussi librement que ceux qui les ont construits.

b. Faire l'ethnographie des dossiers

Il y a peu d'ethnographes qui se soient intéressés à cet objet méprisé, le dossier [Cambrosio, *et al.*, 1990b]. En revanche, j'ai lu beaucoup de pamphlets contre les bureaucrates et les paperassiers. Il paraîtrait que ces ronds-de-cuir remueraient du papier au lieu de travailler. C'est là une accusation aussi grave que gratuite. D'après ce que nous avons vu jusqu'ici, remuer du papier ne peut pas être inutile ; ce doit être au contraire la source d'un pouvoir capital puisque l'on trouve des « gratte-papier » aussi bien dans les laboratoires que dans les bureaux d'étude. Un bureau ressemble d'ailleurs de plus en plus à un laboratoire pour cette raison essentielle que des « domaines » éloignés s'y trouvent là aussi conjugués. Dans le même dossier se superposent des règlements, des curriculum vitae, des contrôles qualité, des calculs économiques, des plans, des cartes,

15. [Hills et Pacey, 1982] ; [Constant, 1983]

des questionnaires, des listings. La « pensée » là encore dépend autant des connexions établies entre pages du dossier qu'entre neurones.

Se moquer des gratte-papier et des dossiers, c'est oublier que nous ne savons *rigoureusement* rien ou, du moins, rien avec rigueur, sans regarder nos fiches de paye, nos cartes, nos tickets, nos factures, nos règlements, nos livrets de famille… Nous sommes incapables de dire combien nous gagnons, quand nous avons été vaccinés, quelle heure il est, quelle est la taille de notre appartement, combien nous pesons, quel bus il faut prendre, sans avoir sous les yeux une inscription bien réglée. Même pour *vérifier* si le document est exact et bien rédigé, c'est encore à *d'autres* dossiers que nous avons recours (annuaires, dictionnaires, archives, fichiers, modèles). De deux choses l'une : ou bien nous savons quelque chose et nous avons sous les yeux un dossier ou un document ; ou nous ne voyons rien et alors nous ne savons que confusément, cherchant à nous rappeler vaguement de quoi il pouvait s'agir. Il est amusant de constater que les sociétés industrielles soient si fières de leur secteur tertiaire et méprisent autant les bureaucrates. Si le grattage de papier n'était pas la source d'un pouvoir unique, on ne voit vraiment pas pourquoi l'on remplirait les tours de Wall Street, de la Défense ou de la City avec des millions de « paper-shufflers ».

Par un curieux effet de symétrie, c'est le même préjugé qui fait croire que les chercheurs « pensent » et que les gratte-papier « ne font rien ». Tous, au contraire, sont absorbés exclusivement par l'exactitude des tracés, des inscriptions, des colonnes, par leur accumulation réglée, leur vérification, leur superposition et leur retraitement. Tous savent parfaitement que la moindre interruption, la moindre faute de frappe et c'est le désordre qui se réintroduirait. Ce qu'on admire chez les uns mais qu'on déteste chez les autres est le fruit de la même obsession : ni le bon sens, ni l'autorité, ni le copinage, ni les autres sens ne valent *plus* que l'inscription devenue pierre de touche de toute réalité. Encore une fois, qu'ils soient comptables, physiciens, inspecteurs, sportifs, surveillants, biologistes, cartographes *compte moins* que la possibilité de rassembler tous les comptes en quelques dossiers. Ce sont les mobiles immuables et combinables qui sont le véritable « échangeur universel ».

La raison pour laquelle nous ne parvenons pas à comprendre l'importance des gratte-papier est que nous supposons qu'il existe quelque part de grandes entités appelées « organisations » ou « institutions » ou « États » ou « forces productives ». Nous utilisons alors ces entités pour « expliquer » la société. C'est aller un peu vite en besogne et ce serait aussi bizarre que d'expliquer le développement des sciences par celui de la méthode scientifique. Avant d'expliquer la société par ces entités, il convient d'abord de se demander comment diable elles sont produites. Comment faire pour qu'il existe un « État », une « économie », une « firme », une « institution » ? Eh oui, il y faut des documents, des papiers, des instruments, des questionnaires ; il faut que tous ces documents soient résumés, sommés, subsumés quelque part. Il faut que quelqu'un les inspecte de l'œil. L'échelle des entités n'est pas une donnée, c'est un résultat (fragile) d'une montagne de dossiers et de bureaucrates[16]. Oublier ce travail d'enregistrement, de sommation, de compilation, de rassemblement, oublier cette mise en scène, c'est croire aux géants. Le géant science est formé par le même mécanisme de projection que le géant société ou le géant firme [Chandler, 1977]. On part de ces projections pour expliquer le monde, au lieu de partir des nombreux centres de calcul qui permettent de composer peu à peu ces géants, c'est-à-dire de changer l'échelle de la capitalisation.

c. Arpenter la métrologie

En nous intéressant aux mobiles immuables au lieu de nous intéresser soit aux « esprits » scientifiques soit aux signes perçus, il semble que nous ayons beaucoup dérivé. En fait, nous sommes arrivés à poser un problème commun à la fois à la sociologie, à l'économie, à la gestion et à l'histoire des sciences ou des techniques : comment capitaliser ; comment donc mobiliser le monde à grande échelle ; comment rendre toute chose mobile et combinable. Braudel l'a bien montré, la capitalisation de l'argent ne suffit pas [Braudel, 1979]. La monnaie est un mobile (particulièrement mobile), immuable (particulièrement immuable) et combinable (particulièrement combinable), mais c'est une trace parmi d'autres qui ne saurait les résumer toutes. Un centre de calcul qui ne compterait que de l'argent serait incapable de gagner quoi que ce soit ; il faut, comme Alpers l'a si magnifiquement montré, qu'il puisse compter aussi des images du monde, des cartes, des récits, des lettres. En ce sens, il n'y aurait pas une histoire des sciences et une histoire de l'économie, il y aurait une histoire commune des moyens et des centres de calcul. Leur problème unique pourrait se formuler ainsi : *comment agir à distance* [Latour, 1987].

C'est certainement la métrologie – au sens large – qui permet de se rendre compte à la fois de l'ampleur et de la fragilité des centres de calcul [de Noblet, Jocelyn, 1983a]. Quels que soient en effet la qualité des calculs opérés dans les centres et le surcroît de force que l'on gagne dans ces laboratoires, encore faut-il que les chaînes continues permettent de revenir depuis les traces vers le monde. C'est là le problème des avenues à deux voies que nous avons signalé depuis le début de cette présentation. Les mobiles immuables permettent de mobiliser le monde en créant des allers et des retours ; encore faut-il que les chemins ne soient pas interrompus. La plus petite incertitude dans l'instrument, le plus petit doute sur la fiabilité de l'inscription, la plus petite trahison dans la longue chaîne qui va du questionnaire au chiffre, et voilà que celui qui croyait tenir le monde dans ses mains ne tient plus qu'un morceau de papier gribouillé.

16. [Fourquet, 1980] ; [Callon et Latour, 1981]

À l'histoire des centres de calcul, il faut donc ajouter l'histoire des réseaux métrologiques qui assurent la constance des constantes, justement, et maintiennent ainsi la supériorité difficilement acquise de ceux qui comptent, dans tous les sens du mot.

Un chiffre fera comprendre l'ampleur du problème et l'étendue de nos ignorances. Hunter estime à 6 % du produit national brut les sommes dépensées aux États-Unis pour maintenir les chaînes métrologiques primaires [Hunter, 1980]. Aussi flou que soit ce chiffre, c'est déjà trois fois l'ensemble des dépenses de recherche et développement. On sait que l'étude de Machlup donne des chiffres beaucoup plus élevés pour l'entretien, la maintenance et, si l'on peut dire, la reproduction élargie de ce qu'il appelle l'économie de l'information [Machlup, 1962]. Pour décider ce que nous avons sur nos comptes en banque, ce que nous devons et ce qu'on nous doit (c'est-à-dire la simple définition des agents économiques), cela nécessite déjà une gigantesque machine à prélever ou à traiter de l'information. Sans elle, c'est-à-dire sans la multiplicité des instruments de mesure, des dossiers, des réseaux de communication, l'existence de tel ou tel agent économique est tout simplement indécidable. Les économistes comme les sociologues ou comme les épistémologues oublient toujours les causes de leurs certitudes. Ils l'attribuent à des vues de l'esprit ou à des structures, sans se rendre compte qu'ils bafouillent dès qu'ils n'ont plus les yeux rivés sur un instrument de mesure.

Cette présence des instruments, présence qui permet à la fois le prélèvement et l'application de la trace, se retrouve, sans que nous nous en rendions compte, dans tous les aspects de la vie quotidienne. Sans regarder nos montres, nous ne pouvons dire exactement le temps ; sans lire sur l'écran à cristaux liquides de la balance le poids et le prix des saucisses que nous achetons, nous sommes incapables de finir la longue dispute qui pourrait commencer avec notre boucher ; sans regarder le chiffre de la course au taximètre, nous sommes incapables de vérifier si le chauffeur de taxi nous trompe ou a raison. Partout, dans tous les détails de nos vies, *dès que nous ne sommes plus familiers* avec ceux à qui nous parlons, le recours aux inscriptions de toutes sortes permet de résoudre les contradictions [de Noblet, Jocelyn, 1983a]. De chaque inscription part un long réseau, parfois interrompu par la fraude, qui nous mène toujours à quelque centre de calcul (centre des impôts, chaîne du temps, chaîne des poids et mesures, administration, etc.).

Le lecteur comprendra, je l'espère, où nous voulons en venir. On a beaucoup parlé pour décrire nos sociétés de désenchantement, de rationalisation, de bureaucratisation. On a vu notre histoire comme celle d'une scientifisation croissante, d'une montée inéluctable des « rapports marchands », de l'abstraction de l'argent, voire de la « déterritorialisation ». Tous ces termes supposent que l'esprit scientifique est dans l'esprit, que la rationalité croît dans les têtes, que les rapports marchands rendent nos pensées indifférenciées. Curieusement, comme ce préjugé est encore plus fort chez ceux qui *critiquent* cet état de choses, le résultat est une belle unanimité sur le désenchantement et l'indifférenciation, caractéristiques de nos sociétés industrielles, de notre modernité et, pour faire bon poids, de notre postmodernité...

Les études ici parcourues indiquent une tout autre direction. Nous ne parvenons à obtenir quelques certitudes fragiles qu'en extrayant quelques mobiles immuables, en les faisant courir le long d'étroits réseaux entretenus à grands frais, interrompus au moindre relâchement de la vigilance. L'esprit qui s'applique, en fin de parcours, à ces traces superposées n'est en rien plus sûr, plus désenchanté, plus rigoureux, plus rationnel ; on peut seulement dire qu'il s'applique à ces traces au lieu d'embrasser la complexe réalité, et que, grâce à l'une des sept ruses résumées plus haut, il gagne parfois de la force, force qu'il ne peut exercer qu'aussi longtemps que les chaînes qui lui permettent de retourner au point de départ ne sont pas coupées. Pour le dire de façon plus philosophique, l'équivalence ne doit jamais être supposée *a priori* ; elle s'obtient comme *un résultat provisoire* du montage d'un instrument. Pour le dire encore d'une façon plus anthropologique, il n'y a pas de monde moderne que l'on pourrait distinguer « des autres ». Le monde moderne est une « vue de l'esprit », comme la science, ou l'économie, ou le capitalisme. C'est ce que l'esprit *croit voir* lorsqu'il oublie qu'il ne voit que des traces et des dossiers au bout d'instruments coûteux à mettre en place et à maintenir. Il y a de nombreuses distinctions, certes, mais aucune n'est aussi fabuleuse que le grand partage entre la raison et la croyance, entre le capitalisme et l'économie primitive.

Même la précédente phrase est encore trop affirmative. Nous espérons seulement convaincre les lecteurs que nous savons au fond fort peu de chose sur les façons dont nous savons. C'est cette soudaine humilité qui nous donne à tous envie de continuer cette anthropologie comparée des sciences, des techniques et des organisations.

Society in the Making: The Study of Technology as a Tool for Sociological Analysis

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Social scientists, whether they are historians, sociologists, or economists, have long attempted to explain the scope, effects, and conditions of the development of technology. They consider technology a specific object that presents a whole range of problems that these experts have tried to solve using a series of different methods available to the social sciences.[1] But at no point have they judged that the study of technology itself can be transformed into a sociological tool of analysis. The thesis to be developed here proposes that this sort of reversal of perspective is both possible and desirable. Not only would it enlarge the methodological range of the social sciences but it would also facilitate the understanding of technological development. To bring this reversal about, I show that engineers who elaborate a new technology as well as all those who participate at one time or another in its design, development, and diffusion constantly construct hypotheses and forms of argument that pull these participants into the field of sociological analysis. Whether they want to or not, they are transformed into sociologists, or what I call engineer-sociologists.

Seeing the process of technological innovation and the role played by engineers in this way defies certain accepted ideas. By taking this perspective I am not simply repeating the already countless criticisms of the notion of innovation as a linear process. This notion describes technological development as a succession of steps from the birth of an idea (invention) to its commercialization (innovation) by way of its development. Everyone now recognizes that the to and fro's of coupling processes that continuously occur between technology and the market are extremely important.[2] Nor in this chapter do I challenge the notion that claims that the role and importance of financial backing or organizational structure varies considerably between periods of elaboration and development of an innovation.[3] What I am questioning here is the claim that it is possible to distinguish during the process of innovation phases or activities that are distinctly technical or scientific from others that are guided by an economic or commercial logic. For example, it is often believed that at the beginning of the process of innovation the problems to be solved are basically technical and that economic, social, political, or indeed cultural considerations come into play only at a later stage.[4] However, more and more studies are showing that this distinction is never as clear-cut. This is particularly true in the case of radical innovations: Right from the start, technical, scientific, social, economic, or political considerations have been inextricably bound up into an organic whole.[5] Such heterogeneity and complexity, which everyone agrees is present at the end of the process, are not progressively introduced along the way. They are present from the beginning. Sociological, technoscientific, and economic analyses are permanently interwoven in a seamless web (Hughes 1983). Using the case study of an innovation, I show how it is possible to use this characteristic in order to transform the study of technology into a tool for sociological analysis; this leads to a new interpretation of the dynamics of technology.

Engineer-Sociologists

To illustrate the capacity of engineers to act as sociologists (or historians or economists), I describe certain aspects of the development of what was intended to be a major innovation: the introduction of an electric car (VEL) in France.[6]

This project was first presented by a group of engineers working for EDF (Electricité de France)[7] in the early 1970s. They outlined the project in a series of technical publications and in applications for funding to government agencies.[8] It is by no means easy to create a new market of this sort in a society organized entirely around the traditional motorcar. The project conjectured not only that the technoscientific problems could be overcome but also that French social structures would change radically.

EDF's engineers presented a plan for the VEL that determined not only the precise characteristics of the vehicle it wished to promote but also the social universe in which the vehicle would function. We will see that in addition to their technical know-how the engineers of EDF used skills more commonly found in social scientists. They resembled their illustrious predecessors from the Renaissance who had deftly played on several registers at the same time (Gille 1978). Like Edison almost a hundred years ago, they continuously mixed technical and social sciences.[9]

First, the EDF defined a certain history by depicting a society of urban post-industrial consumers who were grappling with new social movements. The motorcar occupied a position that was highly exposed, for it formed part of a world that was under attack. Thus it served as a point of departure for the construction of far-reaching and radical demands that would lead to a future that could be discerned only with difficulty. The internal combustion engine is the offspring of an industrial civilization that is behind us. The Carnot cycle and its deplorable by-products were stigmatized in order to demonstrate the necessity for other forms of energy conversion. On the one hand, the motor vehicle was considered responsible for the air pollution and noise that plagues our cities. On the other hand, it was irretrievably linked to a consumer society in which the private car constituted a primordial element of status. However, electric propulsion would render the car commonplace by decreasing its performance and reducing it to a simple, useful object. The electric car could lead to a new era in public transport in the hands of new social groups that were struggling to improve conditions in the city by means of science and technology. The goal would be to put science and technology at the service of the user and to do away with social categories that attempted to distinguish themselves by their styles of consumption. The EDF based this vision on an evaluation of the trajectories of development open to different types of electrochemical batteries.[10] First, public transport could be equipped with improved lead accumulators. Then accumulators and fuel cells could open up the larger market of private transport by enabling the VEL to reach speeds of up to 90 km/h, on the condition that safe catalysts cheaper than platinum could be developed (cheaper but poisonous catalysts had already been found).

By predicting the disappearance of the internal combustion engine as a result of the rise of electrochemical generators and by ignoring traditional consumers so as to better satisfy users who had new demands, the EDP not only defined a social and technological history but also identified the manufacturers that would be responsible for the construction of the new VEL. The CGE (Compagnie Générale d'Electricité) would be asked to develop the electric motor, the second generation of batteries, and to perfect the lead accumulators that would be used in the first generation of the VEL. Renault would mobilize its expertise in the production of traditional automobiles in order to assemble the chassis and make the car bodies. The government would also be enlisted: Such and such a ministry would subsidize those municipalities interested in electric traction. The list went on: Companies that ran urban transport systems were to be put together with research centers, scientists, etc. The EDF defined the roles, and attempted to enroll other entities into them. It also bound the functions of these roles together by building a world in which everything had its own place.

Up to this point the entities are those familiar to the sociologist. There are consumers, social movements, and ministries. But it would be wrong to limit the inventory. There are also accumulators, fuel cells, electrodes, electrons, catalysts, and electrolytes, for, if the electrons did not play their part or if the catalysts became contaminated, the result would be no less disastrous than if the users rejected the new vehicle, the new regulations were not enforced, or Renault stubbornly decided to develop the R5. In the world defined and built by the EDF, at least three new and essential entities must be added: zinc/air accumulators, lead accumulators, and fuel cells with their associated elements (catalysts, electrons, etc.).

The EDF engineers determined not only the repertoire of entities that they enlisted and the histories in which they would take part but also their relative size. For EDF's engineers Renault would no longer be a powerful company seeking to be once more the largest European car manufacturer. Indeed, it would never regain that status. Rather, it was reduced to the level of a modest entity that intervened in the assembly of the VEL. The same is true of the old status groups that would give way to new social movements and their new demands.

The ingredients of the VEL are the electrons that jump effortlessly between electrodes; the consumers who reject the symbol of the motorcar and who are ready to invest in public transport; the Ministry of the Quality of Life, which imposes regulations about the level of acceptable noise pollution; Renault, which accepts that it will be turned into a manufacturer of car bodies; lead accumulators, whose performance has been improved; and post-industrial society, which is on its way. None of these ingredients can be placed in a hierarchy or distinguished according to its nature. The activist in favor of public transport is just as important as a lead accumulator, which can be recharged several hundred times.

This case shows that the engineers left no stone unturned. They went from electrochemistry to political science without transition. The analysis of French society that they proposed was both remarkably incisive and fully elaborated. Five years after the "great cultural revolution" of May 1968[11] and one year before the first oil crisis, they outlined the course of an evolutionary movement that would propel French society from the industrial to the post-industrial age. This change was to occur through pressure from new social movements and with the expected help of electrons.[12]

The sociologist who studies the VEL project cannot but be struck by the similarity between the "sociological" arguments developed by the engineers at EDF and the analyses proposed at the same time by one of the most respected French sociologists, A. Touraine. This similarity, which I come back to shortly, obviously suggests a question: Could not social sciences in some way or another make use of the astonishing faculty engineers possess for conceiving and testing sociological analyses at the same time as they develop their technical devices? It is to answer this question, which supposes that it is possible to compare the sociology of engineers with professional sociology, that I now present the analyses proposed by Touraine and the controversies to which they gave rise.

Sociology and the Problem of Consumption

Where was French society really going in 1973? And, in particular, what destiny lay in store for the traditional motorcar? The engineers at EDF asked themselves these sorts of questions, and they responded to them by conceiving of the VEL project. They were not alone in asking these questions. Sociologists too were trying to answer them, and the analyses they elaborated display great diversity. Several schools confronted each other. For my purposes I need to retain only the opposition between Touraine (1973, 1979) and Bourdieu (1979; Bourdieu and Darbel 1966; Bourdieu and Passeron 1970). These two gave radically different interpretations of the dynamics of consumption.

Touraine is part of a sociological tradition that emphasizes the role of class conflict in making society function and in producing its history. Unlike Marxists, he believes that the central conflict of Western society is no longer the struggle between the working class and the bourgeoisie. Technological development has brought new factors into play. On one side now there are large concerns (big corporations, research and development agencies) that orient scientific research as well as define and control the application of technology. On the other side we find the consumer, whose needs and aspirations are manipulated by the technocrats who run the large concerns. This conflict explains the birth of social movements that challenge (either through categorical demands or through calls for a move "back to basics") the power of the technocracy or its orientations for social and economic development. These movements are relatively widespread and ephemeral. Sociologists must learn to decipher their demands and technocrats must take them into consideration if they wish to safeguard the legitimacy of their choices and decisions. This new type of class conflict defines what Touraine calls post-industrial society.

Bourdieu's vision of society can be arrayed point for point against Touraine's. For Bourdieu, society is not organized around a primordial confrontation between ruling classes and classes that are ruled, fighting for control of technological development. The confrontation is fragmented between various specialist spheres (the field of politics, the field of science, the field of consumption, etc.) that maintain mutual relationships of exchange and subordination. Each field is the site of strategic confrontations between social agents who fight to occupy positions of power. But these different fields, which in their multiplicity embrace the diversity of social practice and express increasing differentiation of societies, are caught in a group logic that lends cohesion to society. This unification is organized around a dominant cultural model, that of the upper classes, in relation to which the other social classes define and orient themselves. Whatever particular field is considered, these classes are in constant competition in order to delineate their differences and to vie for positions on a scale of status. This competition is nowhere more apparent and nowhere more lively than in the field of consumption. The reader will recognize here the essential elements of the theory of social stratification, in which distinction, differentiation, and mobility play an essential role.

Beyond the classical opposition they display between a sociology of social class and a sociology of stratification, Touraine and Bourdieu share the feature that they place the question of consumption at the center of their analyses. Touraine does so in order to show that consumption is largely manipulated by industry and the great technological agencies, Bourdieu to establish its irreducible autonomy. Touraine sees in the definition of demand or need the site of the emergence of new class conflicts, whereas Bourdieu affirms that goods and services, whatever their intrinsic characteristics, are ineluctably reinscribed by consumers into the logic of social distinction.

Although they attribute to consumption the same strategic value, these two analytic schemas lead to two radically different interpretations of its evolution. The automobile and its future provide particularly salient illustrations of this evolution.

If one has a stake in the coming of a post-industrial society, the traditional motorcar is doomed to lose ground because it is an integral part of a social system that is disappearing; it stands as both the symbol and cornerstone of that system. Social movements that diminish the importance of and criticize the use of the automobile anticipate and express the necessity of this evolution. In the Tourainian schema the technocrats/decision makers design products to meet these demands in order to use them for support: This double game, whereby popular protest is used by technocrats to serve their own ends, is the driving force of history. The appearance of a new technology, such as the VEL, is thus much more likely because it introduces a rupture in industrial society and is supported at the same time by social movements and the technocracy.

In Bourdieu's perspective the future of the automobile is inscribed in a different logic. The total banalization of an object of consumption, which plays a central role in struggles for distinction, seems highly improbable. Social movements that protest against the symbol Automobile are without doubt quite right to see in it one of the cornerstones of our societies; but instead of believing in their capacity to create a new era, we should learn the lesson it teaches them against their will. The automobile is at the nerve center of society, so socially embedded that it can be modified only with great care. It must undergo evolution, but this is not purely and simply a case of making it disappear so that it can be replaced with a radically new technology; the only realistic strategy is to transform it gradually through progressive introduction of technical improvements enabling it to respond to new user demands. The best answer that can be given to social movements is to introduce yet more differentiation, not make a tabula rasa of the past.

Who Is Right?

What, in 1970, was the future of the automobile in French society? This question was at the center of the VEL project as it was developed by the engineers at EDF. Furthermore, it is a question that should not have been ignored by sociologists, because, as I have just shown, consumption and its evolution occupied a central place in the theoretical apparatus they had elaborated.

In fact, sociologists were little concerned with the EDF adventure and abstained from establishing some link between their theories and this astonishing story that was unfolding before their eyes. A story so much the more astonishing because, as we will see, the engineers at EDF were to become rapidly engaged in a controversy in which their Tourainian sociology would set itself against the sociology à la Bourdieu employed by the engineers at Renault. The controversy was, however, of a different sort, for success or failure was to be measured in terms of shares of the market.

EDF's engineers did not have to defend their ideas in an academic arena. Any brilliance or originality in the analysis they developed was of little import. For them the analysis was a question of life and death because the economic future of their project was at stake. No more sophisticated arguments and theorizing! What mattered was to be right: to be able to prove by the very success of their innovation that French society was evolving in the way they claimed it was, borne along by the aspirations of protest movements on which they in turn holed to lean for further support. The rest was of no account. In short, if an engineer-sociologist is to be proved right he or she has to create a new market; success is measured by the amount of profit gained. This, in all its simplicity and toughness, is the test of truth.

For three years the engineers of EDF believed that they were right. Nobody dared interrupt their discourse. Car manufacturers, with Renault in the forefront, kept quiet, terrorized by the future promised them. In order to hold their own, they started to work feverishly on the VEL project. They knew little or nothing about electrochemistry and did not know how to tackle the EDF forecasts that cheap high-performance fuel cells would be available by the end of the 1980s, thus opening up the vast market of private transport. To counter their handicap, they signed contracts with specialized research laboratories in order to acquire the knowledge and expertise they lacked. To begin with, the electrochemists confirmed the optimistic predictions made by EDF engineers. How then could anybody resist a movement that allied consumer aspirations, the wishes of the authorities, and available scientific resources (or rather resources thought to be available in the not-too-distant future)? Nothing could stand in the way of this tidal wave. In addition to these existing forces, another event occurred to weaken still further the position of the traditional motor car: the sudden increase in oil prices, making cars much more expensive to run.

Slowly but surely the tide in favor of the VEL and its society was beginning to turn, or, to use the terms so aptly coined by Hughes (1983), reverse salients began to appear. Things began to go wrong for the EDF engineers. Resistance, of the kind so neatly described by Castoriadis to define reality,[13] got underway. As in guerrilla warfare, it started up spontaneously and unexpectedly in several places. Fairly quickly, the catalysts refused to play their part in the scenario prepared by EDF: Although cheap (unlike platinum), the catalysts had the unfortunate tendency of quickly becoming contaminated, rendering the fuel cell unusable. The mass market suddenly disappeared like a mirage. The VEL, recognized EDF's engineers, needed batteries whose performance was sufficient for the average user, and this sort of battery might be too expensive to produce for a long time to come. In addition, Renault challenged the future of other electrochemical generators identified by EDF. For example, Renault showed that the zinc/air accumulators lauded by EDF's engineers were actually a shaky venture elaborated by a handful of researchers at CGE[14] who were pushing the program without being sure that it was realistic. Furthermore, argued Renault engineers, if zinc/air accumulators were to be used in the VEL, this would presuppose the setting up of a vast network of service stations throughout the country whereby the used electrolyte might be changed periodically. Which industrial groups, they asked, would dare to challenge the all-powerful oil consortiums on their own ground? In contrast to the optimistic view of technological innovation taken by EDF, Renault engineers painted a gloomy picture of uncertain strategies and rival industrial groups with conflicting interests.

The Renault engineers did not stop there. They took their criticism further by showing that what EDT detected as signs of the coming of a post-industrial age was in fact only minor technical difficulties in the current age. According to them, the criticism leveled at the traditional motor car did not change the equilibrium of existing social forces, nor was it a sign of a demand for a new mode of development. It merely expressed temporary and local dissatisfaction with the car industry's lack of dynamism and the poor state of public transport. Pollution could easily be reduced and the reorganization of public transport in cities could be improved, in particular, by using more comfortable and higher-performance buses. They argued that in the space of three years protest movements had quieted down, especially those that had been most virulent in speaking out against the automobile society. Recession was looming large and talk was more of reindustrialization than of post-industrial society.

So it was the Renault engineers, in alliance with the contaminating catalysts and aided by the increasing weakness of the protest movements, who completely rehabilitated the traditional motorcar, although the motorcar underwent some subtle changes in the process (it polluted less, used less petrol, cost less to manufacture, etc.) At the same time, they reconstructed French society (present and future) in a different way. This time it was the EDF engineers' turn to remain silent. They had completely lost their position of strength. In the space of a few months the VEL had become a fiction that no one could believe in any longer. The proclaimed revolution had failed to materialize. EDF's engineers had lost. Their "failure" may turn out to be short-lived, for nobody knows what the future holds.

But in the 1980s, contrary to what the EDF engineers confidently predicted, French society has reaffirmed the traditional motor with its attendant struggle for status, and there is no market for the VEL.

This was a remarkable controversy. The engineer-sociologists of EDF were matched by Renault's engineer-sociologists, who developed a sociology that in its arguments and its analyses was close to Bourdieu's. EDF against Renault is, on another stage and with different stakes and new rules, Touraine against Bourdieu.

The failure of the VEL can legitimately be ignored by sociologists. They have a perfect right to want their analyses judged elsewhere than in the economic sphere. This attitude, as defensible as it might be, seems to me only half convincing. Given the similarity of the controversies, should not sociologists take an interest in the engineer-sociologists, not to take them as models but in order to enrich their own analyses and to diversify their own methods of investigation?

To go along this path, we must leave behind the radical difference that separates sociologists and engineer-sociologists. Sociologists, when they develop, as Bourdieu and Touraine did, analyses that are opposed to each other point for point, can coexist without problems, just as in those pre-paradigmatic situations so well described by Kuhn (1970). For engineer-sociologists this sort of ambiguous situation did not make any sense. Either the VEL would find a market and eliminate competing techniques, or it would become a fiction without a future, thus leaving the road free for the traditional automobile. Both the VEL and the traditional motorcar could not be developed at the same time for the same purpose.

In order to transform the study of technologies into a tool of sociological analysis, I find it appropriate to answer this question: What is the particular faculty that engineers have (which sociologists in this case lack) of being able to evaluate the comparative merits of contradictory sociological interpretations? In order to answer this question, I briefly consider the notion of the actor network, which allows the characterization of the original contribution of the engineer-sociologists: the idea of heterogeneous associations.

Actor Networks

As has been noted in the EDF-Renault controversy, the engineers' projects had mixed and associated heterogeneous elements whose identity and mutual relations were problematic. For example, electrons, batteries, social movements, industrial firms, and ministries had been linked together.

The success of the construction was measured by the solidity and longevity of the heterogeneous associations that were proposed by the engineers.[15] For them, it was not simply a matter of supporting a biased interpretation of French society and consumer tastes. They were attempting to link together fuel cells, electric vehicles, and consumers who were to accept using the VEL as a simple means of transportation despite its rather mediocre performance. The proposed associations, and by consequence the project itself, would hold together only if the different entities concerned (electrons, catalysts, industrial firms, consumers) accepted the roles that were assigned to them. To describe these heterogeneous associations and the mechanisms of their transformation or consolidation, I introduce the notion of an actor network.

The actor network is reducible neither to an actor alone nor to a network. Like networks it is composed of a series of heterogeneous elements, animate and inanimate, that have been linked to one another for a certain period of time (Schwartz Cowan, this volume). The actor network can thus be distinguished from the traditional actors of sociology, a category generally excluding any nonhuman component and whose internal structure is rarely assimilated to that of a network. But the actor network should not, on the other hand, be confused with a network linking in some predictable fashion elements that are perfectly well defined and stable, for the entities it is composed of, whether natural or social, could at any moment redefine their identity and mutual relationships in some new way and bring new elements into the network. An actor network is simultaneously an actor whose activity is networking heterogeneous elements and a network that is able to redefine and transform what it is made of. I show in the case of the VEL that this particular dynamic can be explained by two mechanisms: simplification and juxtaposition.

Simplification is the first element necessary in the organization of heterogeneous associations. In theory reality is infinite. In practice actors limit their associations to a series of discrete entities whose characteristics or attributes are well defined. The notion of simplification is used to account for this reduction of an infinitely complex world.[16]

For example, towns consist of more than public transport, the wish to preserve town centers, and the town councils composed of their spokespeople. They differ from one another with respect to population, history, and geographical location. They conceal a hidden life in which anonymous destinies interact. So far as the EDF engineers were concerned, however, towns could be reduced to city councils whose task is the development of a transport system that does not increase the level of pollution.

EDF's engineers did not need to know more. This definition would remain realistic so long as the simplification on which it was based was maintained. In other words, such simplifications will be maintained so long as other entities do not appear that render the world more complex by stigmatizing the reality proposed by them as an impoverished betrayal: The town council is not representative; living conditions in different neighborhoods cannot be reduced to those in the town center; and the system of public transport is but one aspect of a larger urban structure. The same was true for fuel cells. If the catalysts and electrolytes that were trusted became contaminated or destabilized, the fuel cell, which it was hoped would power the VEL, would become appallingly complex. Instead of being easily mastered, fuel cells were transformed into an apparatus whose ever-increasing elements turned out to be beyond control. A "black box" whose operation had been reduced to a few well-defined parameters gave way to a swarm of new actors: scientists and engineers who claimed to hold the key to the functioning of the fuel cell, hydrogen atoms that refused to be trapped by the cheaper catalysts, third world countries that raised the price of precious metals, etc.[17]

Behind each associated entity there hides another set of entities that it more or less effectively draws together. We cannot see or know them before they are unmasked. Hydrogen fuel cells and zinc/air accumulators were two of the elements that made up the world built by EDF's engineers; however, the controversies that developed in their name rapidly divided them into a series of other elements (much as a watch is dismantled by a jeweler to find out what is wrong with it). Thus simplification is never guaranteed. It must always be tested. The catalyst gave way and the fuel cell broke down, thus causing the downfall of the EDF. As for the catalysts, the electrolytes can be decomposed into a series of constituent elements: the electrons in the platinum and the migrating ions. These elements are revealed only if they are brought into a controversy, that is, into a trial of strength in which the entity is under suspicion. Of course, what there is to say about fuel cells, catalysts, and electrons is also true of city councils or administrations. In the project of the EDF engineers, the city was reduced to the city-council-that-wants-to-preserve-the-city-center-at-all-costs. But to preserve its integrity, the city council must stabilize the elements that hold it together: the middle class electorate that trusts it, the pedestrian precinct that pushes the flow of traffic to the edge of the town center, the urban spread, and the system of public transport that enables the inhabitants of the suburbs to come and do their shopping in the town center.

Such a simplified entity exists only in context, that is, in juxtaposition to other entities to which it is linked. Fuel cells, Renault as a car body builder for the VEL, and users who no longer consider the car to be a status symbol are all interrelated. Remove one of these elements and the whole structure shifts and changes. The set of postulated associations is the context that gives each entity its significance and defines its limitations. It does this by associating the entity with others that exist within a network. There is thus a double process: simplification and juxtaposition. The simplifications are only possible if elements are juxtaposed in a network of relations, but the juxtaposition of elements conversely requires that they be simplified.

These juxtapositions define the conditions of operation for the engineers' construction. In fact, it is from these juxtapositions that the associations draw their coherence, consistency, and structure of relationships that exists between the components that comprise it. If they were not placed in a network, these elements would be doomed. These relationships, which define the contribution of each element as well as the solidity of the construction as a whole, are varied. One must abandon the conventional sociological analysis that tries to adopt the easy solution of limiting relationships to a restricted range of sociological categories. Of course, there may be exchange relationships (the user exchanges money for a VEL), subcontractual relationships (the CGE works for EDF), power relationships (EDF brings Renault to its knees), or relationships of domination. But often the relationships between entities overflow simultaneously into all these categories, and some escape completely from the vocabulary of sociology or economics. How can one describe the relationships between fuel cells and the electric motor in terms other than those of electric currents or electromagnetic forces? Not only are the associations composed of heterogeneous elements but their relationships are also heterogeneous. Whatever their nature, what counts is that they render a sequence of events predictable and stable. Hydrogen feeds the fuel cells that power the motor that ensures the performance of the VEL for which the users are willing to pay a certain price. Each element is part of a chain that guarantees the proper functioning of the object. It can be compared to a black box that contains a network of black boxes that depend on one another both for their proper functioning as individuals and for the proper functioning of the whole. What would the battery be without hydrogen? What would become of consumers without their VELs?

Therefore the operations that lead to changes in the composition and functioning of an actor network are extremely complex. The extent to which an entity is susceptible to modification is a function of the way in which the entity in question summarizes and simplifies one network on behalf of another. If we wish to construct a graphical representation of a network by using sequences of points and lines, we must view each point as a network that in turn is a series of points held in place by their own relationships. The networks lend each other their force. The simplifications that make up the actor network are a powerful means of action because each entity summons or enlists a cascade of other entities. Fuel cells mobilize catalysts, electrons, and ions, which all work for the fuel cell. This, in turn, works for the VEL and the EDF actor network. Through these successive simplifications (which are never as apparent as when they fail) electrons, specialists at Renault, the middle class electorate, and researchers at the CGE have all been enlisted and mobilized. EDF's engineers see and know only fuel cells, accumulators, city council spokespeople, and the public transport authorities. But each of these entities enrolls a mass of silent others from which it draws its strength and credibility. Entities are strong because each entity gathers others. The strength of EDF and the durability of the VEL were built by means of these simplified and mobilized entities. Thus a network is durable not only because of the durability of the bonds between the points (whether these bonds concern interests or electrolytic forces) but also because each of its points constitutes a durable and simplified network. It is this phenomenon that explains the conditions that lead to the transformation of actor networks. It is possible to modify the performance of fuel cells to account for the new demands of users only if the catalysts or electron spin states can be modified in order to increase, for example, the power and longevity of the fuel cell. Each modification thus affects not only the elements of the actor network and their relationships but also the networks simplified by each of these elements. An actor network is a network of simplified entities that in turn are other networks.

Transformation thus depends on testing the resistance of the different elements that constitute our actor network.[18] Is it easier to change the expectations of the users, the demands of the municipalities, the interests of Renault, or the longevity of platinum? This is a practical question that is answered through the continual adjustments that are also negotiated changes. To adapt the VEL by changing this or that aspect of its performance is to act on the actor network, and its success thus depends on the capacity to test certain resistances to their limits, whether these spring from social groups, cash flow, or electrodes to be improved.

An actor network, such as the one described in this chapter, can in turn be simplified. The solidity of the whole results from an architecture in which every point is at the intersection of two networks: one that it simplifies and another that simplifies it. It can be mobilized in other actor networks. For example, the VEL can be linked to the TGV (high-speed train) or to the Airbus, thus forming a part of a new French transport policy. Although simplified into a point and displaced in this mariner, it is still composed of associated entities, and although these entities are susceptible to being molded or shaped, they in turn may transform the actor network of which they form a part.

The actor network describes the dynamics of society in terms totally different from those usually used by sociologists. If car users reject the VEL and maintain their preferences for different types of the traditional motorcar, this is for a whole series of reasons, one of which is the problem of the catalysts that turn poisonous. It is these heterogeneous associations that sociologists are unable to take into account and yet that are responsible for the success of a particular actor network. The post-industrial society that Touraine believes is coming depends in this particular case not only on the capacity of new protest movements to influence the choices of technocrats but also on the way in which the catalysts in the fuel cells behave. Tourainian sociological theory, as with most other sociological theories, remains a clever and sometimes perspicacious construction; but it is bound to remain hypothetical and speculative because it simplifies social reality by excluding from the associations it considers all those entities—electrons, catalysts—that go to explain the coevolution of society and its artifacts. This criticism applies equally well to Bourdieu's interpretation of society. Although his theory happens to work better (explaining the success of the Renault actor network), this is pure luck, for in his explanation of car users' preferences he omits most of the elements that make up and influence these preferences. Although Bourdieu happens to be right and Touraine wrong, this is quite by chance. Although Renault turns out to be right, this is because the heterogeneous associations proposed by the EDF engineers disintegrate one by one: the discovery of a cheap catalyst as a substitute for platinum might have proved Bourdieu wrong and rehabilitated Touraine's sociological theory after all.

A New Methodological Tool

In what way could the analyses and the experiments developed by the engineer-sociologists be useful to sociology?

It was in order to answer this question that I introduced the idea of the actor network, which allows us to measure the distance between the heterogeneous and "impure" sociology of the engineers and the "pure" and homogeneous sociology of the sociologists. In the one case sociological and technical considerations are inextricably linked; in the other they are rigorously dissociated. If EDF and Renault sociology cannot be compared with that of Bourdieu and Touraine it is because its success depends not only on the behavior of traditional social actors but equally on that of catalysts or zinc/air batteries.

One can choose to be satisfied with this declaration and maintain the splendid isolation of academic sociology by underlining the radical difference between it and that of the engineer-sociologists. I would like to suggest now that this defensive position, which seeks to safeguard the orthodoxy, cost what may, is not the only possible one. According to whether one is more or less disposed to transform sociology itself, other more or less radical choices can be envisaged. They all lead to a transformation of the study of technology into an instrument of sociological analysis.

First of all, and this does not in the least imperil sociology, it is possible to use the controversies in which the engineer-sociologists are engaged as particularly powerful tools of investigation. To learn about society, sociologists employ tools that have been developed and tested over years: surveys, interviews, opinion polls, participant observations, statistical analyses, and so on. Another way of learning about society, as shown in this chapter, is to follow innovators in their investigations and projects. This method is particularly effective in cases in which, because they are working on radical innovations, engineers are forced to develop explicit sociological theories. In such cases this method enables sociologists to explore large sections of society (peering over the engineer's shoulder, so to speak). It is in this way that any sociologist, whether or not he or she knows anything about Touraine, could have found in the analyses of the engineer-sociologists of EDF valuable aids to the development of an analysis of the role of social movements in the evolution of consumption.

The study of engineer-sociologists can furnish more than a simple source of inspiration. In effect, the sociology developed by the engineer-sociologists is concretely evaluated in terms of market share, rate of expansion, or profit rate. With the failure of the VEL, EDF's theories about French society and its future collapsed (although perhaps only provisionally). The sociologist has here a powerful tool for evaluating different sociological frameworks of analysis. Engineer-sociologists, then, work for the good of sociology. The sociologists can rest content with following the engineer-sociologists, picking up their analyses and examining the way in which they are refuted or validated by the success or failure of the technical apparatus the engineer-sociologists have helped to bring into being. The results of the test may not necessarily be wholly positive or wholly negative. The case under discussion happens to show a complete reversal of fortune. But in other situations engineers may arrive at a compromise solution and progressively change their sociological interpretations, that is, their associations, and consequently change the shape of the technological devices they develop. In any event sociologists who study engineers shaping technologies have a chance to evaluate the validity of certain interpretations and to follow their successive adaptations in the light of the resistance they encounter.

But the sociologists, if they want, can be still more audacious, can display an audacity equal to that of the engineer-sociologists. They can, and this is the path I urge them to envisage, put into question the very nature of sociological analysis itself. From this point of view the study of technology can play a critical role. Instead of being someone whose ideas and experiments can be turned to the advantage of the sociologist, the engineer-sociologist becomes the model to which the sociologist turns for inspiration. The notion of the actor network then becomes central, for it recognizes the particular sociological style of the engineer-sociologist. To transform academic sociology into a sociology capable of following technology throughout its elaboration means recognizing that its proper object of study is neither society itself nor so-called social relationships but the very actor networks that simultaneously give rise to society and to technology.

As I have noted, the functioning of what I propose to call actor networks is not adequately described by the usual frameworks of sociological analysis. In short, not only does the repertoire of associated entities extend beyond that generally accepted in social science but also the composition of this repertoire does not obey any definitive rules. How can the social elements be isolated when an actor network associates the spin of an electron directly with user satisfaction? How can any interpretation of social interaction be established when actor networks constantly attempt to transform the identities and sizes of actors as well as their interrelationships? The fact that actor networks constantly create new combinations of entities renders this task even more difficult. The notion of actor network is developed in order to handle these difficulties. This notion makes it possible to abandon the constricting framework of sociological analysis with its pre-established social categories and its rigid social/natural divide. It furnishes sociological analysis with a new analytic basis that at a stroke gains access to the same room to maneuver and the same freedom as engineers themselves employ.

Dedicated to understanding the working of actor networks, whose analysis is still to be done, sociology will henceforth find itself on new terrain: that of society in the making. It will also progress resolutely along the path opened by Hughes in his different studies (1983 and this volume) consecrated to technological systems. If, however, we prefer the idea of actor network to that of system, it is essentially for two reasons.

First, the engineers involved in the design and development of a technological system, particularly when radical innovations are involved, must permanently combine scientific and technical analyses with sociological analyses: The proposed associations are heterogeneous from the start of the process. The concept of actor network can be used to explain both the first stages of the invention and the gradual institutionalization of the market sometimes created as a result without distinguishing between successive phases. It is applicable to the whole process because it encompasses and describes not only alliances and interactions that occur at a given time but also any changes and developments that occur subsequently. Certain simplifications become impossible to implement; associations are no longer taken for granted. The actor network is modified under the influence of the forces it seeks, although not always successfully, to enroll; but its structure remains that of an actor network whose development can be traced and followed. The concept enables sociologists to describe given heterogeneous associations in a dynamic way and to follow, too, the passage from one configuration to another.

This leads to the second point I would like to mention, if only briefly. The systems concept presupposes that a distinction can be made between the system itself and its environment. In particular, certain changes can, and sometimes must, be imputed to outside factors. The actor-network concept has the advantage of avoiding this type of problem and the many difficult questions of methodology it raises. For example, how do we define the limits of a system and explain concretely the influence of the environment? To answer such questions precisely, we must develop a formal science of systems, thus possibly depriving the analysis of all its descriptive and explanatory value. Hughes manages to avoid this pitfall by using the systems concept in a pragmatic way.[19] By stressing continually all the connections linking the “inside” and “outside” of the system, he comes close to the actor-network concept. By abandoning the concept of system for that of actor network, I believe we are taking Hughes's analysis—neatly summed up in the ambivalent title of his book, *Networks of Power*—a step further.

Notes

I especially thank Ruth Schwartz Cowan and Gerard de Vries for their sharp criticism, which I have probably failed, most of the time, to answer.

1. For an overview of social studies of technology, see MacKenzie and Wajcman (1985).

2. Several studies have been made to clarify the respective roles played by science, technology, and the market in the beginning and development of an innovation. Put in these terms, the question does not have a general answer. The first reason for this is that it is difficult to draw an indisputable boundary between science and technology. The sociology of science of the last ten years has shown empirically that it is impossible to give a general definition of scientific activity (Knorr-Cetina and Mulkay 1983) and has contested the idea of a noncontroversial distinction between science and technology (Callon 1981b). In addition, for a given innovation it is quite often impossible to outline a genealogy in which scientific and technological contributions that are linked to an innovation can be unquestionably separated. This is what two studies—HINDSIGHT (Sherwin and Isenson 1967) and TRACES (Illinois Institute of Technology, 1968)—have shown.

Anyway, it is difficult to distinguish market influences from those of science and technology. This is the conclusion of C. Freeman after having reviewed literature pertaining to this question. Following Mowery and Rosenberg (1979), his critique of two models, "technological push" and "demand pull," led him to propose the notion of "coupling," which leaves all possibilities of interaction open and recognizes that uncertainties in the market and sciences are the very motor of innovation. "The fascination of innovation lies in the fact that both the market and the technology are continually changing. Consequently there is a kaleidoscopic succession of new possible combinations emerging" (Freeman 1982, p. 111). Or "the test of successful entrepreneurship and good management is the capacity to link together these technical and market possibilities by combining the two flows of information" (Freeman 1982, p. 111). Freeman correctly notes that "the notion of 'perfect' knowledge of the technology or of the market is utterly remote from the reality of innovation, as in the notion of equilibrium" (1982, p. 111). It is because the innovation is caught between two series of uncertainties, the first concerning the market and the state of society and the second related to the state of knowledge, that it is impossible to describe it other than as an interactive process (Nelson and Winter 1977). Moreover, this point is confirmed by authors such as Peters and Austin (1985) when they seek to identify the organizational forms that favor innovation. Leaning on numerous case studies, they show that innovation is always a compromise that results from a long series of trials, which are at the same time technical and socioeconomic. Hughes (this volume) develops this argument in detail. See also Kidder (1982), Jewkes et al. (1969), and Callon and Latour (1986).

3. For this point, see the revealing studies of C. Freeman (1982) concerning research and development of synthetic materials and electronics.

4. This hypothesis is often formed by those who are interested in radical innovations. For two examples of this perspective in the fields of economics and history, see two excellent books: Mensch (1979) and Constant (1980).

5. Concerning this point, see the enlightening demonstration provided by Hughes (1983). The cases studies by Bijker and Pinch (1984; also Bijker, this volume), using the notion of interpretative flexibility, also show the impossibility of separating the definition of technical problems from the socioeconomic context to which the inventors associate them. See also Callon (1986).

6. As Woolgar has shown (this volume), engineers are not content with just analyzing the society around them. They do not hesitate, if need be, to play the psychologist and propose interpretations of the cognitive capacities of humans.

7. The EDF is a public company that has a monopoly on the production and distribution of electricity. It devotes a large part of its budget to research in the development of uses for electricity.

8. To study this project, I was able to consult all the archives of different ministries that at one time or another supported the VEL financially. Several interviews were carried out with the different protagonists.

9. This has been analyzed well by Hughes (1983), who shows how Edison conceived the incandescent lamp.

10. In this text the term "battery" is used as a generic term to cover all portable chemical devices for generating electricity.

11. For two contradictory analyses of the May 1968 movement, see Aron (1968) and Touraine (1968).

12. These unforeseen alliances between human beings and animate or inanimate nonhumans have been analyzed in detail by Latour (1984) and Callon (1986).

13. Castoriadis asserts that technology creates what nature is not capable of achieving. How does technology succeed? It succeeds by playing with the differences of resistances that exist within the environment that it uses and transforms, for this environment does not resist in any way and it does not resist stubbornly. Reality is not static because it consists of interstices that permit it to move, gather, alter, and divide; thus there is room to "make." Whether it concerns outside nature, the neighboring tribe, or bodies of people, resistance is regulated. It contains lines of force, veins, and partially systematic progressions. "Technology thus brings about

the division of the world into the following two fundamental regions, which render it human: those elements which resist in all cases and those elements which (at a given stage of their history) resist only in a certain fashion" (Castoriadis 1968). I do not need to be so extreme; I have only to establish a general map of the differentiated resistances that are met by the actors (Latour 1984; Callon and Latour 1981).

14. CGE is a company that specializes in electrotechnology.

15. Concerning the definition and the use of the notion of heterogeneous engineering, see Law (this volume). See also the case of Draper Laboratories studied by MacKenzie (this volume).

16. There is an analogy here with scientific theory. As Hesse (1974) has so persuasively argued, description always entails loss of information and simplification. For a full development of this argument, see Law and Lodge (1984).

17. On the notion of black boxing as a form of simplification, see Callon (1981a) and Law (1985).

18. For a detailed empirical study of the mechanisms of the transformation of an actor network, see Law (1984b).

19. Concerning Hughes's pragmatism in his use of the notion of systems, see the excellent review of *Networks of Power* by Barnes (1984).

Technology and Heterogeneous Engineering: The Case of Portuguese Expansion

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If you want to learn how to pray, go to sea.

—Portuguese proverb, quoted by Diffie and Winius (1977)

How do objects, artifacts, and technical practices come to be stabilized? And why do they take the shape or form that they do? In this chapter I advocate and exemplify an approach to these questions that stresses (1) the heterogeneity of the elements involved in technological problem solving, (2) the complexity and contingency of the ways in which these elements interrelate, and (3) the way in which solutions are forged in situations of conflict. This "network" approach draws on and parallels work by Callon (1980 and this volume) and is developed in relation to secondary empirical material about the technology of the fifteenth- and sixteenth-century Portuguese maritime expansion. In order to clear the ground and situate my argument, I start by commenting briefly on two alternative approaches to the social study of technology.

The first approach is sometimes called social constructivism.[1] This outgrowth of the sociology of science assumes that artifacts and practices are underdetermined by the natural world and argues that they are best seen as the *constructions* of individuals or collectivities that belong to social groups. Because social groups have different interests and resources, they tend to have different views of the proper structure of artifacts. Accordingly, the stabilization of artifacts is explained by referring to social interests that are imputed to the groups concerned and their differential capacity to mobilize resources in the course of debate and controversy. Social constructivists sometimes talk of this process as one of "closure." Closure is achieved when debate and controversy about the form of an artifact is effectively terminated.

The merits of the social constructivist approach are obvious. Many artifacts are, indeed, forged in controversy and achieve their final form when a social group, or set of groups, imposes its solutions on other interested parties by one means or another. The fate of the electric vehicle in France (Callon, this volume) is amenable to such analysis, as are such other cases as the British TSR-2 aircraft (Law 1985), the Concorde aircraft (Feldman 1985), the third airports of London and Paris (Feldman 1985), the bicycle (Pinch and Bijker 1984 and this volume), and aspects of the development of missile guidance systems (MacKenzie, this volume).[2] Indeed, it is easy to think of examples. Whenever there is controversy, the contingent and constructed nature of artifacts becomes manifest, and explanations in terms of differential power and social interests become attractive.

The second approach, which comes from the history of technology and in particular from the work of T. P. Hughes (1979a, 1983, this volume), understands technological innovation and stabilization in terms of a systems metaphor. The argument is that those who build artifacts do not concern themselves with artifacts alone but must also consider the way in which the artifacts relate to social, economic, political, and scientific factors. *All* these factors are interrelated, and all are potentially malleable. The argument, in other words, is that innovators are best seen as system builders: They juggle a wide range of variables as they attempt to relate the variables in an enduring whole. From time to time strategic problems arise that stand in the way of the smooth working or extension of the system. Using a military metaphor, Hughes talks of these problems as reverse salients, and he shows the way in which entrepreneurs tend to focus on such problems and juxtapose social, technical, and economic variables as they search for a solution.

Hughes's study of Edison illustrates both the systemic nature of much technological activity and the importance of the notion of a reverse salient. Edison's problem (his reverse salient) was simultaneously economic (how to supply electric lighting at a price that would compete with gas), political (how to persuade politicians to permit the development of a power system), technical (how to minimize the cost of transmitting power by shortening lines, reducing current, and increasing voltage), and scientific (how to find a high-resistance incandescent bulb filament). That Edison succeeded in resolving this set of problems reveals his success as a system builder, and it also shows that, as Hughes puts it, "the web is seamless"—that the social was indissolubly linked with the technological and the economic.[3]

The social constructivist and systems approaches have much in common. First, they concur that technology is not fixed by nature alone. Second, they agree that technology does not stand in an invariant relation with science. Third, and most important, they both assume that technological stabilization can be understood only if the artifact in question is seen as being interrelated with a wide range of nontechnological and specifically social factors. However, when they specify the relationship between the technological and the social, they start to diverge. Social constructivism works on the assumption that the social lies *behind* and directs the growth and stabilization of artifacts. Specifically, it assumes that the detection of relatively stable directing *social interests* offers a satisfying explanation for the growth of technology. By contrast, the systems approach proceeds on the assumption that the social is not especially privileged. In particular, it presupposes that social interests are variable, at least within certain limits. Although it is true that even on this point the two approaches are starting to reveal some degree of convergence,[4] the basic difference remains: In the end the sociologists prefer to privilege the social in the search for explanatory simplicity, whereas many historians have no such commitment.[5]

In this paper I join forces with Callon and side with the historians in this particular argument. Specifically, I want to suggest that in explanations of technological change the social should not be privileged. It should not, that is, be pictured as standing by itself *behind* the system being built and exercising a special influence on its development. Although it may at times be an important—indeed the dominant—factor in the growth of the system, this is a purely contingent matter and can be determined only by empirical means. Other factors—natural, economic, or technical—may be more obdurate than the social and may resist the best efforts of the system builder to reshape them. Other factors may, therefore, explain better the shape of artifacts in question and, indeed, the social structure that results. To put this more formally, I am arguing, in common with Callon (this volume, 1980b, 1986), that *the stability and form of artifacts should be seen as a function of the interaction of heterogeneous elements as these are shaped and assimilated into a network*. In this view, then, an explanation of technological form rests on a study of both the *conditions* and the *tactics* of system building. Because the tactics depend, as Hughes has suggested, on the interrelation of a range of disparate elements of varying degrees of malleability, I call such activity *heterogeneous engineering* and suggest that the product can be seen as a *network* of juxtaposed components.[6]

As is obvious, this network approach borrows much from Hughes's system-building perspective. There is, however, at least one important way in which it differs from Hughes's approach, and this difference arises from the emphasis within the network approach on conflict. Thus, as the example of the Portuguese, or indeed those of Edison or Renault, reveals, successful large-scale heterogeneous engineering is difficult. Elements in the network prove difficult to tame or difficult to hold in place. Vigilance and surveillance have to be maintained, or else the elements will fall out of line and the network will start to crumble. The network approach stresses this by noting that there is almost always some degree of divergence between what the elements of a network would do if left to their own devices and what they are obliged, encouraged, or forced to do when they are enrolled within the network. Of course, some of these differences are more pressing than others. For the purposes of analysis, however, the environment within which a network is built may be treated as hostile, and heterogeneous engineering may be treated as the association of unhelpful elements into self-sustaining networks that are, accordingly, able to resist dissociation.

This suggestion has an important methodological implication: *It makes sense to treat natural and social adversaries in terms of the same analytical vocabulary.* Rather than treating, for instance, the social in one way and the scientific in another, one seeks instead to follow the fortunes of the network in question and consider its problems, the obduracy of the elements involved in those problems, and the response of the network as it seeks to solve them. As one moves from element to element, no change in vocabulary is necessary; from the standpoint of the network those elements that are human or social do not necessarily differ in kind from those that are natural or technological. Thus the point is not, as in sociology, to emphasize that a particular type of element, the social, is fundamental to the structure of the network; rather it is to *discover* the pattern of forces as these are revealed in the collisions that occur between different types of elements, some social and some otherwise. It is to this task that I now turn.[7]

The Struggle between Cape Bojador and the Galley

In 1291 Ugolino and Vadino Vivaldi set sail from Genoa in two galleys, passed through the Pillars of Hercules "ad partes Indiae per mare oceanum," and vanished, never to be seen by any European again (Diffie and Winius 1977, p. 24; Chaunu 1979, p. 82). In 1497 Vasco da Gama sailed from the Tagus in Lisbon. He too was headed for the Indes by way of the ocean, but unlike the brothers Vivaldi we know what became of his expedition. On May 20, 1498, he anchored in the Calicut Road off the Malabar Coast of southwest India. He entered into negotiations with the Samorin of Calicut about trading in spice. So unsuccessful were these talks that on his second expedition in 1502 da Gama's now heavily armed fleet bombarded the town of Calicut in an effort to force the Samorin into submission (Parry 1963, p. 153). The Portuguese spice trade had begun and with it their domination of the Indian Ocean. I want to suggest that the process that led to this domination can be looked at from the standpoint of system building or heterogeneous engineering. Sometimes the opponents were people, and sometimes they were natural objects. Let me start, then, by talking of galleys.

The galley was primarily a war vessel. It was light and maneuverable, a method for converting the power of between 150 and 200 men into efficient forward motion. In order to reduce water resistance, the galley was long and thin—typically, at least in Venice, about 125 feet in length and 22 feet wide, including outriggers (Lane 1934, p. 3). The hull was lightly sparred, and the planks were laid in carvel fashion, edge to edge to minimize water resistance. The galley was also low. The oarsmen pulled, three to an oar, on between twenty-five and thirty oars on each side. The vessel also carried one mast (possibly more than one, see Landstrom 1978, p. 52), stepped well forward, which carried a triangular lateen sail. This sail assisted the oarsmen, although it was never more than an auxiliary source of power. The ship was steered by means of one or two rudders, and the stern was slightly raised into a "castle." By contrast, the bow was low and pointed, being designed to ram other ships. A typical galley is illustrated in figure 1.

Now let me state the obvious: The galley is an *emergent phenomenon;* that is, it has attributes possessed by none of its individual components. The galley builders associated wood and men, pitch and sailcloth, and they built an array that floated and that could be propelled and guided. The galley was able to associate wind and manpower to make its way to distant places. It became a "galley" that allowed the merchant or the master to depart from Venice, to arrive at Alexandria, to trade, to make a profit, and so to fill his palace with fine art.

The galley is, of course, a technological object. Let me, then, define technology as a family of methods for associating and channeling other entities and forces, both human and nonhuman. It is a method, one method, for the conduct of heterogeneous engineering, for the construction of a relatively stable system of related bits and pieces with emergent properties in a hostile or indifferent environment.

When I say this, I do not mean that the methods are somehow different from the forces that they channel. Technology does not act as a kind of

Figure 1
A galley (Girolamo Tagliente, *Libro Dabaco che Insegnaa fare ogni Ragione Mercantile* (Venice: Raffinello, 1541), 53).

traffic policeman that is distinct in nature from the traffic it directs. It is itself nothing other than a set of channeled forces or associated entities. Thus there is always the danger that the associated entities that constitute a piece of technology will be dissociated in the face of a stronger and hostile system. Let us, therefore, consider the limitations of the galley.

As a war machine in the relatively sheltered waters of the Mediterranean the galley was a great success. As a cargo carrying vessel, however, it had its drawbacks. Its carrying capacity was extremely limited. The features that made it a good war ship—it was slim and low and could carry a large crew that might repel boarders—were an impediment to the carriage of cargo (Lane 1973, p. 122; Denoix 1966, p. 142). Furthermore, the *endurance* of the galley was restricted by the size of its crew. It could not pass far from the sight of land and the possibility of water and provisions. Although the Venetians and the Genoese used galleys to transport valuable cargoes, where reliability was called for, they were replaced in this role by the "great galleys" after about 1320 (Lane 1973, pp. 122, 126).

It must have been in such vessels that the brothers Vivaldi left Genoa in 129l for what they thought would be a ten-year trip to the Indes (Diffie and Winius 1977, pp. 24–52). Perhaps their galleys were larger than normal, precursors of the great galley. Perhaps they had higher freeboards. But their endurance would have been limited and their seaworthiness doubtful—

one can imagine all too well the consequences of running into a storm off the Saharan coast. And, if indeed the Vivaldis were attempting to row down the west coast of Africa, then they would have had to pass what may be regarded as a point of no return—Cape Bojador, or the Cape of Fear. Chaunu summarizes the problem presented by Cape Bojador:

> At twenty-seven degrees north, Cape Bojador is already in the Sahara, so there could be no support from the coast. The Cape is 800 kilometres from the River Sous; the round trip of 1,600 kilometres was just within reach of a galley, but it was impossible to go any further without sources of fresh water, except by sail. In addition there were the difficulties . . . [of] the strong current from the Canaries, persistent mists, the depths of the sea bed, and above all the impossibility of coming back by the same route close hauled. (Chaunu 1979, p. 118)

How brave, then, were the Vivaldi brothers and their men when they sailed their galleys past the pillars of Hercules and out of recorded history! We do not know in what form disaster finally struck. What we can guess, however, is that the galleys, emergent objects constituted by a heterogeneous engineer, were dissociated into their component parts. The technological object was dissolved in the face of a stronger adversary, one better able to associate elements than the Italian system builders. It was a conflict between two opponents, a trial of strength, in which part of the physical world had the final say. Accordingly, it is a paradigmatic case of the fundamental problem faced by system builders: how to juxtapose and relate heterogeneous elements together such that they stay in place and are not dissociated by other actors in the environment in the course of the inevitable struggles—whether these are social or physical or some mix of the two. And it also suggests why we must be ready to handle heterogeneity in all its complexity, rather than adding the social as an explanatory afterthought, for a system—here the galley—associates everything from humans to the wind. It depends precisely on a combination of social and technical engineering in an environment filled with indifferent or overtly hostile physical and social actors.

The Portuguese versus Cape Bojador: Closure and Lines of Force

In the struggle between the Atlantic and the galley, the Atlantic was the winner. We might say that the forces associated by the Europeans were not strong enough to dissociate those that constituted the Atlantic. The heterogeneous engineers of Europe needed to associate and channel more and different forces if they were to dissociate such a formidable opponent and put its component parts in their place. So for over a hundred years Cape Bojador remained the point of no return. Where were the new allies to come from? How might they be associated with the European enterprise?

Three types of technological innovation were important.[8] The first of these took the form of a revolution in the design of the sailing ship in the fourteenth and early fifteenth centuries. The details of this revolution remain obscure, circumstantial, and in any case beyond the scope of this essay, but the result was a mixed-rigged seagoing vessel (figure 2) that had much greater endurance and seaworthiness than its predecessors, one that was able to convert winds from many directions into forward motion. There were no rowers, so manpower was reduced, and it was thus possible to carry sufficient stores to undertake a considerable passage without foraging. This, then, was the first step in the construction of a set of allied entities capable of putting the North Atlantic in its place. The second was the fact that the magnetic compass became generally available in Christian Europe in the late twelfth century. I consider methods of navigation in a

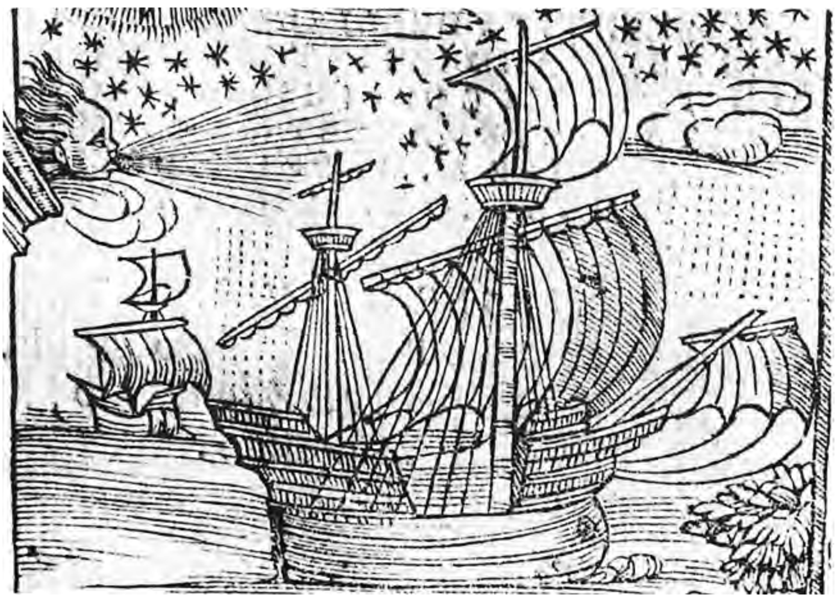

Figure 2

Large late fifteenth-century or early sixteenth-century mixed-rigged vessel (frontispiece from a 1537 Venetian edition of Johannes de Sabrosco's *Sphera volgare nouamente tradotte*).

later section, but here it should be noted that the initial importance of this innovation was that it allowed a reasonably consistent heading to be sailed in the absence of clear skies. Combined with dead reckoning and a portolano chart,[9] the magnetic compass took some of the guesswork out of long-distance navigation, and in particular it meant that the sailor did not need to hug the coast to have some idea of his location. This, then, was the second decisive step toward a change in the balance of forces. When new ships combined newly channeled winds with new methods of navigation and consequent knowledge of position, the ground was prepared for a possible change in the balance of power.

What was the decisive third step? To answer this question, we must know a little about the currents and winds between Portugal and the Canaries. It is relatively easy to sail from Lisbon or the Algarve in a southwesterly direction along the Atlantic coast of Africa. The ship is carried along by the Canaries current and is also carried before the northeast trade winds, which are particularly strong in summer. So far, then, the forces of wind and current assist the project of the sailor. It is, however, more difficult to make the return journey for precisely these same reasons. In a ship good at beating to windward, it is no doubt possible to make some northeasterly headway. But this requires frequent tacking, something that was difficult in the square-rigged ships of the day, which could not, in any case, sail close to the wind. Although the wind blows from the southwest for a period in the winter, thus making the return journey easy (Diffie and Winius 1977, pp. 61, 136), at some unrecorded point sailors decided to try to put the adverse winds and currents to good use by beating out to seaward, away from the Moroccan coast, for it turns out that, so long as one has an appropriate vessel, some means of determining a heading, and an appropriate dose of courage, it is much easier to return to Lisbon or the Algarve this way than by the coast. The vessel sails on a northwesterly heading close hauled against the northeasterly trades. It is gradually able to take a more northerly course as the trades are left behind until the westerlies and North Atlantic drift are encountered, when it becomes possible to head east in the direction of Iberia (Chaunu 1979, pp. 111–115). It was the invention of this circle, called the *volta* by the Portuguese, that marks the decisive third step. Ships were no longer forced to stay close to the coast. Cape Bojador, the classic point of no return, was no longer the obstacle it had previously been. The masters could sail beyond it and expect to be able to return.

The *volta* can thus be seen as a geographical expression of a struggle between heterogeneous bits and pieces assembled by the Portuguese system builders and their adversaries, that is, the winds, the currents, and the capes. It traces on a map the solution available to the Portuguese. It depicts what the Portuguese were able to impose on the dissociating forces of the ocean with the forces they had available. It shows us in a graphic manner how the Portuguese were able to convert the currents, winds, and the rest from opponents into allies and how they were able to associate these elements with their ships and navigational techniques in an acceptable and usable manner.

Now we begin to see the advantages and the drawbacks of the systems metaphor in an empirical context. The metaphor stresses heterogeneity and interrelatedness, but it also tends to direct attention away from the *struggles* that shape a network of heterogeneous and mutually sustaining elements. System builders try to associate elements in what they hope will be a durable array. They try to dissociate hostile systems and reassemble their components in a manner that contributes to what is being built. But the particular form that (dis-)association takes depends on the state of forces. Some of these are obdurate: Currents and winds cannot be tampered with, such is their strength. Some of them are manipulatable, but only with difficulty. Here, for instance, the square-rigged ship and navigational practices, although not immutable, were difficult to influence. Others, however, may be more easily altered. In this case the course sailed by the vessels on their return journey was a matter for discretion as a result of the advances in shipbuilding and navigation of the previous 150 years. Here there was, in the most literal sense, new room to maneuver. The course was no longer rigidly overdetermined for the system builder. Accordingly, the *volta* may be seen as tracing the state of forces and measuring their relative strengths in a literal way. It re-presented the state of shipbuilding, the state of navigation, the state of seamanship, and their collision with the forces of nature. The *volta* was the extra increment of force that allowed the new network to be stabilized, for the course was suddenly the most malleable element in the conflict between the Portuguese desire to return to Lisbon and the natural forces of the Atlantic.

The Caravel and the African Littoral: Closure and Adaptation

Africa, as the Portuguese were to discover, does not reduce to Cape Bojador. The capacity to get round the cape and then return to European waters was all very well, but there was more coastline to explore. South of the cape the coastline becomes even more inhospitable until the Senegal River and Black Africa are reached.

For most of this tricky exploration the Portuguese made use of caravels. Although the origins of this type of vessel are shrouded in mystery (Landstrom 1978, p. 100; Chaunu 1979, p. 243; Parry 1963, p. 65; Unger 1980, pp. 212–215), its fifteenth-century features are well known. Weighing less than 100 tons and being perhaps 70 to 80 feet from stem to stern (Parry 1963, p. 65), the caravel was unusual in being a long sailing ship, having a length-to-breadth ratio of between 3.3 and 3.8 to 1 (Diffie and Winius (1977, p. 118) suggest 3 to 1). It was carvel built, quite light and fine in lines, and drew little water, having a flat bottom and little freeboard (Parry 1963, p. 65; Denoix 1966, p. 143; Landstrom 1978, p. 100). It had only one deck and indeed was sometimes even open or only half-decked. There was no forecastle, and the superstructure of the poop was modest, at best containing one room (Parry 1963, p. 65). In the mid-fifteenth century and certainly on the early voyages of discovery, the caravel normally appeared to have been lateen-rigged on all its masts.

We might say that the caravel was well adapted to the context of offshore exploration. Thus we might note (as have many historians, for example, Denoix (1966, p. 142)) that for such a task one needs a vessel that will not blunder into reefs, is light and handy, draws little water, sails well against the wind, and does not require a large crew. All these attributes were true for the caravel, which was indeed well adapted to its task. But what are we really saying when we say this?

The answer to this question can be found in the notion of a network. System builders seek to create a network of heterogeneous but mutually sustaining elements. They seek to dissociate hostile forces and to associate them with their enterprise by transforming them. The crucial point, however, is that the structure of the network reflects the power and the nature of both the forces available and the forces with which the network collides. To say, then, that an artifact is well adapted to its environment is to say that it forms a part of a system or network that is able to assimilate (or turn away) potentially hostile external forces. It is, consequently, to note that the network in question is relatively stable. Again, to say of an artifact such as the caravel that it is adaptable is to note that a network of associated heterogeneous elements has been generated that is stable because it is able to resist the dissociating efforts of a wide variety of potentially hostile forces and to use at least some of these forces by transforming them and associating them with the project. And this, of course, is precisely the beauty of the caravel in the fifteenth-century context in which it was used by the Portuguese. Properly manned and provisioned, it was able to convert whatever the West African littoral might direct at it into controlled motion and controlled return. It was a network of people, spars, planks, and canvas that was able to convert a wide range of circumstances into exploration without falling apart in any of the numerous ways open to vessels when things start to go wrong. Like the *volta,* then, the caravel achieved stability by reflecting the forces around it. It was well adapted because it maintained stable relations between its component parts by associating everything it encountered with that network as it moved around.

Navigation and the Raising of the Sun: Closure and Metrication

Between 1440 and 1490 the Portuguese explored most of the West African coast. As they moved further south and used increasingly larger *voltas,* the Portuguese saw their problems of navigation become more acute. How could they determine their position when they were so far from land? Because the classical European methods of compass course, plain chart, and dead reckoning were of little assistance, this problem was of great concern to the Portuguese. In the 1480s they developed a practical method for the astronomical determination of latitude on board ship. The general idea was that if the *altura,* or height above the horizon, of the sun or a star (normally the Pole Star) could be determined and compared with the known altura of the port of destination, then the ship could sail north or south until it reached that latitude, and then sail, as appropriate, east or west in the certainty of finding its point of destination.

The measurement of the altura was possible with the use of either the quadrant or the astrolabe. Both devices were standard university instruments of astronomy and astrology that carried a great deal of information that was both unnecessary to the calculation of latitude and simply incomprehensible to the layman. On the back of the astrolabe there was, however, an alidade, which was a rule on a swivel with two pinhole sights. The observer held the instrument upright by a swivel suspension ring, peered along the alidade, and measured the altura of the star by reading off the position of the alidade on a scale marked on the rim (figure 3). The quadrant was an instrument with similar functions. It was in the form of a quarter circle, and the star sight was taken along one of the "radii." The artificial horizon was provided by a plumb line suspended from the center of the "circle" and was measured with a scale along the circumference (Taylor 1956, pp. 158–159). In its university and astrological version the quadrant, like the astrolabe, also carried information about the movements

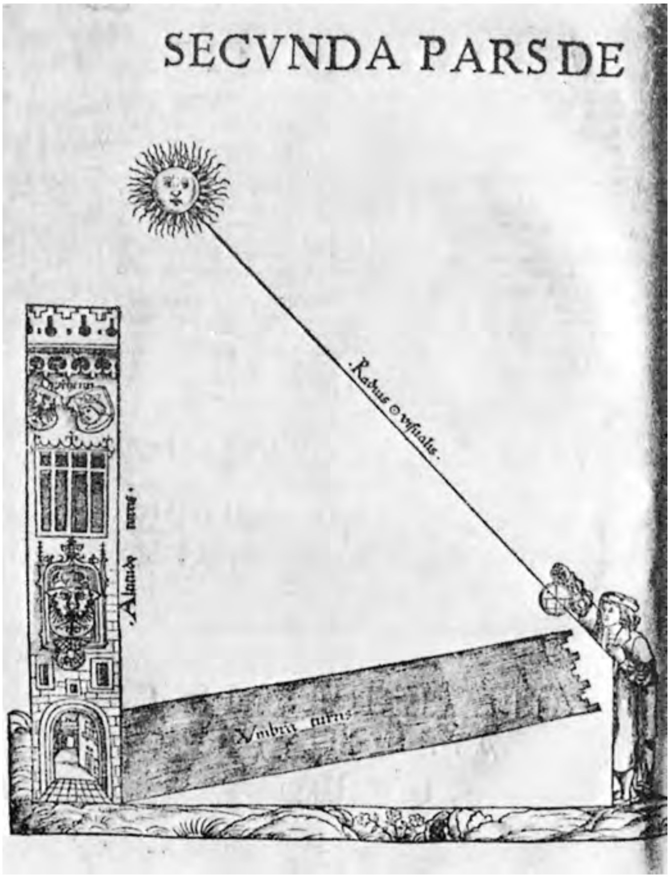

Figure 3
Measuring the altura with an astrolabe (from Sebastian Muenster, *Organa Planetarum* (Basel: Petrus, 1539), 70).

of planets, seasons, and hours. Both of these instruments, shorn of all but their essentials for the measurement of altura, were used by Portuguese explorers, although it seems that the somewhat simpler quadrant was the first to be used by navigators (Taylor 1956, p. 159).

By themselves these instruments were, of course, powerless. The mere fact of sighting a heavenly body through the pinholes of an alidade had nothing per se to do with navigation. That sighting, or the reading that corresponded to it, had to undergo a number of complex transformations before it could be converted into a latitude. The construction of a network of artifacts and skills for converting the stars from irrelevant points of light in the night sky into formidable allies in the struggle to master the Atlantic is a good example of heterogeneous engineering.

I have already mentioned the simplification of the quadrant and astrolabe. This can be treated as the first step in the process.[10] The second stage involved what may be treated as social engineering—the construction of a network of practices that, when associated with the instruments themselves, would lead to the necessary transformations of sun and starlight. This social engineering itself came in three stages. First, in the early 1480s King John II convened a "scientific commission" to find improved methods for measuring the altura. This was made up of four experts: the Royal Physician, Master Rodrigo; the Royal Chaplain, Bishop Ortiz; the geographer, Martin Behaim; and Jose Vizinho, who had been a disciple of the astronomer Abraham Zacuto of Salamanca (Chaunu 1979, p. 257; Taylor 1956, p. 162; Beaujouan 1966, p. 74; Waters 1980, pp. 9–10). The convocation of a "scientific commission" for the purpose of converting esoteric scientific knowledge into a set of widely applicable practices is already remarkable. Even more noteworthy is the fact that these four men, and probably in particular Vizinho, were able to effect that transformation by producing a set of rules for the calculation of the latitude by semieducated mariners. These rules, which form the second part of this experiment in social engineering, took the form of the *Regimento do Astrolabio e do Quadrante,* which was probably available from the late 1480s, at least in handwritten form. The *Regimento* can be read as instructions about how to turn the vessel and its instruments into an observatory—how, in other words, to create a stable if heterogeneous association of elements that had the property of converting measurements of the altura into determinations of the latitude (figure 4).

Even this, however, was not enough. To adopt the new method of sailing, the navigators required a third step: It was necessary to know the latitudes of important coastal features and in particular the major ports and capes. It was, in other words, necessary to generate a *metric* from which the observations might be given absolute north-south meaning and from which the observatory of the ship could be located accordingly. The measurement of important coastal latitudes again involved a major organizational effort. It involved sending out competent observers armed with large wooden astrolabes on the vessels of exploration and having them report back to Lisbon. By 1473 the astronomers in Lisbon had a list of latitudes that reached the equator (Taylor 1956, p. 159), a list that was extended as the century wore on. And it further required that known latitudes be available to mariners, and indeed, a further section of the *Regimento* listed these.

January.												
First.			Second.			Third.			Fourth.			
1			2			3			4			
1593			1594			1595			1596			Yeere of the Lord
1597			1598			1599			1600			
1601			1602			1603			1604			
1605			1606			1607			1608			
1609			1610			1611			1612			
D.	G.	M.	D.	G.	M	D.	G.	M.	D.	G.	M	
1	21	50	1	21	52	1	22	56	1	21	57	
2	21	40	2	21	43	2	22	9	2	21	48	
3	21	30	3	21	33	3	21	36	3	21	38	
4	21	20	4	21	23	4	21	26	4	21	28	
5	21	9	5	21	16	5	21	15	5	21	17	
6	20	58	6	21	1	6	21	4	6	21	7	
7	20	47	7	20	50	7	20	53	7	20	55	
8	20	35	8	20	38	8	20	41	8	20	44	
9	20	22	9	20	26	9	20	29	9	20	32	
10	20	9	10	20	13	10	20	16	10	20	20	
11	19	56	11	20	0	11	20	3	11	20	6	
12	19	43	12	19	47	12	19	50	12	19	53	
13	19	29	13	19	32	13	19	36	13	19	39	
14	19	14	14	19	19	14	19	22	14	19	25	
15	19	0	15	19	4	15	19	8	15	19	11	
16	18	45	16	18	49	16	18	53	16	18	56	
17	18	29	17	18	34	17	18	38	17	18	41	
18	18	14	18	18	19	18	18	22	18	18	26	
19	17	58	19	18	3	19	18	7	19	18	11	
20	17	42	20	17	46	20	17	50	20	17	54	
21	17	25	21	17	30	21	17	34	21	17	38	
22	17	8	22	17	13	22	17	17	22	17	21	
23	16	51	23	16	56	23	17	0	23	17	4	
24	16	32	24	16	38	24	16	43	24	16	47	
25	16	16	25	16	21	25	16	25	25	16	29	
26	15	57	26	16	3	26	16	7	26	16	12	
27	15	39	27	15	45	27	15	49	27	15	54	
28	15	21	28	15	26	28	15	30	28	15	35	
29	15	2	29	15	7	29	15	12	29	15	23	
30	14	43	30	14	48	30	14	53	30	14	58	
31	14	24	31	14	29	31	14	34	31	14	39	

Figure 4
Tables of solar declination from a navigational manual (Pedro de Medina, *The Arte of Nauigation* (London: Thomas Dawson, 1595), 58).

The new method of navigation proved difficult for most mariners. Only the most up-to-date sailors attempted its practice, and there is evidence that Columbus, among others, understood it only imperfectly. Although the details remain unclear, it appears that in the early sixteenth century, and possibly earlier, classes on navigation were taught to pilots at Lisbon (Diffie and Winius 1977, p. 142). Such instruction, however, was not invariably successful. There were complaints in the sixteenth century that many pilots were inexpert. It seems, then, that in the attempt to create a stable network of elements for the conversion of stars into measurement of the latitude—in other words, in the attempt to convert ships into observatories—it was the mariners who constituted the weakest link. The stars were always there, as were the oceans; they could not be budged. Again, once the instruments and the inscriptions were in place, they proved to be fairly durable. But instruments, inscriptions, and stars were not enough. Part of the association of elements to convert stars into latitudes lay in the practices of the mariners, and it was this element that was the most prone to distortion. It was difficult, although not ultimately impossible, to create a new social group necessary for closure: the astronomical navigator.

So far I have tacitly made the assumption that, when success is achieved, it is obvious. If one arrives at one's port of destination (or for that matter runs aground on the reefs of Cape Bojador), the success (or failure) of the enterprise is readily apparent to all. We might say that in the ultimate analysis it was the capacity of the Portuguese to *return* to their point of departure that marked success. The success of astronomical navigation was that it contributed to that return. Yet, however much final closure depended on the capacity to return, decision making on the voyage would not have been possible without a scale of reference. The success of any course sailed could be measured in the interim only against an entirely man-made metric, a metric that depended on inscriptions and the capacity to interpret those inscriptions. We have, then, the construction of a background against which to measure success—something akin to if not identical with the technological testing tradition described by Constant in the context of water turbine engineering (Constant 1983). The history of navigation can, I believe, be understood as the construction of more (locally) general systems of metrication against which the adequacy of particular courses and navigational decisions might be measured.

The Muslim and the Gun: Dissociation

On July 8, 1497, Vasco da Gama's fleet weighed anchor in the Tagus River and set sail. His four tiny vessels carried 170 men and 20 cannons. They also carried merchandise. Two years later two of the original four vessels returned to Lisbon. The cape route to India had been opened, and spices had been brought back.

The Portuguese encountered various difficulties, which arose in part from the hostility of Muslim traders in India (Magalhaes-Godinho 1969, p. 558). Such merchants organized and controlled the Indian Ocean section of the spice trade. They bought spices in the Calicut bazaars and shipped these, through either the Persian Gulf or the Red Sea, to Arabian ports for further shipment to the Mediterranean and Venice. Not surprisingly the Muslims did not welcome the arrival of da Gama on the Malabar coast at Calicut with enthusiasm. Negotiations went badly between the Portuguese and the Hindu ruler of Calicut, the Samorin. There were many reasons for this, but the most important appears to have been the hostility of the Muslim traders on whom the Portuguese were obliged to depend for translation. The translators spread a variety of hostile rumors about the Portuguese, who were then forced to trade directly with Hindu merchants (Diffie and Winius 1977, pp. 182–183).

Once back in Lisbon, the Portuguese pondered the lessons to be learned. One conclusion that they were quick to draw was that it would be necessary to exercise force in the Indian Ocean. Da Gama's first expedition had carried guns, but more would be needed if the hostility of the Muslims was to be mastered. In fact, the Portuguese had come to this conclusion even before da Gama's return. A much larger and more heavily armed second expedition had already set out; the expedition consisted of thirteen vessels and between 1000 and 1500 men and was commanded by Pedro Cabral. Cabral's orders were clear: He had to install an agent to buy spices in Calicut and was instructed to display force when this was necessary, although he was to refrain from conquest (Magalhaes-Godinho 1966, p. 561). Although negotiations started well, things quickly went wrong again. In response, Cabral put to sea, destroyed a number of Muslim vessels, and bombarded the town of Calicut. The story was repeated with da Gama's second expedition, which, however, used even more force. Together these first three sorties cast the die for Portuguese control of the Indian Ocean over the next few years. Control would have to be maintained primarily by force, as there was no room for both Muslim and Portuguese commerce.

At sea the Portuguese were, at least in the short run, able to exert the necessary military power and choke Muslim maritime trade. Portuguese guns proved better (but not more numerous) than Asian guns. European advances in the technology of gun making had overcome many of the problems that beset the late medieval cannon. In particular, with the development of cast bronze guns, the weight of the cannon had been much reduced, and although still prone to heaviness, they were much less likely to blow up in the faces of the gunners than the welded pieces that preceded them. Again, Portuguese vessels, built for the inhospitable Atlantic, were more solid than those of their Muslim adversaries (Boxer 1953, p. 196). Cipolla puts it this way:

> The gunned ship developed by Atlantic Europe in the course of the fourteenth and fifteenth centuries was the contrivance that made possible the European saga. It was essentially a compact device that allowed a relatively small crew to master unparalleled masses of inanimate energy for movement and destruction. (Cipolla 1965, p. 137)

The cannon, the ship, the master, the gunner, the powder, and the cannonballs—all these formed a relatively stable set of associated entities that achieved relative durability because together they were able to dissociate the hostile forces encountered without being dissociated themselves. It is important to note here that some of these hostile forces were physical (the oceans), whereas others were social (the Muslims). Technology, as I have suggested, simultaneously associates and dissociates, and the heterogeneous engineering of the Portuguese was designed to handle natural and social forces indifferently and to associate these forces in an appropriate form of closure.

Having said this, however, it is important not to fall into the trap of technological determinism and assume that it was the technology alone that brought about Portuguese success. As was the case for the caravel, the *volta,* and the practice of astronomical navigation, the durability of the armed warship was a function of a collision between the forces of the Portuguese system builders and those of the seas and, in this case, the Muslims. Thus Boxer (1953, pp. 194–197) argues that the Portuguese "naval and military superiority, where it existed, was relative and limited." It happened that there was no well-armed Muslim shipping in the Indian Ocean. It happened that the Chinese had retired to their coasts. It happened that the Portuguese expeditions were state enterprises, combining the power and organizational ability of the crown with the search for profit. It happened that Muslim merchants traded on their own account and not for their monarchs. It happened that there was little wood available to many of those monarchs in order to build fleets to stop the Portuguese. Under these circumstances the Portuguese were able to dominate shipping in the Indian Ocean. They were not able (and knowing this never sought to) build up sizable colonies on land. There, with the balance of force weighted against them by cavalry and manpower, they risked crushing defeat.

Conclusion

I started by outlining three approaches to the social study of technology. One, that of social constructivism, comes from the sociology of science. I suggested that, although this has many merits, its commitment to a form of social reductionism is unsatisfactory. The second, the systems approach, comes from the history of technology. This stresses the heterogeneity of technological activity and avoids a commitment to social (or technological) reductionism. I argued that this approach, adapted in a way that makes it clear that systems are built, through a struggle, from indifferent or hostile elements, offers a satisfactory model for the analysis of technological innovation. I suggested that "heterogeneous engineers" seek to associate entities that range from people, through skills, to artifacts and natural phenomena. This is successful if the consequent heterogeneous networks are able to maintain some degree of stability in the face of the attempts of other entities or systems to dissociate them into their component parts. It follows from this that the structure of the networks (or systems) in question reflects not only a concern to achieve a workable solution but also the relationship between the forces that they can muster and those deployed by their various opponents. I might, if I were to make more use of the metaphor of force, write of the relative durability or strength of different networks or of different parts of the same network. Thus I have attempted to show by empirical example that, in the collisions among different networks, some components are more durable than others and that the successes achieved by one side or the other are a function of the relative strength of the components in question.

What are the virtues of physical metaphors such as force, strength, and durability? Let me say, first, that I am not strongly committed to these terms. Doubtless other metaphors might serve as well or better. I believe, however, that the strength of the vocabulary lies in its capacity to handle, using the same terms, the various heterogeneous elements that are normally assembled within any system. As I indicated earlier, the method seeks to deal with the social, the economic, the political, the technical, the natural, and the scientific in the same terms on the grounds that (in most empirical cases) *all* of these have to be assembled in appropriate ways if closure is to be achieved. Within any of these (usually distinguished) categories, there may be entities, processes, bodies, objects, institutions, or rules that turn out to have force with respect to the system in question and hence are relatively durable. These may take the form of scientific truths, economic markets, social facts, machines, or whatever. They form, then, a relatively coercive (albeit ultimately revisable) scenery that has to be mastered if a system is to be built. Because, however, durability does not reside in one category alone, I have ignored conventional distinctions among categories, and in particular I have argued that it is not good enough to add the social as an explanatory afterthought. The social (including the "macrosocial") has, rather, to be placed alongside everything else if the collisions and closures between forces and entities are to be understood.

Like Callon, I have thus sought to press the principle of symmetry (Bloor 1976) further than is normal in the sociology of science. In the sociology of science this principle states that the same *type* of explanation should be used for both true and false beliefs. It is intended to counter the tendency commonly found in the sociology of knowledge of explaining true beliefs in terms of the way in which they correspond with reality while leaving false beliefs to be explained in terms of the operation of psychological or social factors. The generalized version of the principle of symmetry (Callon 1986) that I have adopted here states that the same type of explanation should be used for all the elements that go to make up a heterogeneous network, whether these elements are devices, natural forces, or social groups. In particular, the principle of symmetry states that the social elements in a system should not be given special explanatory status.[11] The form that these elements take may be, and often is, a function of the technological or natural features of the system. This is a contingent matter, a function of which components of the system are associated most durably and are hence least susceptible to dissociation.

To say this is not, of course, to suggest that it is always the social that is malleable and the technological or the natural that is durable. It is rather to stress that the relationship between them is one of contingency and that it is important to find a way of treating all components in a system on equal terms. But this leads to a further way in which the network approach is distinguished from that of social constructivism. In social constructivism natural forces or technological objects always have the status of an *explanandum*. The natural world or the device in question are never treated as the *explanans*. They do not, so to speak, have a voice of their own in the explanation. The adoption of the principle of generalized symmetry means that this is no longer the case. Depending, of course, on the contingent circumstances, the natural world and artifacts may enter the account as an *explanans*. And in case it is thought that I am giving too much away to realism, let me say that, so long as we are concerned exclusively with networks that are being built by people, then "nature" reveals its obduracy in a way that is relevant only to the network when it is registered by the system builders. It is not, therefore, that nature is being promoted to some special status. Rather it is, as I have already suggested, that the social is being demoted. In the network approach *neither* nature nor society has any role to play unless they impinge on the system builder.

This is why, in my explanation of the Portuguese expansion, capes and currents are found alongside vessels and mariners. Once the principle of generalized symmetry is adopted, they cannot be excluded. Indeed, to try to reduce an explanation of the Portuguese system to a limited number of social categories would be to fail to explain the specificity of the *volta,* the caravel, or the *Regimento*. Portuguese views of the sun and the adverse winds are needed to make the explanation work.[12]

A further methodological principle follows from this. It is that the scope of the network being studied is determined by the existence of actors that are able to make their presence individually felt on it. If the system builder is forced to attend to an actor, then that actor exists within the system. Conversely, if an element does not make its presence felt by influencing the structure of the network in a noticeable and individual way, then from the standpoint of that network the element in question does not exist. It is clear that the choice of network on which to focus is therefore crucial. If the focus is on one system, then one pattern will emerge. If the focus is on another system or even on an element within the original system, then a different structure will be seen. Thus the system of Portuguese expansion for Henry the navigator contained elements such as vessels and their masters. A shift in focus from Henry to the master and his vessel would bring a further network of sailors, spars, and stores into focus—a network with its own force that, when placed within the system of Portuguese expansion, acted as a single unit. If the vessel and its master did not play the roles defined for them in the network of expansion, then the elements that make them up might, of course, have become individually relevant in Lisbon and been built into Henry's expansion network. Such adjustment is consistent with, and indeed exemplifies, the original proposition that the extent of a network is defined by the presence of actors that are able to make their presence individually felt.[13]

This also means, of course, that the heterogeneous engineer standing at the heart of his or her network is not in principle analytically privileged. It is true that, for the purpose of the particular study, I have chosen to follow one system-building effort—that of the Portuguese maritime planners. I have done this in order to set practical limits to the analysis. In making this decision, however, I have not committed myself to the notion that system builders are primitive entities that are themselves unamenable to analysis. Just as vessels or navigators are fashioned out of the interaction between networks of forces, so too are heterogeneous engineers. Indeed, the fact that these are in a position to build systems is itself the outcome of a set of interactions among forces of different degrees of obduracy. To put it more simply, the king of Portugal is just as much an effect as a cause: He is the effect of a set of endless transactions that are, in principle, available for analysis. In the present study, I chose, for reasons of simplicity, to treat him as a cause and navigation as an effect, but in another study these roles, or ones like them, might just as easily have been reversed.

In summary, there are thus two closely related methodological principles for the study of heterogeneous networks. The first, that of generalized symmetry, states that the same type of analysis should be made for all components in a system whether these components are human or not. The second, that of reciprocal definition, states that actors are those entities that exert detectable influence on others. Applied to a relatively stable system, we can therefore define the extent of that system or network by the range of actors that operate as unitary forces to influence the structure of the network. In this chapter I have attempted to follow these two principles in an analysis of the Portuguese expansion. In reinterpreting the notions of system, adaptation, and technological testing for a historical case, I hope that I have succeeded in showing the relevance of the approach to the analysis of technological innovation.

Notes

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1. It is fully described by Pinch and Bijker (1984 and this volume). See also Bijker (this volume).

2. I am not suggesting that these authors all use a social constructivist approach but that their material is susceptible to an analysis in those terms.

3. For another study using a systems approach, see MacKenzie (this volume).

4. Pinch and Bijker (this volume) talk of the effects of advertising on the formation of social groups.

5. Although I have made reference to the work of Hughes, the same point can, I believe, be made in reference to Constant. His notion of coevolution (1978) also

seems to represent an attempt to grapple with the interrelatedness of heterogeneous elements and to handle the finding that the social as well as the technical is being constructed. In addition, the analysis of the development of traditions of "technological testability" developed by Constant (1983) can be seen as a study of the way in which a wide range of actors comes to a locally enforceable agreement that certain social/technical relations are appropriate and workable.

6. Arguably we are *all* heterogeneous engineers, combining, as we do, disparate elements into the "going concern" of our daily lives. In the present essay I am concerned, however, only with large-scale, technologically relevant system building.

7. As I have indicated, this approach parallels that of Callon. It also, however, owes much to the work of Latour (1984).

8. What follows is an example of what I call rational reconstruction. See the conclusion of this chapter.

9. The portolano or plain (that is, plane) chart was laid out using wind roses and rhumb lines of constant magnetic bearing.

10. In what follows I have been highly selective with respect to material in order to highlight what I take to be the essentials of the process and to avoid getting bogged down in detail. For similar reasons I have also taken the liberty of reorganizing the chronology of events by talking of the establishment of the latitudes of important points on the coast after discussing the *Regimento.* For a fuller sociological account, see Law (1986a).

11. Similar arguments have been made by Woolgar (1981), Yearley (1982), and Gallon and Law (1982).

12. Having said this, however, I willingly concede that in the present chapter I have sometimes been obliged, because of lack of data on medieval and early modern maritime practices, to make use of a kind of "rational reconstruction" in order to show how nature and society affected the Portuguese analysis of their problems. It should be understood that I use rational reconstruction not for the purpose of epistemological judgment but to try, matter of factly, to work out what appears to have happened in cases in which historical data is lacking. For a more extended discussion of rational reconstruction and inadequacies of data, see Law (1985). It is obvious that this procedure is less than ideal, but unless whole empirical areas are to be denied to us, it is obviously unavoidable.

13. It is clear from what has been said that any network stands at the intersection and (if it is relatively stable) profits from the force contributed by endless other networks that have been simplified into individual units. See Callon (1981a) and Law (1984b).

JOHNSON, Jim [LATOUR, Bruno]. 1988. Mixing humans and nonhumans together: the sociology of a door-closer. Social Problems 35(3):298-310.

Mixing Humans and Nonhumans Together: The Sociology of a Door-Closer*

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Is sociology the study of social questions, or is it the study of associations? In this paper the author takes the second position and extends the study of our associations to nonhumans. To make the argument clearer, the author chooses one very humble nonhuman, a door-closer, and analyzes how this "purely" technical artifact is a highly moral, highly social actor that deserves careful consideration. Then the author proposes a vocabulary to follow human and nonhuman relations without stopping at artificial divides between what is purely technical and what is social. The author builds "its" or "his" own text in such a way that the text itself is a machine that exemplifies several of the points made by the author. In particular, the author is constructed and deconstructed several times to show how many social actors are inscribed or prescribed by machines and automatisms.

The most liberal sociologist often discriminates against nonhumans. Ready to study the most bizarre, exotic, or convoluted social behavior, he or she balks at studying nuclear plants, robots, or pills. Although sociology is expert at dealing with human groupings, when it comes to nonhumans, it is less sure of itself. The temptation is to leave the nonhuman to the care of technologists or to study the impact of black-boxed techniques upon the evolution of social groups. In spite of the works of Marx or Lewis Mumford and the more recent development of a sociology of techniques (MacKenzie and Wacjman, 1985; Bijker, Hughes, and Pinch, 1986; Winner, 1986; Latour, 1987), sociologists still feel estranged when they fall upon the bizarre associations of humans with nonhumans. Part of their uneasiness has to do with the technicalities of complex objects and with the absence of a convenient vocabulary allowing them to move freely from studying associations of human to associations of nonhumans. In this paper I want to contribute to the reinsertion of nonhumans into the mainstream of American sociology by examining an extremely simple technique and offering a coherent vocabulary that could be applied to more complex imbroglios of humans and nonhumans.

Reinventing the Door

On a freezing day in February, posted on the door of the Sociology Department at Walla Walla University, Washington, could be seen a small hand-written notice: "The door-closer is on strike, for God's sake, keep the door closed." This fusion of labor relations, religion, advertisement, semiotics, and technique in one single insignificant fact is exactly the sort of thing I want to help describe. As a technologist teaching in an engineering school in Colombus, Ohio, I want to challenge some of the assumptions sociologists often hold about the "social context" of machines.

Walls are a nice invention, but if there were no holes in them, there would be no way to get in or out; they would be mausoleums or tombs. The problem is that, if you make holes in the walls, anything and anyone can get in and out (bears, visitors, dust, rats, noise). So architects invented this hybrid: a hole-wall, often called a *door*, which, although common enough,

* A version of this paper was delivered at Twente, Holland, in September, 1987. This paper owes a lot to Madeleine Akrich's work.

1. See page 304 for the social deconstruction of the authors.

has always struck me as a miracle of technology. The cleverness of the invention hinges upon the hinge-pin: instead of driving a hole through walls with a sledge hammer or a pick, you simply gently push the door (I am supposing here that the lock has not been invented; this would over-complicate the already highly complex story of this door). Furthermore, and here is the real trick, once you have passed through the door, you do not have to find trowel and cement to rebuild the wall you have just destroyed; you simply push the door gently back (I ignore for now the added complication of the "pull" and "push" signs).

So, to size up the work done by hinges, you simply have to imagine that every time you want to get in or out of the building you have to do the same work as a prisoner trying to escape or a gangster trying to rob a bank, plus the work of those who rebuild either the prison's or the bank's walls.

If you do not want to imagine people destroying walls and rebuilding them every time they wish to leave or enter a building, then imagine the work that would have to be done in order to keep inside or to keep outside all the things and people that, left to themselves, would go the wrong way. As Maxwell could have said, imagine his demon working *without* a door. Anything could escape from or penetrate into the department, and there would soon be complete equilibrium between the depressing and noisy surrounding area and the inside of the building. Techniques are always involved when asymmetry or irreversibility is the goal; it might appear that doors are a striking counter example since they maintain the hole-wall in a reversible state, but the allusion to Maxwell's demon clearly shows that such is not the case. The reversible door is the only way to irreversibly trap inside a differential accumulation of warm sociologists, knowledge, papers, and also, alas, paperwork; the hinged door allows a selection of what gets in and what gets out so as to locally increase order or information. If you let the drafts get inside, the drafts will never get outside to the publishers.

Now, draw two columns (if I am not allowed to give orders to the reader of *Social Problems* then take it as a piece of strongly worded advice). In the right column, list the work people would have to do if they had no door; in the left column write down the gentle pushing (or pulling) they have to do in order to fulfill the same tasks. Compare the two columns; the enormous effort on the right is balanced by the little one on the left, and this thanks to hinges. I will define this transformation of a major effort into a minor one by the word *translation* or *delegation*; I will say that we have delegated (or translated or displaced or shifted out) to the hinge the work of reversibly solving the hole-wall dilemma. Calling on a sociologist friend, I do not have to do this work nor even to think about it; it was delegated by the carpenter to a character, the hinge, that I will call a nonhuman (notice that I did not say "inhuman"). I simply enter the department of sociology. As a more general descriptive rule, every time you want to know what a nonhuman does, simply imagine what other humans or other nonhumans would have to do were this character not present. This imaginary substitution exactly sizes up the role, or function, of this little figure.

Before going on, let me cash out one of the side benefits of this table: in effect, we have drawn a scale balance where tiny efforts balance out mighty weights. The scale we drew (at least the one that you drew if you have obeyed my orders—I mean, followed my advice) reproduces the very leverage allowed by hinges. That the small be made stronger than the large is a very moral story indeed (think of David and Goliath). By the same token, this is also, since at least Archimedes' days, a very good definition of a lever and of power: the minimum you need to hold and deploy astutely in order to produce the maximum effect. Am I alluding to machines or to Syracuse's King? I don't know, and it does not matter since the King and Archimedes fused the two "minimaxes" into one single story told by Plutarch: the defense of Syracuse. I contend that this reversal of forces is what sociologists should look at in order to understand the "social construction" of techniques and not at a hypothetical social context they are not equipped to grasp. This little point having been made, let me go on with the story (we will understand later why I do not really need your permission to go on and why, nevertheless, you are free not to go on, although only *relatively* so).

Delegating to Humans

There is a problem with doors. Visitors push them to get in or pull on them to get out (or vice versa), but then the door remains open. That is, instead of the door you have a gaping hole in the wall through which, for instance, cold rushes in and heat rushes out. Of course, you could imagine that people living in the building or visiting the department of sociology would be a well disciplined lot (after all, sociologists are meticulous people). They will learn to close the door behind them and retransform the momentary hole into a well-sealed wall. The problem is that discipline is not the main characteristic of people. Are they going to be so well-behaved? Closing a door would appear to be a simple enough piece of know-how once hinges have been invented; but, considering the amount of work, innovations, sign-posts, recriminations that go on endlessly everywhere to keep them closed (at least in Northern regions), it seems to be rather poorly disseminated.

This is where the age-old choice, so well analyzed by Mumford (1966), is offered to you: either to discipline the people or to *substitute* for the unreliable people another *delegated human character* whose only function is to open and close the door. This is called a groom or a porter (from the French word for door) or a gatekeeper, or a janitor, or a concierge, or a turnkey, or a gaoler. The advantage is that you now have to discipline only one human and may safely leave the others to their erratic behavior. No matter who these others are and where they come from, the groom will always take care of the door. A nonhuman (the hinges) plus a human (the groom) have solved the hole-wall dilemma.

Solved? Not quite. First of all, if the department pays for a porter, they will have no money left to buy coffee or books or to invite eminent foreigners to give lectures. If they give the poor little boy other duties besides that of porter, then he will not be present most of the time, and the damned door will stay open. Even if they had money to keep him there, we are now faced with a problem that two hundred years of capitalism has not completely solved: how to discipline a youngster to reliably fulfill a boring and underpaid duty. Although there is now only one human to be disciplined instead of hundreds (in practice only dozens because Walla Walla is rather difficult to locate), the weak point of the tactic is now revealed: if this one lad is unreliable then the whole chain breaks down. If he falls asleep on the job or goes walkabout, there will be no appeal; the damned door will stay open (remember that locking it is no solution since this would turn it into a wall, and then providing every visitor with the right key is an impossible task). Of course, the little rat may be punished or even flogged. But imagine the headlines: "Sociologists of science flog porter from poor working class background." And what if he is black, which might very well be the case, given the low pay? No, disciplining a groom is an enormous and costly task that only Hilton Hotels can tackle, and that for other reasons that have nothing to do with keeping the door properly closed.

If we compare the work of disciplining the groom with the work he substitutes for, according to the list defined above, we see that this delegated character has the opposite effect to that of the hinge. A simple task, forcing people to close the door, is now performed at an incredible cost; the minimum effect is obtained with maximum spending and spanking. We also notice, when drawing the two lists, an interesting difference. In the first relationship (hinges vis-à-vis work of many people), you not only had a reversal of forces (the lever allows gentle manipulations to heavy weights) but also a reversal of *time*. Once the hinges are in place, nothing more has to be done apart from maintenance (oiling them from time to time). In the second set of relations (groom's work versus many people's work), not only do you fail to reverse the forces, but you also fail to modify the time schedule. Nothing can be done to prevent the groom who has been reliable for two months from failing on the sixty-second day; at this point it is not maintenance work that has to be done, but the same work as on the first day—apart from the few habits that you might have been able to *incorporate* into his body. Although they appear to be two similar delegations, the first one is concentrated in time, whereas the other is continuous; more exactly, the first one creates a clear-cut distinction between production and maintenance, whereas in the other the distinction between training and keeping in operation is either fuzzy or nil. The first one evokes the past perfect ("once hinges had been installed"); the second the present tense ("when the groom is at his post"). There is a built-in inertia in the first that is largely lacking in the second. A profound temporal shift takes place when nonhumans are appealed to: time is folded.

Disciplining the Door-Closer

It is at this point that you have this relatively new choice: either to discipline the people or to substitute for the unreliable humans a delegated nonhuman character whose only function is to open and close the door. This is called a door-closer or a "groom." The advantage is that you now have to discipline only one nonhuman and may safely leave the others (bellboys included) to their erratic behavior. No matter who they are and where they come from—polite or rude, quick or slow, friends or foes—the nonhuman groom will always take care of the door in any weather and at any time of the day. A nonhuman (hinges) plus another nonhuman (groom) have solved the hole-wall dilemma.

Solved? Well, not quite. Here comes the deskilling question so dear to social historians of technology: thousands of human grooms have been put on the dole by their nonhuman brethren. Have they been replaced? This depends on the kind of action that has been translated or delegated to them. In other words, when humans are displaced and deskilled, nonhumans have to be upgraded and reskilled. This is not an easy task, as we shall now see.

We have all experienced having a door with a powerful spring mechanism slam in our face. For sure, springs do the job of replacing grooms, but they play the role of a very rude, uneducated porter who obviously prefers the wall version of the door to its hole version. They simply slam the door shut. The interesting thing with such impolite doors is this: if they slam shut so violently, it means that you, the visitor, *have* to be very quick in passing through and that you *should* not be at someone else's heels; otherwise your nose will get shorter and bloody. An unskilled nonhuman groom thus presupposes a skilled human user. It is always a trade-off. I will call, after Madeleine Akrich, the behavior imposed back onto the human by nonhuman delegates *prescription* (Akrich, 1987). How can these prescriptions be brought out? By replacing them by strings of sentences (usually in the imperative) that are uttered (silently and continuously) by the mechanisms for the benefit of those who are mechanized: do this, do that, behave this way, don't go that way. Such sentences look very much like a programming language. This substitution of words for silence can be made in the analyst's thought experiments, but also by instruction booklets or explicitly in any training session through the voice of a demonstrator or instructor or teacher. The military are especially good at shouting them out through the mouthpiece of human instructors who delegate back to themselves the task of explaining, in the rifle's name, the characteristics of the rifle's ideal user. As Akrich notes, prescription is the moral and ethical dimension of mechanisms. In spite of the constant weeping of moralists, no human is as relentlessly moral as a machine, especially if it is (she is, he is, they are) as "user friendly" as my computer.

The results of such distributions of skills between humans and nonhumans is well known: members of the department of sociology will safely pass through the slamming door at a good distance from one another; visitors, unaware of the *local cultural condition,* will crowd through the door and will get bloody noses. This story is of the same form as that about the buses loaded with poor blacks that could not pass under driveways leading to Manhattan parks (Winner, 1980). So, inventors get back to their drawing board and try to imagine a nonhuman character that will not prescribe the same rare local cultural skills to its human users. A weak spring might appear to be a good solution. Such is not the case because it would substitute for another type of very unskilled and undecided groom who is never sure about the door's (or his own) status: is it a hole or a wall? Am I a closer or an opener? If it is both at once, you can forget about the heat. In computer parlance, a door is an OR, not an AND *gate.*

I am a great fan of hinges, but I must confess that I admire hydraulic door-closers much more, especially the old copper plated heavy one that slowly closed the main door of our house in Colombus, Ohio. I am enchanted by the addition to the spring of an hydraulic piston which easily draws up the energy of those who open the door and retains it, then gives it back slowly with a subtle variety of implacable firmness that one could expect from a well trained butler. Especially clever is its way of extracting energy from each and every unwilling, unwitting passer-by. My military friends at the academy call such a clever extraction an "obligatory passage point," which is a very fitting name for a door; no matter what you feel, think, or do, you have to leave a bit of your energy, literally, at the door. This is as clever as a toll booth.

This does not quite solve all the problems, though. To be sure the hydraulic door-closer does not bang the noses of those who are not aware of local conditions, so its prescriptions may be said to be less restrictive. But it still leaves aside segments of human populations. Neither my little nephews nor my grandmother could get in unaided because our groom needed the force of an able-bodied person to accumulate enough energy to close the door. To use the classic Langdon Winner's motto (1980), because of their prescriptions these doors *discriminate* against very little and very old persons. Also, if there is no way to keep them open for good, they discriminate against furniture removers and in general everyone with packages, which usually means, in our late capitalist society, working or lower-middle class employees (who, even coming from a higher strata, has not been cornered by an automated butler when he or she had their hands full of packages?). There are solutions though: the groom's delegation may be written off (usually by blocking its arm) or, more prosaically, its delegated action may be opposed by a foot (salesman are said to be expert at this). The foot may in turn be delegated to a carpet or anything that keeps the butler in check (although I am always amazed by the number of objects that fail this trial of force, and I have very often seen the door I just wedged open politely closing when I turned my back to it).

As a technologist, I could claim that, provided you put aside maintenance and the few sectors of population that are discriminated against, the groom does its job well, closing the door behind you constantly, firmly, and slowly. It shows in its humble way how three rows of delegated nonhuman actants (hinges, springs, and hydraulic pistons) replace, 90 percent of the time, either an undisciplined bell-boy who is never there when needed or, for the general public, the program instructions that have to do with remembering-to-close-the-door-when-it-is-cold. The hinge plus the groom is the technologist's dream of efficient action, at least it was until the sad day when I saw the note posted on Walla Walla Sociology Department's door with which I started this article : "the groom is on strike." So not only have we been able to delegate the act of closing the door from the human to the nonhuman, we have also been able to delegate the little rat's lack of discipline (and maybe the union that goes with it). On strike. Fancy that! Nonhumans stopping work and claiming what? Pension payments? Time off? Landscaped offices? Yet it is no use being indignant because it is very true that nonhumans are not so reliable that the irreversibility we would like to grant them is complete. We did not want ever to have to think about this door again—apart from regularly scheduled routine maintenance (which is another way of saying that we did not have to bother about it)—and here we are, worrying again about how to keep the door closed and drafts outside.

What is interesting in the note on the door is the humor of attributing a human character to a failure that is usually considered as "purely technical." This humor, however, is more profound than the synonymous notice they could have posted "the groom is not working." I constantly talk with my computer, who answers back; I am sure you swear at your old car; we are constantly granting mysterious faculties to gremlins inside every conceivable home appliance, not to mention cracks in the concrete belt of our nuclear plants. Yet, this behavior is considered by moralists, I mean sociologists, as a scandalous breach of natural barriers. When you write that a groom is "on strike," this is only seen as a "projection," as they say, of a human behavior onto a nonhuman cold technical object, one by nature impervious to any feeling. They call such a projection anthropomorphism, which for them is a sin akin to zoophily but much worse.

It is this sort of moralizing that is so irritating for technologists because the automatic groom is already anthropomorphic through and through. "Anthropos" and "morphos" together mean either what has human shape or what gives shape to humans. Well the groom is indeed anthropomorphic, and in three senses: first, it has been made by men, it is a construction; second it substitutes for the actions of people, and is a delegate that permanently occupies the position of a human; and third, it shapes human action by prescribing back what sort of people should pass through the door. And yet some would forbid us to ascribe feelings to this thoroughly anthropomorphic creature, to delegate labor relations, to "project"—that is to say, to translate—*other* human properties to the groom. What of those many other innovations that have endowed much more sophisticated doors with the ability to see you arrive in advance (electronic eyes), or to ask for your identity (electronic passes), or to slam shut—or open—in case of danger? But anyway, who are you, you the sociologists, to decide forever the real and final shape of humans, to trace with confidence the boundary between what is a "real" delegation and what is a "mere" projection, to sort out forever and without due inquiry the three different kinds of anthropomorphism I listed above? Are we not shaped by nonhuman grooms, although, I admit, only a very little bit? Are they not our brethren? Do they not deserve consideration? With your self-serving and self-righteous social problems, you always plead against machines and for deskilled workers; are you aware of *your* discriminatory biases? You discriminate between the human and the inhuman. I do not hold this bias but see only actors—some human, some nonhuman, some skilled, some unskilled—that exchange their properties.

So the note posted on the door is an accurate one. It gives a humorous but exact rendering of the groom's behavior: it is not working; it is on strike (notice, that the word "strike" is also an anthropomorphism carried from the nonhuman repertoire to the human one, which proves again that the divide is untenable). What happens is that sociologists confuse the dichotomy human/inhuman with another one: *figurative/non-figurative.* If I say that Hamlet is the figuration of "depression among the aristocratic class," I move from a personal figure to a less personal one (class). If I say that Hamlet stands for doom and gloom, I use less figurative entities; and if I claim that he represents western civilization, I use non-figurative abstractions. Still, they all are equally actants, that is to say entities that *do* things, either in Shakespeare's artful plays or in the commentators' more tedious tomes. The choice of granting actants figurativity or not is left entirely to the authors. It is exactly the same for techniques. We engineers are the authors of these subtle plots or *scenariis,* as Madeleine Akrich (1987) calls them, of dozens of delegated and interlocking characters so few people know how to appreciate. The label "inhuman" applied to techniques simply overlooks translation mechanisms and the many choices that exist for figuring or de-figuring, personifying or abstracting, embodying or disembodying actors.

For instance, on the freeway the other day, I slowed down because there was a guy in a yellow suit and a red helmet waving a red flag. Well, the guy's moves were so regular and he was located so dangerously and had such a pale although smiling face that, when I passed by, I recognized it to be a machine (it failed the Turing test, a cognitivist would say). Not only was the red flag delegated, not only was the arm waving the flag also delegated, but the body appearance was also added to the machine. We engineers could move much further in the direction of figuration, although at a cost; we could have given him/her (careful here, no sexual discrimination of robots) electronic eyes to wave only when there is a car approaching or regulated the movement so that it is faster when cars do not obey. Also we could have added—why not?—a furious stare or a recognizable face like a mask of President Reagan, which would have certainly slowed drivers down very efficiently. But we could also have moved the other way, to a *less* figurative delegation; the flag by itself could have done the job. And why a flag? Why not simply a sign: "work in progress"? And why a sign at all? Drivers, if they are circumspect, disciplined, and watchful will see for themselves that there is work in progress and will slow down.

The *enunciator* (a general word for the author of a text or for the mechanics who devised the machine) is free to place or not a representation of himself or herself in the script (texts or machines). The engineer may delegate or not in the flag-mover a shape that is similar to him/herself. This is exactly the same operation as the one I did in pretending that the author of this article was a hardcore technologist from Colombus, Ohio. If I say "we, the technologists," I propose a picture of the author-of-the-text which has only a vague relation with the author-in-the-flesh, in the same way as the engineer delegates in his flag-mover a picture of him that bears little resemblance to him/her.[2] But it would have been perfectly possible for me and for the mechanics to position no figurated character at all as the author *in* the scripts *of* our scripts (in semiotic parlance there would be no narrator). I would just have had to say things like "recent developments in sociology of science have shown that" instead of "I," and the mechanics would simply have had to take out the dummy worker and replace it by cranks and pullies.

Appealing to Gods

Here comes the most interesting and saddest lesson of the note posted on the door: people are not circumspect, disciplined, and watchful, especially not Walla Walla drivers after the happy-hour on Friday night. Well, that's exactly the point that the note made: "The groom is on strike, *for God's sake,* keep the door closed." In our societies, they are two systems of appeal: nonhuman and super-human, that is machines and gods. This note indicates how desperate its frozen and anonymous authors were (I have never been able to trace them back and to honor them as they deserved). They first relied on the inner morality and common sense of humans. This failed; the door was always left open. Then they appealed to what we technologists consider the supreme court of appeal, that is, to a nonhuman who regularly and conveniently does the job in place of unfaithful humans. To our shame, we must confess that it also failed after a while. The door was again always left open. How poignant their line of thought is! They moved up and backward to the oldest and firmest court of appeal there is, there was, and ever will be. If human and nonhuman have failed, certainly God will not deceive them.

2. The author-in-the text is Jim Johnson, technologist in Columbus, Ohio, who went to Walla Walla University, whereas the author-in-the-flesh is Bruno Latour, sociologist, from Paris, France, who never went to Columbus nor to Walla Walla University. The distance between the two is great but similar to that between Steven Jobs, the inventor of Macintosh, and the figurative nonhuman character who/which says "welcome to Macintosh" when you switch on your computer. The reason for this use of pseudonym was the opinion of the editors that no American sociologist is willing to read things that refer to specific places and times which are not American. Thus I inscribed in my text American scenes so as to decrease the gap between the prescribed reader and the pre-inscribed one. (*Editors' Note:* Since we believed these locations to be unimportant to Bruno Latour's argument, we urged him to remove specific place references that might have been unfamiliar to U.S. readers and thus possibly distracting. His solution seems to have proven our point. Correspondence to the author-in-the-flesh should go to Centre de Sociologie de l'Innovation, Ecole Nationale Supérieure des Mines, 62 boulevard Saint-Michel, 75006 Paris, France.)

I am ashamed to say that, when I crossed the hallway this fatal February day, the door *was* open. Do not accuse God, though, because the note did not appeal directly to Him (I know I should have added "Her" for affirmative action reasons, but I wonder how theologians would react). God is not accessible without mediators. The anonymous authors knew their catechisms well, so instead of asking for a direct miracle (God Him/Herself holding the door firmly closed or doing so through the mediation of an angel, as has happened in several occasions, for instance when Paul was delivered from his prison), they appeal to the respect for God in human hearts. This was their mistake. In our secular times, this is no longer enough.

Nowadays nothing seems to do the job of disciplining men and women and forcing them simply to close doors in cold weather. It is a similar despair that pushed the road engineer to add a Golem to the red flag to force drivers to beware—although the only way to slow drivers is still a good traffic-jam. You seem to always need more and more of these figurated delegates aligned in rows. It is the same with delegates as with drugs; you start with soft ones and end by shooting up. There is an inflation for delegated characters too. After a while they weaken. In the old days it might have been enough just to have a door for people to know how to close it. But then, the embodied skills somehow disappeared; people had to be reminded of their training. Still, the simple inscription "keep the door closed" might have been sufficient in the good old days. But you know people; they no longer pay attention to such notices and need to be reminded by stronger devices. It is then that you install automatic grooms, since electric shocks are not as acceptable for men as for cows. In the old times, when quality was still good, it might have been enough just to oil it from time to time, but nowadays even automatisms go on strike.

It is not, however, that the movement is always from softer to harder devices, that is, from an autonomous body of knowledge to force through the intermediary situation of worded injunctions, as the Walla Walla door would suggest. It also goes the other way. Although the deskilling thesis appears to be the general case (always go from intra-somatic to extra-somatic skills; never rely on undisciplined men, but always on safe delegated nonhumans), this is far from true. For instance, red lights are usually respected, at least when they are sophisticated enough to integrate traffic flows through sensors. The delegated policemen standing there day and night is respected even though it has no whistles, gloved hands, and body to enforce this respect. Imagined collisions with the other cars or with the absent policemen are enough to keep drivers and cars in check. The thought experiment "what would happen if the delegated character was not there," is the same as the one I recommended above to size up its function. The same incorporation from written injunction to body skills is at work with car user manuals. No one, I guess, will cast more than a cursory glance at the manual before igniting the engine. There is a large body of skills that we have now so well embodied or incorporated that the mediations of the written instructions are useless. From extra-somatic they have become intra-somatic. Incorporation in human or in nonhuman bodies is also left to the authors/engineers.

Offering a Coherent Vocabulary

It is because humans, nonhumans, and even angels are never sufficient in themselves and because there is no one direction going from one type of delegation to the other, that it is so useless to impose a priori divisions between which skills are human and which ones are not human, which characters are personified and which remain abstract, which delegation is forbidden and which is permissible, which type of delegation is stronger or more durable than the other. In place of these many cumbersome distinctions why not take up a few simple descriptive tools?

Following Madeleine Akrich's lead, we will speak only in terms of *scripts* or scenes or scenarios played by human or nonhuman actors, which may be either figurative or non-figurative. Humans are not necessarily figurative; for instance you are not allowed to take the highway policeman as an individual chum. He/she is the representative of authority, and if he/she is really dumb, he/she will reject any individualizing efforts from you, like smiles, jokes, bribes, or fits of anger. He/she will fully play the administrative *machinery.*

Following Akrich, I will call the retrieval of the script from the situation *description.* These descriptions are always in words and appear very much like semiotic commentaries on a text or like a programming language. They define actors, endow them with competences and make them do things, and evaluate the sanction of these actions very much like the narrative program of semioticians.

Although most of the scripts are in practice silent either because they are intra- or extra-somatic, the written descriptions are not an artifact of the analyst (technologist, sociologist, or semiotician) because there exist many states of affairs in which they are *explicitly* uttered. The gradient going from intra-somatic to extra-somatic skills through discourse is never fully stabilized and allows many entries revealing the process of translation. I have already listed several entries: user manuals, instruction, demonstration or drilling situations (in this case a human or a speech-synthesizer speaks out the user manual), practical thought experiments ("what would happen if instead of the red light a policemen were there"). To this should be added the innovator's workshop where most of the objects to be devised are still at the stage of projects committed to paper ("if we had a device doing this and that, we could then do this and that"); market analysis in which consumers are confronted with the new device; and, naturally, the training situation studied by anthropologists where people faced with a foreign device talk to themselves while trying out various combinations ("what will happen if I attach this lead here to the mains?"). The analyst has to capture these situations in order to write down the scripts. The analyst makes a thought experiment by comparing presence/absence tables and collating all the actions done by actants: if I take this one away, this and that other action will be modified.

I will call the translation of any script from one repertoire to a more durable one *transcription* or *inscription* or encoding. Translation does not have here only its linguistic meaning but also the religious one, "translation of the remains of St Christel," and the artistic one, "translating the feelings of Calder into bronze." This definition does not imply that the direction always goes from soft bodies to hard machines, but simply that it goes from a provisional less reliable one to a longer-lasting, more faithful one. For instance, the embodiment in cultural tradition of the user manual of a car is a transcription, but so is the replacement of a policeman by a traffic-light. One goes from machines to bodies, whereas the other goes the other way. Specialists of robotics have very much abandoned the pipe dream of total automation; they learned the hard way that many skills are better delegated to humans than to nonhumans, whereas others may be moved away from incompetent humans.

I will call *prescription* whatever a scene presupposes from its *transcribed* actors and authors (this is very much like "role expectation" in sociology, except that it may be inscribed or encoded in the machine). For instance, a Renaissance Italian painting is designed to be viewed from a specific angle of view prescribed by the vanishing lines, exactly like a traffic light expects that its users will watch it from the street and not sideways. In the same way as they presuppose a user, traffic lights presuppose that there is someone who has regulated the lights so that they have a regular rhythm. When the mechanism is stuck it is very amusing to see how long it takes drivers before deciding that the traffic light is no longer mastered by a reliable author. "User input" in programming language is another very telling example of this inscription in the automatism of a living character whose behavior is both free and predetermined.

This inscription of author and users in the scene is very much the same as that of a text. I already showed how the author of this article was ascribed (wrongly) to be a technologist in

Ohio. It is the same for the reader. I have many times used "you" and even "you sociologists." If you remember well, I even ordered you to draw up a table (or advised you to do so). I also asked your permission to go on with the story. In doing so, I built up an *inscribed reader* to whom I prescribed qualities and behavior as surely as the traffic light or the painting prepared a position for those looking at them. Did you *subscribe* to this definition of yourself? Or worse, is there any one at all to read this text and occupy the position prepared for the reader? This question is a source of constant difficulties for those who do not grasp the basics of semiotics. Nothing in a given scene can prevent the inscribed user or reader from behaving differently from what was expected (nothing, that is, until the next paragraph). The reader-in-the-flesh may totally ignore my definition of him or her. The user of the traffic light may well cross on the red. Even visitors to the department of sociology may never show up because Walla Walla is too far away, *in spite of* the fact that their behavior and trajectory have been perfectly anticipated by the groom. As for the computer user input, the cursor might flash for ever without the user being there or knowing what to do. There might be an enormous gap between the prescribed user and the user-in-the-flesh, a difference as big as the one between the "I" of a novel and the novelist. It is exactly this difference that so much upset the authors of the anonymous appeal posted on the door. It is because they could not discipline people with words, notes, and grooms, that they had to appeal to God. On another occasion, however, the gap between the two may be nil: the prescribed user is so well anticipated, so carefully nested inside the scenes, so exactly dovetailed, that it does what is expected. To stay within the same etymological root, I would be tempted to call the way actors (human or nonhuman) tend to extirpate themselves from the prescribed behavior *des-inscription* and the way they accept or happily acquiesce to their lot *subscription.*

The problem with scenes is that they are usually well prepared for anticipating users or readers who are at close quarter. For instance, the groom is quite good in its anticipation that people will push the door open and give it the energy to reclose it. It is very bad at doing anything to help people arrive there. After fifty centimeters, it is helpless and cannot act, for example, to bring people to Washington state. Still, no scene is prepared without a preconceived idea of what sort of actors will come to occupy the prescribed positions. This is why I said that, although *you* were free not to go on with this paper, *you* were only "relatively" so. Why? Because I know you are hard-working, serious American sociologists, reading a serious issue of *Social Problems* on sociology of science and technology. So, I can safely bet that I have a good chance of having you read the paper thoroughly! So my injunction "read the paper up to the end, you sociologist" is not very risky. I will call *pre-inscription* all the work that has to be done upstream of the scene and all the things assimilated by an actor (human or nonhuman) before coming to the scene as a user or as an author. For instance, how to drive a car is basically pre-inscribed in any (western) youth years before he or she comes to passing the driving licence test; hydraulic pistons were also pre-inscribed for slowly giving back the energy gathered years before innovators brought them to bear on automated grooms. Engineers can bet on this pre-determination when they draw up their prescriptions. This is what Gerson and his colleagues call "articulation work" (Fujimura, 1987). A lovely example of efforts at pre-inscription is provided by Orson Welles in *Citizen Kane* , where the hero not only bought a theater for his singing wife to be applauded in, but also bought the journals that were to do the reviews, bought off the art critics themselves, and paid the audience to show up—all to no avail, since the wife eventually quit. Humans and nonhumans are very, very undisciplined no matter what you do and how many predeterminations you are able to control upstream of the action.

Drawing a side-conclusion in passing, we can call *sociologism* the claim that, given the competence and pre-inscription of human users and authors, you can read out the scripts nonhuman actors have to play; and *technologism* the symmetric claim that, given the competence and pre-inscription of the nonhuman actors, you can easily read out and deduce the behavior prescribed to authors and users. From now on, these two absurdities will, I hope, disappear from the scene, since the actors at any point may be human or nonhuman and since the displacement (or translation, or transcription) makes the easy reading-out of one repertoire into the next impossible. The bizarre idea that society might be made up of human relations is a mirror image of the other no less bizarre idea that techniques might be made up of nonhuman relations. We deal with characters, delegates, representatives, or, more nicely, lieutenants (from the French "lieu" "tenant," i.e., holding the place of, for, someone else); some figurative, others nonfigurative; some human, others nonhuman; some competent, others incompetent. You want to cut through this rich diversity of delegates and artificially create two heaps of refuse: "society" on one side and "technology" on the other? That's your privilege, but I have a less messy task in mind.

A scene, a text, an automatism can do a lot of things to their prescribed users at close range, but most of the effect finally ascribed to them depends on a range of other set-ups being aligned. For instance, the groom closes the door only if there are people reaching the Sociology Department of Walla Walla. These people arrive in front of the door only if they have found maps and only if there are roads leading to it; and, of course, people will start bothering about reading the maps, getting to Washington state and pushing the door open only if they are convinced that the department is worth visiting. I will call this *gradient* of aligned set-ups that endow actors with the pre-inscribed competences to find its users a *chreod* (a "necessary path" in the biologist Waddington's Greek): people effortlessly flow through the door, and the groom, hundreds of times a day, recloses the door—when it is not stuck. The result of such an alignment of set-ups is to decrease the number of occasions in which words are used; most of the actions become silent, familiar, incorporated (in human or in nonhuman bodies)—making the analyst's job so much harder. Even the classic debates about freedom, determination, predetermination, brute force, or efficient will— debates which are the twentieth century version of seventeenth century discussions on grace—will be slowly eroded away. (Since *you* have reached this point, it means I was right in saying earlier that you were not at all free to stop reading the paper. Positioning myself cleverly along a chreod, and adding a few other tricks of my own, I led you *here* . . . or did I? Maybe you skipped most of it; maybe you did not understand a word of it, oh you undisciplined American sociologist readers!)

There is one loose end in my story: why did the little (automatic) rat go on strike? The answer to this is the same as for the question earlier of why few people show up in Walla Walla. It is not because a piece of behavior is prescribed by an inscription that the predetermined characters will show up on time and do the job expected of them. This is true of humans, but it is truer of nonhumans. In this case the hydraulic piston did its job, but not the spring that collaborated with it. Any of the words above may be used to describe a set-up at any level and not only at the simple one I chose for the sake of clarity. It does not have to be limited to the case where a human deals with a series of nonhuman delegates; it can also be true of relations among nonhumans. In other words, when we get into a more complicated lash-up than the groom, we do not have to stop doing sociology; we go on studying "role expectation," behavior, social relations. The non-figurative character of the actors should not intimidate us.

The Lieutenants of Our Societies

I used the story of the door-closer to make a nonhuman delegate familiar to the ears and eyes of sociologists. I also used reflexively the semiotic of a story to explain the relations between inscription, prescription, pre-inscription, and chreods. There is, however, a crucial difference between texts and machines that I have to point out. Machines are lieutenants;

they hold the places and the roles delegated to them, but this way of shifting is very different from other types (Latour, 1988b).

In story-telling, one calls *shifting out* any displacement of a character either to another space or to another time or to another character. If I tell you "Millikan entered the aula," I translate the present setting—you and me—and shift it to another space, another time, and to other characters (Millikan and his audience). "I," the enunciator, may decide to appear or to disappear or to be represented by a narrator who tells the story ("that day, I was sitting on the upper row of the aula"); "I" may also decide to position you and any reader inside the story ("had you been there, you would have been convinced by Millikan's experiments"). There is no limit to the number of shiftings out a story may be built with. For instance, "I" may well stage a dialogue inside the aula between two characters who are telling a story about what happened at the Academy of Science in Washington, DC. In that case, the aula is the place *from which* narrators shift out to tell a story about the Academy, and they may or may not *shift back in* the aula to resume the first story about Millikan. "I" may also *shift in* the entire series of nested stories to close mine and come back to the situation I started from: you and me. All these displacements are well-known in literature departments and make up the craft of talented writers.

No matter how clever and crafty are our novelists, they are no match for engineers. Engineers constantly shift out characters in other spaces and other times, devise positions for human and nonhuman users, break down competences that they then redistribute to many different actants, build complicate narrative programs and sub-programs that are evaluated and judged. Unfortunately, there are many more literary critiques than there are technologists and the subtle beauties of techno-social imbroglios escape the attention of the literate public. One of the reasons for this lack of concern may be the peculiar nature of the shifting-out that generates machines and devices. Instead of sending the listener of a story into another world, the technical shifting-out inscribes the words into another matter. Instead of allowing the reader of the story to be at the same time away (in the story's frame of reference) and here (in his armchair), the technical shifting-out forces him to chose between frames of reference. Instead of allowing enunciators and enunciatees a sort of simultaneous presence and communion with other actors, technics allow both of them to ignore the delegated actors and to walk away without even feeling their presence.[3]

To understand this difference in the two directions of shifting out, let us venture out once more onto a Columbus freeway. For the umpteenth time I have screamed to Robin, "don't sit on the middle of the rear seat; if I brake too hard, you're dead." In an auto shop further along the freeway I come across a device *made for* tired-and-angry-parents-driving-cars-with-kids-between-two-and-five (that is too old for a baby seat and not old enough for a seat belt) and-from-small-families (that is without other persons to hold them safely) and-having-cars-with-two-separated-front-seats-and-head-rests. It is a small market but nicely analyzed by these Japanese fellows and, given the price, it surely pays off handsomely. This description of myself and the small category into which I am happy to *subscribe* is *transcribed* in the device—a steel bar with strong attachments to the head rests—and in the advertisement on the outside of the box. It is also *pre-inscribed* in about the only place where I could have realized that I needed it, the freeway. Making a short story already too long, I no longer scream at Robin and I no longer try to foolishly stop him with my extended right arm: he firmly holds the bar that protects him—or so I believe—against my braking. I have delegated the continuous injunction of my voice and extension of my right arm (with diminishing results as we know from Feschner's law) to a reinforced, padded, steel bar. Of course, I had to make two detours: one to my wallet, the second to my tool box. Thirty bucks and five minutes later I had fixed

3. To the shame of our trade, it is an art historian, Michael Baxandall (1985), who offers the most precise description of a technical artifact (a Scottish Iron Bridge) and who shows in most detail the basic distinctions between delegated actors which remain silent (black-boxed) and the rich series of mediators who remain *present* in a work of art.

the device (after making sense of the instructions encoded with Japanese ideograms). The detour plus the translation of words and extended arm to steel is a shifting out to be sure, but not of the same type as that of a story. The steel bar has now taken over my competence as far as keeping my son at arms length is concerned.

If, in our societies, there are thousands of such lieutenants to which we have delegated competences, it means that what defines our social relations is, for the most part, prescribed back to us by nonhumans. Knowledge, morality, craft, force, sociability are not properties of humans but of humans *accompanied by* their retinue of delegated characters. Since each of those delegates ties together part of our social world, it means that studying social relations without the nonhumans is impossible (Latour, 1988a) or adapted only to complex primate societies like those of baboons (Strum and Latour, 1987). One of the tasks of sociology is to do for the masses of nonhumans that make up our modern societies what it did so well for the masses of ordinary and despised humans that make up our society. To the people and ordinary folks should now be added the lively, fascinating, and honorable ordinary mechanism. If the concepts, habits, and preferred fields of sociologists have to be modified a bit to accommodate these new masses, it is small price to pay.

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HOW TO WRITE '*THE PRINCE*' FOR MACHINES AS WELL AS FOR MACHINATIONS

Bruno Latour
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Expanding *The Prince* to redefine democracy

Machiavelli, a republican at heart, established the foundations of democracy in his ***Discourses on the First Decade of Livy.*** In spite of this he is often taken as a dangerous and amoral cynic because he wrote ***The Prince***. In practice, however, the two works are one and the same: if democracy is to be stable the harsh realities of power have to be understood. For Machiavelli the duplicity does not come from his own analysis or even from the hearts of the princes he is analysing, but from the historians who distinguish virtues and evils in an arbitrary way. For instance Hannibal was able to maintain united an army made up of many races and nations: "For this, his inhuman cruelty was wholly responsible. It was this, along with his countless other qualities, which made him feared and respected by his soldiers. If it had not been for his cruelty, his other qualities would not have been enough. The historians, having given little thought on this, on the one hand admire what Hannibal achieved, and on the other condemn what made his achievements possible" (p.97). In his book Machiavelli offers a set of rules which go beyond the distinction between good and evil made by moralists, citizens or historians. These rules can all be deduced from this paramount one: how to maintain power for a little longer in spite of ennemies and adverse fortunes. Once this rule is clearly understood what appeared until then as bizarre or shocking exceptions are considered as different tactics or strategies to achieve one single goal. For example acting virtuously should be neither the rule nor the exception but one possibility among others: “The fact is that a man who wants to act virtuously in every way necessarily comes to grief among so many who are not virtuous. Therefore if a prince wants to maintain his rule he must learn not to be virtuous, and to make use of this or not according to need” (p.91). Although this sentence did a lot to harm Machiavelli's reputation it is, from his point of view, the only way to increase the chances of morality and not an easy way out of it. His books aims at offering a position in which the margins of negotiations of the virtuous democrats is at least as great as that of the blood-thirsty tyrants. If you want to be virtuous, he says to all republicans, you need much more than your self-righteous sense of morality, you need many more allies, many of whom will betray you. Instead of contenting yourself with ethics, enlist allies, fight ennemies and beware of all.

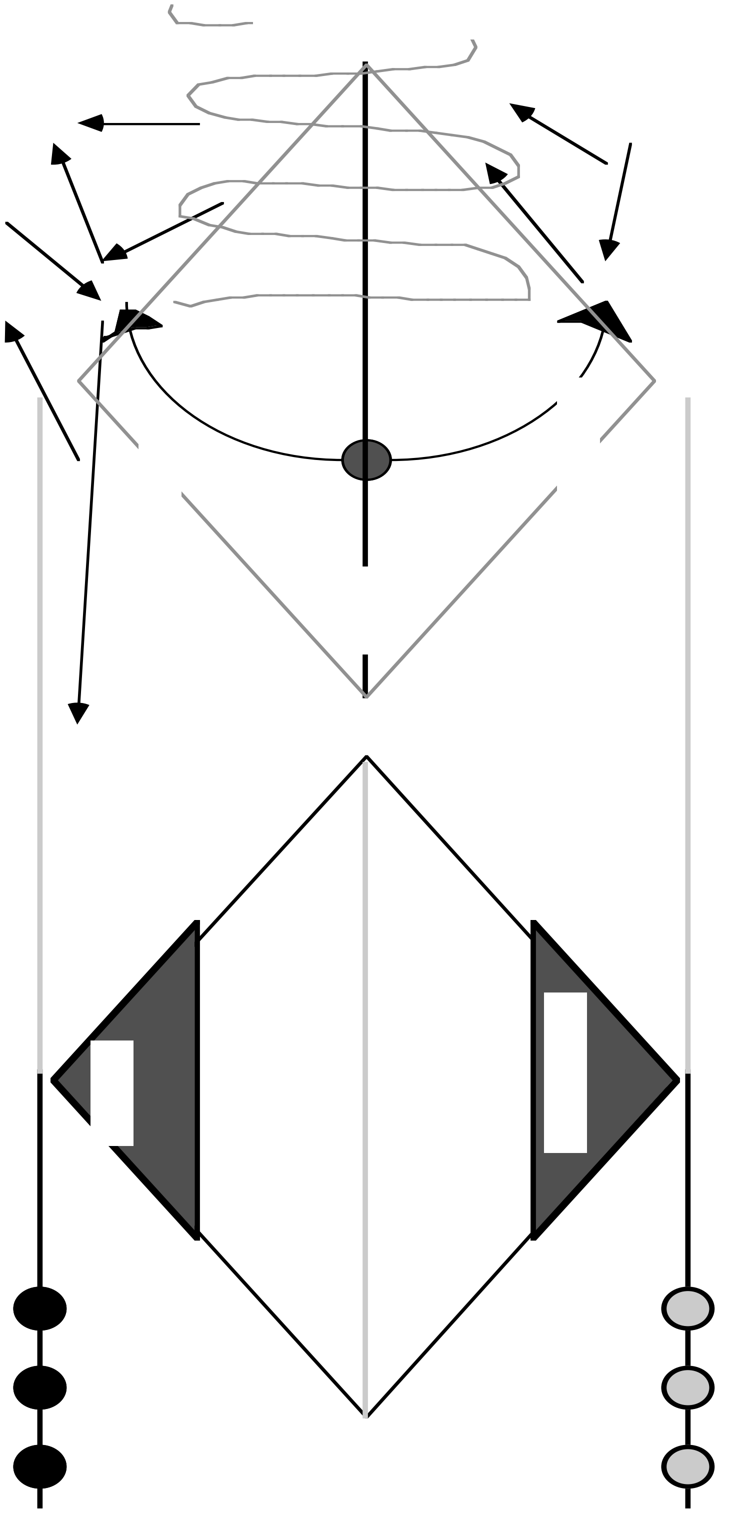
For all its cunning, passion and generosity, Machiavelli could not anticipate the duplicity of today's Princes nor could he anticipate the pusillanimity and self-righteousness of today's democrats. The machinations he described are based on passions and manipulations of other men. The only non-human allies that he explicitely adds to the *combinazione* are fortresses and weapons, the former because they slow down the taking over by enemies, the second because “there is simply no comparison between a man who is armed and one who is not” (p.88). Apart from these —not to mention supernatural allies that he ironically sets aside- Machiavelli builds his plots by keeping men in check through the handling of other men who are in turn kept in line by other men. Thus his world is a social one. To constantly repair the decaying social order, social forces are, if not the only, at least the main resources.

This is no longer the case today and this is why Machiavelli's world, no matter how troubled and bloody, appears to us, by contrast, a fresh and easy one to understand, and why his astute stratagems seem to us disarmingly naive compared to those we have to entangle today. The duplicity we have to understand is no longer in Princes and Popes that break their word, but in the simultaneous appeal to human and non-human allies. To the age-old passions, treacheries and stupidity of men or women, we have to add the obstinacy, the cunning, the strength of electrons, microbes, atoms, computers, missiles. Duplicity indeed, since the Princes always have two irons in the fire: one to act on human allies, the other to act on non-human allies. In brief, threatened democrats who had to fight for centuries against machinations, have now, in addition, to find their way through machines. This paper explores the ways in which ***The Prince*** might be expanded so as to describe at once machines and machinations, techniques and society.

Technology and society are two artefacts due to analysts' duplicity

As in Machiavelli's time the duplicity is first of all in the analysts' own interpretations. Instead of following at once the Prince weaving his way through human and non-human allies, they transform this disorderly crowd into two homogeous sets: one is made by pairing humans with humans; the other by lumping together all the non-human elements of the strategies they have to explain. The South African apartheid system is less unnatural than this segregation that implies a policy of separated development for social ties on the one hand and for techniques on the other. It is impossible to grasp the modern forms of power if we do not first understand that what is called 'society' and what is (wrongly [1]) called 'technology' are two artefacts created simultaneously and symetrically by analysts who have too narrow a definition of power to track down the powerful. This transformation of the Prince's cunning into two parallel lines that never intersect each other has as much meaning as separating Hannibal's prowess from Hannibal's cruelty, or preparing a battle by putting at one end of the field all the paraphernalia and, at the other end, all the naked men. It is as if Thomas Hughes (1979) in his exemplary study of Edison had put on one line all the technical elements (lamps, power stations, transformers...) and on the other all the social ones (organisation, finance, public relations...), and had later tried to establish some connections between the two sets! If the history of Hannibal is made obscure by historians' moralism, what should be said of the history of the socio-technical imbroglios that we often have to read?

The first thing that should be done in order to expand ***The Prince*** and render history less opaque is to get rid of these twin artefacts, society and technique. To do so we simply have to place ourselves in the new Princes' own position. This is what Machiavelli did, thus transcending the narrow definition of ethics of his predecessors, and this is what the best contemporary analysts of socio-technics have done [2]. If it were possible to summarize the few field studies we possess in one single diagram I will offer this one:



Each of these case studies shifts the attention away from the two artefacts of society and technique (left part of the diagram) and leads us to a socio-technical position in which we see the innovators, or entrepreneurs, appealing from one set of alliances with human actors to another set of alliances with non-human actors, thus increasing the heterogeneity of the mixture at each turn of the negotiation (right part of the diagram). As Gilfillan wrote in his peculiar style: "men compete with men today not by teeth but by tools, not by thews but by thots" (1935/1963) (p.19). This is what John Law aptly called 'heterogeneous engineering' (1986) or what, in a similar context, Thomas Hughes named 'the seamless web' (1979; this volume). The duplicity is to be seen in the joint negotiation between heterogeneous allies —middle line of the right diagram—, no longer in the segregated development of two estranged communities —top and bottom line of the left diagram. The analyst who draws the lessons from these case studies, instead of being quartered in between technics and society, is now as free as the actors he or she is observing (Callon:1986). Needless to say, this new position is **not** a happy-medium that would carefully balance social aspects with technical ones, no more than Machiavelli's Prince is half honest and half devious. It is a strategical position that makes all the ethical, social and technical definitions subservient to a new goal —that will be defined below.

It is interesting to see that the main result of sociological or historical field studies is also the main thrust of economical and managerial enquiries such as the SAPPHO project aptly summarized by Christopher Freeman (1982). "The single measure which discriminated most clearly between success and failure was 'user-needs understood'. This should not be interpreted as simply, or even mainly, an indicator of efficient market research. It reflects just as much on R & D and design as well as on the management of innovation. The product or process had to be designed, developped and freed of bugs to meet the specific requirements of the future users, so that 'understanding' of the market had to be present at a very early stage" (p.124). This result is confirmed by the studies of innovation we have done (Callon and Latour:1986; Coutouzis:1984; Coutouzis and Latour: 1986) but also by a more managerial litterature (Peters and Austin: 1985). It is not underrating the quality of these studies to say that they are not really surprising from a Machiavellian point of view. This 'Sapphic wisdom' simply stresses that, in a war, the one who wins is the one who relates the soldiers, the weapons, and the logistics to winning over a specific enemy on a specific ground. It is the opposite that would indeed be a surprise ! To take a more pacific example, it is as if someone marvelled at the discovery that to play well at ***Scrabble*** the same player should at once inspect the changing structure of the board and try out all the combinations of the letters he or she had drawn. Such is the sorry state of our sociology and of our technology that we find these sociological or management studies new and important.

A machine is indeed a machination, but on more than one front

Now that we have rid ourselves of this excess of duplicity <u>added</u> by the flattering analysts of the past to the Prince's cunning, we have to understand this cunning itself. The first question to raise, if we wish to follow our Machiavellian model, is in what sort of fights the Prince is engaged that requires him to appeal to human and non-human allies.

Marx offered an answer to this question which has been so influential that it first stimulated and later stifled analysis of socio-technics. He placed the Prince —renamed capitalist— in a class struggle so that whenever a machine or a mechanism was introduced in the production process, it was to displace, replace, unskill, humiliate and discipline the workers: that is to break their resistance. The tactical rules were simple: if your workers bother you, appeal to machine-makers; if they strike or are undisciplined replace ties among workers by ties among parts of one mechanism (Mac Kenzie: 1984). In this Braverman's new world (1974) each machine is a machination against the workers, and Ludism is, whatever its forms, a resistance to this ploy (the intellectual counterpart of it being what I would be tempted to call 'Elludism').

The main difficulty of this position has been very nicely pointed out by Donald MacKenzie (1984). Whenever the introduction of a machine does <u>not</u> attack the workers, many Marxists are left speechless and start talking about technical factors and other determinisms. When a machine does deskill textile workers they know what to say; when companies create new highly skilled workers they see this as a puzzling exception, or even, in MacKenzie's terms as an "obverse trend". For a century the exceptions have proliferated, but Marxists have moved only reluctantly from this tenet that the only way to prove that 'technology is socially shaped' —their words— is by showing the class struggle at work. The idea rarely dawns on them that a Prince might have more than two enemies —the workers and the other Princes— and that, struggling on many fronts at once, he might from time to time need highly skilled and independent-minded collaborators to resist, for instance, other Princes. Moralist historians praise Hannibal's prowess but deplore his cruelty; Marxists deplore capitalists' cruelty and have nothing but praise for technics that increases the workers' skills. Same contradiction in both cases. They suppose one single division (good/evil; capitalists/workers) when there exist many among which the Prince chooses according to his one overriding goal. Perceptive when the capitalists' main struggle was to discipline 19th century peasants or craftsmen, Marxists are today almost always on the wrong foot. When there is no obvious class struggle to explain technology they either have to invent a devious one, so devious that it is hidden to everyone but themselves, or, worse, they have to admit that some aspects of technology may be 'neutral' or even 'good' after all.

It would be as absurd to say that the class-struggle no longer counts as to say that Machiavellian's Princes are always perverse. What we have to understand is how many struggles the Prince is engaged in, so that, according to need, he sometimes exploits, sometimes rewards, sometimes lies, sometimes tells the truth, sometimes skills, sometimes deskills. How many fronts are to be added to the class-front to have the beginning of an idea of how subtle the Prince's stratagems have to be? Let me list the most obvious.

The struggle inside the palace with his own collaborators, advisors, departments, is far from the least important as has been documented by Machiavelli in his study of the 'Nobles' and by modern sociologists of organizations. Many technics —especially softer ones— are devised, borrowed, transformed, to keep collaborators at bay or under control. The struggle is especially fierce when the Prince is not yet in command but has to fight against others who say they are the Prince. The dimension of the Prince should not be assumed beforehand but varies in time from being a whole country to being just one man in the crowd (Callon and Latour: 1981). It is never sure whether the Prince, like Proteus, is an individual, an assembly, a techno-structure, a nation or a collective.

A third front is constantly opened by other Princes. To resist their takeover, many new allies (human and non-human alike) should be fetched and kept in line —and this may necessitate a softening on the home front. The three fronts together (workers, collaborators, peers) already require quite a lot of ingenuity —that is, a lot of 'heterogeneous engineering'.

A fourth one is of paramount importance and is studied by Machiavelli under the name of 'people' or, by modern economists, under the name of 'consumers'. How to convince people to follow the Prince, or consumers to take up the goods? To what extremities is not a Prince led in order to interest, please, seduce, force, capture, or imprison consumers. How unreliable and feckless people are, always shifting from opinion to another, enslaved by fashion and passion. To keep them well aligned, one needs constantly renewed and fresher resources. The four fronts together (workers, collaborators, peers, consumers) already require the proliferation of socio-technical innovations and especially of this new Leviathan, the giant corporation, so masterly described by Chandler (1977).

A fifth one is as important and too much overlooked. Machiavelli touched on it briefly when he talks of fortifications and weaponry, but engineers and technologists have documented it at length. How to convince non-human allies to have a bearing on human affairs, to engage in social struggle, to have some relevance for establishing power. How to shape and fetch microbes, electrons, atoms, and to make them play a useful role in keeping men and women in place. How unreliable, feckless, undisciplined they are, always escaping our grasp, shifting from one opinion to another, betraying our expectations. How much confidence should be put in the people who claim to talk in the names of these non-human actors?

Fighting on the five fronts at once necessitates quite a bit of socio-technical ingenuity and creates what Machiavelli could not have anticipated, that is, these 'Networks of Power' beautifully described by Hughes (1983) in which many strongholds to keep people in place are actually made of electricity, copper, meters or even out of thin air. "The bond of love is one which men, wretched creatures that they are, break when it is to their advantage to do so; but fear is strengthened by a dread of punishment which is always effective" (p.96), answers Machiavelli to the question whether it is better to be loved than feared. Clever indeed, but how cleverer it is to bind together men, these wretched creatures that are always ready to break their contracts and go to gas companies or to competitors, by wires, meters, copper, and filament lamps. Instead of a tiny list that includes love and fear, the modern Prince has a long mixed list that includes many other elements in addition to love and fear.

William McNeil (1982) has summarised all the many battlefields together under his key notion of <u>mobilisation</u> of men and resources. Each innovation, whether in organisation, in ship design, in metallurgy, or in communications, is assessed for its contribution to civil or to foreign wars. Commerce is a subset of politics and there is not much difference between commercial wars and other wars except a slight preference, in his terms, for 'market behaviour' over 'command behaviour'. The European Princes he describes, like the Italian ones Machiavelli had portrayed, are all of a similar force. This means that the slight supplement of strength offered by engineers and later by scientists may indeed tip the balance. Each of them, caught between a Beirut of civil wars (cold and hot, commercial and military) and a total (simulated) atomic foreign war, has to innovate to survive for a bit longer. That is, each of them is ready to betray his 'society' and fetch more and more foreign allies to help him out, thus increasing the socio-technical mixture [(3)].

Keeping in mind all the fronts at once and never lumping together the non-human allies is all the more necessary since this is the key to understanding why the technics are sophisticated and the black boxes are black. The more that compromises on wider fronts have to be made, the more human and non-human elements have to be stitched together and the more obscure the mechanisms become. It is not because it escapes 'society' that 'technology' has become complex. The complexity of the socio-technical mixture is <u>proportionate to</u> the number of new ties, bonds and knots, it is designed to hold together. If 'technology' appears to have an inside it is because it has an outside. More exactly, society and technics are two sides of the same Machiavellian ingenuity. This is why, instead of the empty distinction between social ties and technical bonds we prefer to talk of <u>assoc</u>iation. To the twin question "is it social?/ is it technical?" we prefer to ask "is this association stronger or weaker than that one?" (Callon and Latour: 1981; Latour:1986; 1987,a).

There are of course many other fronts, but I have said enough to show how narrow the definition of a 'social shaping of technology' would be if it took into account only the one showdown that confronts a capitalist and his workers. Marx was right, a machine is the occupation of a position –very much like a word in the ***Scrabble*** game. But he was wrong about the number of elements simultaneously held by this position. In addition, let us also include in the picture all the trade offs, truces, shifts of alliances, that the activity of one front renders necessary on the others fronts so that, when the tension eases a bit, we are not immediately led to the conclusion that the war is ended and that no further strategy is implemented. By saying this, I am not trying to innocent the Prince, but simply to give the analyst at least <u>as much</u> intelligence and deviousness as the Prince has.

Conversely, I have said enough to make it clear that simply adding some matter-of-fact technical elements to a sociological or economic discussion does not render full justice to the Machiavellian ploys I wish to describe. Like several others economists, Rosenberg (1982) claims to “open the black box”. This is all very well, but what he does is to offer a clear, uncontroversial and homogeneous description of the technical parts of the innovation he studies. This has no more sense than if Tolstoy had described the battle of Borodino according to the chief-of-staff's plan (1869/1986). The technical part is not made of linear, homogeneous elements that could be used as a quiet backdrop for staging the disorderly pattern of political and management life. It is a controversial mixture that cannot, that should not be described in a matter-of-fact tone. It is precisely when turning towards the non-human elements that the polemical, controversial, stragegic discourse should increase, not decrease. Why? Simply because this is where fresh resources to win over polemics, controversies and battles may be found. If a new Tolstoyan style should be invented, it is for the technical battles (Latour:1984/1987, b). Opening the black box is a good idea, as long as people know that it is <u>Pandora's</u> black box that is at stake... (4)

We have reached a point at which the choice between human and non-human allies in any combination is made by the Prince or by the analyst without any privilege or simplification. Florentine Princes had an easy task compared to those of the new Princes, and in consequence Machiavelli's job was straightforward compared to ours. To grasp this point we have to sum up the Prince's goal in such a way that what appear as exceptions, or contradictions, are now seen as a possible range of alternatives among which the Prince freely chooses. “Keep your word” is obviously not a good rule since a Prince who would follow it would soon disappear, although “lie” is not the rule either. “Deskill your workers” is not the rule since it is sometimes necessary to give them skills. “Be the first to innovate” is not a general principle, since it is often necessary not to innovate first (Rosenberg:1982 pp.104-120). “Be offensive” is not a good advice either in war or in management since, as Freeman rightly points out (1982, p.170), “be defensive” or “be dependent” or “copy” are good alternatives. “Please the consumers” is often less efficient in some (French?)

industries than the opposite advice “do away with consumers”. “Rely on machines” is balanced by the counter-advice “never trust them”.

If I draw a common lesson from ***The Prince*** and from field studies of innovators at work, it is that each Prince needs to recruit others to fulfil his goals but that these others, being by definition feckless and unreliable, have to be kept in line. Either no one helps you out and so no power is granted to you; or they do help you out but then they pursue their own goals, not yours. The more grandiose the Prince's projects are, the more paradoxical his task becomes. The name of the game is thus always to solve this quandary: how to control those that are enrolled? (Latour:1987a, chapter III) Machiavelli was looking for a point of view from which all the contradictory advices given to the Prince will make sense: stay in power a bit longer in spite of the vagaries of fortune. The point I would chose is rather this one: make your environment such that whatever other human or non-human actors think or do, they are either kept at bay or else they help strengthen your position, making the world safer, more predictable and more enjoyable for you. With this very general goal in mind [(5)], chose whatever tactics and strategies that fulfill it.

The elementary stitch in the ‘seamless web’

We are now clear on three points: the Prince is engaged on many fronts at once; it is to hold some of these fronts that non-human elements are brought in, recruited, disciplined and made tractable; simply adding technical details to social elements will tell us nothing about the crucial novelty in the practical ways of achieving power [(6)]: how are human and non-human alliances stitched together? The problem really is to define the elementary stitch of the ‘seamless web’, the movement of the needle, so to speak. Although it is often confused by artificial distinctions, this movement is quite simple: when your advance on one front is stalled, explore new possible allies which would be unexpected enough to tip the balance of forces; bring them together so that they act as one single force; make them have a bearing on the struggle at hand (Latour 1987, a). For reasons that are not clear to me, some analysts tend to call ‘science’ the first movement, ‘technology’ the second, ‘economics’ the third, and make every effort to clearly sever them from one another or to attribute the medal of honor to one of them. In practice, however, the Prince —individual, collective, bureaucratic, or collegial— has simultaenously to define all the allies and all the enemies at once. As Mowery and Rosenberg (1979, reprinted in Rosenberg: 1982) have shown, it is as hard to decide what the consumers want, what the state of the art is, what nature may provide.

Hoddeson's beautiful study (1981) of the recruitment of Millikan's electrons by the Bell company should be enough to show that the needle can sew only if it does the three movements at one go: inventing consumers and markets, reshaping physics, creating technics. Yes, the electrons are an unexpected ally that could allow the Bell C° to get rid of the old mechanical repeaters and thus stretch its telephone line through the American continent. No, the electrons are not enough because, in Millikan's laboratory, they are undisciplined, untractable, useless as such, 'abstract' or 'analytical' as Simondon would have said (1969). Brought together in the new electronic repeater inside one of the first basic science industrial laboratories, they start to be tractable and disciplined, 'concrete' or 'organic' in Simondon's terms; they start to be a black box, a piece of equipment. But still, this is not yet enough. As in every battle, you need not only to know the balance of forces but also how to position them; many other elements are needed to position the electronic repeater in such a way that Alexander Bell can call Mr Watson in San Francisco and say "Hello, Mr Watson, would you come upstairs… ".

This movement that creates the first continental line and stitches together the East and West Coast of the United States, tying the Bell C° to millions of Americans who have to pass through its lines if they want to reach each other and strengthen their familial or business bonds, is it science-based? Technics-based? Economic-based? Is this an instance of market-pull? Or of technical-push? ***The Prince*** will never be expanded nor will we ever understand the fabulous expansion of the new Princes if we keep maintaining these dichotomies. 'Science', 'technology', 'economics' are three different faulty labels applied to only one serious strategical problem: stepping aside, recruiting new allies, drilling them so that they act on command, bringing them into the battle, winning the day -or losing it. As for every strategy, money spent, time passed and labor-force employed are useful <u>indicators</u> of the moves, but they do not provide an explanation of them.

The expression ‘anthropology of science and technique’ has been coined to account for this richly embroidered cloth that weaves together so many foreign elements: stones with laws, Kings with electrons, telephones with love, fear with atoms, stars with laborers. Ethnographers, who are so clever at describing this rich tapestry when studying exotic cultures, are struck by a strange blindness when they happen to turn their eyes towards the modern world and see nothing but two heaps, one made of drab machines and the other of sleek machinations (Latour: 1984/1987,b). As to the moralists, we may let them rest in peace; they believe that man is being dominated by technology !

Two symmetric misinterpretations stifle the development of this new anthropology of science: first a privilege granted to ‘social’ strategies, second a privilege granted to the hardware. Let us first do away with ‘social explanations’. For instance, every time I want to reinforce the bonds with my old mother I also reinforce the Bell C°. Is this because I submit to a show of force from Ma Bell? Not at all. The Bell C° has insinuated themselves in such a way that whatever I do and think, they spread in a painless, quiet and necessary way. They have made themselves an obligatory passage point for everything else. Is it possible to explain Bell's influence by using terms such as ‘power’, ‘force’, ‘domination’ that have been devised by social scientists to describe Machiavellian politicians? No, because the mixture of non-human allies (wires, satellites, electricity, copper, optic fibres) has been woven to get away from the stalled fronts defined by classic political struggles. You can never <u>reduce</u> socio-technical stratagems to social explanations not because they are not stratagems, but because they have been devised to beat down social explanations in the first place ! Social scientists are always a war late, seeing devious political plots <u>behind</u> techniques, when the socio-techniques allow the Prince to add new fresh unexpected ways of redefining power. You expected to watch a show of force; you feel nothing but a violent desire to get in touch with your old mother through the telephone. Love, electronics and management are bound together. It is because the list of power ploys defined by Machiavellian social scientists is <u>shorter</u> than the one of the new Princes that they either have to consider most of science and technology as partially neutral, or else reduce telephones, atom bombs and contraceptive pills to hidden plots they are free to invent. Against every <u>new</u> invention they repeat the <u>same</u> interpretation: it is due to the power of the multinationals, of capitalism, of so and so... They have on the one hand a long heterogeneous list of contrivances to be explained and, on the other, a short homogeneous and repetitive list from which to offer the explanation (7).

But the discussion of the Prince's moves is as much stifled when a privilege is granted to non-human allies as if they were the only and best way to win the day. This is never the case. In a study that is not outmoded because it has the sharpness of an origin myth, Marc Bloch has illustrated this point beautifully (1935, reprinted in MacKenzie and Wajtman, 1985). In the late Middle Ages, the grinding stones, the gears, the wheels and the rivers are good unexpected allies that, once tied together in one mill, makes a formidable stronghold. But their efficiency stops there. A stronghold can be in the middle of a battlefield, thus bearing on the issue of the battle, or away from the battlefield. If each household goes on grinding corn by hand, the Prince, who holds the communal mill, will hold nothing but wood, water and stones. The mill will become a stronghold only if the Prince fetches the militia, enforces the King's ruling, the Church's teachings and compell every household to break their hand-grinders and to pass through the miller's stone. Many industries and even countries have floundered because the solidity of the strongholds they had build reassured them that no strategical analysis was necessary any more. It is not the solidity of the gathered allies that count but the solidarity it offers with other human struggles. It is not the two parallel lines of the first diagram above that tell us anything, but the meandering negotiation of the middle line. The huge iron and steel plants of Lorraine are rusting away, no matter how many elements they tied together, because the world they were supposing to hold has changed. (8) They are much like these beautiful words ***Scrabble*** players love to compose but which they do not know how to place on the board because the shape of the board has been modified by other players.

The same limit could be found in the notion of trajectory through which machines are transformed into biological species endowed with a sort of autonomous life. For instance, is Wernecke's photo camera on the same species line as Eastman's one (Jenkins: 1975)? In a sense yes, since Wernecke's ideas have been seized and copied by Eastman. But why did Eastman seize them? Because he started with a completely different strategy, that of a mass market for amateur photography, and then went back to earlier systems that were yet unpatented. The deep transformation Wernecke's black box underwent in Eastman's hands has nothing to do with biological mutation and selection. It has to do with a new strategy of how to design a camera that becomes indispensable to millions of people. It is only retrospectively, once Eastman has succeeded in capturing and holding a mass market with his deeply different camera, that museum-keepers can align the two artefacts in the same show-case and point out the differences with nice labels and arrows. The hardware is only the shadow projected by the socio-technical plot. Reduced to itself, it is as much a ghost as society.(9)

Because of these two symmetric misinterpretations the information we get on the Prince's moves is rendered incomprehensible. We either get the social relations —meaningless without the non-human allies that keep them in place— or the hardware —meaningless without the strategical positions it occupies. When we read through the literature of social sciences or of the natural ones, our situation is often as absurd as that of a geographer who would get, from navigators sent around the world, either the longitudes or the latitudes of the points he wishes to map but never the two together! In order to map out what ties all of us together we have to invent a projection system that provides both for the information about human and about non-human actors.

The longitude and the latitude of our projection system

The new Princes are free to chose human or non-human resources to weave their ways around the many confrontations they are engaged in. The Prince is like Plato's royal Weaver that he portrays as the ideal statesman. He never stops weaving, but what he weaves together is sometimes soft, sometimes hard, sometimes human, sometimes non-human. His only concern is to decide which tie is weaker and which one stronger in a given encounter. Pusillanimous observers will see either new social ties being redefined, or new technical associations being introduced, and will then marvel at how the two might be related, interconnected, reflected, influenced... If we wish to be a bit more audacious and follow the new Princes as closely as Machiavelli did with the older ones, we should be able to define the woof and the warp of the seamless web.

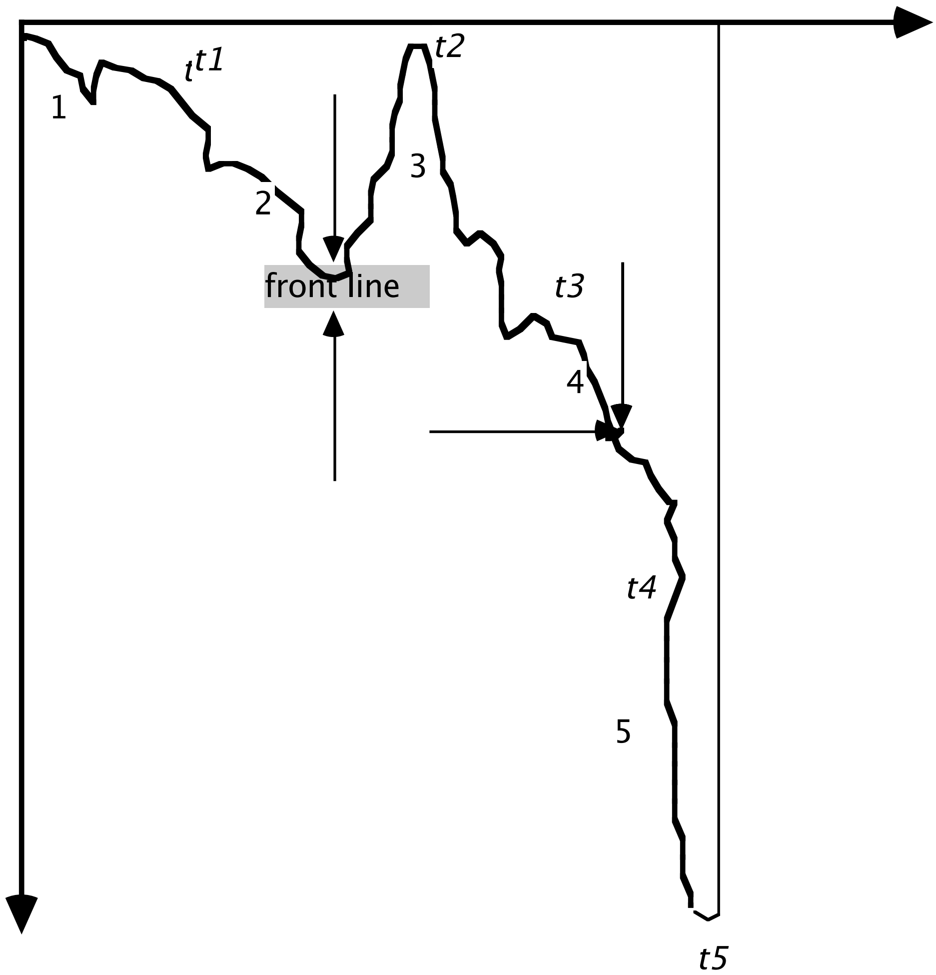
Following the cartographic metaphor, we will define the longitude and the latitude of the projection system, in such a way that every socio-technical imbroglio may be defined by two dimensions:

how many (10)people are convinced and take it as an uncontrovertible black box;

if it is interrupted by people who doubt it and wish to open the box, what sort of transformations has the project to undergo in order to convince more people, that is what sort of fresh non-human allies have to be fetched ?

In the next diagram, I have sketched these two dimensions: the transformation (or translation, or negotiation) on the horizontal line; the success of the enterprise on the vertical one . The life history of a given project is represented by the meandering line. The more it moves toward the right the more it has to depart from the original idea, that is the harder the struggle and the more heated the controversy. The more it moves toward the top, the less people are interested and convinced in the future of the project. The surface behind the meandering line is an approximation of the number of elements tied to the fate of the project. This means that toward the end (5), when many people use the black box as a routine fixture that is no longer transformed, it is also the time when the largest amount of resources and people have been aligned to keep the users in line.

Transformation of the project through negotiations



A few features of this diagram interest me. First, although it overlaps with the usual categories (research, 1; development, 2 to 4; production and sales 5) the project never stops from being a <u>front line</u>, even when it seems that everything has been done and that ‘mere consumers’ are now to be convinced. From the beginning to the end it never stops from being the resultant of a fourfold strategy: whom should I convince? How strong is the resistance of those I choose to convince? What new resources should I enrol? What transformations should the project undergo? Second, time (t1 to t5) is not one of the dimensions of the diagram but one of the <u>consequences</u> of the process of conviction and enrolment. “It takes time” or “it goes fast” depending on the number of people to convince and on the ability of the Prince to negotiate. But a more suggestive feature is that the <u>reality</u> of a project is a variable result of the Prince's strategy. At t2 for instance the degree of reality of the project <u>decreases</u> and approaches zero. The feasability, credibility, absurdity of a project entirely depends on the stitching and knotting made by the strategist. Neither reality nor time (or the state of the art) explain the evolution of a project, they are both dependant variables.

Whatever the future connections between economics of R.&D, micro-sociology of innovations and history of technique, it is already clear that some effort will have to be put into adapting the diagrams, the type of data and probably the mathematics, to these notions of translation, fronts, association, persuasion. This integration probably passes through an understanding of the metrological character of the sciences like accounting, management and economics. Every new stratagem, in order to succeed, has also to define, develop, position and enforce <u>its own ways of assessing itself</u>. Every innovation is considered as risky, difficult to evaluate, expensive, unreliable, not because we do not have good economical or technical tools to assess it, but because it is part of the innovation to redefine the very tools that evaluate how risky, expensive, efficient, reliable it is. In other words, there is an uncertainty principle in this topic that is inherent not to a weakness in our instruments but to the very phenomenon we wish to detect. Either you have an innovation and part of this innovation is in the struggle to set up measurement instruments or to settle responsibility —in this case, you lack precise definitions and the whole business is uncertain; or you do have good figures, reliable statistics, but then they are the final result of a stable, quiet and routinised network —and in this case you are no longer studying an innovation. It is thus a contradiction to approach innovations with stabilised devices in order to evaluate productivity or to attribute responsibility to labor, to capital or to management. The challenge is to adapt our economics and our sociology to the network quality of the Prince's moves (Callon, Law, Rip :1986).

Back to democracy

Now that we are expert at avoiding the twin impression that society or techniques exist, it is possible to understand what makes the new ***Prince*** so very difficult to write and his powers so hard to check. Machiavelli's Principates who had seized power had very few extra-human resources to render their position irreversible. Apart from God —appealed to equally by all—, apart from swords and a few stone walls, the Principates had to rely on ties such as passions, fears, loves and ambitions as soft as the bodies they had to attach. The mega-machine so dear to Mumford's heart was not a machine and this is why his central metaphor is so misleading. No matter how heated the fights, the foreign armies that the Princes go and fetch from outside in order to win are never that foreign. At worst they are made up of mercenaries —that Machiavelli considered as the least reliable allies, that is of humans, who again have to be kept in line by the same soft human bonds. The situation starts to be deeply different when the Principates are ready to step aside, to make a detour, to betray and to bring into the fight allies that are real strangers and do not look at all like men and women. A generalised arms race is going to be triggered, which no Prince can avoid. To the piling of tender human bonds, will be added the piling of harder non-human bonds; to the software race of the past, will be added a hardware race, of which the weapons race is but a particular case, as McNeil has so masterly shown in a book which is obviously the best draft of ***The Prince*** one can find (1982).

One small example will show the consequences of this over-Machiavellism. The radical Paris municipality and the major private railroad companies had fought for two decades when, at the end of the last century, the subway was finally decided upon. But how was it to make sure that the railroad companies would not take over the subway if, by chance, a new right-wing municipality won the election? How can the momentary balance of forces be rendered irreversible? One solution was to use narrower tracks for the subway than for the railways. The military objected on national security grounds. Convinced by this threat in case of national war, but not wanting to abandon their (cold) civil war position, the municipality finally decided to make the subway tunnels smaller than the smaller coaches of the railroad companies (Daumas et al. 19) [(10)]. They shifted their alliance from legal or contractual ones, to stones, earth and concrete. What was easily reversible in 1900 became less and less reversible as the subway network grew. The engineers of the railway company now took these thousands of tunnels built by the subway company as destiny and as an irreversible technical constraint.

This is why the question of the freedom of the engineers and of the people is only relative to the number of non-human ressources weaved in their struggle. Still, they remain free to decide, like Sartrian characters, what will play the role of fate and what willl play the role of freedom. The best proof is that, 70 years later, when the nationalised rail-roads and the nationalised subways decided to interconnect their networks, the engineers were asked to reverse this irreversible situation, at least locally, and to enlarge a few of these tunnels. Here is where the hardware race best manifests itself. What could have been reversed by election 70 years ago, had to be reversed at a higher cost. Each association made by the socialist municipality with earth, concrete and stones had to be unmade, stone after stone, shovel of earth after shovel of earth. Worse, to shake each of these older associations, new, more powerful tools had to be recruited, drilled and positioned into the struggle (bulldozers, explosives, drill-tunnel machines). The megamachine became bigger. People now flow by the million inside the landscape of the new ***RER*** subway network.

But it is the second consequence of the hardware-race that is the more striking. Holding a point is necessary but not sufficient, since it also means remaining in one place. What would be better, would be to keep the strongholds and yet to move elsewhere. Alas, the Prince knows very well that leaving his Palace or his Fortress, entails treachery, betrayal, revolts. How can he move on and nevertheless remain in charge? Politics provides the answer: by delegating powers to others. But delegation to other men would be as unreliable and shaky as the human bonds themselves. Why not delegate some powers to a few non-human actors that would thus be in charge of their fellow non-human actors? Why not invent a sociology and a politics of the things themselves[11]? For instance, policemen at each cross-road are useful to regulate traffic, but then they cannot move elsewhere fulfilling other functions. Replacing their arms and white gloves by traffic lights is one of these ways of being absent and yet remaining present. Drivers and traffic lights will look after themselves. Yes, but drivers are feeble creatures tempted to cross even when the light is red if there is no other car at the intersection. Why not hook up the lights to the wheels of the oncoming cars through an electric impulsion, so that the lights automatically adapt their rythm to the traffic flows? The lights are now checked and triggered by an adaptable supervisor who no longer wears a helmet. An automatism is born that will soon become more complicated and ‘concrete’ or ‘organic’ —in Simondon's sense— because series of traffic lights will be regulated by one computer. Then all the series will be visualised at the Police headquarters on the screen, in front of which is seated a policeman with white gloves. When we go from Machiavellian politics to automatisms, we do not go from sociology to technology, we pursue the same associology with a longer list of bonds and bondages. The story is not that of men and women being replaced by machines. The story is of a complete and continuous redistribution of roles and functions, some of them being held in place by human, other by non-human ties (12).

Inertia and automatism are thus the two main effects of the hardware race. This is where the question of democracy raised by Machiavelli comes in, a question that is the only justification of his amoral picture of the Prince and of our associological description of the new Princes. The two most common clichés about technology, its inertia that would be too strong for anyone to resist, and its inner complexity that would be too much for any one to fathom, are real enough, not as the <u>cause</u> of the Prince's moves, but as the <u>effects</u> that the Prince strives to achieve.

The first principle of technical democracy is thus never to offer this goal to the Prince on a golden plate. Alas, this capitulation is very frequent among well-minded analysts of technology who accept that there are trajectories, inertia, and inner complexities, in brief that technology exists. Another capitulation occurs when analysts of society, no less well-minded than the former, insist that there is something like an overarching society, knowable, at least in principle, that should control and check the development of technology. These two symmetric capitulations paralyse democracy because the only way to envision a modification of a technique is then by appealing to an <u>alternative</u> technology and society (13). If there is a Technology and if there is a Society and if the only way to think possible changes is by imagining an alternative Society, then the Prince is perfectly free in his palace, unhindered, weaving at leisure human and non-human actors, redefining locally, as much as pleases him, what ties all of us together. Observers outside will see nothing but techniques moving, thanks to their own autonomous thrust and a society moving in parallel according to its own autonomous laws. Instead of the harsh constraints of democracy, the Prince will only hear moralists' remonstrances and a few empty talks about the 'participation of the public in technical decisions' —once everything has been decided upon. If science and techniques are politics pursued by other means, then the only way to pursue democracy is to get inside science and techniques, that is, to penetrate where society and science are simultaneously defined through the same stratagems. This is where the new Princes stand. This is where we should stand if the Prince is to be more than a few individuals, if it is to be called 'the People'.

An earlier version of this paper was read at the meeting on Technology and Social Change, organized by the Center for Canadian Studies, Edinburgh, june 1986. I thank Michel Callon, Madeleine Akrich and also the Dutch colleagues met at the "De Borderij" , in Eschende, for many stimulating discussions.

(1) Convincing Anglo-Saxon writers that techno-logy should be used in the same sense as epistemo-logy, that is as the science of techniques, and not as a redundant word for the artefacts themselves is, I know, a lost cause. I will maintain this acceptatnce, however, and when I use technology it will be ironically.

(2) In this paper, I am pilfering the work of Thomas Hughes, Michel Callon, John Law, Mickès Coutouzis, Madeleine Akrich and many others. For three recents reference books, see W. Bijker, T. Hughes and T.Pinch (eds) (1986); J. de Noblet (editor) (1983); D. MacKenzie and Wajtman (1985) and the special issue of the ***Année Sociologique*** edited by B.P. Lécuyer. To this should be added the still useful masterpiece of Gilfillan (1935/1961). See also Elzen (forthcoming).

(3) MacNeil (1982) is probably the clearest writer to formulate -if not solve- the anthropological puzzle: "why Us and not They?". The Great Divide is not to be found in mental, technical or political abilities but along these lines: in which society is it possible for a Prince to appeal to foreign, non-human emigrants and mercenaries and not be considered as mean or outcast? Which society accepts harder facts and harder artefacts as so many ways of pursuing politics on a larger scale? Which society is so Balkanized that a few harder facts and artefacts are able to tip the balance?

(4) The literary constraints on what I could call a good field study of socio-technique is easy to pin down. Every time there are as many versions of the technical aspects as there are actors in the story, it is a good story. Every time there is only one, it is a useless account, even if other chapters add to it the 'social', 'economic' or 'managerial' aspects of the same story.

(5) Phrased as it is, this goal retains psychological traits as if I was defining what people, in their inner soul, really strives for. In spite of this limitation, I maintain it here because it is in keeping with Machiavelli's definition of power and motives. For a less psychological interpretation, see Latour (1987, b, second part).

(6) The expression 'power' is taken here uncritically although it is, of course, the first notion that should be deconstructed once technical elements come into play. For a critique of the notion see Latour (1986).

(7) The sorry limitation of the list is not a problem for social scientists because they believe that each word in the list constitutes the cause of

which the various technics are simply the effects. Thus they are not surprised if the same powerful cause is able to trigger many different effects. For the Prince there is no cause, only effects. The cause is never more than a retrospective attribution once everything has been put into place.

(8) This is why Bertrand Gille's notion of a 'système technique' (1978) is misleading, even though it is useful to group artefacts without being limited by the harware. For instance, in his technical system, the gear of the mill would go with the wheel and with the river and with the grinding stone and with the roads onto the same list. But what about the Church, the King and the armed men? They are part of the same Machiavellian list, not of Gille's one. These elements are to be found in <u>another</u> page, when Gille deal with the social or economic or cultural structure.

(9) More generally, the biological metaphors appear useless to me, first because evolutionary biology is itself a mess of conflicting versions of what is a surviving strategy for organisms, and, second, because, in biology, it is the organisms themselves which are the calculating Princes. This is not to say that biological study of early hominid tools are not perfectly sensible as Leroi-Gourhan (1967) showed so forcefully, but this is because they are part of the body itself as much as brain or hands. Once they are distinct from the body they can no longer be lumped together in trajectories except inside museums. This is not to say that an evolutionary study of artefacts is not possible, but to do so it is a generalized socio-biological point of view that would be required. From this point of view the body itself would be seen as the technical stabilisation of earlier strategies -hardwiring versus soft wiring, genes versus learning (Dawkins: 1982).

(10) "How many" is simply a rough indication of the relation of forces and <u>not</u> a quantitative measure, since part of the negociation is to define, calibrate, diffuse, impose et upkeep the metrological chains that allow to define the forces in a quantitative way.

(10) I purposely chose an example which is the perfect counterpart of the New-York architect Moses studied by Winner (1980) and also by MacKenzie (1984).

(11) The notions of delegation, distribution of roles and 'inner sociology' forms the basis of a comparative semiotic of technical artefacts that could be called techno-graphy.

(12) Ruth Cowan has demonstrated this unexpected redistribution in an excellent study of housewives at work (1983). They work a lot more with many new automatisms that render indispensable quite a few new companies, but they are also transformed, redefined, reagenced. Reducing such a story to woman-freed-by-machinism or to women-enslaved-by-capitalism would be a pity.

(13) This position is nowhere more striking than among Marxists who have developed an extreme sado-masochist relation to technology —sadic because in its Stalinian version it allows large scale killing in the name of an alternative society, masochist in the European left-wing way because it allows people to be deliciously inefficient, maimed and tortured in the name of an alternative society —but still be right.

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Le Prince : Machines et machinations

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Machiavel, républicain de cœur, a établi les fondements de la démocratie dans son *Discours sur la première Décade de Tite-Live*. Malgré cela, on le considère souvent comme un cynique d'une dangereuse amoralité parce qu'il a aussi écrit *le Prince*. Pratiquement pourtant, les deux œuvres sont de même nature : si l'on veut que la démocratie soit solide, il faut avoir compris les dures réalités du pouvoir. Pour Machiavel, le double langage ne tient pas à sa propre analyse ni même aux cœurs des souverains qu'il analyse, mais bien aux historiens qui distinguent arbitrairement les vices et les vertus. Hannibal, par exemple, fut capable de maintenir la cohésion d'une armée composée de plusieurs peuples et races : " Ce fut entièrement grâce à une cruauté inhumaine. Jointe à ses autres qualités — et elles étaient innombrables — elle le fit craindre et respecter de ses soldats. S'il n'avait pas eu cette cruauté, ses autres qualités eussent été insuffisantes. Les historiens, qui ont peu réfléchi à ce problème, admirent d'un côté ce que Hannibal a réalisé, mais condamnent de l'autre ce qui a rendu ces réalisations possibles " (p. 667)* . Dans *le Prince*, Machiavel présente un ensemble de règles de gouvernement qui vont *au-delà* de la distinction que font les moralistes, les citoyens ou les historiens entre le bien et le mal. Toutes ces règles peuvent se déduire d'une notion essentielle : comment garder le pouvoir longtemps malgré les ennemis et les revers de fortune ? Une fois cette notion essentielle clairement conçue, tout ce qui apparaissait auparavant comme des exceptions choquantes ou bizarres est perçu correctement comme différentes stratégies ou tactiques pour parvenir à un seul et même but. Ainsi, l'action vertueuse ne sera ni une règle ni une exception, mais simplement une possibilité parmi tant d'autres : " Le fait est que l'homme qui veut agir vertueusement en toute circonstance connaît nécessairement l'échec parmi tant d'hommes

(*) Les citations françaises du *Prince* sont tirées de la Pléiade.

qui ne sont pas vertueux. Dans ces conditions, si un prince veut se maintenir au pouvoir, il doit apprendre à ne pas être vertueux, et à faire usage ou non de la vertu en fonction des besoins " (p. 339). Bien que cette phrase ait puissamment contribué à décrier la réputation de Machiavel, elle exprime au contraire, de son point de vue, la seule manière possible d'augmenter les chances de la moralité et non pas une échappatoire commode. Son livre aspire à définir une position dans laquelle la marge de manœuvre des démocrates vertueux est au moins *aussi importante* que celle des tyrans assoiffés de sang. Si vous voulez être vertueux, dit-il à tous les républicains, il vous faut beaucoup *plus* que votre pharisaïsme moral, beaucoup plus d'alliés, dont beaucoup vous trahiront. Au lieu de vous satisfaire de discours éthiques, faites-vous des alliés, combattez vos ennemis et méfiez-vous de tout.

Malgré toute son astuce, sa passion et sa générosité, Machiavel n'était pas en mesure d'anticiper par l'imagination la duplicité des Princes d'aujourd'hui, ni la pusillanimité et le pharisaïsme des démocrates modernes. Les intrigues qu'il a décrites sont fondées sur les passions et les manipulations des hommes par d'autres hommes. Les seuls alliés " non-humains " qu'il ajoute explicitement à la *combinazione* sont les forteresses et les armements, les premières parce qu'elles ralentissent l'arrivée éventuelle des ennemis, les seconds parce que " il n'y a simplement aucun rapport entre un homme qui est armé et un homme qui ne l'est pas " (p. 353). Cela mis à part — sans parler des alliés surnaturels qu'il met ironiquement de côté — Machiavel construit ses intrigues par des combinaisons successives d'échecs et de succès, les hommes se contrôlant et se dominant tout à tour. Son monde est un monde *social*. Pour restaurer l'ordre social constamment menacé de décrépitude, les forces de la société sont, sinon les seules, du moins les principales ressources.

Actualité de Machiavel

Ce n'est plus le cas aujourd'hui et c'est la raison pour laquelle l'univers de Machiavel, malgré ses troubles sanglants, nous apparaît par contraste facilement compréhensible ; c'est aussi pourquoi ses astucieux stratagèmes nous semblent si désarmants de naïveté comparés à ceux que nous devons ourdir à présent. La duplicité qu'il nous faut comprendre ne se trouve plus chez les Princes ou les Papes, qui ont fait leur temps, mais dans le recours simultané à des alliés *humains et non-humains*. Aux éternelles passions, traîtrises et autres stupidités des hommes et des femmes, il nous faut ajouter l'entêtement, la ruse et la force des électrons, des microbes, des atomes, des calculateurs et des missiles. Duplicité bien sûr, car les Princes ont toujours deux fers au feu : l'un pour agir sur les alliés humains, l'autre pour mettre en œuvre les alliés non-humains. En résumé, les démocrates en péril qui eurent à combattre durant des siècles contre des machinations doivent se colleter aussi maintenant avec des machines. Ce chapitre explore les voies qui permettraient d'étendre les analyses du *Prince* à la description des machines *et* des machinations, de la technologie *et* de la société.

Technologie et société sont deux objets créés par le double langage de l'analyste

Comme au temps de Machiavel, la duplicité est avant tout dans les propres interprétations de l'analyste. Au lieu de suivre le Prince faisant son chemin grâce à ses alliés humains et non-humains, elles transforment cette masse désordonnée en deux ensembles distincts et homogènes, groupant d'un côté les humains entre eux, de l'autre considérant en bloc tous les éléments non-humains des stratégies qu'il leur faut analyser et expliquer. Le système de l'*apartheid* sud-africain est moins artificiel que cette séparation qui implique une politique de développement séparé, d'un côté pour les liens sociaux, de l'autre pour la technologie. Or il est impossible de comprendre les formes modernes du pouvoir si l'on ne saisit pas d'emblée que ce que l'on appelle " société " et ce que l'on appelle à tort[1] " technologie " sont deux *objets fabriqués (artefacts)*, créés simultanément et symétriquement par les analystes qui ont trop rétréci la définition du pouvoir pour trouver la puissance. Transformer la finesse du Prince en deux lignes parallèles à

1. Convaincre les auteurs anglo-saxons que le terme " techno-logie " devrait être utilisé comme " épistémo-logie " — c'est-à-dire comme signifiant " science des techniques " et non comme un doublet pour désigner les artefacts eux-mêmes — est, j'en suis bien persuadé, une cause perdue. Je continuerai à plaider pour l'acception que je donne personnellement à ce mot, mais quand je l'utiliserai ici, ce sera contre mon gré ou ironiquement.

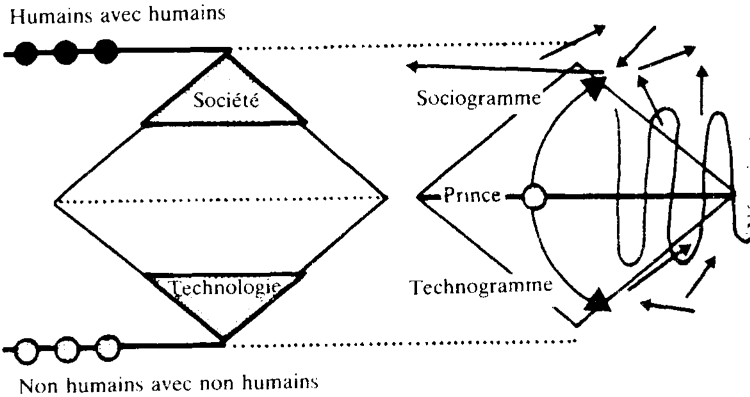
l'infini a autant de sens que de séparer les prouesses d'Hannibal de sa cruauté ou que de préparer une bataille en mettant d'un côté tout le matériel et de l'autre tous les hommes nus. C'est exactement comme si Thomas Hughes (1979), dans son étude exemplaire sur Edison, avait mis ici tous les éléments techniques (lampes, stations électriques, transformateurs...), là tous les éléments sociaux (organisation, financements, relations publiques...), puis tenté d'établir ensuite quelque rapport entre ces deux ensembles ! Si l'histoire d'Hannibal est rendue obscure à cause du moralisme des historiens, que ne doit-on pas dire de l'histoire des imbroglios socio-techniques que nous avons trop souvent à lire ?

La première chose que l'on devrait faire pour étendre les analyses du *Prince* et pour rendre l'histoire moins opaque est de se débarrasser de ces deux objets fabriqués que sont la société et la technologie. Il suffit pour cela de se placer simplement dans la position des nouveaux Princes. On suivra ainsi la démarche même de Machiavel, qui dépassa la définition étroite de la morale donnée par ses prédécesseurs ; c'est également ce qu'ont fait les meilleures analystes contemporains dans le domaine de l'interaction entre technique et société[2]. Si l'on peut résumer les quelques études de terrain que l'on possède par un seul diagramme, je proposerai celui-ci :

Chacune de ces études de cas se détourne des deux objets traditionnels que sont société et technologie (partie gauche du schéma) pour nous amener à une position socio-technique dans laquelle nous voyons les décideurs, ou entrepreneurs, recourir d'un ensemble d'alliances à l'autre (de l'humain au non-humain, et réciproquement), augmentant ainsi l'hétérogénéité du mélange à chaque tournant de la négociation (partie droite du schéma). Selon les mots mêmes de Gilfillan :
" Les hommes rivalisent aujourd'hui entre eux non pas avec leurs dents mais avec leurs outils " (1935-63) (p. 19). C'est ce que John Law a justement appelé " ingénierie hétérogène " (1986) ou ce que Thomas Hughes nommait, dans un contexte similaire : " le tissu sans couture " (1979). La duplicité apparaît dans la

2. Dans cet article, je pille les œuvres de Thomas Hughes, Michel Callon, John Law, Mickès Coutouzis, Madeleine Akrich et de plusieurs autres. Pour trois ouvrages de référence récents, voir W. Bijker, T. Hughes et T. Pinch (éd.) (1987) ; J. de Noblet (éd.) (1983) ; D. MacKenzie et Wajcman (1985) et le numéro spécial de l'*Année sociologique* édité par P. Lécuyer. On y ajoutera le livre toujours essentiel de Gilfillan (1935/1961). Voir aussi Elzen (à paraître).

négociation commune entre alliés hétérogènes (ligne médiane du schéma de droite), et non plus dans le développement séparé de



deux communautés séparées (lignes du haut et du bas dans le schéma de gauche). L'analyste qui tire les leçons de ces études de cas, au lieu d'être déchiré entre technologie et société, est désormais aussi libre que les agents qu'il (ou elle) observe (Callon, 1986). Inutile de dire que cette nouvelle position *n'est pas* un heureux compromis qui équilibrerait soigneusement les aspects sociologiques et les aspects technologiques, pas plus que le Prince de Machiavel n'est à moitié honnête, à moitié vicieux. C'est une position stratégique qui subordonne toutes les définitions éthiques, sociales et techniques à un nouveau but — qui sera défini plus loin.

Il est intéressant de noter que le principal résultat des études de terrain sociologiques ou historiques est aussi la visée essentielle des investigations économiques et de programmation, comme le projet SAPPHO parfaitement résumé par Christopher Freedman (1982) : " Le seul paramètre discriminatoire entre échec et succès a été la " relation besoins-utilisateurs ". Cela ne doit pas être interprété comme simplement, voire principalement, un indicateur d'étude de marché efficace ; cela ne porte atteinte ni à X ni à Y ni au projet, pas plus qu'à la direction de l'entreprise. Le produit ou le procédé doit être étudié, développé et débarrassé de ses défauts pour satisfaire les besoins spécifiques des futurs usagers, de sorte que la " compréhension du marché doit être présente dès le tout début du processus " (P. 124). Ce résultat est confirmé par les études de nouveauté que nous avons faites (Callon et Latour, 1986 ; Coutouzis, 1984 ; Coutouzis et Latour, 1986), mais aussi par une littérature plus orientée vers le *management* (Peters et Austin, 1985). Ce n'est pas diminuer la qualité de ces études que de dire qu'elles ne sont pas vraiment surprenantes d'un point de vue machiavélien. Cette " sagesse sapphique " souligne simplement que, dans une guerre, celui qui gagne est celui qui coordonne les soldats, les armes et la logistique pour triompher d'un ennemi spécifique sur un terrain spécifique. C'est plutôt le contraire qui serait à la vérité surprenant ! Pour prendre un exemple plus pacifique, c'est comme si quelqu'un s'étonnait de ce que, pour bien jouer au *Scrabble*, il faille à la fois examiner l'aspect changeant de la grille et la multiplicité des combinaisons possible des lettres que l'on a tirées. L'état déplorable de notre sociologie et de notre technologie fait que nous arrivons à trouver nouvelles et importantes de telles études de sociologie ou de *management*.

Une machine est effectivement une machination, mais à plus d'un titre.

Maintenant que nous nous sommes libérés de cet excès de duplicité *ajouté* par les analystes flatteurs du passé à l'habileté manœuvrière du Prince, il nous faut nous interroger sur cette habileté elle-même. La première question à soulever, si nous voulons suivre notre modèle machiavélien, est la suivante : quels genres de combats obligent le Prince à recourir à des alliés humains et non-humains ?

Marx a fourni à cette question une réponse si influente qu'elle a d'abord stimulé, puis étouffé l'analyse de l'interaction socio-technique. Il a placé le Prince — rebaptisé " capitaliste " — dans une situation de lutte de classes, de sorte que chaque machine ou chaque mécanisme introduit dans le processus de production fût en fait destiné à déplacer, remplacer, déqualifier, humilier et finalement mettre au pas les travailleurs : en somme, briser leur résistance. Les règles tactiques de ce schéma sont simples : si vos ouvriers vous ennuient, recourez aux fabricants de machines ; s'ils font la grève ou manquent de discipline, remplacez les liens entre eux par les relations entre les diverses composantes d'un mécanisme (MacKenzie, 1984). Dans ce nouveau monde à la Braverman (1974), chaque machine est une machination contre les travailleurs et le " luddisme ", quelle que soit sa forme, est une résistance contre ce stratagème, (je serais tenté d'appeler " éluddisme " la contrepartie intellectuelle).

La principale difficulté de cette position a été joliment notée par Donald MacKenzie (1984). Lorsque l'introduction d'un dispositif technique *n'attaque pas* les travailleurs, de nombreux marxistes restent sans voix, puis commencent à évoquer facteurs techniques et autres déterminismes. Lorsqu'une machine déqualifie les ouvriers du textile, ils savent quoi dire ; lorsque des compagnies créent des postes d'ouvriers hautement qualifiés, ils parlent d'exceptions incompréhensibles, ou même, selon la terminologie de MacKenzie, d' " orientation antagoniste ". Pendant un siècle, les exceptions ont proliféré, mais les marxistes ont difficilement abandonné la doctrine selon laquelle la seule façon de prouver " le déterminisme social de la technologie " — selon leur terminologie — est de montrer la lutte des classes en action. L'idée leur est rarement venue à l'esprit qu'un " Prince " pouvait avoir plus de deux ennemis — les travailleurs et les autres " Princes " — et que, luttant sur plusieurs fronts à la fois, il pouvait avoir besoin de collaborateurs hautement qualifiés et libres d'esprit pour résister, par exemple, à d'autres Princes. Les historiens moralisateurs louent les prouesses d'Hannibal mais déplorent sa cruauté ; les marxistes déplorent la cruauté du capitaliste et louent à haute voix la technologie qui accroît la qualification du travailleur : même contradiction dans les deux cas. Ils posent en principe une seule division (bien/mal ; capitalistes/travailleurs), là où il en existe plusieurs parmi lesquelles le Prince choisit en fonction de l'objectif principal. Excellents analystes lorsque l'objectif essentiel du capitaliste fut de discipliner les paysans ou les ouvriers du XX^{e} siècle, les marxistes d'aujourd'hui sont presque toujours à côté de la plaque. Ainsi, lorsqu'il n'y a visiblement aucune lutte de classes pour expliquer une technologie nouvelle, il leur faut ou bien en inventer une particulièrement *dissimulée*, et si dissimulée qu'elle échappe à tout le monde sauf à eux, ou bien — ce qui est pire — admettre que certains aspects de la technologie peuvent être " neutres ", voire " positifs " après tout.

Il serait toutefois aussi absurde de dire que la lutte des classes n'existe plus que de dire que les Princes de Machiavel sont toujours pervers. Ce qu'il nous faut comprendre, c'est bien le nombre de luttes dans lesquelles le Prince est engagé, de sorte que, en fonction des besoins, il doit tantôt exploiter, tantôt récompenser ; tantôt mentir, tantôt dire la vérité ; tantôt qualifier, tantôt déqualifier. Combien de fronts faut-il ainsi *ajouter* au front de classe pour commencer à avoir une idée de la subtilité nécessaire aux stratagèmes du Prince ? Je voudrais ici faire une liste des plus évidents.

La lutte dans le palais avec ses propres collaborateurs, ses conseillers et ses services est loin d'être la moins importante, comme on le constate d'après l'étude des " Nobles " selon Machiavel et d'après les modernes sociologues de l'organisation. De nombreuses technologies — spécialement les " douces " — sont élaborées, empruntées ou transformées pour tenir les collaborateurs à distance ou sous contrôle. La lutte est particulièrement dure lorsque le Prince ne commande pas directement, mais lorsqu'il a à combattre d'autres gens qui disent qu'ils sont le Prince. La dimension même du " Prince " ne doit pas être supposée d'avance ; elle varie avec le temps depuis le pays entier jusqu'à un seul homme dans la masse des autres (Callon et Latour, 1981). Il n'est jamais établi si le Prince, comme Protée, est un individu, un ensemble, une technostructure, une nation ou un collectif.

Le troisième front est ouvert en permanence par les autres Princes. Pour résister à leurs entreprises, de multiples alliés nouveaux (humains et non-humains, indifféremment) doivent être convoqués et mis en œuvre — et cela peut nécessiter un apaisement du front intérieur. La conjonction des trois fronts — travailleurs, collaborateurs et pairs — requiert déjà des trésors d'ingéniosité, c'est-à-dire des trésors d' " ingénierie hétérogène ".

Un quatrième front est aussi capital ; il est étudié par Machiavel sous le nom de " peuple ", ou par les économistes modernes sous le nom de " consommateurs " : comment persuader le peuple de suivre le Prince, ou les consommateurs d'acheter les produits ? À quelles extrémités le Prince n'est-il pas amené pour intéresser, séduire, contraindre, capturer ou emprisonner les consommateurs ? Le peuple est tellement ondoyant et divers, passant brutalement d'une opinion à une autre au gré des modes et des passions. Pour le maintenir dans une direction constante, il faut en permanence des ressources constamment renouvelées. La conjonction des quatre fronts (travailleurs, collaborateurs, consommateurs, pairs) requiert désormais la multiplication des nouveautés socio-techniques et spécialement de ce nouveau Léviathan qu'est la compagnie géante, si magistralement décrite par Chandler (1977).

Un cinquième front est aussi important, même si on l'oublie trop souvent. Machiavel l'a évoqué brièvement en parlant de fortifications et d'armements, mais les ingénieurs et les technologues l'ont amplement développé : comment amener des alliés non-humains à participer aux affaires humaines, à prendre part aux luttes sociales, à jouer un rôle dans l'établissement du pouvoir ? Comment former et manœuvrer les microbes, les électrons, les atomes et leur faire jouer un rôle dans le maintien en place des hommes et des femmes, malgré leurs caprices, leur versatilité et leur manque de discipline ? Ne fuient-ils pas notre prise, passant d'une opinion à une autre et décevant notre attente ? Quelle confiance accorder à des gens qui prétendent parler au nom de ces acteurs non-humains ?

Combattre sur les cinq fronts en même temps requiert beaucoup d'ingéniosité socio-technique et engendre ce que Machiavel n'a pas pu anticiper, c'est-à-dire ces " réseaux ce pouvoir " que Hughes a magnifiquement décrits (1983), dans lesquels de nombreuses forteresses pour maintenir les gens en place sont faites d'électricité, de cuivre, de compteurs ou même d'air pur. " Les liens de l'affection sont tels que les hommes, dans leur misère, les brisent quand cela les avantage ; mais la crainte est renforcée par une menace de punition qui est toujours efficace " (p. 666) : telle est la réponse de Machiavel à la question de savoir s'il vaut mieux être aimé que craint. Voilà qui est intelligent ; mais il l'est beaucoup plus encore de maintenir enchaînés les hommes, ces misérables créatures toujours prêtes à rompre leurs contrats pour rallier la concurrence, par des ondes, des compteurs, du cuivre et des lampes à filament. Au lieu d'une liste restreinte ne comportant que l'amour et la crainte, le Prince moderne dispose d'un vaste arsenal qui comprend, outre l'amour et la crainte, de nombreux autres éléments.

William McNeill (1982) a résumé tous ces terrains d'affrontement sous la notion-clef de *mobilisation* des hommes et des ressources. Chaque innovation, que ce soit dans le domaine de l'organisation, du dessin des navires, de la métallurgie ou des communications, est évaluée en fonction de sa contribution aux guerres civiles ou étrangères. Le commerce est un substitut à la politique et il n'y a pas beaucoup de différence entre guerres commerciales et autres guerres, excepté une petite préférence terminologique pour " comportement de marché " au lieu de " comportement de commandement ". Les Princes européens qu'il décrit, comme les Italiens que Machiavel avait décrits en son temps, sont tous de même force. Cela signifie que le léger supplément de puissance apporté par les ingénieurs, puis par les scientifiques, peut effectivement faire pencher la balance. Chacun d'eux, coincé entre un Beyrouth de guerres civiles (froide et chaude, commerciale et militaire) et une guerre atomique totale (simulée), doit innover à tout prix pour survivre quelque temps. En d'autres termes, chacun d'eux est prêt à trahir sa " société " et à recourir de plus en plus à des alliés étrangers pour l'aider, accroissant du même coup le mélange socio-technique[3].

Avoir présente à l'esprit la simultanéité de tous ces fronts et ne jamais grouper ensemble les alliés non-humains est d'autant plus nécessaire que c'est la clef pour comprendre pourquoi les technologies sont sophistiquées et pourquoi les " boîtes noires " sont noires. Plus on doit faire de transactions sur des fronts élargis, plus on doit coudre ensemble des éléments humains et non-humains et plus les mécanismes deviennent obscurs. Ce n'est pas parce qu'elle échappe à la " société " que la " technologie " est devenue complexe. La complexité du mélange socio-technique est *proportionnelle* au nombre de liens, de relations et de nœuds qu'il est destiné à nouer. Si la " technologie " paraît avoir un " dedans ", c'est bien parce qu'elle a un " dehors " ou, pour parler plus exactement, société et technologie sont deux aspects de la même ingéniosité machiavélienne. C'est pourquoi, au lieu de la distinction dénuée de sens entre liens sociaux et relations techniques, nous préférons parler d'*association*. À l'alternative " est-ce social ou technique ? ", nous préférons substituer la question " telle association est-elle plus forte ou plus faible que telle autre ? " (Callon et Latour, 1981 ; Latour, 1986 ; 1987).

Il y a bien sûr beaucoup d'autres fronts, mais je crois avoir suffisamment montré combien la définition de la " formation sociale de la technologie " serait étroite si l'on ne prenait en compte que l'antagonisme entre le capitaliste et ses ouvriers. Marx avait raison de dire qu'une machine vaut l'occupation d'une position — à l'instar d'un mot dans le jeu de *scrabble* ; mais il

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3. McNeill (1982) est sans doute l'écrivain qui a formulé le plus clairement — à défaut de le résoudre — le puzzle anthropologique : " pourquoi nous et pas eux ? " La grande séparation ne doit pas être cherchée dans les aptitudes mentales, technologiques ou politiques, mais le long des problèmes suivants : dans quelle société est-il possible au Prince de recourir à des mercenaires et alliés étrangers et non-humains sans être considéré comme un faible ou un hors-la-loi ? Quelle société accepte le recours à des faits et à des artefacts plus *hard* comme autant de moyens de poursuivre la politique à plus grande échelle ? Quelle société est à ce point " balkanisée " que quelques faits et artefacts plus *hard* suffisent à faire pencher la balance ?

se trompait sur le nombre d'éléments détenus simultanément grâce à cette position. En outre, il faut inclure dans le tableau tous les échanges, toutes les trêves et tous les renversements d'alliance que l'activité sur un front rend nécessaires sur les autres, de sorte que, quand les tensions s'y relâchent un peu, on ne saurait en conclure immédiatement que la guerre est finie et qu'il ne faut pas entamer de stratégie supplémentaire. Dire cela, ce n'est pas disculper le Prince, mais simplement donner à l'analyste *autant* d'intelligence et de sournoiserie que celui-ci.

Réciproquement, j'en ai dit assez pour faire comprendre que le simple ajout de quelques éléments techniques factuels à une discussion sociologique ou économique ne rend pas justice aux stratagèmes machiavéliens que je voudrais ici analyser. Comme de nombreux autres économistes, Rosenberg (1982) prétend " ouvrir la boîte noire ". L'intention est excellente, mais il ne fait en réalité qu'une description claire, neutre et homogène des parties technologiques des innovations qu'il étudie. Cela n'a pas plus d'utilité que si Tolstoï avait décrit la bataille de Borodino d'après le plan du chef d'état-major (1869-1952). En fait, la partie technologique n'est pas faite d'éléments linéaires et homogènes que l'on pourrait utiliser comme toile de fond tranquille pour mettre en scène le " modèle " (*pattern*) désordonné de la vie politique ou directoriale. Il s'agit d'un mélange discutable qui ne peut pas — qui ne doit pas — être décrit sur le ton du factuel. C'est précisément quand on se tourne vers les éléments non-humains que le discours polémique, contradictoire et stratégique doit prendre de l'importance et non en perdre. Pourquoi ? Simplement parce que c'est là que l'on peut trouver des ressources nouvelles pour traiter de polémiques, de controverses et de batailles. Un nouveau style tolstoïen serait souhaitable pour les batailles techniques (Latour, 1984 ; 1988). Ouvrir la boîte noire est une excellente idée, pourvu que l'on sache que c'est la boîte noire... de Pandore qui est en jeu[4].

Nous sommes parvenus au point où le choix entre alliés humains et non-humains est effectué, pour n'importe quelle combinaison, par le Prince ou par l'analyste sans aucun privilège

4. Les contraintes littéraires de ce que je pourrais appeler une bonne étude de terrain sur l'interaction socio-technologique sont faciles à cerner. Chaque fois qu'il y a autant de versions des aspects techniques qu'il y a d'acteurs dans l'histoire, c'est une bonne histoire. Chaque fois qu'il n'y en a qu'une, c'est un compte-rendu inutile, même si d'autres chapitres le complètent par les aspects " sociaux ", " économiques " ou " directoriaux " de la même histoire.

se trompait sur le nombre d'éléments détenus simultanément grâce à cette position. En outre, il faut inclure dans le tableau tous les échanges, toutes les trêves et tous les renversements d'alliance que l'activité sur un front rend nécessaires sur les autres, de sorte que, quand les tensions s'y relâchent un peu, on ne saurait en conclure immédiatement que la guerre est finie et qu'il ne faut pas entamer de stratégie supplémentaire. Dire cela, ce n'est pas disculper le Prince, mais simplement donner à l'analyste *autant* d'intelligence et de soumoiserie que celui-ci.

Réciproquement, j'en ai dit assez pour faire comprendre que le simple ajout de quelques éléments techniques factuels à une discussion sociologique ou économique ne rend pas justice aux stratagèmes machiavéliens que je voudrais ici analyser. Comme de nombreux autres économistes, Rosenberg (1982) prétend " ouvrir la boîte noire ". L'intention est excellente, mais il ne fait en réalité qu'une description claire, neutre et homogène des parties technologiques des innovations qu'il étudie. Cela n'a pas plus d'utilité que si Tolstoï avait décrit la bataille de Borodino d'après le plan du chef d'état-major (1869-1952). En fait, la partie technologique n'est pas faite d'éléments linéaires et homogènes que l'on pourrait utiliser comme toile de fond tranquille pour mettre en scène le " modèle " (*pattern*) désordonné de la vie politique ou directoriale. Il s'agit d'un mélange discutable qui ne peut pas — qui ne doit pas — être décrit sur le ton du factuel. C'est précisément quand on se tourne vers les éléments non-humains que le discours polémique, contradictoire et stratégique doit prendre de l'importance et non en perdre. Pourquoi ? Simplement parce que c'est là que l'on peut trouver des ressources nouvelles pour traiter de polémiques, de controverses et de batailles. Un nouveau style tolstoïen serait souhaitable pour les batailles techniques (Latour, 1984 ; 1988). Ouvrir la boîte noire est une excellente idée, pourvu que l'on sache que c'est la boîte noire... de Pandore qui est en jeu[4].

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ou simplification. Les Princes florentins avaient la tâche facile comparativement aux nouveaux Princes et le travail de Machiavel était simple comparé au nôtre. Pour saisir ce point, il faut embrasser d'un coup d'œil l'objectif du Prince, de sorte que ce qui apparaît comme exceptions ou contradictions puisse être vu comme simples alternatives parmi lesquelles le Prince choisit librement. " Tenez votre parole " n'est évidemment pas une bonne règle puisque le Prince qui la suivrait disparaîtrait rapidement, mais " mentez " n'est pas pour autant ni davantage la règle. " Déqualifiez vos ouvriers " n'est pas la bonne règle, puisqu'il est parfois nécessaire de leur donner une qualification. " Innovez le premier " n'est pas un principe général, puisqu'il est souvent nécessaire de ne pas être le premier à innover (Rosenberg, 1982, pp. 102-20). " Attaquez " n'est pas le bon conseil, ni en guerre ni en *management*, puisque, comme Freedman le fait justement remarquer (1982, p. 170), " restez sur la défensive ", " soyez dépendants " ou " copiez " sont aussi de bons choix possibles. " Plaisez aux consommateurs " est souvent moins efficace pour certaines industries (françaises ?) que le conseil opposé " négligez les consommateurs ". " Fiez-vous aux machines " est aussi recommandable que l'avis opposé " ne leur faites jamais confiance ".

Si je tire une leçon commune du *Prince* et des études de terrain sur les décideurs à l'ouvrage, c'est parce que chaque " Prince " a besoin de recruter d'autres hommes pour réaliser ses objectifs, mais aussi parce que ces autres hommes, étant par définition changeants et peu fiables, il faut les maintenir en bride. Personne n'est là pour vous tirer d'affaire et, par là même, aucun pouvoir ne vous est garanti ; si d'autres vous viennent en aide, c'est parce qu'ils poursuivent leurs propres objectifs, et non les vôtres. Plus les projets du Prince sont grands, plus sa tâche devient paradoxale. L'intérêt du jeu est donc toujours de résoudre la difficulté suivante : comment contrôler ceux qu'il faut obligatoirement recruter (Latour, 1987, chapitre III) ? Machiavel essayait d'imposer la conception selon laquelle tous les avis contradictoires donnés au Prince signifient en fait : cramponnez-vous au pouvoir malgré les vicissitudes de la fortune. La conception que je choisirais est plutôt la suivante : façonnez votre entourage de sorte que, quoi que fassent ou pensent les acteurs humains ou non-humains, ils soient tenus en bride, ou mieux, vous aident à conforter votre position en rendant le monde plus sûr, plus prévisible et plus profitable pour vous. Avec cette perspective générale à l'esprit[5], choisissez n'importe quelles tactiques ou stratégies pour y parvenir.

La couture de base dans le « tissu sans couture »

Trois points sont clairs désormais : le Prince est engagé sur plusieurs fronts à la fois ; c'est pour tenir certains de ces fronts que des éléments non-humains sont introduits, enrôlés, disciplinés et rendus manœuvrables ; la simple addition d'éléments techniques à des éléments sociaux ne nous apprendra rien sur la nouveauté cruciale en matière de moyens pratiques d'acquérir le pouvoir[6] : comment des alliances entre humain et non-humain peuvent-elles être conclues ? Le problème est de définir la couture initiale de ce " tissu sans couture " — le mouvement de l'aiguille, pour ainsi dire. Bien qu'il soit souvent brouillé par des distinctions artificielles, ce mouvement est très simple : quand votre avancée sur un front est battue en brèche, recherchez la possibilité de nouvelles alliances qui soient suffisamment inattendues pour rééquilibrer la balance des forces ; liez-les ensemble de façon à ce qu'elles agissent comme une seule et même force ; lancez-les de façon décisive dans la bataille en cours (Latour, 1987). Pour des raisons que je trouve peu claires, certains analystes tendent à appeler " science " le premier mouvement, " technologie " le second, " économie " le troisième, et font tous leurs efforts pour les séparer les uns des autres, ou pour attribuer le prix d'excellence à l'un d'eux au détriment des autres. Dans la pratique, cependant, le Prince — qu'il soit individu, collectivité, bureaucratie ou oligarchie — doit simultanément définir tous ses alliés et tous ses ennemis d'un bloc. Comme Mowery et Rosenberg (1979) — repris dans Rosenberg, 1982 — l'ont montré, il est également difficile de déterminer ce que veulent les consommateurs, ce que le stratagème peut être et ce que la nature peut fournir.

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5. Ainsi exposé, ce but revêt certains aspects psychologiques, comme si je définissais ce que les gens s'efforcent d'obtenir dans l'intimité de leur âme. Malgré cette limite, je le garde parce qu'il cadre bien avec la définition que Machiavel donne du pouvoir et des motivations. Pour une interprétation moins psychologique, voir Latour (1988, deuxième partie).

6. L'expression " pouvoir " est prise ici sans critique préalable, bien que ce soit évidemment la première notion qui doive être " démontée " une fois les éléments techniques entrés en jeu. Pour une critique de cette notion, voir Latour (1986).

La belle étude de Hoddeson (1981) sur l'enrôlement des électrons de Millikan par la compagnie Bell devrait suffire à montrer que l'aiguille ne peut coudre que si elle exécute les trois mouvements à la fois : trouver les consommateurs et les marchés, redéfinir la physique, créer la technologie. Oui, les électrons sont des alliés inattendus qui peuvent permettre à la compagnie Bell de se débarrasser des vieux mécanismes à répétition et d'étendre son réseau téléphonique à travers le continent américain. Non, les électrons ne sont pas suffisants parce que, dans le laboratoire de Millikan, ils sont indisciplinés, non manœuvrables, inutilisables en l'état, " abstraits " ou " analytiques " comme aurait dit Simondon (1969). Regroupés ensemble par le nouveau répétiteur électronique dans le cadre de l'un des premiers laboratoires industriels de science fondamentale, ils commencent à être manœuvrables et disciplinés, " concrets " ou " organiques " selon les termes de Simondon ; ils commencent à constituer une boîte noire, une pièce d'équipement. Pourtant, ce n'est toujours pas suffisant. Comme dans toute bataille, il vous faut non seulement connaître la balance des forces mais aussi la manière de les disposer ; il faut beaucoup d'autres éléments pour placer le répétiteur électronique de façon à ce que Alexander Bell, à San Francisco, puisse appeler M. Watson et lui dire : " Allô, M. Watson, pouvez-vous monter un instant... ".

Le mouvement qui crée le premier réseau continental et relie la côte Est à la côte Ouest des États-Unis, liant à la compagnie Bell les millions d'Américains qui doivent passer par ses lignes s'ils veulent entrer en contact et renforcer leurs relations de famille ou d'affaires, — est-il fondé sur la science ? Fondé sur la technologie ? Fondé sur l'économie ? Les analyses du *Prince* ne pourront jamais être étendues et nous ne pourrons pas comprendre la fabuleuse expansion des nouveaux Princes si nous conservons ces distinctions archaïques. " Science ", " technologie " et " économie " sont trois étiquettes différentes et erronées appliquées à un seul et même problème stratégique sérieux : faire un pas de côté, recruter de nouveaux alliés, les contraindre à obéir au commandement, les jeter dans la bataille, gagner la journée — ou la perdre. Comme pour toute stratégie, l'argent dépensé, le temps passé et la force de travail employée sont des *indicateurs* utiles des manœuvres, mais ne fournissent aucune explication sur elles.

L'expression " anthropologie de la science et de la technologie " a été forgée pour rendre compte de ce tissu aux multiples ornements et broderies, qui coud ensemble des éléments si étrangers et si nombreux : des pierres et des lois, des rois et des électrons, des téléphones et de l'amour, de la peur et des atomes, des étoiles et des travailleurs. Les ethnographes, qui sont si habiles pour décrire ce genre de tissu bariolé lorsqu'ils étudient les cultures exotiques, sont frappés d'un étrange aveuglement quand il leur arrive de tourner les yeux vers le monde moderne ; ils ne voient que deux masses, l'une composée de machines grises, l'autre de machinations doucereuses (Latour, 1984, 1988). Laissons-les, comme les moralistes, dormir en paix ; ils croient toujours que l'homme est dominé par la technologie !

Deux interprétations erronées et symétriques entravent le développement de cette nouvelle anthropologie de la science : d'abord, un privilège accordé aux stratégies " sociales " ; ensuite, un privilège accordé au *hardware*. Débarrassons-nous d'abord des " explications sociales ". Par exemple, chaque fois que je veux resserrer les liens avec ma vieille mère, je fortifie du même coup la compagnie Bell. Suis-je soumis pour autant à une démonstration de force de " Ma Bell " ? Pas du tout. La compagnie Bell s'est installée de telle façon que, quoi que je pense ou fasse, elle se diffuse et s'étend sans effort, tranquillement et inéluctablement. Elle s'est constituée elle-même en point de passage obligé pour tout le reste. Peut-on expliquer l'influence de Bell en usant de termes tels que " force ", " puissance ", " domination ", utilisés par les historiens et les sociologues pour décrire les politiques de Machiavel ? En aucune façon, parce que le mélange d'alliés non-humains (ondes, satellites, électricité, cuivre, fibres optiques) a été constitué pour se dégager des fronts bloqués définis par les luttes politiques classiques. On ne peut jamais *réduire* des stratagèmes socio-techniques à des explications sociales — non pas parce que ce ne sont pas des stratagèmes, mais bien parce qu'ils ont été élaborés pour contourner les explications sociales et les réduire à néant ! Les sociologues scientifiques ont toujours une guerre de retard et voient des manœuvres politiques tortueuses *derrière* les technologies, alors que les socio-technologies permettent au Prince d'ajouter des moyens nouveaux et inattendus pour redéfinir son pouvoir. Vous vous attendiez à subir une démonstration de force ; vous ne sentez rien d'autre que le violent désir de parler à votre vieille mère au téléphone. L'affection, l'électronique et le *management* sont liés entre eux. C'est parce que la liste des ruses de pouvoir définies par les sociologues machiavéliens est *plus courte* que celle des nouveaux Princes ; ils ont à considérer l'essentiel de la science et de la technologie comme partiellement neutre, ou à réduire le téléphone, les bombes atomiques et les pilules contraceptives à l'état de ruses cachées qu'ils sont libres d'inventer. Contre toute *nouvelle* invention, ils répètent la même interprétation : cela est dû au pouvoir des multinationales, du capitalisme, etc. etc. D'un côté, ils ont une longue liste de combinaisons à expliquer, de l'autre une liste brève et répétitive pour fournir les explications[7].

Mais la discussion des manœuvres du Prince est tout autant entravée lorsqu'un privilège est accordé aux alliés non-humains, comme s'ils constituaient le meilleur et le seul moyen de gagner la journée. Ce n'est jamais le cas. Dans une étude qui n'est pas dépassée parce qu'elle a la valeur et la netteté d'un mythe fondateur, Marc Bloch a illustré ce point remarquablement (1935, repris dans MacKenzie et Wacjman, 1985). À la fin du Moyen-Âge, les meules, les engrenages, les roues et les rivières sont d'excellents alliés inattendus qui composent, une fois regroupés dans un moulin, une formidable forteresse. Mais leur efficacité s'arrête là. Une forteresse peut se trouver sur le champ de bataille — et elle influence alors décisivement l'issue de la bataille — ou *loin du* champ de bataille. Si chaque famille continue à écraser son grain à la meule à main, le Prince, qui détient le moulin communal, ne possédera rien d'autre que du bois, de l'eau et des pierres. Le moulin ne deviendra une forteresse que si le Prince rassemble des milices, fait respecter le pouvoir du Roi et les enseignements de l'Église, et oblige chaque ménage à briser sa meule à main pour venir moudre son grain au moulin communal. Beaucoup d'industries et même des pays se sont enlisés parce que la solidité des forteresses qu'ils avaient construites les assurait — à tort — qu'ils n'avaient plus à développer d'analyse stratégique. Ce n'est pas la solidité des alliés obtenus qui compte, mais la solidarité que cela procure avec d'autres luttes humaines. Ce ne

7. La limitation regrettable de la liste n'est pas un problème pour les sociologues parce qu'ils croient que chaque *mot* de la liste constitue la *cause* de ce dont les diverses technologies sont simplement les effets. Ils ne sont donc pas surpris de voir la même cause puissante capable de produire tant d'effets différents. Pour le Prince, il n'y a pas de cause, uniquement des effets. La " cause " n'est jamais qu'une assignation rétrospective une fois que tout a été mis en place.

sont pas les deux lignes parallèles du premier diagramme ci-dessus qui nous apprennent quelque chose, mais bien la négociation sinueuse du milieu. Les immenses usines de fer et d'acier de la Lorraine sont mangées de rouille, quel qu'ait été le nombre des éléments qu'elles reliaient, parce que le monde qu'elles étaient supposées maintenir a changé[8]. Elles ressemblent beaucoup à ces mots magnifiques que les joueurs de *scrabble* aiment à composer, mais qu'ils ne savent comment placer sur la grille parce qu'elle a été modifiée par les autres joueurs.

La même limite peut être trouvée dans la notion de trajectoire par laquelle les machines sont transformées en espèces biologiques dotées d'une sorte de vie autonome. Par exemple, la caméra de Wernecke appartient-elle à la même lignée génétique que celle d'Eastman (Jenkins, 1975) ? En un sens oui, puisque les idées de Wernecke ont été prises et copiées par Eastman. Mais pourquoi Eastman les a-t-il reprises ? Parce qu'il partait avec une stratégie complètement différente, celle d'un marché de masse pour les photographes amateurs, avant de se tourner vers les systèmes antérieurs qui n'étaient pas encore brevetés. La profonde transformation que la boîte noire de Wernecke subit dans les mains d'Eastman n'a rien à voir avec une mutation biologique ou une sélection ; elle concerne seulement une nouvelle stratégie : comment mettre au point une caméra qui devienne indispensable à des millions de gens ? Ce n'est que rétrospectivement, après qu'Eastman eut réussi à gagner et à garder un marché de masse avec sa caméra profondément différente, que les conservateurs de musée ont pu aligner les deux objets dans la même vitrine en marquant les différences avec de jolies étiquettes et des flèches. Le *hardware* n'est que *l'ombre* projetée par la ruse socio-technique. Réduit à lui-même, il est aussi fantomatique que la société[9].

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8. C'est la raison pour laquelle la notion de " système technique " de Bertrand Gille (1978) est malencontreuse, malgré son utilité pour regrouper des artefacts sans être limité par le *hardware*. Par exemple, dans ce système technologique, l'engrenage du moulin irait sur la même liste que la roue et la rivière et la meule et les routes. Mais que dire de l'Église, du Roi et des gens d'arme ? Ils appartiennent à la même liste chez Machiavel, mais non chez Gille. Ces éléments figureront sur une autre page, où Gille traitera de la structure sociale, économique ou culturelle.

9. Plus généralement, les métaphores biologiques me semblent inutiles, d'abord parce que la biologie évolutionniste est en elle-même un nœud de contradictions à propos de ce qui est en fait une stratégie de survie pour les organismes ; ensuite parce que, en biologie, ce sont les organismes eux-mêmes qui sont les Princes calculateurs. Cela ne signifie pas que l'étude biologique des premiers outils des Hominidés ne soit parfaitement sensée, comme Leroi-

À cause de ces deux interprétations erronées et symétriques, l'information que nous acquérons sur les manœuvres du Prince est rendue incompréhensible. Ou bien nous saisissons les relations sociales — sans aucune signification si elles sont privées des alliés non-humains qui les gardent en place — ou bien le *hardware* — sans signification non plus s'il est privé des positions stratégiques qu'il occupe. Si l'on parcourt la littérature des sciences sociales ou des sciences naturelles, la situation est souvent aussi absurde que celle du géographe qui obtiendrait des navigateurs envoyés autour du monde soit les latitudes, soit les longitudes des points qu'il souhaite reporter sur la carte, mais jamais les deux en même temps ! Pour " cartographier " ce qui nous lie tous ensemble, il nous faut inventer un système de projection qui fournisse en même temps les informations sur les acteurs humains et non-humains.

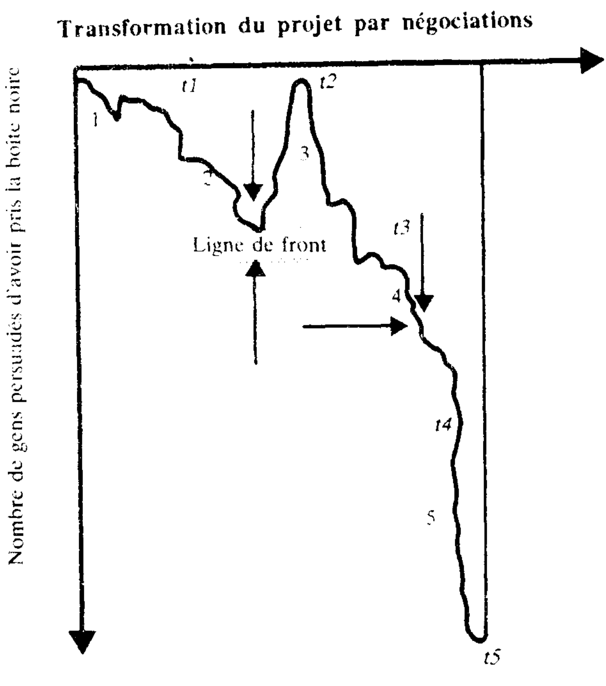
Longitude et latitude de notre système de projection

Les nouveaux Princes sont libres de choisir des ressources humaines ou non-humaines pour tisser leur trame dans les nombreux conflits où ils sont engagés. Le Prince est comme le Tisserand royal que Platon décrit comme l'homme d'État idéal. Il ne s'arrête jamais de tisser, mais ce qu'il entrelace ainsi est tantôt *soft*, tantôt *hard*, tantôt humain, tantôt non-humain. Son seul problème est de décider quel nœud est plus fort et lequel est plus faible dans une circonstance donnée. Des observateurs pusillanimes verront soit la redéfinition de nouveaux liens sociaux, soit l'introduction de nouvelles associations techniques, et s'émerveilleront alors de la possibilité entre les deux de relations, d'interconnexions, de reflets, d'influences. Si l'on veut être un peu plus audacieux et suivre les nouveaux Princes d'aussi près que Machiavel a suivi les anciens, on doit être capable de définir la chaîne et la trame du " tissu sans couture ".

Gourhan (1967) l'a montré de manière si péremptoire, mais ces outils sont aussi distincts du corps lui-même que le cerveau ou les mains. Une fois qu'ils sont distincts du corps, ils ne peuvent pas être groupés avec lui selon des trajectoires, excepté dans les musées. Cela ne signifie pas non plus qu'une étude évolutionniste des artefacts soit impossible, mais elle requiert un point de vue socio-biologique généralisé. De ce point de vue, le corps lui-même serait à considérer comme la stabilisation technologique des stratégies primitives — connexion *hard* contre connexion *soft*, inné contre acquis (Dawkins, 1982).

En reprenant et poursuivant la métaphore cartographique, nous allons essayer de définir la longitude et la latitude du système de projection de telle façon que tout imbroglio socio-technique puisse être défini selon deux dimensions : d'abord *combien* de gens sont persuadés et le tiennent pour une boîte noire non contestable ; en deuxième lieu, si le processus est interrompu par des gens qui le mettent en doute et qui veulent ouvrir la boîte, *quelle sorte de transformations* le projet doit-il subir pour persuader davantage de gens, c'est-à-dire quelle sorte de nouveaux alliés non-humains doit être requise ?

Dans le schéma suivant, j'ai esquissé ces deux dimensions : la transformation (ou translation, ou négociation) en abscisse, le succès de l'entreprise en ordonnée. L'histoire de la vie d'un projet donné est représentée par la ligne sinueuse. Plus on avance, plus on s'éloigne de l'idée originale, plus dure est la lutte et plus violente la contestation. Plus la ligne se rapproche du haut, moins les gens sont nombreux à être intéressés et convaincus par l'avenir du projet. La surface située derrière la " ligne de front " sinueuse représente approximativement le nombre d'éléments liés à la destinée du projet. Cela signifie que le moment de la fin prochaine (5), quand une foule de gens utilisent la boîte noire comme un équipement de routine qui n'est plus transformé, est aussi le moment où le plus grand nombre de ressources et de personnel a été mobilisé pour tenir les usagers en bride.



Quelques éléments de ce schéma m'intéressent. Premièrement, bien qu'il recouvre les catégories usuelles — recherche, (1) ; développement, (2) à (4) ; production et ventes, (5) — le projet ne cesse jamais d'être une *ligne de front*, même quand il semble que tout a été fait et qu'il faut à présent convaincre les simples consommateurs. Du commencement à la fin, il ne cesse jamais d'être la résultante d'une stratégie quadruple : qui dois-je convaincre ? Quelle est la force de résistance de ceux que j'ai choisi de convaincre ? Quelles nouvelles ressources dois-je enrôler ? Quelles transformations le projet doit-il subir ? En second lieu, le temps ((t1) à (t5)) n'est pas une des coordonnées du schéma, mais une des *conséquences* du processus de persuasion et d'enrôlement. " Cela prend du temps " ou bien " cela va vite ", tout dépend du nombre de gens à persuader et de l'habileté du Prince à négocier. Un élément plus suggestif est que la réalité d'un projet est un résultat variant en fonction de la stratégie du Prince. A (t2) par exemple, le degré de réalité du projet *décroît* et avoisine zéro. La faisabilité, la crédibilité ou l'absurdité d'un projet dépendent entièrement des coutures et des nœuds confectionnés par le stratège. Ni la réalité, ni le temps, ni l'état des choses n'expliquent l'évolution d'un projet, tous deux sont des variables dépendantes.

Quelles que soient les futures connexions entre les économies de X et de Y, la micro-sociologie des innovations et l'histoire de la technologie, il est d'ores et déjà clair qu'il faudra faire des efforts pour adapter les schémas, le type de données et probablement les mathématiques, à ces notions de translation, de fronts, d'association et de persuasion. Cette intégration passe probablement aussi par une compréhension du caractère métrologique de sciences telles que comptabilité, *management* et économie. Chaque nouveau stratagème, pour réussir, doit également définir, développer, positionner et faire respecter *ses propres méthodes d'affirmation de soi-même*. Chaque innovation est également risquée, difficile à évaluer, coûteuse et peu fiable, non pas parce que nous n'avons pas de bons outils économiques ou techniques pour l'estimer, mais parce que l'innovation elle-même doit redéfinir les outils appropriés pour évaluer sa chance, son coût, son efficacité et sa fiabilité. En d'autres termes, il y a dans ce sujet un principe d'incertitude qui est inhérent non pas à la faiblesse de nos instruments, mais bien au phénomène lui-même que nous voulons détecter. Ou bien l'on a une nouveauté dont une partie réside dans la lutte pour constituer des instruments de mesure ou pour établir la responsabilité : en ce cas, on manque de définitions précises et l'affaire entière est frappée d'incertitude ; ou bien l'on a de bons chiffres, des statistiques fiables, mais qui sont le résultat final d'un réseau stable, tranquille et réduit à la routine — et dans ce cas, on n'étudie plus de nouveauté. Il y a ainsi une contradiction entre l'approche des nouveautés grâce à des instruments éprouvés pour évaluer la productivité, et l'attribution de responsabilité au travail, au capital et au *management*. Le défi réside dans l'adaptation de notre économie et de notre sociologie à la qualité du réseau des manœuvres du Prince (Callon, Law et Rip. 1986).

Retour à la démocratie

Maintenant que nous sommes capables d'éviter l'illusion de l'existence de la société ou de la technologie, il est possible de comprendre ce qui rend le nouveau *Prince* si difficile à écrire et ses pouvoirs si difficiles à combattre. Les " puissants " de Machiavel qui s'étaient emparé du pouvoir avaient peu de ressources extra-humaines pour rendre leur position inexpugnable. Mis à part Dieu — à qui tous avaient également recours —, les épées et quelques murs de pierre, les princes de l'époque ne pouvaient compter que sur des moyens *soft* comme les passions, les craintes, les amours et les ambitions, moyens aussi *soft* que les corps qu'ils permettaient d'attacher. La " méga-machine " chère au cœur de Mumford n'était pas une vraie machine et c'est pourquoi sa métaphore fondamentale est si déroutante. Quelle que soit l'ardeur de la lutte, les armées étrangères que les Princes vont constituer à l'étranger pour triompher ne sont jamais qu'étrangères. Au pire, elles sont faites de mercenaires — de ceux dont Machievel considérait qu'ils étaient les moins fiables des alliés, c'est-à-dire d'hommes que l'on doit tenir à nouveau en bride par les mêmes liens humains, *soft*. La situation commence à se modifier radicalement lorsque les Princes sont prêts à emprunter d'autres voies, à faire un détour, à trahir et à introduire dans le combat des alliés qui sont vraiment des étrangers et qui ne ressemblent pas du tout à des hommes ou à des femmes. Une *course aux armements* généralisée est ainsi déclenchée, que nul Prince ne saurait éviter. À l'accumulation des liens humains *soft* vient alors s'ajouter l'accumulation de liens non-humains plus *hard ;* à la course au *software* du passé vient s'ajouter une course au *hardware,* dont la course aux armements n'est que l'un des aspects, ainsi que McNeill l'a magistralement démontré dans un livre qui est à l'évidence le meilleur brouillon d'un nouveau *Prince* que l'on puisse trouver (1982).

Un petit exemple montrera les conséquences de ce " surmachiavélisme ". La municipalité radicale de Paris et les grandes compagnies privées de chemin de fer avaient lutté pendant deux décennies avant que ne fût décidée la construction d'un métro à la fin du siècle dernier. Comment faire pour que ces compagnies ne missent pas la main sur le métro, si d'aventure une municipalité de droite venait à être élue ? Comment l'équilibre temporaire des forces pouvait-il être préservé ? Une première solution était d'utiliser un écartement de voie plus petit pour le métro que pour les trains ; les militaires s'y opposèrent pour des raisons de sécurité nationale. Convaincue par la réalité de cette menace en cas de guerre nationale, mais refusant d'abandonner leurs positions de guerre (froide) civile, la municipalité décida finalement de faire des galeries de métro plus petites que le plus petit des wagons de chemin de fer (Daumas *et al.*, 1977)[10]. Ils transférèrent ainsi leurs alliances du domaine légal ou contractuel à celui de la pierre, de la terre et du béton. Ce qui était aisément réversible en 1900 le devint de moins en moins au fur et à mesure que le réseau grandissait ; les ingénieurs du métropolitain prirent les kilomètres de tunnel construits par la compagnie comme élément technique inéluctable et définitif.

C'est ainsi que la question de la liberté des ingénieurs et du peuple est en fait exactement liée au nombre de ressources non-humaines qui sont impliquées dans leur lutte. Certes, ils restent libres de décider, comme les personnages de Sartre, qui incarnera le destin et qui incarnera la liberté. La meilleure preuve en est que, soixante-dix ans plus tard, lorsque les chemins de fer nationalisés, devenus S.N.C.F., et le métro nationalisé, devenu R.A.T.P., décidèrent d'interconnecter leurs réseaux, les ingénieurs furent chargés d'inverser une situation " irréversible " et d'élargir quelques-uns de ces tunnels. C'est là où la course au *hardware* se manifeste le mieux. Ce qui aurait pu être inversé par des élections soixante-dix ans auparavant dut être inversé quand même, mais à un prix plus élevé. Chaque alliance conclue par la municipalité

10. J'ai choisi à cet effet un exemple qui est l'antithèse parfaite de l'architecte de New York Moses, étudié par Winner (1980) ainsi que par MacKenzie (1984).

radicale socialiste avec la terre, le béton et les pierres dut être défaite, pierre à pierre, pelletée après pelletée. Pire encore, pour détruire chacune de ces alliances anciennes, des outils nouveaux et plus puissants durent être mis en œuvre, manœuvrés et engagés dans le combat (bulldozers, explosifs, machines à forer les tunnels, etc.). La " méga-machine " devint plus grande encore. Des millions de gens parcourent maintenant le réseau souterrain du R.E.R.

Mais la seconde conséquence de la course au *hardware* est d'autant plus frappante. Tenir une position est nécessaire, mais non suffisant, puisque cela implique aussi de rester sur place. Il serait mieux de garder ses acquis tout en étant capable de se déplacer ailleurs. Par malheur, le Prince sait parfaitement que quitter son palais ou sa forteresse, c'est ouvrir la porte à la trahison, à la traîtrise et aux révoltes. Comment bouger et rester au pouvoir ? La politique fournit une réponse : en délégant le pouvoir à d'autres. Mais la délégation de pouvoir à d'autres hommes est aussi fragile et aussi peu fiable que les liens humains eux-mêmes. Pourquoi ne pas déléguer des pouvoirs à quelques agents non-humains qui seraient ainsi chargés de leurs correspondants non-humains ? Pourquoi ne pas inventer une sociologie et une politique des choses *elles-mêmes*[11]. Par exemple, des policiers sont utiles à chaque carrefour pour régler le trafic, mais ils ne peuvent plus se déplacer ailleurs pour d'autres opérations. Remplacer leurs bras et leurs gants blancs par des feux de circulation est l'une des manières d'être absent tout en restant présent. Les conducteurs et les feux de circulation s'arrangeront entre eux. Oui, mais les conducteurs sont de faibles créatures, tentées de franchir le carrefour même si le feu est au rouge lorsqu'il n'y a aucun véhicule en vue. Pourquoi donc ne pas relier les feux aux roues même des véhicules par une impulsion électrique quelconque, de sorte que ces feux adaptent leur rythme au flux du trafic ? Désormais, les feux sont pilotés par un surveillant beaucoup plus " souple ", qui ne porte pas de képi ou de casquette. Un *automatisme* est né, qui deviendra rapidement plus complexe et " concret " ou " organique " — selon la terminologie de Simondon — parce qu'un ensemble de feux de circulation seront réglés par un ordinateur. Puis tous ces

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11. Les notions de délégation, de distribution des rôles et de " sociologie interne " forment les bases de la sémiotique comparative des produits techniques, que l'on pourrait appeler techno-graphie.

ensembles seront " visualisés " à la Préfecture de Police sur un écran devant lequel sera assis un policier en gants blancs. En procédant du machiavélisme politique aux automatismes, nous ne procédons pas de la sociologie à la technologie ; nous poursuivons simplement la même " associologie " avec une liste *plus longue* de relations et de liens. L'histoire n'est pas celle du remplacement des hommes et des femmes par des machines ; l'histoire est celle de la redistribution complète et permanente des rôles et des fonctions, certains d'entre eux étant maintenus en place par des liens humains, d'autres par des liens non-humains.[12]

L'inertie et l'automatisme sont ainsi les deux principaux effets de la course au *hardware*. C'est là que la question de la démocratie soulevée par Machiavel rentre en jeu, question qui est la seule justification de la présentation amorale du Prince et de notre description " associologique " des nouveaux Princes. Les deux clichés les plus courants à propos de la technologie — son inertie, qui serait trop forte pour que l'on pût y résister ; sa complexité interne, qui serait trop grande pour que quelqu'un pût en prendre la mesure — correspondent bien à des réalités, non pas comme *causes* des manœuvres du Prince, mais comme *effets* que le Prince s'efforce d'obtenir.

Le premier principe d'une démocratie technique est ainsi de ne jamais offrir ce résultat au Prince sur un plateau doré. Malheureusement, cette capitulation anticipée est très fréquente parmi les analystes de la technologie, les mieux intentionnés, qui admettent les trajectoires, les inerties et les complexités internes — bref, l'existence de la technologie. Capitulation également lorsque les analystes de la société, non moins bien intentionnés que les précédents, affirment qu'il existe quelque chose comme une société prééminente, connaissable au moins en principe, qui doit contrôler et dominer le développement de la technologie. Ces deux capitulations symétriques paralysent de fait la démocratie parce que la seule façon d'envisager une modification de la technologie et de la société est alors de faire appel à une technologie et à une

12. Ruth Cowan a démontré cette redistribution inattendue dans une excellente étude sur le travail des ménagères (1983). Avec de nouveaux automatismes (qui rendent quelques nouvelles compagnies indispensables), les femmes travaillent davantage, mais elles sont elles-mêmes transformées, redéfinies, réagencées. Réduire cette histoire aux " femmes-libérées-par-la-mécanisation " ou aux " femmes-réduites-en-esclavage-par-le-capitalisme " serait regrettable.

société *de remplacement.*[13] S'il existe une Technologie et s'il existe une Société et si le seul moyen de concevoir des changements est d'imaginer une Société et une Technologie de rechange, le Prince peut dormir tranquille dans son palais : il est parfaitement libre de mélanger à loisir les agents humains et non-humains, retouchant localement en fonction des besoins, autant qu'il lui plaît, les liens qui nous lient tous. De l'extérieur, les observateurs ne verront rien d'autre que des changements de technologie, dus à ses propres progrès autonomes, et des changements de société, en fonction de ses propres lois autonomes. Au lieu des contraintes strictes de la démocratie, le Prince ne subira que les remontrances des moralistes et quelques discours creux sur la " participation du public aux décisions techniques " — une fois que tout aura été décidé et entériné. Si la science et la technologie ne sont que de la politique poursuivie par d'autres moyens, la seule façon de rechercher la démocratie est de pénétrer la science et la technologie, c'est-à-dire de pénétrer là où la société et la science sont définies simultanément par les mêmes stratagèmes. C'est précisément là que se tiennent les nouveaux Princes. C'est là que nous devons être s'il est vrai que le Prince est plus qu'une oligarchie et si nous voulons pouvoir l'appeler " le peuple ".

(traduit et adapté de l'anglais
par Denis A. Canal)

Notes

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13. Cette position n'est nulle part plus saisissante que chez les marxistes, qui ont développé une relation sado-masochiste extrême avec la technologie : sadique, parce que sa version stalinienne autorise les massacres de masse au nom d'une société alternative, masochiste dans la gauche européenne parce qu'elle permet aux gens d'être délicieusement inefficaces, mutilés et torturés au nom d'une société alternative — mais toujours dans la certitude du bon droit.

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Technology is society made durable

Bruno Latour

Abstract

Is it possible to devise a set of concepts that could replace the technology/society divide? This set of new concepts – association and substitution – might help to rephrase some of the traditional questions of social order and especially that of the durability of domination of power. However, instead of using different tools to analyse power and weakness, it is argued that power and domination are simply different values of variables that should be studied in their whole range. By reconstructing networks it is argued that a full description of power and domination may be obtained.

For a long time social theory has been concerned with defining power relations (Barnes 1988), but it has always found it difficult to see how domination is achieved. In this paper I argue that in order to understand domination we have to turn away from an exclusive concern with social relations and weave them into a fabric that includes non-human actants, actants that offer the possibility of holding society together as a durable whole. To be sure, the distinction between material infrastructure and symbolic superstructure has been useful to remind social theory of the importance of non-humans, but it is a very inaccurate portrayal of their mobilisation and engagement inside the social links. This paper aims to explore another repertoire for studying this process of mobilisation. In the first part, I will use a very simple example to illustrate what I believe to be the right focus for detecting the entry point of techniques into the human collective. In the second part, I will analyse the beautiful case of the Kodak camera studied by R. Jenkins to show how social theory could benefit from history of technology. Finally, I will try to explain how stability and domination may be accounted for once non-humans are woven into the social fabric.

1 From context and content to association and substitution

Consider a tiny innovation commonly found in European hotels: attaching large cumbersome weights to room keys in order to remind customers that they should leave their key at the front desk every time they leave the hotel instead of taking it along on a tour of the city. An imperative statement inscribed on a sign – 'Please leave your room key at the front desk before you go out' – appears to be not enough to make customers behave according to the speaker's wishes. Our fickle customers seemingly have other concerns, and room keys disappear into thin air. But if the innovator, called to the rescue, *displaces* the inscription by introducing a large metal weight, the hotel manager no longer has to rely on his customers' sense of moral obligation. Customers suddenly become only too happy to rid themselves of this annoying object which makes their pockets bulge and weighs down their handbags: they go to the front desk on their own accord to get rid of it. Where the sign, the inscription, the imperative, discipline, or moral obligation all failed, the hotel manager, the innovator, and the metal weight succeeded. And yet, obtaining such discipline has a price: the hotel manager had to ally himself with an innovator, and the innovator had to ally herself with various metal weights and their manufacturing processes.

This minor innovation clearly illustrates the fundamental principle underlying all studies of science and technology: the *force* with which a speaker makes a statement is never enough, *in the beginning*, to predict the path that the statement will follow. This path depends on what successive listeners do with the statement. If the listener – in this case the hotel customer – forgets the order inscribed on the sign, or if he doesn't speak the language, the statement is reduced to a bit of paint on the piece of board. If the scrupulous customer obeys the order, he has complied with the imperative, thereby adding reality to it. The strength of the statement thus depends in part on what is written on the sign, and in part on what each listener does with the inscription. A thousand different customers will follow a thousand different paths after reading the order. In order to be able to predict the path, the hotel manager has two choices. He can either make all the customers equal by ensuring that they will know how to read the language and that they will know that going to a hotel in Europe means that one has a private, locked room but that the key must be left at the desk upon exiting the hotel every day. Or he can *load* his statement in such a way that lots of different customers all behave in the same manner, regardless of their native language or their experience with hotels. The choice is between incorporation and excorporation.

The grammatical imperative acts as a first load – 'leave your keys'; the inscription on the sign is a second load; the polite word 'please', added to the imperative to win the good graces of the customer constitutes a third; the mass of the metal weight adds a fourth. The number of loads that one needs to attach to the statement depends on the customers' resistance, their carelessness, their savagery, and their mood. It also depends on how badly the hotel manager wants to control his customers. And finally, it depends on the cleverness of the customers. The *programs* of the speaker get more complicated as they respond to the *anti-programs* of the listeners. If a weird client could break the ring connecting the light key to the heavy weight, the innovator would then have to add a soldered ring to prevent such breakage. This is an anti-anti-program. If a paranoid hotel manager wanted to ensure zero key loss, he could place a guard at each door to search the customers – but then he would probably lose his customers instead. It is *only* once most of these anti-programs are countered that the path taken by the statement becomes *predictable*. The customers obey the order, with only a few exceptions, and the hotel manager accepts the loss of a few keys.

But the order that is obeyed is *no longer the same* as the initial order. It has been *translated*, not *transmitted*. In following it, we are not following a sentence through the context of its application, nor are we moving from language to the praxis. The program, 'leave your key at the front desk', which is now scrupulously executed by the majority of the customers is simply not the one we started with. Its displacement has transformed it. Customers no longer leave their room keys: instead, they get rid of an unwieldy object that deforms their pockets. If they conform to the manager's wishes, it is not because they read the sign, nor because they are particularly well-mannered. It is because they cannot do otherwise. They don't even think about it. The statement is no longer the same, the customers are no longer the same, the key is no longer the same – even the hotel is no longer quite exactly the same (Akrich 1987; Latour 1991; Law 1986a).

This little example illustrates the 'first principle' of any study of innovation in science and technology: the fate of a statement is in the hands of others (Latour 1987b). Any vocabulary we might adopt to follow the engagement of non-humans into the social link should consider both the succession of hands that *trans*port a statement and the succession of *trans*formations undergone by that statement. To take these successive transformations into account, the very meaning of the word 'statement' must be clarified. By statement we mean anything that is thrown, sent, or delegated by an enunciator. The meaning of the statement can thus vary along the way, and it does so as a function of the load imposed by the enunciator. Sometimes it refers to a word, sometimes to a sentence, sometimes to an object, sometimes to an apparatus, and sometimes to an institution. In our example, the statement can refer to a sentence uttered by the hotel manager – but it also refers to a material apparatus which forces customers to leave their keys at the front desk. The word 'statement' therefore refers not to linguistics, but to the *gradient* that carries us from words to things and from things to words.

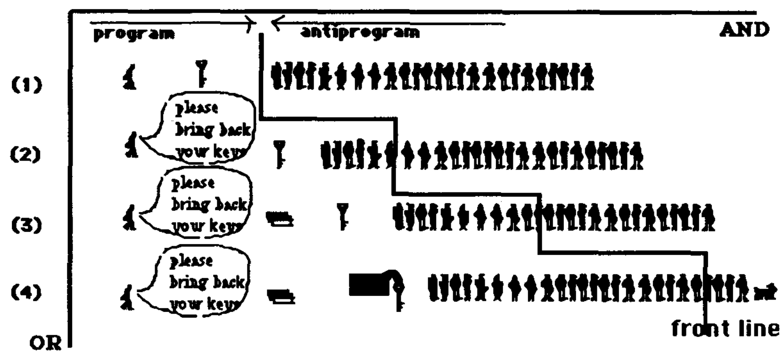
Even with such a simple example, we can already understand that when studying science and technology, we are not to follow a given statement through a *context*. We are to follow the simultaneous production of a 'text' and a 'context'. In other words, any division we make between society on the one hand and scientific or technical content on the other is necessarily arbitrary. The only non-arbitrary division is the succession of distinctions between 'naked' and 'loaded' statements. These, and *only these*, are the distinctions and successions which make up our socio-technical world. These are the ones we must learn to document and to record.

We wish to be able to follow both the *chain* of speakers and their statements and the *transformation* of speakers and their statements. We thus define two dimensions: association (akin to the linguist's syntagm) and substitution (or paradigm for the linguists). To simplify even further, we can think of these as the AND dimension, which is like latitude, and the OR dimension, which plays the role of longitude. Any engagement of non-humans can be traced both by its position on the AND-OR axes and by the recording of the AND and OR positions which have successively defined it. The vertical dimension corresponds to the exploration of substitutions, and the horizontal dimension corresponds to the number of actors which have attached themselves to the innovation (see Latour, Mauguin and Teil in press).

To trace a diagram on the example of the key, we will pick the hotel manager's point of view as an origin. He is the speaker, or the enunciator – that is, the one who emits the statement. The track that the manager wishes his customers – the listeners – to follow we will call the *program of action*. We shall use numbers in parentheses to enumerate the successive versions of a program of action as seen from a single point of view. We will place all the programs to the left of the chosen point of origin, and all the anti-programs to the right. Let us also agree to enumerate the segments of the programs of action with numbers in parentheses. Finally, let us agree to draw the dividing line between programs and anti-programs in bold face; this line corresponds to the front of the tiny controversy we are following here.

Figure 1

The hotel manager successively adds keys, oral notices, written notices, and finally metal weights; each time he modifies the attitude of some part of the 'hotel customers' group



In version (4), the hotel manager and almost all of his customers are in agreement, while in version (1) the manager is the only one to wish for the return of his flighty keys. The syntagm or the association or the AND dimension have extended themselves in a lasting manner. But this extension to the right had a price: it became necessary to descend along the OR dimension by enriching the program of action with a series of subtle translations. The manager's wishes are supplemented first by a sentence in the imperative tense, then by a written sign, and finally by metal weights. The customers were nibbled away at little by little: they finally abandoned their anti-program and 'surrendered' to the program. But the finances, the energy, and the intelligence of the hotel manager have also been nibbled away at! In the beginning, the wish was naked; in the end – an end which can only be provisional, as other anti-programs could always manifest themselves – it was clothed, or loaded. In the beginning it was unreal; in the end, it had gained some reality.

Such a diagram does not retrace the displacement of an immutable statement *within a context of use or application*. Nor does it retrace the displacement of a technical object – in this case a key weighed down by metal – within a context of use or application. Instead, it retraces a movement which is neither linguistic, nor social, nor technical, nor pragmatic. The diagram keeps track of successive changes undergone by customers, keys, hotels, and hotel managers. It does this by recording the ways in which a (syntagmatic) displacement in the associations is 'paid for' by a (paradigmatic) displacement in the substitutions. In such a diagram every move towards the right is to be paid by moving downward.

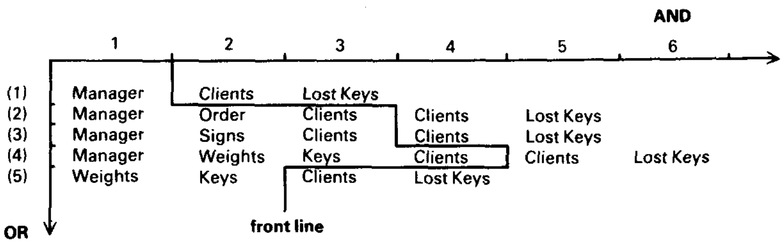
The degree of attachment of an actant to a program of action varies from version to version. The terms 'actant' and 'degree of attachment' are symmetrical – that is, they apply indifferently to both humans and non-humans. The key is strongly attached to the weight by a ring, just as the manager is very attached to his keys. It does not matter here that the first link is called 'physical' and the second 'emotional' or 'financial' (Law 1986b; Bijker and Law 1992; Bijker, Hughes and Pinch 1986). The problem is precisely for the hotel manager to find a way to attach his keys to the front desk when his customers go out, and he does this by attaching his customers to the front desk in a stronger and more lasting manner than that with which the keys are attached to his customers' pockets or handbags!

We notice in the diagram that the social group of the hotel customers finds itself transformed little by little. The accumulation of elements – the will of the manager, the hardness of his words, the multiplicity of his signs, the weight of his keys – ends up trying the patience of some customers, who finally give up and agree to conspire with the manager, faithfully returning their keys. The group of customers which has not been enrolled at the (provisional) end is composed (according to the manager) either of folks of unmanageably bad faith or of exceptionally distracted professors. This gradual transformation, however, does not apply to the 'hotel customers' social group alone; it also applies to the keys. Suddenly, indifferent and undifferentiated keys have become

'European hotel keys' – very specific objects which we must now distinguish and isolate just as carefully as we did with clients. Herein lies the whole point of following innovations. Innovations show us that we never work in a world filled with actors to which fixed contours may be granted. It is not merely that their degree of attachment to a statement varies; their competence, and even their definition, can be transformed. These transformations undergone by actors are of crucial importance to us when we follow innovations, because they reveal that the unified actor – in this case, the hotel-customer-who-forgets-the-key – is itself an association made up of elements which can be redistributed. It is opening and closing these black boxes that, until now, have made understanding the entry points of innovations such a delicate process.

Note that in the case presented here the success of the innovation – that is, its extension toward the right from the manager's perspective – is only made possible by constantly *maintaining* the entire succession of accumulated elements. It is only because the hotel manager continues to want his keys back, reminds customers aloud, puts up signs, and weighs down the keys that he can finally manage to discipline his customers. It is this accumulation that gives the impression that we have gained some reality. But another scenario could be imagined.

Figure 2



The manager might ask his customers to leave their keys, but, after putting up a few signs, he feels that he's done enough and has nothing more to say. As a result, there are just as many customers who do not follow either the oral or the written instructions. A technicist at heart, our good man chooses a technical fix and proceeds to delegate all the work to the object. He weighs down all his keys without bothering to put up signs or deliver oral instructions any more. He gets a few more customers to conspire with his wishes, but soon gets disgusted and abandons his program. What is left in this case? A bunch of keys strongly attached to a bunch of metal weights by some beautiful metal rings, and customers who merrily carry the key-weight combination wherever they go. As for the hotel manager, no one knows what he wants any more. In this scenario the final version (5) would associate fewer elements from the point of view of the original enunciator and is thus, by our definition, less real. But for us, who wish to observe the mobilisation of non-human into a human assembly, the only interesting reality is the *shape* of the front line. Whereas the asymmetry between the feasible and the unfeasible, the real and the imagined, or the realistic and the idealistic dominates most studies of innovation, our account only recognizes *variations of realization and de-realization*. The front line traced by the exploration of what holds and what does not hold together records the compatibilities and the incompatibilities of humans and non-humans – that is, the socio-logics of the worlds in which we live.

These two possible scenarios in our example show how difficult it is to avoid the twin pitfalls of sociologism and technologism. We are never faced with objects or social relations, we are faced with chains which are associations of human (H) and non-humans (NH). No one has ever seen a social relation by itself – or else it is that of the hotel manager unable to discipline his customers – nor a technical relation – or else it is that of the keys and the weights forgotten by everyone.

Instead we are always faced by chains which look like this

H-NH-H-NH-NH-NH-H-H-H-H-NH (where H stands for a human-like actant and NH for a non-human).

Of course, an H-H-H assembly looks like social relations while a NH-NH-NH portion looks like a mechanism or a machine, but the point is that they are always integrated into longer chains. It is the chain – the syntagm – we study or its transformation – the paradigm – but it is never some of its aggregates or lumps. So instead of asking 'is this social', 'is this technical or scientific', or asking 'are these techniques influenced by society' or is this 'social relation influenced by techniques' we simply ask: has a human replaced a non-human? has a non-human replaced a human? has the competence of this actor been modified? has this actor – human or non-human – been replaced by another one? has this chain of association been extended or modified? Power is not a property of any one of those elements but of a chain.

2 Weaving together a story of technology

The main difficulty of integrating technology into social theory is the lack of a narrative resource. We know how to describe human relations, we know how to describe mechanisms, we often try to alternate between context and content to talk about the influence of technology on society or vice-versa, but we are not yet expert at weaving together the two resources into an integrated whole. This is unfortunate because whenever we discover a stable social relation, it is the introduction of some non-humans that accounts for this relative durability. The most productive way to create new narratives has been to follow the development of an innovation (Bijker *et al.* 1986; Bijker and Law 1992; Hughes 1983). Those recent histories allow one to go from powerless engineers to domination that is so complete that it has become invisible. It is now the landscape in which human action and will flow effortlessly.

Consider Jenkins's story of the simultaneous invention of the Kodak camera and of the mass market for amateur photography (Jenkins 1975, 1979). Let us abridge this story by identifying each program and anti-program and by successively recording all the new actors, be they human or non-human, single or collective.

Table 1

Abridged script of a socio-technical path (according to Jenkins)[1]

(1) professional-amateur (A)/ daguerrotype (B)

(2) professional-amateur (A)/ wet collodion (C) **1850/** paper manufacturing (D)-//- doing everything oneself right away

(3) professional-amateur (A)/ paper manufacturing (D)/ *dry* collodion plates made ahead of time (E) **1860–1870** -//-

(4) professional-amateur / paper manufacturing / more sensitive dry **gelatin** plates **1870–1880/** companies that manufacture plates ahead of time -//-

(5) professional-amateur / paper manufacturing / dry **gelatin** plates/ companies that manufacture plates ahead of time/ continuous plate coating machine/ Eastman -//-

(6) **(5)**/ capital from Strong/ EASTMAN DRY PLATE COMPANY **1881–1883** -//- low entry price/ easy competition

(7) **(6)** consortium of plate manufacturers -//- still limited market/ fragile plates

(8) **flexible Walker film/**Walker's Pocket Camera **1884** -//-

(9) roll film instead of plate film/ camera using the films -//- nothing other than heavy cameras using plate film exists on the market

(10) camera using the films/ Warnerke's 1870 prototype in England non-patented roll/ roll holder/ two paper rolls coated with collodion -//- too expensive/ difficult unloading/ uncertain markers/ distortion leading to fuzzy pictures/ not too reliable/ still for professional

(11) Eastman/ Walker/ high status company/ commercial network/ roll holder/ flexible film in rolls/ production line manufacturing machine -//-

(12) **(11) 1884** gelatin layers plus collodion -//- fragile

(13) **(12)** paper/ collodion -//- fragile

(14) **(13)** paper/ gelatin -//- fragile

(15) **(14)** paper/ soluble gelatin/ less soluble photosensitive gelatin -//- distortion

(16) **(15)** / gelatin on the back to avoid distortion/ thick gelatin layer -//-

(17) **(16)**/ roll holding frame/ spring against distortion/ removable parts against loading and unloading/ measurement drum/ trigger to advance film/ puncher for exact marking -//-

(18) **(17)** / **early 1884** continuous paper machine for serial printing -//-

(19) **(18)** / patents -//- **1885** encroaching Houston patents inventing punch holes in roll film for exact marking, avoiding superimposed pictures

(20) **(19)** / Houston **spring 1889** sells the patent -//- very expensive patent

(21) **(20)** new commercial company EASTMAN DRY PLATE AND FILM COMPANY/ Strong/ Walkers/ eight stockholders //subcontractor manufactures roll holder -//- film cracks

(22) **(21)** / **end 1885** film available in long strips -//-

(23) **(22)** / seduces photography leaders/ worldwide rewards **June 1885** London -//-

(24) **(23)**/ Warnerke says 'it's better than mine and different because of mass production' -//- film too delicate to develop/ doesn't appeal to professionals of lesser quality than plates

(25) Eastman printing paper very good/ professional market interested/ Eastman company does fixing and development in series/ 1887 6000 developments a day -//- market still limited to development

(26) film not good for professional **good for amateurs** -//- abandon of amateur professional **(opening of black boxes (2) to (6))**
(27) good for amateur/ mass market -//- no camera **summer 1887**
(28) mass market/ flexible film **(16)**/ existing cameras/ development fixing by the Eastman Company -//- amateurs not interested because existing camera hard to use
(29) mass market/ flexible film **(16)**/ existing cameras/ development fixing by the Eastman Company/ user doesn't have to do anything -//- the Eastman company does all the work
(30) mass market/ **Eastman camera/** flexible film/ **1887 Kodak name/** 25 dollars/ 100 exposures/ Eastman commercial network/ manual of use/ advertisement -//-
(31) **(30)** triumphant reception -//- film still fragile
(32) **(31)** then replacement of support for nitrocellulose paper/ displacement of rolls in front of instead of behind focal plane -//-
(33) **(32)** whole world/ rewards/ mass market verified -//- celluloid problems sales go down **1892 1893**
(34) **(33)**/new support for film/market takes off -//- potential competitors and patents
(35) **(34)**/ buys back all the patents -//-
(36) **(35)/1899** large industry/ mass production/ mass market increased to amateurs from 7 to 77 years old/ hundreds of thousands of cameras sold-//-

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This table summarizes a success story, that of the simultaneous building of a new object (the Kodak camera) and of a new market (the mass-market). What is remarkable in the story is that you are never faced with two repertoires – infrastructure and superstructure, techniques and economics, function and style – but with shifting assemblies of associations and substitutions. The film is substituted to the plates, the dry collodion is substituted to the wet collodion, capitalists replace other capitalists, and above all, average consumers replace professional-amateurs. Is the final consumer forced to buy a Kodak camera? In a sense, yes, since the whole landscape is now built in such a way that there is no course of action left but to rush to the Eastman company store. However, this domination is visible only at the end of the story. At many other steps in the story the innovation was highly flexible, negotiable, at the mercy of a contingent event. It is this variation that makes technology such an enigma for social theory. Let us now examine several of those enigmas by using the simplified story of the Kodak camera.

a) Trajectory or translation?

The first of these enigmas is the notion of *trajectory*. For example, the curator of a museum of technology trying to put together an exhibit on the history of photography might be tempted to link succeeding versions of early cameras in a display case. These, after all, are hard, physical objects which can be easily preserved and shown. The curator does not deny the existence of the 'rest' – of all the photographers, subjects, markets, and industries that surrounded the cameras. Instead, all this gets transformed into a context *in which* the technical object moved, grew, changed, or became more complex. Yet, if we compare Warnerke's invention with Eastman's first camera, we notice that they are exactly as dissimilar as version (10) is from version (24) of the table above – an episode in which Warnerke most courteously recognizes Eastman's originality. The degree of resemblance has to be taken as an index on an association chain.

From the perspective of the trajectory of a glass-and-wood object moving through society, these two innovations should no more be linked in a museum display case than a sewing machine and an operating table. By cutting across the translations, the notion of trajectory invents surrealist '*cadavres exquis*'. And yet, from the perspective of the flow of associations and substitutions, there does indeed exist some link, established by Warnerke and Eastman themselves. But this link is not supported by wood, reels, or glass. The two inventions do not have a single non-human in common: they only appear to do so in retrospect. Eastman's exploration work alone establishes a link between the roll holder designed for professional amateurs in England and the automatic camera mass-produced in America. Either we give this work a place in our analyses, in which case the link is not fortuitous, or we don't, in which case the link between the two is nothing but an artefact of the technical history of technology.

b) Forms or contents?

Rather than confusing the secondary mechanism of attribution with the primary mechanism of mobilization, we should stick to the latter. An innovation is a syntagmatic line (AND) containing just as many humans and non-humans as were recruited to counter the anti-programs. If even a single segment differs from one version to the next, the innovation is simply *no longer the same*. If all the segments but one are distinct, there is absolutely no reason to group two versions in the same showcase. We still have the diffusionist's (Latour 1987b) bad habit of considering that one particular segment of a program of action is the essence of an innovation, and that the others are merely context, packaging, history, or development. But the only essence of a project or of a knowledge's claims is its total *existence*.

This existentialism (extended to things!) provides a precise content to the distinction between questions of rhetoric (or packaging) and substantive questions. Network analysis has been widely criticized for transforming scientists into washing machine salesmen, people constantly worried about rhetoric and enrolments and very little concerned about the content of their discoveries. But this objection is doubly unfair, both for washing machine salesmen, who surely exercise much more subtlety than they are usually given credit for, and for innovators. Is the invention of the word 'Kodak' important or not? Is merely deciding to build a market enough? Or is such a decision superfluous? Is the whole thing simply a marketing problem? All these questions should acquire a precise meaning: does the actor 'the name Kodak' lead to a modification in the durability of the syntagm, and if so how much of a modification? In Jenkins's narrative, the actor 'name Kodak' in version (30) is an actor among twenty-three other actors, and only allows the recruitment of a single new actor in version (31). In this precise case, we can measure the exact weight of rhetorical packaging. The contingency or necessity itself varies according to the size of the syntagm and the amount of substitution it later endures.

Consider, however, the case of the Turkish astronomer in Saint-Exupéry's *The Little Prince*. When he demonstrates the existence of asteroid B 612 dressed in his traditional national costume, his colleagues treat him with scorn and laughter. The next day, he makes 'the same' demonstration dressed in a three-piece suit and wins the esteem of the colleagues. The only difference is the astronomer's clothing. Here indeed we have a case in which the weight of mere rhetoric is essential. Only a diffusionist, an essentialist, or an epistemologist would find it ridiculous that the astronomer's first demonstration was missing nothing but a tie.

Those who follow innovations know perfectly well that a tie may make all the difference, and that there is no reason to *equate* the syntagm 'demonstration + Turkish national costume + collegial laughter' with the syntagm 'demonstration + three-piece suit + collegial esteem'. But we do not necessarily have to conclude that the weight of a tie and a three-piece suit is in principle and for ever essential to mathematics! The analyst should never pre-determine the weight of what counts and what does not, of what is rhetoric and what is essential, of what depends on Cleopatra's nose and what resists all contingencies. The weight of these factors must be *calculated* as a function of the movement of syntagms and they will be different in each story.

c) Social context or technical content?

Symmetrical to the illusion of a trajectory crossing a context is that of a context crossed by innovations. We need to dismiss this other sociological ghost as well if we wish to understand how the weaving of humans and non-humans is done.

Can one say that the amateur professionals of the first days of photography closed their minds to technological progress as of 1886, and that the larger public opened its mind to progress as of 1892? Can one explain the diffusion of photography by examining the nature of the social groups interested in it? In other words has the notion of interest to be stabilised in order to account for the path of the knowledge claims? No, because the social groups themselves were deeply transformed by the innovations. The professional amateurs interested in Eastman's dry-plate – versions (5) and (6) – were extremely disappointed in roll film – version (24) – whose quality was vastly inferior to that of the plates; they were interested in printing and developing pictures on Eastman's photographic paper (25), and totally non interested in the Kodak camera. They actively sorted the proposed innovations, but they also were altered, modifying their laboratories and delegating the task of plate, then paper, preparation to individual companies. What we observe is *a group of variable geometry entering into a relationship with an object of variable geometry*. Both get transformed. We observe a process of translation – not one of reception, rejection, resistance, or acceptance.

The same applies to the amateurs. The amateur in version (36) who only has to click the Kodak camera, thereby imitating millions of other amateurs, and who does not need any laboratory since he can send the camera with the films to be developed at Eastman's factories, is no longer the same as the one in version (24), who bought intimidating cameras whose film got stuck and produced fuzzy pictures. The amateur market was explored, extracted, and constructed from heterogeneous social groups which *did not* exist as such before Eastman. The new amateurs and Eastman's camera *co-produced* each other. We see neither resistance to, nor opening of, nor acceptance of, nor refusal of technical progress. Instead we see millions of people, held by an innovation that they themselves hold.

And what about Eastman? Is he a fixed actor? Not at all. The contours of what Eastman can and wants to do, as well as the size and the design of his company also vary in this story. Contrary to the claims of those who want to hold either the state of technology or that of society constant, it is possible to consider a path of an innovation in which *all the actors* co-evolve. The unity of an innovation is not given by something which would remain constant over time, but by the moving translation of what we call, with Serres, a *quasi-object* (Serres 1987).

d) Realistic or unrealistic?

By dissolving the difference between that which mutates and the surroundings in which an innovation mutates, we should remove yet another problem: that of the asymmetry between the realizable and the unrealizable.

Reading Eastman's socio-technical narrative, we can easily see that version (36) is not the realization – or objectivation, or reification, or incarnation – of version (1), since none of the same actors can be found at the (temporary) end of the controversy. And yet we are dealing with the progressive construction of reality. But the continuity of this story is not that of a slightly crazy idea that finally becomes reality; it is that of a translation which completely transforms that which gets transported. The real is no different from the possible, the unrealistic, the realizable, the desirable, the utopian, the absurd, the reasonable, or the costly. All these adjectives are merely ways of describing successive points along the narrative. Version (24) only seems unfeasible when compared to the violent event of version (26); version (10) is not an incarnation of version (9), as the two only have a single element in common. The narrative thus should employ the *same tools* to treat each stage of our story without ever having to judge how 'intrinsically' realistic or unrealistic an association is. The only reality that it records is socio-logical.

A major result of this manner of recording socio-logics is that 'reality' is not a final, definitive state demanding no further effort. A chain of associations is *more real* than another one if it is *longer* – from the perspective of the enunciator designated as a starting point in the story. Maintaining reality is thus paid for by a continual extension in the syntagm (AND). Thanks to this narrative, the 'inertial force' of innovations – that famous state in which they would be irreversible and would zoom through society under their own steam – is quite simply dissolved. So is the symmetrical 'inertial force' of groups incapable of 'accepting' an innovation. Nothing becomes real to the point of not needing a network in which to upkeep its existence. No gene pool is well adapted enough to the point that it needs not reproduce. The only possible thing to do is to diminish the margin of negotiation or to transform the most faithful allies in black boxes. The only absolutely impossible thing is to diminish the number of associated actors while pretending at the same time that the existence of the innovation continues to be just as 'real'. Domination is never a capital that can be stored in a bank. It has to be deployed, black-box, repaired, maintained.

e) Local or global?

The narrative should also account for another little mystery: the progressive passage from the microscopic to the macroscopic. Network analysis and field work have been criticized for giving interesting demonstrations of local contingencies without being able to take into account the 'social structures' which influence the course of local history. Yet, as Hughes has shown in a remarkable study of electrical networks (Hughes 1979, 1983) the macro-structure of society is made of the same stuff as the micro-structure – especially in the case of innovations which originate in a garage and end up in a world that includes all garages – or, conversely, in the case of technological systems which begin as a whole world and end up on a dump. The scale change from micro to macro and from *macro to micro* is exactly what we should be able to document.

If a version does indeed represent a progressive change of scale from micro to macro with the inclusion of greater and greater numbers of black boxes (each of which counts 'as one'), then we can also document, using the same tool, the progressive re-opening, dispersion, and disbanding of actors passing from the macro level to the micro level. The socio-technical world does not have a fixed, unchanging scale, and it is not the observer's job to remedy this state of affairs. The same innovation can lead us from a laboratory to a world and from a world to a laboratory. Respecting such changes of scale, induced by the actors themselves, is just as important as respecting the displacement of translations. Given the tools of network analysis that we have at our disposal, trying to endow actors with a fixed dimension as well as a fixed form is not only dangerous, but simply unnecessary.

f) Slow or fast?

It is worth noting one last consequence of substituting socio-logics to asymmetric notions of the real and the possible. The passage of time becomes the consequence of alliances and no longer the fixed, regular framework within which the observer must tell a tale. The observer has no more need for a regulated time frame than for actors with fixed contours or predetermined scales. Like the relativist in physics, the relativist (or relationist) science or technological studies is content with what Einstein so beautifully called 'mollusc of reference' (Einstein 1920). Just as we let actors create their respective relationships, transformations, and sizes, we also let them mark their measure of time; we even let them decide what comes before what.

The OR dimension records the order in which different versions succeed one another – as seen from the perspective of the observer chosen as a starting point – but it does not regularly measure time. Referring back to the Eastman example, thirty years elapse between versions (1) and (15), but only a few months go by between versions (25) and (30). Should we then conclude that the innovation 'drags its feet for thirty years' and 'accelerates brusquely' in 1887 as historians so often say? We could indeed reach this conclusion, but words such as 'fast' or 'slow', 'mature' or 'premature', 'feasible', 'utopian', 'real', merely float on the surface of translation movements without explaining anything. The number and speed of events depend entirely on movements of alliance or rupture performed by the actors. If you can reconstitute these movements, you obtain the dimension of temporality as well; if you cannot reconstitute these movements, the regular passage of time won't tell you anything. What the socio-technical graph reconstitutes is the historicity of innovations ever dependent on the socio-logics of actors. Like everything else, time must be constructed. It is not given to you. The innovator never rests on the seventh day.

3 Repairing relativism

Admitting that we are now capable of displaying the fine variations of a socio-technical exploration, how does this ability help us *explain* the contingent shape adopted by a particular trajectory? The three Graces of Truth, Efficiency, and Profitability, so handy for providing causes in science, technology, and economics, are obviously unusable, as they are the result and not the cause of these displays. Eastman's cameras in versions (8) to (29) are neither profitable nor efficient. They will take on these qualities, but only somewhere around version (36). It is thus impossible to use the end of the story to explain its beginning or its development. The study of innovations is no more teleological than Darwinian evolution. But there is no question of substituting sociological interests for the three Graces as the motor of history. Stable Interests, like good Efficiency or sure Profitability, need stable networks and instruments to be able to make predictions. But the amateurs do not know that they need photography before version (36). Stockholders wait twenty years to decide whether their interests are better served by plates, films, or Kodak cameras. And as for Eastman, he designs his interests little by little as his research develops. Both economics and stable sociology arrive on the scene *after* the decisive moments in the battle. They arrive after the points where large AND variations are paid for by large OR displacements, and they deal with states in which large AND displacements are only paid for by tiny OR displacements.[2]

Since an explanation of an innovation's path cannot be retrospective, it can only spring from the socio-logics of programs and anti-programs. Can anti-program actors be either recruited, ignored, or rebuffed? Can program actors maintain their association if such and such an actor is recruited, ignored, or rebuffed? At all times, the front line of a controversy generates such questions. It is the answers to these *particular* questions that make or break an innovation. And all these answers depend on how actors resist the proposed tests: if I add actor D to a syntagm made of ABC, what will A do? What will B and C do? To understand the path taken by an innovation, we must evaluate the resistance put up by the successive actors that it mobilizes or rejects. Explanation does not follow from description; it is description *taken that much further*. We do not look for a stabilized and simplified description before we begin to propose an explanation. On the contrary, we use what they do to an innovation or a statement to define the actors, and it is from them and them alone that we extract any 'cause' we might need. Paradoxically our explanation are 'internalist' in the sense that they all come from the inherent topography of specific networks.

a) Defining actors by the list of their trials

We define an actor or an actant only by its actions in conformity with the etymology. If an innovation is defined by a diagram in which its essence is co-extensive to its existence – that is, the ever-provisional aggregate of its versions and their transformations – then these versions and transformations are in turn completely defined by the actants that constitute them. But where do we get these actants from? Where do the hotel customer, the manager, the key, and the sign come from? What would be the use of displaying innovations without reductionism if we use a reductionist definition of actants? Luckily for us an actant is defined exactly like an innovation. All we have to do is shift our perspective: instead of using an innovation that passes from actor to actor as a starting point, we must use one of these actors in whose 'hands' successive versions of the innovation pass. Here again, the linguistic metaphor can help us. A linguist can study either a syntagm – a group of associated elements in a meaningful sentence – or the element itself in the framework of all the meaningful sentences in which it appears, that is a paradigm. This would be like moving from:

The fisherman
The fisherman / fishes /
The fisherman / fishes / a shark/
The fisherman / fishes / a shark / with/ a gun
The painter /fishes / a trout / with / a knife

to

The painter/ paints/ pictures
The painter/ paints/ houses
The painter/ is /a/ substantive
The painter/ is/ / hyper-realistic

What changes is the point we choose to hold fixed. In the first case, our object is the length of the syntagm as well as the group of paradigms that can be substituted in each articulation. In the second case, our object is a specific articulation, and we wish to reconstitute the group of syntagms in which it occurs. Defining the essence of innovations by the existence of their successive and simultaneous actants, and then turning around to define the actants by the successive innovations in which they appear, is no more circular or contradictory here than in linguistics.

How do we define an actant? An actant is a list of answers to trials – a list which, once stabilized, is hooked to a name of a thing and to a substance. This substance acts as a subject to all the predicates – in other words, it is made the origin of actions (Callon 1991). How do we define our hotel manager of the key story? He certainly 'is' the obstinate speaker who reminds customers to leave their keys, but he is also more than that. He 'is' also the one who makes up the bills, orders clean sheets, places ads in the phone book, summons painters, etc. The key also can be defined not merely by its appearance in our innovation story, but by the list of everything it must submit to in all the innovation stories in which it appears. Its sole purpose in life is not returning to the front desk; it also throws bolts, get stuck when a drunken customer tries to force a lock, gets imitated by a master key, etc. And as for the metal weight, it does not merely intervene as a modest attachment to a hotel key. It undergoes many other tests, which define it much more completely: it melts at 1800° in a furnace, it is made up of iron or carbon, it contains up to 4% silicon, it turns white or grey when it breaks, etc.

The longer the list, the more active the actor is. The more variations that exist among the actors to which it is linked, the more polymorphous our actor is. The more it appears as being composed of different elements from version to version, the less stable its essence. Conversely, the shorter the list the less important the actor. The more diversity it encounters among the different actors it meets, or the more difficult it is to open its black-box, the more coherent and firm it is. The list of tests undergone by a given actor defines its historicity, just as a socio-technical graph defines the historicity of an innovation or knowledge claim.

Just as an innovation can become increasingly predictable by black-boxing longer and longer chains of associations, an actor can become so coherent as to be almost predictable. If A is always associated with B or dissociated from D in the succession of stories, we can safely assume that when A relates to B in a new narrative, it will link itself with B and unlink itself from D. We can thus begin to deduce the *performance* of actors from their *competence*. We are then, but only then, allowed to be normative again, but these norms are not forced onto the data, they are extracted from the actor's own efforts at rendering each other's behaviour more predictable. Power and domination are the words given to those stabilizations and not an account of their coming into being. They are only one possible state of the associations. An essence emerges from the actor's very existence – an essence which could dissolve later. Its history becomes a nature to use Sartre's expression, but perhaps we should add to later become history again. The actor has gone from Name of Action to Name of Object (Latour 1987a). The lists constructed from the joint story of innovations and actors highlight the continual variation in an actor's isotopy, i.e., in its stability over time. Its behaviour becomes either more and more or less and less predictable. The list allows us to go from extremely shaky certainty to necessity, or from necessity to uncertainty. The force of habit, or of habitus, will either exert itself *or not*; it will act or not as a function of the historical records of the actor.

b) Following the relativist variations of translation

In spite of this circular definition of actors and innovation we are still far from providing explanations: we can only predict how long an association will last if an innovation grabs an actor or if an actor grabs an innovation. To be more precise, we can only predict such reactions for those cases that interest us the least: those in which the innovation is already a black box, in which the actors have such a stable history that it has almost become second nature, in which the traditional notion of power and domination may be predictably used. How can we manage to anticipate reactions in other cases when domination is not yet exerted? To do so, we must tame a third source of variation.

Since we are capable of mutually defining actants and innovations without any further essentialism we can therefore map the translation operation. This crucial operation engenders the establishment – albeit local and provisional – of social links. Thanks to translation, we do not have to begin our analysis by using actants with fixed borders and assigned interests. Instead, we can follow the way in which actant B attributes a fixed border to actant A, the way in which B assigns interests or goals to A, the definition of those borders and goals shared by A and B, and finally the distribution of responsibility between A and B for their joint action. In a universe of innovations solely defined by the associations and substitutions of actants, and of actants solely defined by the multiplicity of inventions in which they conspire, the translation operation becomes the essential principle of composition, of linkage, of recruitment, or of enrolment. But since there no longer exists any external point of view to which we could ascribe the degree of reality or of success of an innovation, we can only obtain an evaluation by triangulating the many points of view of the actors. It is thus crucial to be able to shift easily from one observer to another.

Consider a particularly elegant translation operation by Pasteur:

> To the Minister of Public Education
> Paris, 1 August, 1864
>
> Minister,
>
> Wine constitutes one of the greatest agricultural riches of France. The value of this product of our soil is increased by the commercial treaty with England. Thus in all wine-growing countries, there is interest in improving methods with a view to increasing both the number and quality of those wines that can be profitably exported.
>
> Unfortunately, our knowledge of this precious beverage leaves much to be desired. Studies of its composition are so incomplete that only in the past two years have two of its main components – glycerine and succinic acid – been identified. Despite the progress of modern chemistry, there is no more knowledgeable and precise treatise on wines than that of Chaptal, which came out more than sixty years ago. This is sufficient to indicate how much remains to be done.

> For the past five years, I have been working on the problem of fermentation. I have taken particular interest in the fermentation of alcohol at the heart of the wine-making process. The very progress of my research has led me to want to continue it *in situ* and in countries known for the production of those wines that are most valued in France. I wish to study the fermentation processes there, and in particular to examine the microscopic vegetable matter that is the sole cause of this great and mysterious phenomenon.
>
> I intend to carry out this work during my next leave. There will be about six weeks of travelling and of study, with one assistant and a few necessary items of equipment and chemical products. I estimate the outlay to be 2500 francs.
>
> The aim of this letter is to put this project before your Excellency, and to ask for a grant to cover the cost of its execution. This will not be the end of my interest in the matter. I will follow it up with work in future years, at the same time of the year.
>
> Further, I am the first to admit that there may be no immediate practical consequences of my studies. The application of the results of science to industry is always slow. My present goals are very modest. I should like to arrive at a better knowledge of the crytogamic plant that is the sole cause of fermentation in grape juice.

Successive layers of actants – the Minister, chemistry, my research, my trip to the Arbois – get goals and borders attributed to them. Each of these layers is characterized by incompatible vocabulary: 2500F, the trade treaty with England, succinic acid, the cryptogamic plant. (Hence the word translation.) An anti-program gets attributed to each of these programs of action: it would be nice to sell wine to England, but these wines are diseased; it would be nice to know the origins of these diseases, but wine chemistry is sixty years old; I would like to pursue my research, but I lack money and assistants. On the one hand, the translation operation consists of defining successive layers of vocabulary, of attributing goals, and of defining impossibilities; on the other hand, it consists of displacing – hence the other meaning of translation – one program of action into another program of action. The overall movement of the translation is defined by a *detour* and by a *return*. In the end, by giving Pasteur 2500F, the Minister is supposed to restore the balance of payments and thereby attains his goals.

But the translation operation is always risky. Indeed, nothing guarantees that the detour will, in the end, be paid, rewarded by a return. In fact, Pasteur, always clever, gives a good indication of this in his last paragraph. The only goal that must be attained, he said, is that of pure knowledge of the cryptogamic plant: applying this knowledge – i.e., the return – is always problematic. One can imagine many other possible scenarios: the Minister might be uninterested in the wine trade, wine diseases might be due solely to chemical phenomena, the 2500F might never materialize, or Pasteur could change his research project. Those things composed and linked by the translation operation might disperse themselves like a flight of birds. This is precisely the possibility we must predict if we want to explain and produce some evaluations. And how else could we do this, since we no longer have an external referent, except by submitting Pasteur's version of the goals and desires of all the human and non-human actors to a *test* by *comparing* them with the goals and desires they give themselves or attribute to Pasteur? Indeed, nothing guarantees that the operation proposed by Pasteur corresponds to the version held by the actants named Minister, chemistry, cryptogamic plant, England, or ferment. In order to measure the potential success or failure of the translation operations – relative, of course, to an enunciator and to an observer – we must verify whether or not they occupy the position expected by Pasteur. The durability of Pasteur's position is not to be explained by his power, but only by the convergence between what he expects others to do and what others expect him to do. It is this negotiation process that is always forgotten by those who use already acquired domination to explain future one.

Suppose that we notice through further interviews and documents that as far as the Minister is concerned, the problem of balancing payments has nothing to do with wine and its diseases. His problem lies with silk, whose trade is hampered by Japan. As for the chemists, they certainly do not occupy the position predicted by Pasteur. Their tragedy has nothing to do with the fact that their discipline is out of date; on the contrary, they are concerned about the dramatic return to vitalism, which is slowing down progress in chemistry. In fact, Pasteur and his fermentations figure prominently in their anti-programs! And finally, the ferments: they're beginning to die from lack of air, thereby annihilating Pasteur's efforts to cultivate them. By comparing what Pasteur says the others want and what the others say they want, we can easily imagine that Pasteur might have a few problems in getting his funds, because those mobilized in his version *do not occupy* the position he assigned them, at least, not yet. Such a comparison would show the actants' state of alignment or dispersion and would help predicting the complexity of future negotiations.

This example shows us that it is not merely statements which vary as a function of innovations. Both also vary *as a function of the perspective* of the observer or of the informant.

Until now, the starting points of all the narratives have remained stable. We told the story of the hotel keys from the manager's perspective, and we told the Kodak story from the perspective of Eastman and Jenkins. Yet a program's capability to counter an anti-program obviously depends on how well an actor's conception of others corresponds to their conceptions of themselves or of the said actor. If this convergence is weak, the actor will populate his world with other beings; but these beings will behave in an unpredictable fashion, attaching or detaching themselves to the program from version to version. If, on the other hand, this convergence is strong, the actor can begin to make predictions – or, in any case, to guarantee the consistent behaviour of the beings constituting his world.

We thus have to do more than follow the sequence of events surrounding an innovation: we should *compare the different versions* given by *successive* informants of the 'same' syntagm. We do not have an outside referee to test the credibility of a claim. The degree of alignment or dispersion of the accounts will be enough to evaluate the reality of a claim. Consider a sentence often cited by language philosophers: 'the present king of France is bald'. This sentence has launched endless discussion in the philosophy of language, because it is both grammatically correct and completely devoid of meaning, as it does not 'correspond' to any real state of affairs. It is said that this sentence has a signified but no referent. Can we evaluate the credibility of this sentence without having to take refuge in the notion of referent? If we are able to shift the observer's point of view and to keep track of it, it is possible.

Historians know Charles the Bald, but not the present king of France. Hairdressers know a few bald people, but no kings, not to mention kings of France; they do, however, hold scalps, creams, and hair lotions close to their hearts. Much is presently happening in Berlin and in Cambodia, but none of it has anything to do with the king of France. There are indeed people who run France, but they call themselves Presidents, and not kings. The only people who take this sentence into consideration are linguists and philosophers, who use it as a cliché! Based on this script, we could calculate the degree of convergence or of divergence between the actors mobilized by the sentence *and what the actors say about themselves when questioned*. In the present case, none of the actors who have been mobilized can take up the statement without adding other, completely disparate statements. There are thus very few allies and many new actors, except in the last version. For the only version that adopts this sentence unproblematically is that of philosophers, who stabilize it by turning it into a classic puzzle in the philosophy of language.

This classic example allows us to loop network analysis back on itself. There is never any need to leave our networks, even if we are talking about defining the truth, the exactitude, the coherence, the absurdity, or the reality of a statement. The judgement of reality is immanent in, and not transcendant to, the path of a statement. To put this the other way around, forbidding oneself to exit a network does not entail forbidding oneself to judge. In this example, we can correctly judge the degree of truth of the statement 'the present king of France is bald' without ever appealing to the notion of referent; in fact, this notion is the only mythical element in the whole bald king story. Indeed, all statements have a reality, and this reality can be evaluated precisely by comparing, each time, what an actor says about another actor with what this other actor says about itself. This comparison delineates a network which is both the existence and the essence of the statement. Unicorns, bald kings of France, black holes, flying saucers, appearances of the Virgin, chromosomes, atoms, Roger Rabbit, and utopian technological projects all possess, without excess or residue, the degree of realism delineated by their networks. This point is not relativist: all statements are not equal. It is relationist: showing the relationships between the points of view held by mobilized and by mobilizing actors gives judgements as fine a degree of precision as one could wish for. The philosophy of language, science, or technology do not know how to reconstruct or calculate these judgements with any finesse (Pavel 1986); they are content with coarse, hasty judgements on the manifest absurdity or the inevitable reality of such and such a statement or project.

Conclusion

If we abandon the divide between material infrastructure on the one hand and social superstructure on the other, a much larger dose of relativism is possible. Unlike scholars who treat power and domination with special tools, we do not have to start from stable actors, from stable statements, from a stable repertoire of beliefs and interests, nor even from a stable observer. And still, we regain the durability of social assemblage, but it is shared with the non-humans thus mobilised. When actors and points of view are aligned, then we enter a stable definition of society that looks like domination. When actors are unstable and the observers' points of view shift endlessly we are entering a highly unstable and negotiated situation in which domination is not yet exerted. The analyst's tools, however, do not have to be modified and the gradient that discriminates between more and less stable assemblages does not correspond in the least to the divide between technology and society. It is as if we might call technology the moment when social assemblages gain stability by aligning actors and observers. Society and technology are not two ontologically distinct entities but more like phases of the same essential action.

By replacing those two arbitrary divisions with syntagm and paradigm, we may draw a few more methodological conclusions. The *description* of socio-technical networks is often opposed to their *explanation*, which is supposed to come afterwards. Critics of the sociology of science and technology often suggest that even the most meticulous description of a case-study would not suffice to give an explanation of its development. This kind of criticism borrows from epistemology the difference between the empirical and the theoretical, between 'how' and 'why', between stamp-collecting – a contemptible occupation – and the search for causality – the only activity worthy of attention. Yet nothing proves that this kind of distinction is necessary. If we display a socio-technical network – defining trajectories by actants' association and substitution, defining actants by all the trajectories in which they enter, by following translations and, finally, by varying the observer's point of view – we have no need to look for any additional causes. The explanation emerges once the description is saturated. We can certainly continue to follow actants, innovations, and translation operations through *other networks*, but we will never find ourselves forced to abandon the task of description to take up that of explanation. The impression that one can sometimes offer in the social sciences an explanation similar to those of the exact sciences is due precisely to the stabilization of networks, a stabilization that the notion of explanation simply does not 'explain'! Explanation, as the name indicates, is to deploy, to explicate. There is no need to go searching for mysterious or global causes outside networks. If something is missing it is because the description is not complete. Period. Conversely, if one is capable of explaining effects of causes, it is because a stabilized network is already in place.

Our second conclusion relates to relativism and the heterogeneity of networks. Criticisms of studies of controversy insist on the local, soft, and inconsistent nature of the results. They have the impression that network analysis recreates 'that night when all the cows are grey' ridiculed by Hegel. Yet networks analysis tends to lead us in exactly the opposite direction. To eliminate the great divides between science/society, technology/science, macro/micro, economics/research, humans/non-humans, and rational/irrational is not to immerse ourselves in relativism and indifferentiation. Networks are not amorphous. They are highly differentiated, but their differences are fine, circumstantial, and small; thus requiring new tools and concepts. Instead of 'sinking into relativism' it is relatively easy to float upon it.

Finally, we are left with the accusation of immorality, apoliticism, or moral relativism. But this accusation makes no more sense than the first two. Refusing to explain the closure of a controversy by its consequences does not mean that we are indifferent to the possibility of judgement, but only that we refuse to accept judgements that transcend the situation. For network analysis does not prevent judgement any more than it prevents differentiation. Efficiency, truth, profitability, and interest are simply properties of networks, not of statements. Domination is an effect not a cause. In order to make a diagnosis or a decision about the absurdity, the danger, the amorality, or the unrealism of an innovation, one must first describe the network. If the capability of making judgements gives up its vain appeals to transcendance, it loses none of its acuity.

Notes

Translated by Gabrielle Hecht, revised by the author and corrected again by John Law. Part of this article has appeared in French in Vinck, D., ed., (1991), *La Gestion de la recherche*, Bruxelles: De Boeck.

1 I take the story as essentially correct since I simply want to show how such a narrative may help social theory in integrating technology to its canonical questions. When a version reuses a former one simply adding to it the number of the black-boxed version is included in bold. The symbol -//- points out the dividing line between programs and anti-programs (from the point of view of Eastman). For all the coding problems see Latour, Mauguin and Teil (in press).
2 This division of labour is not a weakness of economics or sociology. It is simply linked to the problem of controlling large amounts of things: an object's ability to recruit large numbers of either masses or markets in a predictable manner depends on the stability of both the object and its network.

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• *ABSTRACT*

This paper reports on an attempt to create a new research tool, to follow the dynamics of science and technology. 'Socio-Technical Analysis' develops new quantitative indicators and graphic representations with which to map the development of a scientific controversy, or a technical innovation. The aim of the paper is to describe this approach, to stimulate reflexion and criticism, and to launch what can only be a collective project.

A Note on Socio-Technical Graphs

Bruno Latour, Philippe Mauguin and Geneviève Teil

We wish to report on an attempt to create a visual and conceptual space that might be of some use to scholars in the STS community, and to those of us engaged in teaching scientists and engineers. The aim of this Note is to stimulate reflection, to provoke criticism, and to exchange software and data in what can only be a collective project.[1]

In order to map the development of a scientific controversy or of a technical innovation, the STS field has learned to doubt the dichotomy between nature, on the one hand, and society, on the other.[2] It is not clear, however, what other narrative resources could replace the convenient alternation of 'not only . . . but also' ('not only social factors but also objective ones'; 'not only technical constraints but also political factors'). Alternative narratives have been developed under the heading 'actor–network theory' that stress the heterogeneity and variability of associations of human and non-humans.[3] Unfortunately, they are themselves made difficult to grasp because of the alternation between a social interpretation, that seems to reduce the content of science to a purely strategic show of force where might makes right, and a naturalistic interpretation that appears to grant back to non-humans the unproblematic presence of nature.[4] It appeared to us that it would be of some advantage to

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replace the distinction between nature and society by another set of distinctions that would cut across the first, and thus would render it difficult (or even impossible) to fall back on the previous debates. Hence the idea of socio-technical graphs (STG), that we are developing for pedagogical as well as for analytical purposes.

Mapping Scientific Controversies

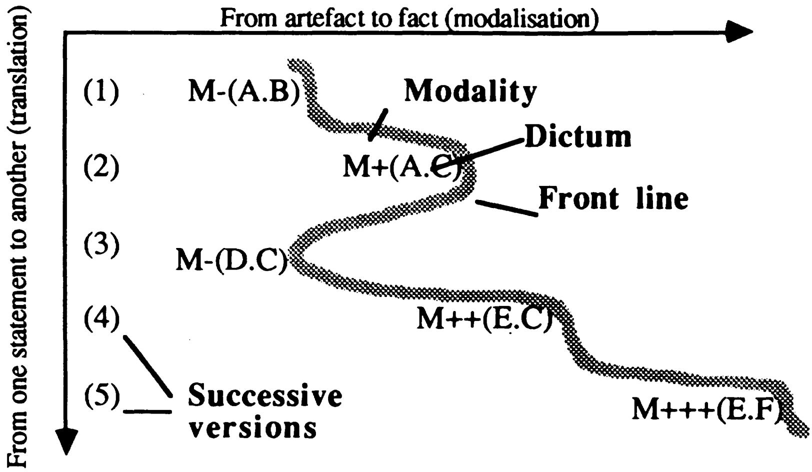
The principle of the STG is derived from earlier work by one of us on the mapping of scientific controversies. It has been shown that the trajectory of any statement may be mapped in two dimensions: the modalization made by others of the dictum, and the modification of this dictum.[5] The first dimension is an indication of the number of people convinced by a given statement — modalities going from extreme criticism to tacit acceptance — while the second dimension defines the amount of transformation that a statement undergoes, either by becoming a new statement, or by being associated with new elements. One of the results of studying controversies with those mappings is that it is impossible to move along the first dimension — modalization — without a deep transformation of the statement. This relative impossibility thus defines a front line — roughly equivalent to the frontier of science — that can be taken as the unique signature of a given controversy. It is this mapping that allowed us in the past to show the irrelevance of internalist explanations of science (where a statement is said to be accepted by its own internal virtue), and of externalist or consensual explanations (where a statement is said to be believed without the transformation of those who accept it, or of what is accepted). Instead, this mapping allowed us to define a statement as a series of transformations — or translations — undergone by a collective of people and things.[6] Any given statement thus becomes, not a point fixed in time and space, but a specific exploration of a socio-technical space: what is held together by whom, and who is held together by what?

Paradigms and Syntagms

The principle of the STG is a generalization and an operationalization of the study of scientific controversies.

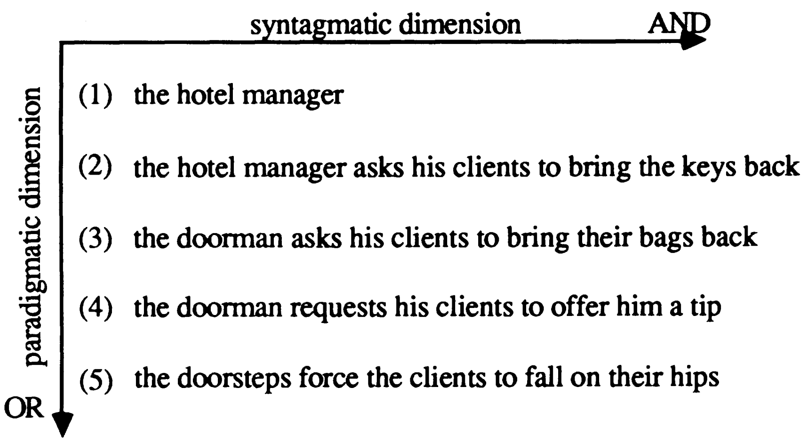
The first task is to make more precise the definition of the two

FIGURE 1



Successive versions of the transformation of a dictum and of its modalities (the signs − and + as well as the position indicating the degree of rejection or acceptance). The point of this diagram is to show that the dictum accepted at version (5) is deeply different from the initial statement (1).

FIGURE 2



A succession of sentences may be defined either because they add new meaningful units to a sentence (AND) or because they substitute new alternative words (OR) to one or several units inside a sentence.

dimensions which will be used as the 'latitude' and 'longitude' for the mapping process. Linguistics offers two useful definitions. It is traditional in the exploration of a linguistic structure to distinguish the 'syntagmatic' dimension from the 'paradigmatic' one.[7] A 'syntagm' is a set of different units that may be added in a sentence while still being meaningful. A 'paradigm' (no relation to Kuhn's meaning) is the set of different units that may replace a unit in a syntagm without rendering the sentence meaningless. For instance the following set of sentences explores the syntagmatic dimension:

the hotel manager
the hotel manager asks his clients
the hotel manager asks his clients to bring their keys back
the hotel manager asks his clients to bring their keys back to the front desk

while this set explores the paradigmatic dimension:

the hotel manager ask his clients to bring their keys back
their bags
their towels
their maps

The first (syntagmatic) dimension defines how many different elements may be held together in a meaningful assemblage, while the second (paradigmatic) dimension defines the meaningful substitutions that may be done at each point along the syntagm. The first dimension defines *association*, and the second *substitution* — or, still more synthetically, AND and OR.

An exploration of a locutor struggling for a sentence through the syntagmatic and the paradigmatic dimensions of language may be mapped on to a diagram (Figure 2) that resembles that of Figure 1.

Unfortunately, the narrative of a scientific controversy or of a technical innovation is different from the exploration of a linguistic structure in one crucial aspect. For each language, there exists a more or less fixed structure that endows each locutor with the basic competence to judge what is a meaningless association or substitution. The sentence 'the hotel manager beats his clients to bring their keys back' would be considered pragmatically meaningless, while the sentence 'the hotel manager eats its clients to bring us key back' would be deemed grammatically incorrect. No such grammar is available to decide whether a transformation of a scientific statement is possible or impossible, since research and innovation aims at circumventing the pre-existing limits of any given pragmatics.

Not only is there no deep, stable, *a priori* structure to evaluate the meaningfulness of a given association or substitution in the narratives of an innovation,[8] but the very definition of units is in debate, and so are the various points of view of the many locutors. This is precisely the reason why we all study controversies and innovation — that is, science in action. While we may retain the two dimensions AND and OR that extend earlier work on controversies, we have to devise an additional set of specific mapping principles in order to cope with the peculiar difficulties of our field.

Specifications of the Socio-Technical Graphs

As usual, it is easier to define the minimal constraints of the STG than to devise the specific visualizations and software that will implement them.

A good mapping of the trajectory of a statement should respect the following specifications.

— The mapping will always start from a narrative that will be appropriated from other sources (historians' accounts, interviews, printed documents, databanks); it will never be more than a re-representation in graphic form of an already existing text,[9] and so will never be more concrete, more accurate, more complete than the narrative it sums up.

— The aim of this mapping, like that of any other instrument, is to get rid of most of the initial information, while outlining the features that are deemed relevant to our enquiry.[10]

— The aim is not to compete with what the 'thick narrative' of an historian or of an ethnographer of technology could provide, but to offer a quick and easy comparative basis for many narratives coming from many sources.

— The mapping will not re-employ any element coming from the society/nature dichotomy (for instance the human/nonhuman divide). We should never have to presume the stability of either the objects (internalism) or the subjects (externalism); a trajectory is to be defined only by association and substitution of a set of units.

— The mapping will be focused on outlining the specific phenomena of our field: heterogeneity of the alliances, local character, variations of scale, continuous drifts of the projects and statements, black-boxing and stabilization, sudden reversals of forces.

— The units should not be defined by their essence, but only by their action; they have to be variable, and they should be defined only by the trajectories in which they are engaged. In other words, trajectories and units should be cross-defined.

— The mapping should be observer-dependent, allowing a quick and easy comparison of diverse and sometimes contradictory accounts of the trajectories and of the units.

— The shift between accounts should remain possible by comparing their degree of dispersion or alignment, and not by having to choose one over another.

— The visual displays should be optically coherent, so that the representation is readable in a space where all or most of the geometrical features are rendered meaningful. Once the minimum training to read the map and the conventions is obtained, there should be no added idiosyncratic features that could limit the inspection and the comparison between researchers, or between case studies.

— Finally, the whole procedure should be capable of implementation on one of the existing software programs, and be usable for research as well as for teaching purposes.[11]

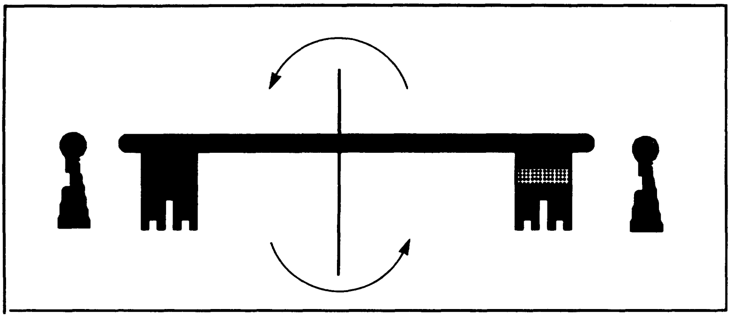
There are no doubt many different ways to fulfil these specifications for STG. We want to describe one family of such graphs that will certainly be replaced by many more sophisticated tools in the near future.

Recoding a Simple Narrative

Let us choose a very simple example of a narrative to show how it could work.

Name of the project: Berliner Key[12]
Name of the locutor: Bernhard
Text to be encoded: 'Since asking tenants of a cooperative building to relock front doors behind them at night did not seem sufficient to be obeyed, the Berliner Homeowner Association printed signs 'Please relock the doors behind you at night' to be put out by the janitors; when that failed as well, they then decided to install a new lock with such a strange mechanism that the tenants could not get their key back without relocking the door behind them. When that was done they extracted

FIGURE 3
The Berliner Key



compliance from most tenants who now dutifully relock the doors in order to get their key back.'

This narrative, told from one point of view — Bernhard's — outlines a (micro)controversy between two groups (the Berliner Homeowner Association and the Tenants) that goes through a series of successive transformations (verbal injunctions, printed signs, new mechanism) to a point where the association's initial goal appears to be reached by enrolling the undisciplined tenants.

The question for STG is not to evaluate the credibility or realism of such a story, but only to see how it could be coded into a graph that would retain some of its relevant features for following an innovation.[13]

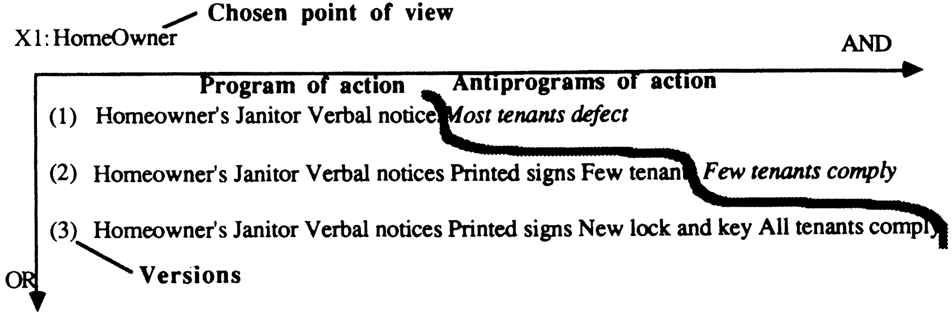
The chosen point of view — not necessarily the same as that of the narrator — is denoted X1, X2, and so on.

A first syntagm is defined by an association of units. Each of those units is considered as an actant, and a specific file is opened for each of those actants when they enter a syntagm (see below).[14]

A syntagm is defined only by associations of actants, with no attempt at qualifying the relations between units. That they are associated together or not is the only piece of information retained.[15]

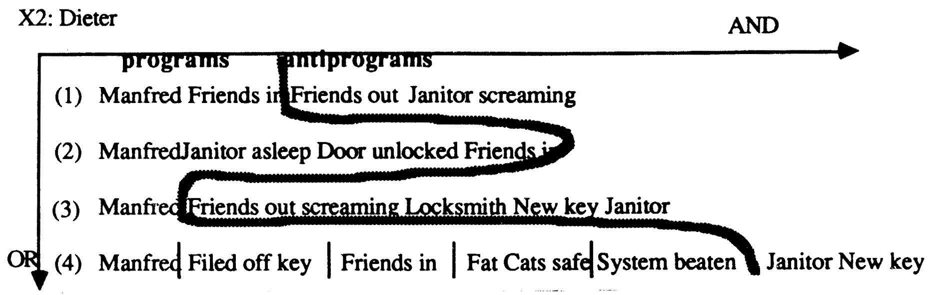
Each syntagm is reconstructed into two branches: the programme of actions that associate the allies; and the antiprogrammes that gather the opponents.[16] The definition of what counts as an anti-

FIGURE 4



The diagram extracts a set of words, divides them into programme and antiprogrammes, and lists from one version to the next those who appear, who disappear and who shift from one side of the front line to the other.

FIGURE 5



Same diagram as in Figure 4, but with a narrative that modifies the point of view, the actants and the shifting frontier of allies and enemies.

programme depends on the choice of a point of view. If the story above is told from the tenants' side, the programme of action will be 'to remain free to let friends go in and out at night without bothering to relock the front door'. The boundary line between programmes and antiprogrammes defines the front line the evolution of which we want to be able to trace.

The first syntagm is then modified in only two ways so as to obtain the next version — coded (2), (3), and so on: either a new element is added to the syntagm, or one of the old elements is replaced by another one. As long as there is no information to tell us that an actant has left a syntagm, it is repeated from one version to the next.

When a series of actants stay together through successive versions without defecting, they may be aggregated in a black-box and given either a new name or the name of one of the actants.[17] It is important, however, to be able to reopen the black-box and to redistribute its components if necessary. At the beginning of a narrative, each actant is a black-box that we will learn to reopen (or not) only later, when comparing accounts.

Once this recoding is done, the story is limited to its bare outline and encapsulated in one diagram. The evolving drama of the story is, however, retained: every time the Homeowner Association adds a new element, they extract more compliance from the Tenants. With the invention of the new Berliner key they make the Tenants shift from the antiprogrammes to their programmes (see Figure 4).

Simple tests may be done visually to see which actant is stable, which one is reliable, which one induces deep modifications when added, and which one is insignificant (see below). Although relations can no longer be qualified — since grammar is reduced to semantics — it is still possible to obtain very primitive association rules such as: for observer X1, at version (3), when the actant 'New lock and key' is introduced, then 'Tenants' go from programme to antiprogramme, provided the other actants of version (2) remain present. This tells us something about the compatibility and incompatibility of tenants, keys, homeowners, janitors and printed warning. We lose most of the information given in the narrative, but we preserve the feature that interests us most: when an ally defects or is made reliable.

Circulating through Contradictory Accounts

However, since there exists no structure of science and technology that could tell us *a priori* which are the accounts that are meaningful and which ones meaningless, it is essential for us to be able to compare contradictory accounts. It is also the only way to repair the danger of giving a functionalist account of programmes and antiprogrammes. What is dangerous in a functionalist argument is not the function *per se*, but the essentialism that goes with it, and the avoidance of controversies about what counts as a function. In other words, relativism should redeem the sins of functionalism. This is why it is so essential to be able easily to shift points of view.

> Name of the project: Berliner Key
> Name of the locutor: Manfred
> Text to be encoded: 'It is a pain in the neck not to be able to let friends in and out of our rooms at night. The janitor is always there to relock the door and our friends have to scream to be heard from the street. Before, we could go down and leave the door unlocked when the janitor was asleep. But the bloody locksmith invented his new key and we were forced to relock it. No problem for me. I filed off my key and I do not have to relock it! And the Fat Cats believe they are safe . . . In alternative Berlin we know how to beat the System.'

For this new account, it is possible to draw another diagram of the same type as the former one (see Figure 5).

This is a rather different story. Only the Locksmith and the New key are the same as in the former one, but, since they are not associated within the same syntagm by the two observers X1 and X2, they are not exactly the same.[18] The Janitor appears in the two stories, but is modified in the second since *it* now has the additional property of being asleep! To the New key is added a crucial ingredient that reverses the previous state of associations: the File. As for the disciplined tenants of the first story, they have become one clever tenant, Manfred, who beats the System. The Homeowner Association is not mentioned in the second story, but another actant appears that might be a synonym: the Fat Cats.[19]

Tests may now be made in order to decide the degree of dispersion of the two accounts. If we superimpose version (3) of account X1 and version (4) of version X2 (the sign '//' designating the front line between allies and opponents), we may obtain results such as this:

> X1 (3) Homeowner's *Janitor* Verbal notices Printed signs *New lock & key* All tenants comply//
>
> X2 (4) Manfred Filed off key Friends in Fat Cats safe System beaten//*Janitor New lock & key*

FIGURE 6

Card number : 1
Name of actant Janitor

Observer	N°	Version
X1	(1)	Janitor Homeowners Verbal notices//Most tenants defects
...	...	...
X2	(2)	Janitor asleep Dieter Door unlocked Friends in
...	...	...

An actant is equivalent to the list of the actions in which it is engaged in the various accounts. If the actant gains coherence and solidity it may be granted an essence in addition to its existence. A substance is thus added to its qualities. Then, it is endowed with humanity or non-humanity. But each of these operations is reversible and should be documented.

If the two accounts were aligned, it would mean that whenever an actant is cited in one narrative it is inserted in the same syntagm in the other. If two accounts were totally divergent, it would mean that no two actants are the same, or that they are engaged in completely different syntagms. Because of the principle of symmetry, it is crucial for our goal to have the same visualizing devices for convergent and divergent accounts.[20] The analyst should never have to decide *a priori* if there is a unity in the story he or she is telling (apart from being studied by the same analyst, and to have the same code name — for instance, here to be part of the 'Berliner Key' project).[21]

Going from Trajectories to Actants and Back

The same relativism should be maintained for the very definition of the actants. According to the specification above, we do not know what an actant is, apart from the fact that it is mobilized in one version of one narrative viewed from the point of view of one observer. At the beginning an actant is nothing but a word in a text, a label. If for each actant named in a story we open a card, this card will then be incremented by the various entries alluding to this actant in all the various accounts. Who for instance is the 'Janitor'? We know strictly nothing about this actant, except that the card that bears its name will read like Figure 6.

An actant is defined by all the syntagms in which it is successively engaged, exactly as a syntagm is defined by all the actants it associates. But, in the same way that it is possible to compare the degree of convergence or dispersion of two accounts, it is possible to compare the relative coherence or incoherence of an actant. If, in all the successive versions, or in all the accounts, the same actant's name is associated with the same syntagm, then we can consider it as a predictable entity, or as a black-box. If, on the contrary, no two accounts offer the same syntagm for the same name, then we will have to consider it as an unreliable actor. Between those two extremes, variations are more interesting. An actant may gain predictability from one version to the next, or from one account to the next, or it can lose predictability. It is essential to record this variable geometry of the actant, since it is one of the main discoveries of science studies.[22] The Tenants, for instance, vary from one version to the next in the first account, and vary again when we go from 'All the tenants comply according to X1' to 'Manfred defects and beats the System according to X2'. If our visualization does not allow us to follow the moving shape of actants which are endowed with variable scale, motives, interests and definitions, and which can become stable or unstable, it will not be usable for tracing the trajectories of innovations or of controversies.

One point deserves to be underlined again: it should be clear from the definition of an actant that exactly the same principles apply for the word 'file' in the second story, although a file is considered a thing. We learn something on *what is* a file when we see that its association in version (4) completely transforms the situation — according to Manfred:

> X2 (3) Manfred//Friends out screaming Locksmith New key
> X2 (4) Manfred *Filed off key* Friends in Fat Cats safe System beaten//*Janitor New lock & key*

The essence of a file is modified by this narrative; that is, the card 'File' is implemented with a new syntagm that makes it able to modify the state of the relations between Fat Cats and Tenants in Berlin. Since an actant is only what it does, there is no other way to modify the essence than by modifying the action inside the card. This modification introduced by X2 may be small compared to all the other accounts in which 'a file' is used unproblematically. But we know from our work in science studies that such is not always the case. The interpretative flexibility of a thing may be as great as that of an individual or of a social group like that of the Tenants above.[23] It is essential to apply the same test of coherence or incoherence to the cards that designate non-humans, as to those which designate collective beings or individual humans. The *isotopy*, as semioticians say[24] — the stability in space and time of an actant in a narrative — should not be taken for granted, but obtained by what the various stories make of it. In principle, a non-human like a 'file' is no more and no less flexible than a collective person like 'Homeowner Association', or an individual like 'Manfred'. More exactly, the many differences between them should not be defined *a priori*, but should emerge from the chains of associations making up their definition.[25]

Does this mean that might makes right? An anonymous referee made what appears to be a cogent criticism of the 'simple-minded counting of actants', by citing the following example:

> In developing his telephone for Western Union in 1877, Thomas Edison incorporated far *more* technical elements in his design than Alexander Graham Bell, and Western Union was able to utilize its *larger* existing network to introduce *more* of Edison's telephones faster than its *tiny* rival American Bell. Yet American Bell *prevailed* and *forced* Western Union and Edison to cede the US telephone to them. Why? Not because American Bell had *more* telephones, capital, or enrolled actors but because Bell and his backers were able to assemble a *small* but *unassailable* set of patents covering the telephone. In network terms, American Bell prevailed over the powerful Western Union not through the *number of actors* but by bonding *several key* non-human actors together.[26] (our emphasis)

It is precisely because we do not know the force of any given actor that we have to be completely agnostic in allocating their definition. In this story, a well defined patent is stronger than capital and techniques, because it allows the weak Bell to tie himself to the whole legal system of the United States. As the words we have emphasized indicate well enough, there is always a metrology at work in the accounts of those who critique the slogan 'might makes right' — a metrology which is always, in the last instance, some sort of 'simple-minded counting of actants' ('prevailed', 'forced', 'unassailable', 'key non-humans'). The goal of STG is to push the analysts to be explicit about this metrology that allows them to say, as in the case of Bell's patents, that right makes might, that right is thus *stronger* than might. It is this very variation of scale that we want to be able to document, whereby a tiny actor becomes stronger than the strong, but without believing in some *a priori* definition of who or what is strong and who or what is weak.

Implementing the STG on Hypercard

In this presentation of STG, we have defined two forms of *cards* and three types of indicators or tests.[27]

There are two types of cards:

— One that summarizes the shifting trajectories of associations and substitutions considered by various observers (the Project card according to X).
— Another that recapitulates the actants' varying definitions (the Actant card).

There is no essential difference between them except that, in the first case, we follow the transformations of a syntagm through the substitutions of each of its components, while in the second we follow one component through all the syntagms in which it is engaged. It is like shifting from the study of sentences to that of words.

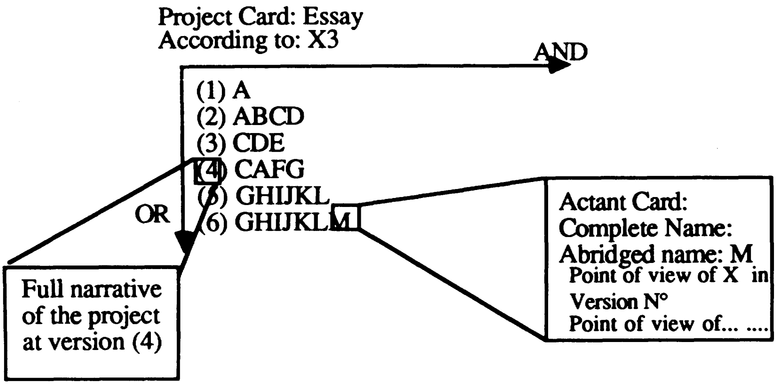
In addition, we have indicated the necessity of having three types of *indicators*:

— A first group of tests should analyze the path of one trajectory (Evolution Indicators).
— A second group should analyze the dispersion or alignment of various accounts of the same trajectory and thus decide, among other things, how much it is 'the same' (Observer Indicators).
— The third group will provide us with the degree of coherence or incoherence of a given actant, and thus determine its relative stability (Isotopy Indicators).

Although the name and application of these tests are different, they are all similar in their principles, since they compare chains of associations and substitutions. We have implemented these two cards, and are implementing these three types of tests, on Hypercard in order to check the feasibility of the specifications above. To keep this Note short, we will limit the presentation to a few of those indicators.

In trying to present the outline of our mapping, we run into a difficulty due to the difference between a Hypercard medium and a text. Texts oblige one to choose between the detailed narrative and its simplified and abstracted version, whereas hypertexts allow one to circulate very fast between an abstracted version and the detailed narrative from which it originates. Thus the bare outline that follows

FIGURE 7



Each actant is both a letter of the alphabet chosen according to its ranks of entry into the story (told by observer X3) and a Hypercard 'button' that allows one to go back to the Actant card that lists all its 'actions'. It is possible by clicking on the 'button' version to go back to the initial narrative. (Cards may also include texts, pictures, films.)

will appear abstract, since the actants will be reduced to numbers, but if the readers can 'click' on each of those numbers transformed into 'buttons', they will get back to the narrative, and will get a more concrete feeling for what we are after.

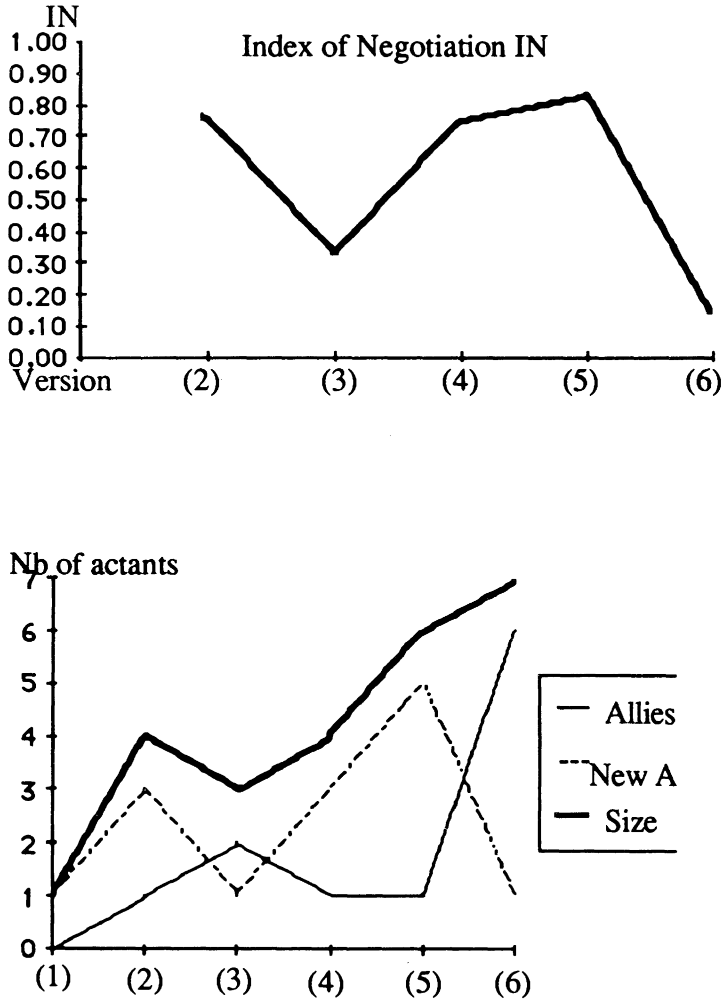
Let us replace actors' names by letters of the alphabet, and let us eliminate, for the sake of simplicity, the actors who make up the anti-programmes.[28] Then the narrative takes the following shape. We choose here an imaginary example that includes one exemplary moment of renegotiation — version (3) — in between two moments of persuasion — (1) to (2) and (4) to (6) — and arrive at Figure 7.

Calculating the Indicators

Such a diagram makes it possible to calculate a number of indicators, which should help in evaluating the unique signatures of a trajectory and in comparing projects and accounts.

Which are the most interesting Evolution Indicators for following one given innovation? The first one is obviously the indicator S for

FIGURE 8



Signatures of a trajectory of associations and substitutions on the same case. Those indicators simply aim at directing attention to the versions where interesting renegotiation seems to happen.

Size, which gives the number of associated elements in each successive version. The second indicator of interest to us is the one that compares the number of elements maintained from one version to the next: we will call it A for Allies. We shall call the new actors recruited in moving from one version to another N for New actors. For each version, identified by a subscript n, we thus obtain:

$$S_{(n)} = A_{(n)} + N_{(n)}$$

(Note that, for the moment, the 'seniority' of an actor is relative only to the transformations that occur from one version to the next. Thus a 'lost' actor that gets recruited a second time counts as a new actor — see Appendix.)

Thanks to these first few indicators we can define an Index of Negotiation, IN:

$$IN_{(n)} = N_{(n)} / S_{(n)}$$

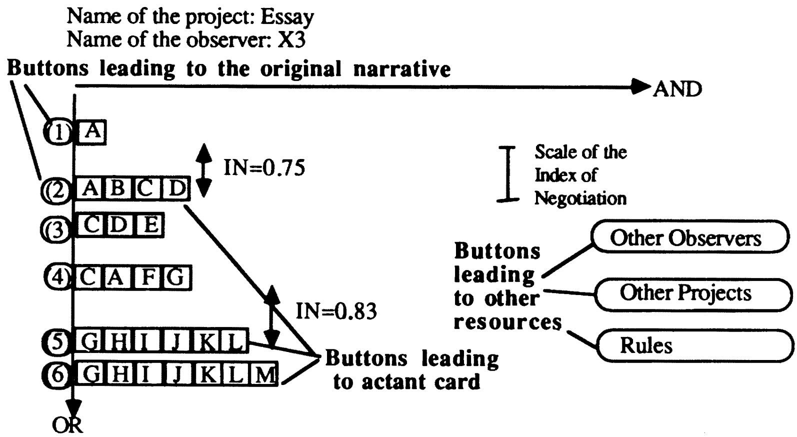
The smaller the value of this index, the less the innovator has to negotiate to maintain his or her project in existence. Conversely, a high value of this index means that the project has to be extensively renegotiated. For our imaginary example, we obtain the following numbers:

	S (Size)	A (Allies)	N (New actors)	IN (Negotiation)
(1)	1	–	–	–
(2)	4	1	3	0.75
(3)	3	2	1	0.33
(4)	4	1	3	0.75
(5)	6	1	5	0.83
(6)	7	6	1	0.14

If we now draw the graph of our first three indicators, we obtain a series of curves (Figure 8) which are specific for the innovation under examination, and which should help in determining what part of the narrative one may wish to examine in more detail.

By using IN, the index of negotiation, and S, the index of size or of association, we can now recapitulate the path of an innovation and build, with the same 'buttons' as above, the 'Home card' of a project.

FIGURE 9



This is the Socio-Technical Graph properly speaking. It is designed as the Home card of a Hypercard stack. Each button leads to the actant card. Each version button leads to the original narrative (which could be made of graphic or video documents in a pedagogical interface). Each version is spaced from the former one by a distance that reflects the index of negotiation IN.

We will call this map the Socio-Technical Graph of a project: see Figure 9.

Conclusion

Similar indicators may be devised to evaluate the dispersion of accounts and the coherence of actants. If several accounts converge, and if the actants they mobilize have a high degree of coherence, then the degree of predictability of the project increases. At the limit it might even be possible to predict the next move. If, on the contrary, there is a high degree of dispersion among accounts, and if the actants they enrol have no stable definition, the interpretative flexibility will be so great that no prediction will be possible.[29] In either case, the STG is built along the same principles and simply records the shifting shapes of the alliances. Indicators of Evolution, Observer and Isotopy simply help in guiding the reader through the databank, and in highlighting important phases.

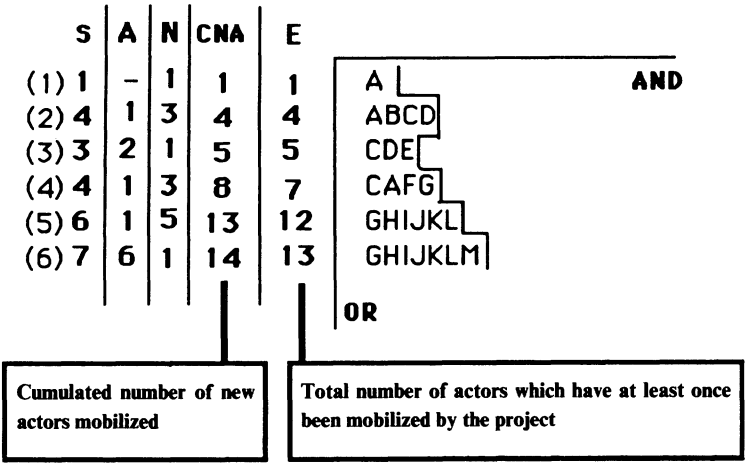
More work is obviously needed to implement the specifications above, to be able to treat, for analytical purposes, large and complex case-studies. Still more work is needed to turn the shell of the STG into an interactive simulator adjusted to the teaching of science students. We welcome discussion of this Note, and collaboration on finding other ways to set up socio-technical graphs.[30]

• *APPENDIX*

It is possible to produce a synthetic characterization of the paths of innovations by defining a few more Evolution Indicators.[31] Until now, we have only compared different versions one by one. It is clear, however, that new actors can be remobilized by a version (n) which had already been mobilized by previous versions. Thus the cumulation of new actors from version to version over a given period can be different from the total number of actors associated with the project during this same period. We will therefore distinguish between Cumulated New Actors, CNA, and the exploration, E, of the project. CNA indicates the variation of the degree of attachment of the actors, while E represents the size of the population of actors mobilized by the project. In the examples above, we obtain E by considering the rank of letters in alphabetical order. E is a synthetic indicator which allows us to distinguish innovations that explore a large number of new actors from those that recombine a small number of potential allies in different configurations. So, for the example above, we obtain Figure A1.

Some projects are strongly attractive. This means that all the new actors which one day participated in the project in a version (n), find themselves associated again in the next version (n + 1). These actors constitute the aggregate of new actors: they are those who move from the index N(n) to the index A(n + 1). Conversely, some of these new actors have disappeared in the (n − 1) version; these are the lost new actors. In order to measure our innovation, we calculate its Yield

FIGURE A1



Index, Y. This index is calculated by dividing [(the cumulative number of the aggregate of new actors) – (the cumulated number of lost new actors)] by the exploration E. The indicator thus obtained measures either the capacity of a project to attach itself to the majority of the actors it mobilizes or, on the contrary, its tendency to visit a large number of new actors without fixing itself anywhere.

$$Y_{(n)} = [(\Sigma\ ANA) - (\Sigma\ LNA)]/E_{(n)}$$

where ANA = aggregate of new actors

and LNA = lost new actors

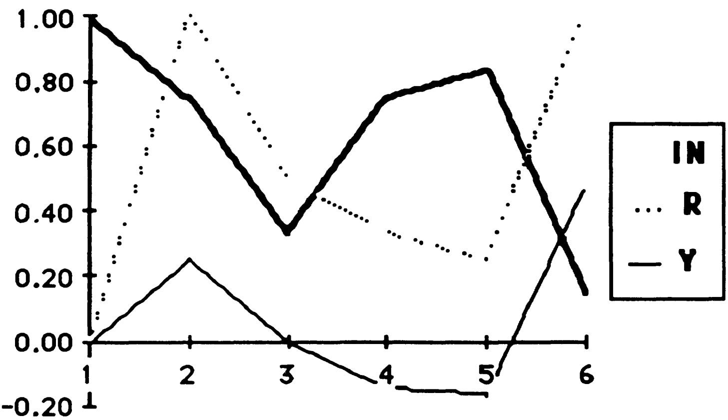
This index takes values between '1' and '– 1'.

A final synthetic index can be obtained by dividing the number of associated elements A which remain stable in a version (n) by the size S of the previous version (n – 1). This index defines the 'reality', R of the project — that is, the 'resistance' it needs to be able to move from one version to the next without putting what it already acquired into question:

$$R(n) = A(n)/S(n - 1)$$

All these indicators allow us to compare trajectories whose size and content are completely dissimilar, and which come from vastly distant empirical sources. For the three indicators of negotiation (IN), reality (R), and yield (Y), we obtain profiles for the above example as presented in Figure A2.

FIGURE A2



Indices of Negotiation (IN), Reality (S), and Yield (Y) for the same example.

• *NOTES*

An earlier draft of this paper has been entirely rewritten to take into account four anonymous referee reports and extended criticisms by Mike Lynch. It has also benefited from an earlier version of Jim Scott's paper (see note 1, below). The Hypercard stack of our preliminary implementation is running on a Macintosh II. Another presentation of those arguments with an extensive historical example may be found in B. Latour, P. Mauguin and G. Teil, 'Une méthode nouvelle de suivi des innovations. Le chromatographe', in D. Vinck (ed.), *La Gestion de la recherche: Nouveaux problèmes, nouveaux outils* (Bruxelles: De Boeck, 1991), 419–80, and B.

Latour, 'Technology is Society Made Durable', in J. Law (ed.), *Technology, Power and the Modern World* (Keele, Staffs.: Sociological Review Monograph, in press). This work has been supported by a grant from the Ministère de la Recherche et de la Technologie and from the Innovation Department of Rhône Poulenc.

1. J.K. Scott, 'Exploring Socio-Technical Analysis: Monsieur Latour is not Joking!', *Social Studies of Science*, Vol. 22, No. 1 (February 1992), 59–80.
2. B. Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987).
3. M. Callon, J. Law and A. Rip (eds), *Mapping the Dynamics of Science and Technology* (London: Macmillan, 1986).
4. See O. Amsterdamska, 'Surely, You Must be Joking, Monsieur Latour! Review of *Science in Action*', *Science, Technology and Human Values*, Vol. 15 (1990), 495–504, for the accusation of sociologism, and H. Collins and S. Yearley, 'Epistemological Chicken', in A. Pickering (ed.), *Science as Practice and Culture* (Chicago, IL: The University of Chicago Press, 1992), for the accusation of naturalism.
5. The dictum is that part of the sentence which is not modified by qualifying it, while the moving part is called modality: see Latour, op. cit. note 2, 60 (the directions of the diagram have been reversed for reasons of consistency), and B. Latour and S. Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 2nd edn 1986).
6. This is the 'first principle' of science studies: see Latour, op. cit. note 2, Chapters 1 and 3.
7. For a classical definition in structural linguistics, see O. Ducrot and T. Todorov (eds), *Dictionnaire encyclopédique des sciences du langage* (Paris: Le Seuil, 1972).
8. There are two definitions of a technical system. The first one, by B. Gille (ed.), *Histoire des Techniques* (Paris: Encyclopédie de la Pleïade, 1978), could be assimilated to a linguistic structure, but has never been demonstrated. The second one has been demonstrated by T.P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, MD: Johns Hopkins University Press, 1983), but the structural effects are the results of the system builders' actions, not their cause. In neither case can the linguistic metaphor be implemented.
9. This is a limit of all second degree scientific instruments. An STG can be as good as a narrative, but not better. It is not acceptable criticism of a graph to allude to the dubious quality of the narratives it encodes.
10. One anonymous referee 'vehemently disagreed' with this wording, but offers another that is, in our view, strictly equivalent: 'maps should be used to get control of as much data as possible and to use this data to identify the key features'. Since a map is never a territory, as the saying goes, simplification is a necessary feature of instruments: see S.L. Star, 'Simplification in Scientific Work: An Example from Neuroscience Research', *Social Studies of Science*, Vol. 13 (1983), 205–28, and Star and J. Griesemer, 'Institutional Ecology, "Translations" and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907– 39', *Social Studies of Science*, Vol. 19 (1989), 387–420. For a bibliography, see B. Latour, 'Drawing Things Together', in M. Lynch and S. Woolgar (eds), *Representation in Scientific Practice* (Cambridge, MA: MIT Press, 1990), 19–68, and the other articles in this excellent collection. See also J. Law and G. Fyfe (eds), *Picturing Power: Visual Depictions and Social Relations* (Keele, Staffs.: Sociological Review Monographs, 1988).

11. Those of us who teach scientists and engineers badly need a simulator that would allow students to relearn the lessons of the many case studies studied by our field. The management games used in business school are ill adjusted to our teaching requirements, since the scientific information and the technical constraints played out in those games are not renegotiable. To enter many different case studies in a simulator, a common 'shell' has to be devised. We take STGs to be one small step in this direction.

12. For a more complete story, see B. Latour, 'Inscrire dans la nature des choses ou la clef berlinoise', *Alliage*, Vol. 6 (1991), 4–16.

13. We have been working for many years on a coding system that would automate the extraction of key words from a text. STGs may be fed either manually (as is the case here) or automatically by using the clusters obtained through Leximappe™ (see op. cit. note 3) and Candide™ (see G. Teil, *Une station de travail pour la sociologie des sciences [A Workstation for Bibliometric Studies in Sociology of Science]*, Thèse de Doctorat, ENSMP, Paris, 1991).

14. Actant means both 'action' and 'behaviour'. This term from semiotics is useful in spite of the criticisms (op. cit. note 4) because it does not oblige us to discriminate between humans and non-humans, and because it defines an entity only by the list of actions in which it is engaged.

15. Although this decision might seem arbitrary, there are ways to justify this reduction of grammar to semantics (see Teil, op. cit. note 13).

16. An 'antiprogramme' is every plan that is said to oppose a given plan. Like the word 'actant', it is a term from semiotics: see M. Akrich, 'Comment décrire les objets techniques', *Technique et culture*, Vol. 5 (1987), 49–63, and B. Latour, 'Where are the Missing Masses, Sociology of a Few Mundane Artefacts', in W. Bijker and J. Law (eds), *Shaping Technology—Building Society: Studies in Sociotechnical Change* (Cambridge, MA: MIT Press, forthcoming).

17. See Teil, op. cit. note 13.

18. The difference and the identity of any actant and of any project is defined, not by itself, but by its profile of associations and substitutions. One of the goals of STGs is to devise precise ways to determine degrees of identity and difference, and maybe to calculate them.

19. Synonymy is having the same profile of association, and the machine may be instructed to recognize it: see Teil, op. cit. note 13.

20. On the first principle of symmetry, see D. Bloor, *Knowledge and Social Imagery* (London: Routledge & Kegan Paul, 1976), and for the generalized principle of symmetry, see M. Callon, 'Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieux Bay', in John Law (ed.), *Power, Action and Belief: A New Sociology of Knowledge?* (Keele, Staffs.: Sociological Review Monographs, & Boston, MA: Routledge & Kegan Paul, 1985), 196–229, and also Latour, op. cit. note 2.

21. M. Coutouzis and B. Latour, 'Le village solaire de Frango-Castello: pour une ethnographie des techniques modernes', *Année Sociologique*, Vol. 36 (1986), 113–68, reports a real case rather like this theoretical solution: one of the observers claimed that he was building a solar village for the development of poor Cretans, while the other claimed that the first one was building a secret atomic plant for the benefit of the US Army. No wonder that the negotiation between the two parties was rather tense.

22. Classical social theory had a problem accepting the variable geometry of social actors, because it deemed all technical and scientific non-humans to be stable elements. When studying controversies or innovations, it is, on the contrary, often the case that

an actor modifies its scale ('IBM' becomes 'one of the members of the board of directors of IBM'), and its interests. As to the non-humans, we have learned to follow how they move from 'existence' to 'essence' and back: see M. Callon, 'Réseaux technico-économiques et irréversibilités', in R. Boyer, B. Chavanne and O. Godard (eds), *Les figures de l'irréversibilité en économie* (Paris: Editions de l'EHESS, 1991), 195–230.

23. On this crucial feature, see W.E. Bijker and T. Pinch, 'The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other', in Bijker, T.P. Hughes and Pinch (eds), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, MA: MIT Press, 1987), 17–50.

24. See A.J. Greimas and J. Courtès (eds), *Semiotics and Language: An Analytical Dictionary* (Bloomington, IN: Indiana University Press, 1982).

25. This is the main point of contention within SSK between actor-network theory and the sociological position. The latter believes it necessary to recognize in advance the essence of individual humans and collective persons, and to distinguish their action from the mere behaviour of natural objects. We believe that both essence and differentiation are the result of attribution work that can be studied empirically. On this dispute, see Collins & Yearley, op. cit. note 4, and the response in M. Callon and B. Latour, 'Do not Throw out the Baby with the Bath School', in Pickering (ed.), op. cit. note 4.

26. Anonymous referee; see also, on this example, M.E. Gorman and W.B. Carlson, 'Interpreting Invention as a Cognitive Process: the Case of Alexander Graham Bell, Thomas Edison and the Telephone', *Science, Technology, and Human Values*, Vol. 15 (1990), 131–64.

27. In addition, a very primitive form of inference engine may be built; the rules are not entered *a priori*, but are simply the representation of the contingent associations: 'if New key' is associated with 'Manfred + File', then 'System beaten'. It is important to maintain data in this form to turn STG into an interactive simulator. The player will be asked to try out new combinations, and will be limited by the 'rules' already learned. But since the rules are observer-dependent, it will be the task of the player either to 'interrogate' a new observer, to open one of the black-boxes, or to enter new data.

28. They may, however, still be elicited from the reading of the graphs: for instance, we can learn from Figure 4 that 'Tenants' were the antiprogrammes of version X1(1), since they enter the syntagm later; we can learn from Figure 7 that 'E' was in the anti-programme at version (2), since when it enters it requests the elimination of A and B; and so on. Such information might be the basis for 'rules' of association and dissociation.

29. Such variation is the basis of another possible use of STGs for management of complex technical projects. We ran two such case studies with the Innovation department of the French chemical concern Rhône-Poulenc: see Latour, Mauguin & Teil, op. cit. note 1.

30. See, for instance, the elaborate coding system developed by Gooding in order to follow Faraday's experimental process, in D. Gooding, 'Mapping Experiment as a Learning Process: How the First Electromagnetic Motor was Invented', *Science, Technology, and Human Values*, Vol. 15 (1990), 165–201.

31. See also Scott, op. cit. note 1, for other indicators.

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The Life and Death of an Aircraft: A Network Analysis of Technical Change

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Imagine a technological project that lasts for a number of years, involves the mobilization of tens or hundreds of thousands of workers, designers, managers, and a plethora of heterogeneous bits and pieces including designs, parts, machine tools, and all the rest. Imagine that this project is developed in a constantly changing environment—that requirements, interests, and even the actors themselves change during the course of its lifetime. Imagine that not hundreds but hundreds of thousands of decisions are made. And imagine that in the end it is cancelled amid a welter of acrimony. How can we describe such a project in a way that is more than "simple" history? How can we describe it in a way relevant for the analysis of other projects and technological innovations? How can we explain the decision to close the project? How can we explain its failure? And how can we do this in a way that lets us avoid taking sides?

Despite the recent growth in interest in the social analysis of technology, few tools currently available are really useful. Our problem is that it is too simple (though it contains an element of truth) to say that context influences, and is simultaneously influenced by, content. What we require is a tool that makes it possible to describe and explain the coevolution of what are usually distinguished as sociotechnical context and sociotechnical content. In recent work we have used a network metaphor to try to understand this kind of process (Callon and Law 1989). We have considered the way in which an actor attempts to mobilize and stabilize what we call a *global network* in order to obtain resources with which to build a project. In our language, then, a global network is a set of relations between an actor and its neighbors on the one hand, and between those neighbors on the other. It is a network that is built up, deliberately or otherwise, and that generates a space, a period of time, and a set of resources in which innovation may take place. Within this space—we call it a *negotiation space*—the process of building a project may be treated as the elaboration of a *local network*—that is, the development of an array of the heterogeneous set of bits and pieces that is necessary to the successful production of any working device. We have suggested, that is, that the notions of context and content that are used as common analytical devices in the sociology of science and technology may be transcended if projects are treated as balancing acts in which heterogeneous elements from both "inside" and "outside" the project are juxtaposed.

In this chapter we push our analysis a stage further by considering the dynamics of a large British aerospace project. We consider the way in which the managers of that project sought to position their project in a global network in order to obtain the time and the resources needed to build and maintain a local network. And we discuss the way in which the shape of that project was influenced not only by the efforts of those managers, but also by events and strategies that influenced the shape of the global network. Thus we trace the strategies and contingencies that led to the creation of both local and global networks, the fortunes or the managers as they sought to shape both networks and control the relations between them, and the eventual collapse of the project when the relationship between them finally got completely out of hand.

At one level, then, our story is banal. It is the description of a large military technology project that went wrong. But although this project has considerable interest for the history of British aerospace, here our aim is not primarily to add to the catalog of accounts of military waste. Rather it is analytical. Like many others in this volume, we are concerned to develop a vocabulary of analysis that will allow us to describe and explain all attempts to build durable institutions. Analytically, the fact of the failure in the present project is best seen as a methodological convenience: controversy surrounding failure tends to reveal processes that are more easily hidden in the case of successful projects and institutions.

A Project and Its Neighbors

The TSR.2 project was dreamed up in the Operational Requirements Branch of the Royal Air Force (RAF) in the late 1950s. (TSR stands for Tactical Strike and Reconnaisance; the meaning of the 2 is a mystery.) The structure of the project and its aircraft were conceived in the course of a set of negotiations with neighboring actors. Thus, those who advanced the project sought to establish for it a shape that would allow it to survive. In some cases it was a question of securing sufficient resources from neighboring actors. In other cases it was a question of securing their neutrality for an appropriate period. In both cases, it was a question of coming to appropriate arrangements—of defining the relationship between the project and its neighbors.[1]

The origin of this process can be traced to a General Operational Requirement (GOR 339) developed by the Operational Requirements Branch and to a policy for the rationalization of the aircraft industry implemented by the procurement branch of the British government, the Ministry of Supply. So far as the RAF in general was concerned, it was necessary that the end product be an aircraft. All other transactions were predicated on this assumption. That a combat aircraft was needed was not, in fact, that clear in the late 1950s. The defense policy of the United Kingdom as spelled out in the 1957 Defence White Paper was that of nuclear deterrence based on ballistic missile retaliation. So far as the Ministry of Defence was concerned, it was important that the end product not be a strategic bomber—this alternative having been ruled out by the White Paper. This suggested that the project should be a combat aircraft, and given British defense commitments as conceived by the Ministry, it was appropriate that it should be a tactical strike and reconnaissance aircraft (TSR).

So far as the Treasury was concerned, it was important that the end product be cheap. Given this perspective, which was based on its perceived need for economies in defense spending, the Treasury tended to doubt the need for any aircraft at all. At most support could be found for a single combat aircraft. This meant that the aircraft would have to fulfill all the possible combat aircraft requirements of the RAF. Accordingly, there was pressure for a versatile aircraft—a requirement fulfilled by the TSR definition—and also one that might be sold overseas, thereby cutting its unit cost.

So far as the Navy was concerned, it was also necessary to overcome a high degree of hostility. The Navy was purchasing a small tactical strike aircraft called the Buccaneer, and was anxious to persuade the RAF to buy this same aircraft because this would cut unit costs for the Navy and relieve pressure on the arms procurement budget overall. The response of the Operational Requirements Branch was to propose a large, supersonic, precision-strike, long-range aircraft that was quite different from the Buccaneer. Although this response was not what was sought by the Navy, it was intended to neutralize the (Treasury-assisted) attempts by the latter to impose the Buccaneer.

So far as the Ministry of Supply was concerned, it was important that the aircraft project be consistent with a policy for rationalizing the airframe and aeroengine industry. There were upward of a dozen airframe manufacturers in the United Kingdom in the late 1950s. The Ministry felt that there was room for two or three at most. Accordingly, the project was conceived as an instrument for bringing a large and powerful industrial consortium into being: it would not be awarded to a single firm.

These transactions shaped and helped to define the project. Let us note a number of important characteristics of this process.

The TSR.2 project displayed what we may call variable geometry: it represented different things to different actors. In other words, it possessed a high degree of "interpretive flexibility." For the Ministry of Defence and the RAF, it was not a strategic bomber but a tactical strike and reconnaissance aircraft. For the Treasury it was relatively (though insufficiently) cheap. For the Navy it was a successful competitor to the Buccaneer, and for the Ministry of Supply it was an instrument of industrial policy.

At the same time, however, it was also a relatively simple object to each of those other actors. Though our account is, of course, schematic, most of the complexities of the aircraft and its project were also invisible to these outside actors. But the simplification involved in bringing this project into being was reciprocal: the outside actors were, in turn, simplified from the standpoint of the project. Thus the Treasury was (and is) a highly complex bureaucracy with a wide range of policy concerns and procedures. From the standpoint of the project most of these were irrelevant. The Treasury was a "punctualized" actor—an actor that was reduced to a single function, that of the provision of funds.

This process of reciprocal simplification has several consequences. One is that from the standpoint of both its neighbors and an outside observer, the project can be treated as a series of transactions. Some of these took the form of economic exchanges: in return for the provision of funds the project would provide accounts, progress reports, and, ultimately, a working aircraft. Some were political in character: in return for a demonstrated need for a large and complex aircraft, the objections of the Navy to the project would be overruled. Yet others were defined technically (the General Operational Requirement, and the more specific Operational Requirement that followed it) or industrially (the provision of contracts in exchange for a rationalization of the aircraft industry). In an earlier paper (Callon and Law 1989) we referred to what is passed between an actor and its neighbors as *intermediaries*, and we will adopt this (deliberately general and nonspecific) terminology here to refer to what passes between actors in the course of relatively stable transactions. And, as indicated earlier, we will use the term *global network* to refer both to the set of relations between an actor and its neighbors, and to those between its neighbors.

It is also important to note that transactions leading to reciprocal simplification shaped not only the project itself but also the actors that entered into transactions with it. Again, this shaping operated through a variety of mechanisms: often the formulated *interests* of existing actors were redefined. In 1957 the Ministry of Defence did not "know" that it needed a TSR aircraft. It simply knew that it did not need a strategic bomber to replace the existing V bomber force because ballistic missiles would fulfill this role. In the process of interacting with the Operational Requirements Branch, the ministry was persuaded or became aware of its interest in a TSR aircraft. A similar process overtook the RAF. At the beginning of the process it knew only that it wanted a new combat aircraft, and that there were important obstacles to this ambition. By the end it perceived its interests in terms of the TSR.2. A similar but even more dramatic process overtook the airframe manufacturers. They started out with a general interest in obtaining contracts to produce new aircraft, and ended up finding that it was in their interest to merge with manufacturers that had previously been rivals to design and manufacture a TSR aircraft. So profound was the process in this case that they were not simply reshaped—they were turned into new actors in their own right.

However, the actors shaped by the project were not, in all cases, influenced by operating on their perceived interests. Thus the expressed interests of the Navy with respect to the project remained unchanged in the following years: it was hostile and wished to see it cancelled. However, because of the definition of the aircraft described above and a series of bureaucratic political ploys that will not be detailed here, the project and those whose support it enlisted (notably the RAF itself) boxed in the Navy. The latter was hostile, but it was also unable to press its hostility home. In this case power plays and bureaucratic strategems acted to shape the Navy. The neutrality of the Treasury was secured in part by similar means.

We are emphasizing this process of mutual shaping because it is important to understand that actors are not simply shaped by the networks in which they are located (although this is certainly true), but they also influence the actors with which they interact. In one way this is obvious, for the latter class of actors are themselves located in and shaped by a global network. However, the point is worth making explicitly because it breaks down an abstract distinction common in social analysis between (determined) actor and (determining) structure, or between content and context. Neighbors do indeed shape new actors as they enter into transactions with them, but they are in turn reshaped by their new circumstances.[2]

Finally, we should note that financial resources, a set of specifications, the tolerance of certain neighbors, and the neutralization of others offered the project managers the resources to go about fulfilling their side of the explicit and implicit bargains that they had entered into. In short, like many of the other cases described in this volume, the project had created for itself a time and a space within which it might deploy the resources it had borrowed from outside. It had, accordingly, achieved a degree of autonomy, a "negotiation space." We will now consider some of the transactions that took place within this negotiation space.

Designing a Local Network

By the autumn of 1957 the negotiation space for the project managers was quite limited. In general they were obliged to adopt a step-by-step approach: for instance, no funds would be forthcoming unless they produced intermediaries in the form of clearer ideas about the design of the aircraft, its likely manufacturers, the costs involved, and the probable delivery date. The first stage in this process was to specify the design features of the aircraft more fully. Thus GOR 339 was quite general, specifying the kind of performance required rather than detailing the design of an aircraft. The latter would be necessary if such skeptics as the Treasury were to be convinced that a consortium of manufacturers was indeed capable of producing the proposed aircraft within budget. Accordingly, the process of giving shape to the project continued. Now, however, the focus of the project managers turned inward: they started to try to elaborate a network of design teams, design features, schedules, and contractors. They started to create and mobilize actors in what we will call a local network.[3]

The first step in this process was to ask the British aircraft industry to submit outline designs in the autumn of 1957. This posed no particular problem, for the firms in question were hungry for work and readily mobilized. In all there were nine submissions (Gardner 1981, 25), though here we will mention only the three most relevant to our story (Williams, Gregory, and Simpson 1969). Vickers offered two possibilities. One was for a small single-engine aircraft that was relatively cheap but diverged considerably from GOR 339. The other was for a much larger aircraft that conformed closely to GOR 339. Both proposals advocated a "weapons systems" approach to design with an integrated approach to airframe, engines, equipment, and weapons (Wood 1975, 156). Although this represented a departure from traditional methods of military aircraft procurement in which airframes were designed, built, and tested first, and weapons and equipment were added afterward, the approach was well received in Whitehall, in part because of an extensive selling exercise by Vickers and in part because it accorded with Ministry of Supply thinking and recent American experience.

Nevertheless, although the general philosophy of the submission was clear, well articulated, and closely argued, Vickers were not able to do all the necessary design work and saw themselves going into partnership with another firm, English Electric, which had designed and manufactured the successful Canberra light bomber and the Lightning supersonic fighter. However, English Electric had made its own submission, code-named the P17A, which was a detailed aerodynamic and airframe design for a 60,000 to 70,000 lb. delta-winged Mach 2 strike bomber with twin engines and two seats (Hastings 1966, 30; Williams, Gregory, and Simpson 1969, 18; and Wood 1975, 155). Though the P17A met many of the specifications of GOR 339, it lacked an all-weather capability and a vertical or short takeoff capacity (Williams, Gregory, and Simpson 1969, 18). English Electric countered the latter deficiency by arguing that short takeoff was not the most urgent requirement (which was, in their view, the replacement of the Canberra), but suggested that this could be provided at a later date by a platform that would lift, launch, and recover the P17A in the air. This platform was to be designed and built by Short Brothers, which submitted a preliminary design (Hastings 1966, 29; Williams, Gregory, and Simpson 1969, 18; Wood 1975, 155).

With the airframe manufacturers mobilized and a set of submissions in place, the second stage in the elaboration of the local network started—consideration of what design or combination of designs would best fulfill the various requirements negotiated with neighboring actors. Though the small Vickers design was favored by the Treasury because it was likely to be relatively cheap, the large submission was particularly attractive to the Air Staff, the RAF, and sections of the Ministry of Defence. This was because it strengthened the commitment of the Air Staff both to a short-takeoff aircraft (which would have to be large because it would need two powerful engines) and to a weapon systems approach. The staff, the Ministry of Defence, and the Ministry of Supply were also impressed by the integrated design philosophy advocated by the company and were persuaded that Vickers had the management capacity to control and integrate a complex project (Wood 1975, 158; Gardner 1981, 33). However, they were also impressed by the English Electric submission, which was generally conceded to be "a first class design" (Wood 1975, 155), was the product of wide experience with supersonic aircraft, and also had the advantage that it could use existing avionics equipment in the short run. In addition, though contact between the two firms had been limited (with English Electric contractually tied to Short Brothers), Vickers had indicated its wish to have English Electric as its partner. Accordingly, the Air Staff came to the conclusion that a combination of the large Vickers-type 571 and the English Electric P17A would be both appropriate and capable of being used to mobilize actors in the global network.[4]

Accordingly, with a putative design and potential contractors in hand, the Air Staff returned to the global network in June 1958. Specifically, they went to the Defence Research Policy Committee (Gardner 1981, 32). This group was responsible for the overall control of defense procurement and as part of its role assessed and allocated priority to the projects put to it by user services and the appropriate supply departments (Williams, Gregory, and Simpson 1981, 32). Cabinet-level approval was ultimately obtained, and GOR 339 was replaced in early 1959 by a tighter, more technical and definitive requirement, Operational Requirement (OR) 343 (Gardner 1981, 33; Wood 1975, 158), and an associated Ministry of Supply specification, RB 192 (Gunston 1974, 41).[5] All was now in place: a preliminary network of local actors had been mobilized and had contributed to creating the intermediaries needed to satisfy the global actors or turn their objections aside. The design for a local network of firms, technical components, management procedures, and the rest had been approved. Intermediaries would start to flow from the global network in order to mobilize a more permanent local network.

The Creation of a Local Network

Vickers and English Electric did not wait for contracts to be awarded formally. In late 1958 they set about the difficult task of building a permanent local network of designers, designs, production teams, management, and subcontractors that would bring about the construction of a TSR.2 within the time and budget permitted by neighboring actors. The first step was to try to integrate and take control of two quite separate industrial organizations and designs. Several problems had to be overcome in this process of designing and mobilizing a local network. First, the designers who had previously worked in two teams some 200 miles apart had rather different approaches to design. Thus the Vickers team, which was based in Weybridge in Surrey and near Winchester in Hampshire, had concentrated on electronic systems, on airborne systems in general, on fuselage design and on short takeoff and landing (Williams, Gregory, and Simpson 1969, 29). The English Electric team was based on Warton in Lancashire and had concentrated on supersonic aspects of the design, the implications of low-level flight, and had, as we have noted, submitted the more detailed airframe design. The process of getting to know one another and settling down to collaborative work was difficult but generally successful in the end (Beamont 1968, 137; Beamont 1980, 134; Williams, Gregory, and Simpson 1969, 47), and a joint team of fifty designers undertook a detailed study of the technical and design problems raised by GOR 339 by the early months of 1959. Following this a division of labor evolved that reflected the relative skills of the two teams: the Weybridge group worked on systems including cost-effectiveness and weapons, while the Warton team worked on aerodynamics (Wood 1975, 164).

But the local network was not composed of people alone. For instance, the problems posed by the differences between the two designs were at first considerable. The most fundamental of these arose out of the different requirements suggested by supersonic flight and a short takeoff capability. High-speed flight suggested a small wing with low aspect ratio, a low thickness-to-chord ratio and a high leading edge sweep—all features of the P17A. A short-takeoff capability suggested the need for a low wing loading, which in turn implied that the wing should be large, and it also suggested a high thickness-to-chord ratio and a low leading edge and trailing edge sweep. Sir George Edwards, head of Vickers and later of the merged British Aircraft Corporation, is reported to have said at one stage, "The Vickers STOL study and the English Electric machine with a tiny low level wing ... seemed irreconcilable" (Gunston 1974, 44). The team wrestled with these different requirements and eventually resolved ~~them in a single solution by:~~ a. providing very large flaps that increased both the thickness-to-chord ratio and the angle of attack; b. forcing high-pressure air over the flaps in order to improve lift at low speeds by preventing the breakup of airflow over the top surface of the wing; and c. increasing the thrust-to-weight ratio by specifying two extremely powerful engines (Gunston 1974, 46; Williams, Gregory, and Simpson 1969, 25, 39; Wood 1975, 165).

Although this was the most fundamental design decision—for given the Operational Requirement, many other decisions about engines, moving surfaces, undercarriage, and integral fuel tanks were seen by the team to be foreclosed—other and somewhat separable design difficulties also arose. One of these concerned the location of the engine. The necessity for thin, uncluttered wings suggested that ~~these~~ should be located within the fuselage, as in the English Electric design. Vickers were skeptical about this, worrying about cooling problems and the risk fire. However, in the end the English Electric view carried the day (Wood 1975, 163). Another concerned the short-takeoff capability of the aircraft. In 1959 the Air Staff were hoping for this, but the designers quickly concluded that the proposed aircraft was too heavy, and they sought—and were given—permission to build an aircraft that would take off instead from half runways and rough strips (Gunston 1974, 41).

In March 1960 the wing position was moved by three inches as a result of these and similar deliberations (Hastings 1966, 40; Gardner 1981, 105), but after this the design was changed little in concept, and a brochure and drawings were issued to the workshops in 1962 (Wood 1975, 165).[6] A putative local network of technical components had been specified. All that remained was to turn these from paper into metal.

Integrating their designs and their design teams were not the only problems of integration and control confronted by the two firms. There was also a question about how the production work should be allocated. Although the contract from the Ministry of Supply stated that the two firms were to share the work equally, it was also made clear that Vickers was the prime contractor and would exercise overall mangement control (Hastings 1966, 35; Williams, Gregory, and Simpson 1969, 22). This led to some ill feeling in English Electric, which felt that it should have received its own contract directly from the ministry. The problem was exacerbated by the commitment to a development batch approach. The prototypes and development aircraft would be built on the production line for the main series rather than being built by hand, separately. The location of the production line had, therefore, to be determined early on, and negotiations were difficult (Gardner 1981, 32).

Relations between Global and Local Networks

While the design and creation of a local network went ahead, there were continuing difficulties in the interaction between the local network and the global network that had brought it into being. As we have already indicated, in principle the Ministry of Supply was committed to a weapons systems approach to procurement—the whole machine including all its avionics, armaments, and other subsystems should be conceived as a whole. In the view of the Ministry, this approach had implications for management:

> Since the failure of only one link could make a weapons system ineffective, the ideal would be that complete responsibility for co-ordinating the various components of the system should rest with one individual, the designer of the aircraft. (*Supply of Military Aircraft* 1955, 9)

The approach thus implied centralized control. It suggested that a single locus should shape and mobilize the local network *and* that this locus should have control over all transactions between the local and global networks. It should, in short, become an *obligatory point of passage* between the two networks.

As we have indicated, Vickers was indeed appointed prime contractor and was responsible in principle for controlling the entire project (Hastings 1966, 35; Williams, Gregory, and Simpson 1969, 22). In practice, however, the Ministry of Supply (later Aviation) did not vest all responsibility for control in Vickers. Rather, the project was controlled by a complex series of committees on which a range of different agencies were represented, and no single agency was in a position to control all aspects of the project. The failure of the management of the newly formed British Aircraft Corporation to impose itself as an obligatory point of passage led to a number of complaints by the latter about outside interference. These fell into two groups:

1. Actors in the global network were able to make (or veto) decisions that affected the structure of the local network:

a. Many of the most important contracts were awarded directly by the Ministry; the contract for the engines provides a case in point. The design team took the unanimous view that this should be awarded to Rolls Royce. This recommendation was based on the belief that a reheat version of the RB 142R offered the thrust-to weight ratio necessary for the aircraft, was lighter, and had more potential than an alternative enhanced Olympus engine made by

Bristol Siddeley (Hastings 1966, 41; Wood 1975, 164). However, the Ministry of Supply had other views, apparently deriving from its concern to pursue an industrial policy of merger, and despite this recommendation awarded the contract to Bristol Siddeley (Clarke 1965, 77; Gardner 1981, 29; Gunston 1974, 41; Williams, Gregory, and Simpson 1969, 21). In fact, overall, the BAC controlled only about 30 percent of the project expenditure itself (Gunston 1974, 67; Hastings 1966, 40).

b. The Air Staff tended to make decisions without reference to the BAC. The problem here was that the RAF continued to develop its ideas about the ideal performance and capabilities of the TSR.2. This tendency to upgrade specifications was encouraged by the fact that contractors would often talk directly to the Air Staff and the Air Ministry. Sometimes such discussions would lead to changes in the specification of equipment whose specifications had already (or so the BAC thought) been fixed. One result was that, at least in the view of the BAC, progress toward freezing the design of the aircraft was impeded (Hastings 1966, 144; Gardner 1981, 101; Williams, Gregory, and Simpson 1969, 49).

2. Given the number of global actors that had a right to express their views in the committee structure, arriving at a clear decision was sometimes difficult.

a. It was often impossible to get a quick decision from the various government agencies. Hastings (1966, 160) describes the case of the navigational computer that was the responsibility of a firm called Elliott Brothers. The specification for this computer was very demanding, and Elliott concluded that the only way in which this could be met within the time allowed was by buying the basic computer from North American Autonetics. The Ministry resisted this because it had sponsored basic research on airborne digital computers in 1956–57. The Ministry ultimately accepted Elliott's view, but the equipment required was complex and the price was high. This brought into play Treasury representatives, who insisted that the decision be reviewed after a year. The whole argument delayed the development of the computer and (or so Hastings argues) added £750,000 to the cost.

b. On a number of occasions the Treasury used its position to try to cancel the project, or at least reduce its cost, and there seems little doubt that an initial delay in issuing contracts was in part a function of Treasury reluctance. When the committee structure was further elaborated in 1963, the opportunities for discussion about costs became greater still. Indeed, the Projects Review Committee, which included Treasury membership, had no representatives from industry (Hastings 1966, 38; Williams, Gregory, and Simpson 1969, 82).

c. The technical committees often made decisions with relatively little thought of cost, whereas those committees concerned with costs had little information about, or ability to determine, the technical necessity of the tasks they were examining (Hastings 1966, 35; Williams, Gregory, and Simpson 1969, 22). Certainly it appears that the RAF sought optimum performance in a way that was relatively cost-insensitive. (Hastings 1966, 59–60). The Air Staff tendency to delay was strengthened by the weapons systems philosophy and the development batch approach to procurement, both of which reinforced the RAF desire to be sure that the design was absolutely right before it was frozen, because it was so difficult to introduce modifications once this had occurred (Williams, Gregory, and Simpson 1969, 53).

Difficulties in Mobilizing a Local Network

We have described the reaction of the British Aircraft Corporation to the fact that outside actors refused to let it serve as an obligatory point of passage between the project's global and the local networks. However, the growth of mistrust between the Ministry and the BAC was two-way. The Ministry came to believe that the prime contractor was failing to exercise adequate management control (Hastings 1966, 157; Williams, Gregory, and Simpson 1969, 54). In particular, it was suggested that there was no single "iron man" at the BAC to direct the project (Wood 1975, 172), and at one point the ministry felt obliged to represent this view very strongly to the firm. Thus, although the Ministry's point of view has not been as well documented as that of the BAC, it is pretty clear that for much of the period after 1959 *neither* acted as an obligatory point of passage between local and global networks, and there was continual "seepage" as local actors lobbied their global counterparts, which influenced and in some cases impeded the smooth running of the project.

Indeed, the construction of the local network presented many problems. Perhaps the most serious of these concerned the engines. It is clear in retrospect that neither the Ministry nor Bristol Siddeley knew what they were letting themselves in for when the contract was awarded. The Ministry specified the engines in very general terms, and it was at first thought that their development would be a fairly straight-forward matter of upgrading an existing type, the Olympus (Williams, Gregory, and Simpson 1969, 27, 52). It turned out that this was not the case. The engine that was developed had a much greater thrust than its predecessor and operated at much higher temperatures and pressures. When it was first proved on the test bed, it turned out that its cast turbine blades were too brittle, and it was necessary to replace them with forged blades at considerable cost in both time and money (Hastings 1966, 42; Gardner 1981, 104).

This was not the only difficulty experienced by Bristol Siddeley. Serious problems arose with the reheat system, it proved impossible to install the completed engine in the fuselage, and there was also a weakness in the joint between the main engine and the jet pipe. However, the most serious problem appeared only late in the process of development. After proving the engine for over 400 hours on the test bed (Hastings 1966, 43), it was installed beneath a Vulcan in late 1962. On December 3 this aircraft was taxiing during ground tests at the BSE works at Filton in Bristol when the engine blew up, "depositing," as Wood (1975, 174) reports it, "a large portion of smouldering remains outside the windows of the company press office." The aircraft was reduced to burning wreckage, and although the crew was saved, a fire engine that approached the flames without due caution was caught up in the inferno (Gunston 1974, 56).

Within forty-eight hours it was clear that the failure had been caused by primary failure of the low-pressure compressor shaft. What was not clear, however, was what had caused this failure. Bristol Siddeley hypothesized that it might be due to stress and ordered that the thickness of the shaft be doubled. At the same time it ordered an exhaustive series of tests—a further, elaborately mobilized network of actors—to investigate the reasons for the failure. These led to further unpredictable and unexplained explosions. Finally, in the summer of 1964 the cause of the problem was diagnosed. In the original unmodified engine, the low-pressure shaft had turned on three bearings. However, the design team had become concerned that the middle of these three bearings might catch fire at the high operating temperatures; this bearing had therefore been removed and then, to provide the shaft with sufficient rigidity, the diameter of this shaft had been increased (Beamont 1968, 139; Hastings 1966, 43; Wood 1975, 174). Under certain unusual circumstances, the air between this shaft and its high-pressure neighbor started to vibrate at a frequency that corresponded to the natural frequency of resonance of the low-pressure shaft. When this happened, disintegration quickly followed. However, even with a diagnosis at hand, a solution was going to require further time and money.[7]

Not all of the local network problems concerned the engines. It also proved very difficult to control the subcontractors. As we have indicated, same subcontractors appealed over the head of the BAC to the ministry in order to obtain favorable decisions about costs (Hastings 1966, 36; Gardner 1981, 101). Others colluded with the air staff to specify equipment that was unduly sophisticated. Again, from 1959—and more so from 1962, when the political climate began to undermine the project—many subcontractors doubted whether the aircraft would actually fly. This feeling was a function of another kind of seepage between the local and global networks—specifically the knowledge that the project had powerful opponents in government. The subcontractors thus sought to protect themselves (and recover their costs in full within each contract) by charging high prices, and they also tended to give the work low priority (Beamont 1968, 143; Gardner 1981, 102; Williams, Gregory, and Simpson 1969, 28). In addition there was a tendency to charge a wide range of development work to the TSR.2 because it was the only advanced military aircraft project in Britain (Gunston 1974, 53; Gardner 1981, 102). In any case, much of the work was not amenable to precise costing in advance (Gunston 1914, 60; Williams, Gregory, and Smith 1969, 27, 51). Although the aim of the ministry and the BAC was to issue fixed price contracts as this became possible, this goal was not achieved for many of the most important areas of work because unanticipated technical problems arose or the specification of the equipment was altered.

The Global Network Reshaped

The consequences of the failure to build a satisfactory local network made themselves felt in a number of ways. The RAF had been promised that the TSR.2 would be available for squadron service by 1965, but it was clear, with the engines still unproved in the middle of 1964, that this deadline had substantially slipped. The Ministry of Defence had likewise been promised a vital weapon with which to fight a war in Europe or the Commonwealth by 1965. This was not going to be available. The Treasury had been promised a cheap and versatile aircraft. Though it is true that some of the blame for the cost overrun can be laid at the door of the Treasury itself, by 1963 the estimated cost of the aircraft had nearly doubled. The Navy, which had been hostile from the outset, saw the project swallowing up more and more of the procurement budget. By 1963, then, all the relevant actors in the global network, whether sympathetic to the project or not, saw it as being in deep trouble. It was simply failing to deliver the intermediaries to the global network that it had promised when it had been given the go-ahead. Thus, although the data in table 1.1 are calculated on a variety of bases and are not in all cases strictly comparable with one another, they sufficiently illustrate this general trend.

However, although these difficulties were serious, they did not necessarily mean that the project was doomed. If the necessary intermediaries could be obtained from the global network, it would be able to continue: funds from the Treasury, expertise and support from the RAF, political support from the Ministry of Defence, and specialist services from such departments as the Royal Aircraft Establishment—these would allow it to continue. The RAF and the Minister, though not necessarily the whole of the Ministry of Defence, remained strong supporters of the project. With the government committed, it was not possible for the Treasury, the Navy, or indeed, the hostile sections of the Ministry of Defence, to stop the project. Accordingly, the funds continued to flow. However, armed

Table 1.1
Estimated costs and delivery dates of TSR.2

Date of estimate	Development estimate	Production estimate	Total
January 1959	£25–50m	up to £200m	up to £250m
December 1959	£80–90m (for 9 aircraft)		
October 1960	£90m	c. £237m (for 158 aircraft)	c. £330m
March 1962	£137m		
January 1963	£175–200m		
November 1963			£400m (overall, Ministry of Aviation)
January 1964	£240–260m		
February 1964			£500m (overall, Ministry of Defence)
January 1965			£604m (overall, Ministry of Aviation) £670m (overall, contractors) (R&D and production of 150 aircraft)

with the knowledge that came from their participation in the cat's cradle of government and industry committees, the skeptics were in a strong position to undermine the project by indirect means. This involved taking the fight into a wider arena.

The project had been conceived and shaped within the context of a limited number of global actors. Government departments, the armed services, the aerospace industry—these were the relevant actors that had given life and shape to the project. Though sections of the specialist press had some knowledge of the project, public statements by ministers had been very limited, and until 1963 it had had a very low profile. Gradually, however, this started to change as new actors first learned about the project and then indicated their opposition to it.

The most important of these was the Labour Party, which had declared its opposition to "prestige projects" such as Concorde and TSR.2 and had promised to review them if it was returned to power in the next General Election. Labour views about the TSR.2 had been unimportant in the early days of the project, and indeed were unformed. However, by 1963 this was beginning to change. The Labour Party was riding high in the opinion polls, and a General Election was due by October of 1964 at the latest. Whispering in government and by other insiders and a series of admissions from the Ministries of Aviation and Defence about delays and escalating costs led the TSR.2 to became an object of political controversy from 1963 onward. This process was reinforced by a highly controversial setback to the project—the failure to persuade the Australian government to purchase the TSR.2 for the Royal Australian Air Force. In a blaze of publicity, the Australians opted for the rival F111, an aircraft built to a similar specification by the American firm, General Dynamics.

Thus, although supervision of the project remained in Whitehall, the number of actors, including critics, involved in its surveillance multiplied in 1963. The cost of the project was officially given as £400m. in November 1963. However, the Labour Party Opposition argued that this was a gross underestimate and put the figure closer to £1,000m., an estimate that was fiercely disputed by the Government (*The Times*, Nov. 12, 1963, p. 5). Furthermore, the Opposition argued that cost was one of the major reasons for the failure to procure the Australian order, a charge angrily rejected by the Government, which claimed that the constant carping of critics in the United Kingdom had led the Australians to doubt whether the aircraft would ever be produced (*The Times*, Dec. 4, 1963, p. 7).

Other critics suggested that the aircraft had become too expensive for its role and too expensive to be risked in combat, *The Times* suggesting that at £10m. per machine, it was "the most expensive way yet devised of blowing up bridges" (Sept. 28, 1964 p. 10).

Further political disagreements centered around the role of the aircraft. The cancellation of the British ballistic missile Blue Streak in 1960, followed by the 1962 cancellation of the American Skybolt, which had replaced Blue Streak, had led certain commentators to speculate that it might be possible to use the TSR.2 in a strategic nuclear role. This suggestion (which had always been seen as a possibility within government) was picked up by the 1963 Defence White Paper (Omnd. 1936) and attracted criticism both from those who felt that the aircraft was neither fish nor fowl, such as *The Times* and *The Economist*, and the left wing of the Labour Party, which was committed to a policy of unilateral nuclear disarmament. Yet others including Denis Healey, the Labour defense spokesmen, concluded that this "strategic bonus" did not so much represent a change in the specification of the aircraft as an attempt by the government to persuade its backbenchers of the soundness of its nuclear defense policy (*The Times*, March 5, 1963 p. 14). Controversy also surrounded the continued delays in the first test flight. Healey highlighted the symbolic importance of the maiden flight when he claimed in Parliament at the beginning of 1964 that the BAC had "been given an order that it must get the TSR.2 off the ground before the election, and that (this) was a priority" (*The Times*, Jan. 17, 1964, p. 14). However, though he was much too professional a politician to let the Conservative government off lightly for its alleged incompetence, he was also much too agile to foreclose his own options by promising to cancel the project if the Labour Party were to win the General Election.

Endgame

By the autumn of 1964 the project was at a crucial stage. The local network was practically in place: the TSR.2 was almost ready for its maiden flight, albeit very much behind schedule and over budget. But the structure of the global network had altered. Disagreement was no longer confined to the Treasury and the Navy and the RAF, the Ministry of Defence, and the Ministry of Aviation. (Indeed, some of these agencies were starting to alter their views of the project.) The dispute was now public, and the Conservative Government had committed itself firmly and publicly to the TSR.2, while the Labour

Opposition, though reserving its position, was generally highly critical of the cost and utility of the project. The future of the project thus depended on two factors. First, it was important to demonstrate the technical competence of the project, and the best way to do this was for it to have a successful first flight. This would reinforce the position of those who wished to see the project through. At the same time, the outcome of the General Election was also vital. Conservative success would probably assure the future of the project. Labour victory would call it into question.

The maiden flight took place just eighteen days before the General Election. Roland Beamont, the test pilot, describes the rather subdued group of engineers, technicians, managers, and RAF personnel who assembled at Boscombe Down before the flight. Most knew, as the large crowd beyond the perimeter wire did not, of the potentially lethal nature of the engine problem, and they knew that although its cause had been diagnosed, it had not yet been cured. In fact the flight was highly successful, the aircraft handled well, and there was no hint of the destructive resonance that had plagued the engines. Deep in the election battle the Prime Minister, Sir Alec Douglas Home, described it as "a splendid achievement" (Beamont 1968, 151). The aircraft was then grounded for several months in order to modify the engines and tackle minor problems with the undercarriage.

The General Election took place on October 15. The result was close, and it was not until the following day that it became clear that the Labour Party had been returned to power with a tiny majority of five. The new administration started work in an atmosphere of crisis as a result of a large balance of payments deficit, and it decided to cap defence expenditure at £2,000 million. It also ordered a detailed scrutiny of the various military aircraft projects and started a review of the proper future shape and size of the aircraft industry (Campbell 1983, 79). In February the new Prime Minister, Harold Wilson, made it clear that the future of the TSR.2 would depend on four factors: first, a technical assessment of the aircraft and its alternatives; second, the fact that although the overseas purchase of an alternative aircraft would save £250 million, this would also involve considerable dollar expenditure; third, the future shape of the aircraft industry, and the possible unemployment that would result from carcelling the program; and fourth, the nature of the terms that could be negotiated with the BAC.[8]

At the beginning of April spokespersons for the principal actors in the newly reconstructed global network—the Cabinet Ministers responsible for departments of government—met to take a decision. They considered three possible courses of action: to continue with the TSR.2; to cancel it and put nothing in its place; and to cancel it and replace it with the similar F111 (Crossman 1975, 191; Wilson 1971, 90). The Treasury remained hostile to the TSR.2 and accordingly sought cancellation. Although it was concerned that a large purchase of an alternative American aircraft such as the F111 would impose severe dollar costs, it was prepared to accept that an *option* for the purchase of this aircraft should be taken out on the understanding that this did not imply a firm commitment. The Ministry of Defence was also in favor of cancellation on cost grounds, and it was joined by those, such as the Navy, that favored the claims of other services and projects (Hastings 1966, 68, 70). The Minister of Defence was in favor of an F111 purchase, but there was same uncertainty whether Britain really needed this type of aircraft in view of the country's diminishing world role (Williams, Gregory, and Simpson 1969, 31). He was thus happy to take out an option on the American aircraft rather than placing a firm order.

The position of the Minister of Defence probably in part reflected a shift in the view of the Air Staff. The combination of delay and cost overrun, together with the much tougher policy of economies introduced by the new Minister of Defence, had convinced the Air Staff that it was most unlikely that there would be a full run of 150 TSR.2s, and this had led to doubt about whether it would be possible to risk such a small number of expensive aircraft in conventional warfare. For some officers this pointed to the desirability of acquiring larger numbers of cheaper aircraft that might be more flexibly deployed. In addition, though the technical problems of the TSR.2 appeared to be soluble, its delivery date was still at least three years away. Because the F111 was designed to essentially the same specification and was already in production, the RAF found this quite an attractive alternative (Reed and Williams 1971, 181).

The Ministry of Aviation was concerned that a decision to scrap the TSR.2 would seriously reduce the future capacity of the British aircraft industry to mount advanced military projects, and tended to favor cancellation, combined with the purchase of a lower-performance British substitute. However, most ministers, including the Minister of Aviation, believed that the industry was much too large for a medium-sized nation. The real problem was that there was not yet in place a policy about its future shape and size. Even so, the TSR.2 was costing about £1 million a week, and further delay in cancellation did not, on balance, seem justified.

In general, the government was concerned that cancellation would lead to unemployment. With a tiny Labour majority in Parliament, ministers were anxious not to court unneccessary unpopularity. Against this, however, ministers felt that the resultant unemployment would mostly be temporary: that many of those working on the TSR.2 would quickly be absorbed by other projects or firms.

Nevertheless, the decision was by no means clear-cut: there was no overall Cabinet majority for any of the three options (Wilson 1971, 90). A number of ministers—mainly, it seems, those who were not directly involved—wanted to postpone cancellation until a long-term defence policy was in place (Crossman 1975, 190). Overall, however, those who wanted to maintain the project were outnumbered by those in favor of cancellation with, or without, the F111 option, and the vagueness of the latter commitment ultimately made it possible for these two groups to sink their differences.

The cancellation was announced by the Chancellor of the Exchequer, James Callaghan, in his Budget Day speech on April 6, 1965. The result was political uproar as the Conservatives sought to voice their anger and frustration at what they regarded as a foolish and shortsighted decision. A censure motion was debated on April 13. Amid charge and countercharge, Minister of Aviation Roy Jenkins concluded the debate for the government by agreeing that the TSR.2 was a fine technical achievement:

> But, to be a success, aircraft projects must be more than this. They must have controllable costs; they must fulfill the country's needs at a price that the country can afford; they must be broadly price competitive with comparable aircraft produced in other countries, and they must have the prospect of an overseas market commensurate with the resources tied up in their development. On all these four grounds I regret to say that the TSR.2 was not a prize project but a prize albatross. (*Hansard*, April 13, 1965, c.1283)

The result of the censure debate was a resounding victory for the Government: it secured a majority of twenty-six, and any residual Opposition hopes that the the project might, somehow, be saved were dashed when members of the small Liberal Party voted with the Government.

Conclusion

In this chapter we have shown that the success and shape of a project, the TSR.2, depended crucially on the creation of two networks and on the exchange of intermediaries between these networks. From the global network came a range of resources—finance, political support, technical specifications and, in some cases at least, a hostile neutrality. These resources were made available to the project and generated what we have called a negotiation space. This was a space and a time within which a local network might be built that would in turn generate a range of intermediaries—but most obviously a working aircraft—that might be passed back to the actors in the global network in return for their support. We have also noted, however, that there were continual seepages between the global and the local networks in the case of the TSR.2 project. Actors in the global network were able to interfere with the structure and shape of the local network, while those in the local network were able to go behind the back of the project management, and consult directly with actors in the global network. The result was that project management was unable to impose itself as an obligatory point of passage between the two networks, and the troubles that we have detailed followed.[9]

The history we have described offers further evidence for several important findings of the new sociology of technology. First, it illustrates the interpretive flexibility of objects—the way in which they mean different things to different social groups. Second, as is obvious, it represents a further example of the social shaping of technology—namely the way in which objects are shaped by their organizational circumstances (Pinch and Bijker 1987; MacKenzie and Wajcman 1985; Callon 1986; Law 1987; MacKenzie 1987; MacKenzie and Spinardi 1988; Akrich, this volume; Bijker, this volume; Latour, this volume). Thus we have sketched out the way in which the TSR.2 aircraft changed in shape both literally and metaphorically during the course of its development, and the relationship between these changes and the compromises that grew up for a time between the relevant human and nonhuman actors—compromises that achieved, as we have seen, no final solidity but that were, in turn, reworked as a function of new circumstances in the local and global networks.

Thus back in 1957 what we might call *aircraft number one* did not have a physical shape at all in the minds of the Air Staff or the Ministry of Supply (see table 1.2). It was rather the performance specification—a role to be played—and some of the circumstances in which it should be built. And this role reflected their view of what would pass muster with other relevant actors. Thus, the RAF wanted a flying combat aircraft, but the Ministry of Defence had a view of the future that left room for neither a strategic bomber nor a fighter.

Table 1.2
Three aircraft

Aircraft shape	Interested actors (+ definition of aircraft)	Hostile actors (+ definition of aircraft)	Neutral actors
1 • long range • supersonic • low altitude • STOL • all weather • large	RAF: • combat aircraft • in and out of Europe • dispersable • precision bombing/reconnaissance Defence: not strategic bomber	Navy: • Buccaneer Treasury: • cheap, versatile Buccaneer?	
2 • wing shape, delta, thin • two powerful engines • blown flaps • engines in fuselage • twin engines • integral fuel tanks	RAF: • large, twin-engine, sophisticated • TSR aircraft • STOL • long range Defence: • TSR aircraft BAC: • STOL difficult • VTOL impossible	Navy: • (blocked) Treasury: • (blocked)	Labour party • in ignorance
3 • option on F111 • TSR.2 cancelled	BAC: • buy 140 Conservative party: • TSR.2 essential Unions: • maintain work	RAF: • buy cheaper, more certain aircraft Defence: • buy cheaper aircraft Treasury: • cap expenditure • limit overseas spending Navy: • adopt Buccaneer Aviation: • buy chepaer U.K. aircraft Labour party: • cancel	

A tactical bomber and reconnaissance aircraft was the only remaining possibility—an aircraft that would play out specific, nonstrategic roles in Europe and British dependencies overseas. By contrast, the Treasury was quite uninterested in the defence of the Western Alliance. Much more important was the defence of the public purse in the face of ever more costly military technologies. Accordingly, it wanted no aircraft, or (second best) an existing aircraft, or if this was not possible (third, fallback, option), then no more than *one* type of new aircraft. The RAF judged it could force the Treasury to its fallback position, so it responded by specifying a single versatile aircraft. The Navy had strong views about defence needs, but it saw these in its own, quite different, carrier-based way. Accordingly, it wanted the RAF to procure a version of its small, subsonic Buccaneer. In a more negative sense, this was a strong incentive for the RAF to argue the need for a large, supersonic aircraft that was qualitatively different from its naval rival. And the Ministry of Supply wanted an aircraft that would he built by a consortium of firms rather than one alone.

Though it was touch and go, the Air Staff judged things rightly and the global network required by this shadow aircraft number one was stabilized. The result was *aircraft number two*—this time one that had, albeit on paper, a physical shape. This shape was partly a function of the global network of institutional actors mentioned above. But many other actors, considerations, and negotiations helped to structure the design. Thus the shape of the wings represented a compromise between the demanding specification required by the RAF on the one hand, and design skills, knowledge of aerodynamics and materials strengths, and the practice of wind-tunnel testing on the other. How on earth was short takeoff and landing to be reconciled with high-altitude Mach 2.5 flight and low-altitude, low-gust response? The wing was the physical answer to this question. It represented a compromise between these different considerations. But it also represented a compromise between the English Electric and Vickers design teams—in which English Electric had the upper hand. Similar reasoning—again in favor of English Electric—led to a decision about the location of the engines. These, it was decided, would lie within the fuselage to clear wing surfaces and avoid undue differential propulsive force in case of single engine failure—and this despite the potential fire hazard that so concerned the Vickers team. And it is possible to travel through the aircraft explaining the shape of each system as a physical compromise between the specification, the design teams, and a range of inputs from aerodynamics to the views of experts at the Royal Aircraft Establishment.

It can be argued that aircraft number two grew out of aircraft number one. Certainly many of the constraints and resources that went to shape number one helped to shape number two. But the process is not one of unilinear development. Aircraft number two was not simply the "unpacking" of a set of implications that were built into aircraft number one. Aircraft number one posed a set of problems to which there were many possible solutions. Aircraft number two represented a particular set of solutions to those problems—compromises negotiated by further numerous actors. Or, in some cases at least, it represented refusal to accept the problems posed by GOR 339, as is most obvious in the case of the short takeoff and landing requirement where the available rules of aerofoil behavior overruled the wishes of the Air Staff. In this instance, then, we see (if anything) the obverse of the social shaping of technology: it was the technical around which the social was being bent.

But if aircraft number two represents a translation rather than a simple development of aircraft number one, a translation shaped by a set of compromises between a somewhat different set of actors, then the metamorphosis of the project is yet more obvious for *aircraft number three*. This, which is more usually known as the F111, gradually took shape after the General Election. Thus we have traced the changes that took place among many of the most important actors after October 1964. The Treasury imposed rigorous economies and expressed extreme concern about the ever-increasing costs of the TSR.2 project, its short run, and its lack of export prospects. The Ministry of Aviation sought to shape a smaller and better-adapted aircraft industry. The Ministry of Defence was involved not only in cost cutting but also in a Defence Review that might lead to the abandonment of many British overseas responsibilities and with it, part of the rationale for the TSR.2. The Air Staff were increasingly concerned that they would not obtain the full 140 TSR.2s. For their different reasons *all* of these were prepared, with greater or lesser enthusiasm, to abandon the TSR.2 and take out an option on the F111. Accordingly, the project for a tactical strike and reconnaissance aircraft had been reshaped yet again by the relations between the actors involved, and with that reshaping the object that lay at its focal point had undergone metamorphosis yet again. This reshaping is summarized in table 1.2.

So much for the shaping and reshaping of TSR.2.[10] But how should we describe such a "translation trajectory?"[11] This, then, is our third concern. If technologies are interpretively flexible, if they are shaped by their contexts but they also shape the latter, then can we say nothing general about the contingent and iterative processes that generate them? Our answer, as we hinted in the introduction, is to deploy a network vocabulary and, specifically, to make use of the concepts of *global network*, *local network*, and *obligatory point of passage*. Our proposal is that the shape and fate of technological projects is a function of three interrelated factors.

The *first* is the capacity of the project to build and maintain a global network that will for a time provide resources of various kinds in the expectation of an ultimate return. Note that the successful construction of a global network has a specific and important consequence: it offers a degree of privacy for project builders to make their mistakes in private, and without interference—it offers a negotiation space (see Callon and Law 1989). In the ideal case the project builder thus obtains a degree of autonomy in its attempts to generate a return. It also—again in the ideal case—achieves both complete control over and responsibility for those attempts.

The *second* is the ability of the project to build a local network using the resources provided by the global network to ultimately offer a material, economic, cultural, or symbolic return to actors lodged in the global network. Put less formally, it is the ability to experiment, to try things out, and to put them together successfully. It is also the ability to control whatever has been produced and feed it back into and so satisfy the understandings that have been entered into with other actors in the global network.

The *third* factor, which is entailed in the first two, is the capacity of the project to impose itself as an obligatory point of passage between the two networks. Unless it is able to do so, it has 1. no control over the use of global resources that may, as a result, be misused or withdrawn, and 2. it is unable to claim responsibility in the global network for any successes that are actually achieved in the local network. It is, in short, in no position to profit from the local network.

Note, now, that the objects and actors in *both* global and local networks are heterogeneous. Thus in the case of the TSR.2 we mentioned a range of important institutional actors in the form of Whitehall ministries. But we also touched upon geopolitical factors (the presumed interests of a range of nation states) and technological changes (the advance of missile and anti-aircraft technologies). And we might equally well have considered the role of such naturally occurring features as prevailing winds (they were vital in the calculation of ferry ranges), and terrain cross-sections (which went into the calculation of the risks involved in low-level flying), or, for that matter, such human geographical but global considerations as the availablility and distribution of airstrips of different lengths.

But if global networks are heterogeneous, then so too are local networks. The TSR.2 project mobilized institutional actors in the form of contractors, subcontractors, and specialist agencies such as the Institute for Aviation Medicine. It mobilized tens of thousands of draftsmen, designers, market personnel, and fitters. It involved the use of a great body of high-status knowledge in the form of scientific and technical expertise and a large amount of equally important shop-floor knowledge and skills. And it involved numberless machine tools, jigs, motor vehicles, chaser aircraft, and test rigs, not to mention an awesome quantity of paperwork in the form of drawings, instructions, management charts, brochures, sales pamphlets, maps, and publicity handouts.

If the elements that make up global and local networks are heterogeneous, then the extent upon which they can be depended is also problematic: the degree to which they may be mobilized is variable, reversible, and in the last instance can only be determined empirically. In other words, the extent to which it is possible for a project to control its two networks and the way in which they relate is problematic, and it is the degree and form of mobilization of the two networks and the way in which they are connected that determines both the trajectory and success of a project (figure 1.1).

Concentrating on the two networks, it is possible to plot any project in a two-dimensional graph, where the x axis measures the degree of mobilization of local actors (control over local network) and the y axis measures the extent to which external actors are linked (control over global network). Furthermore, it is possible to describe the translation trajectory of any project (figure 1.2).

Thus, in the case of the TSR.2, the project started in the center of the diagram and climbed up the vertical axis as it sought to distinguish its product from the Buccaneer (A). Then, as the management structures were elaborated, it sought to move along the x axis to the right (B), and this tendency was strengthened as a design was agreed between the two former design teams, which in turn facilitated the formation of a single, unified design team (C). However, this position was not maintained. Little by little, as the subcontractors failed to fall into line, and in some cases interacted directly with the RAF, the degree to which the project management monopolized the internal network declined (D). This process reached a nadir when the low-

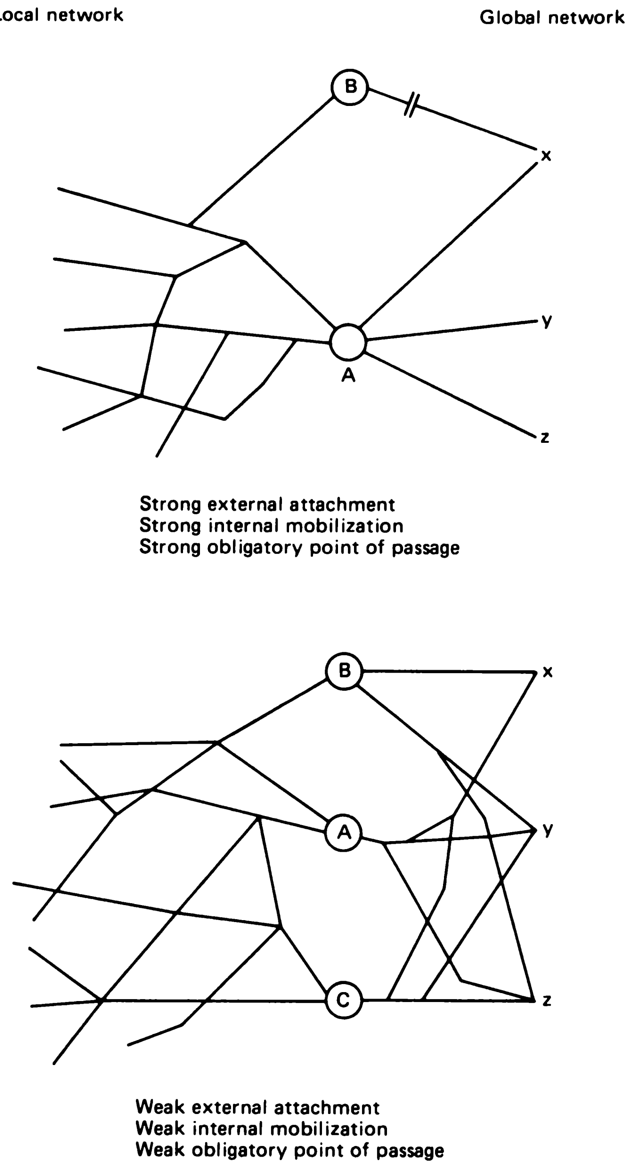

Figure 1.1
Strongly and weakly mobilized networks.

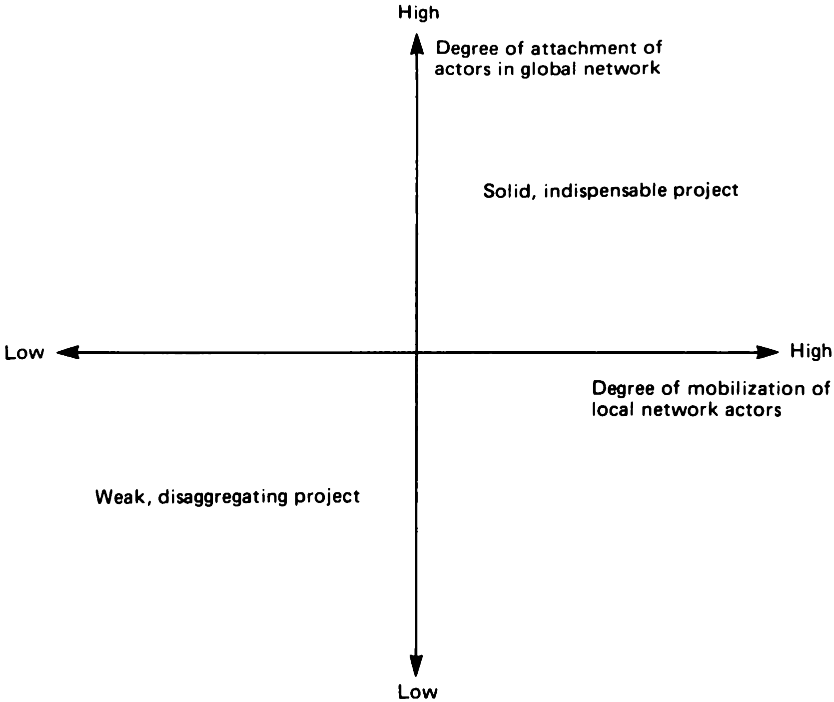

Figure 1.2
Mobilization of local and global networks.

pressure shaft of the engine disintegrated and the latter blew up (E), and the Australians opted to purchase the F111 (F). However, after much remedial work the successful maiden flight took place and a degree of control over the local network was reasserted (G). Accordingly, the project moved back into quadrant 1, but with changing political circumstances and the availability of the F111, it reentered this quadrant lower down the *y* axis. Finally, with the election of a Labour government, the F111 came to be seen as a realistic alternative, and the project slipped down into quadrant 4 (H), and with cancellation it concluded by losing complete control of the local network, so ending up at the lowest point in quadrant 3 (I) (see figure 1.3). The major turning points in the trajectory of the project across this diagram can be depicted as a table of choices and consequences (see table 1.3).

We conclude, then, with the thought that the trajectories of technological projects are contingent and iterative. Sometimes, to be sure, a project or a technology may move forward in a manner that

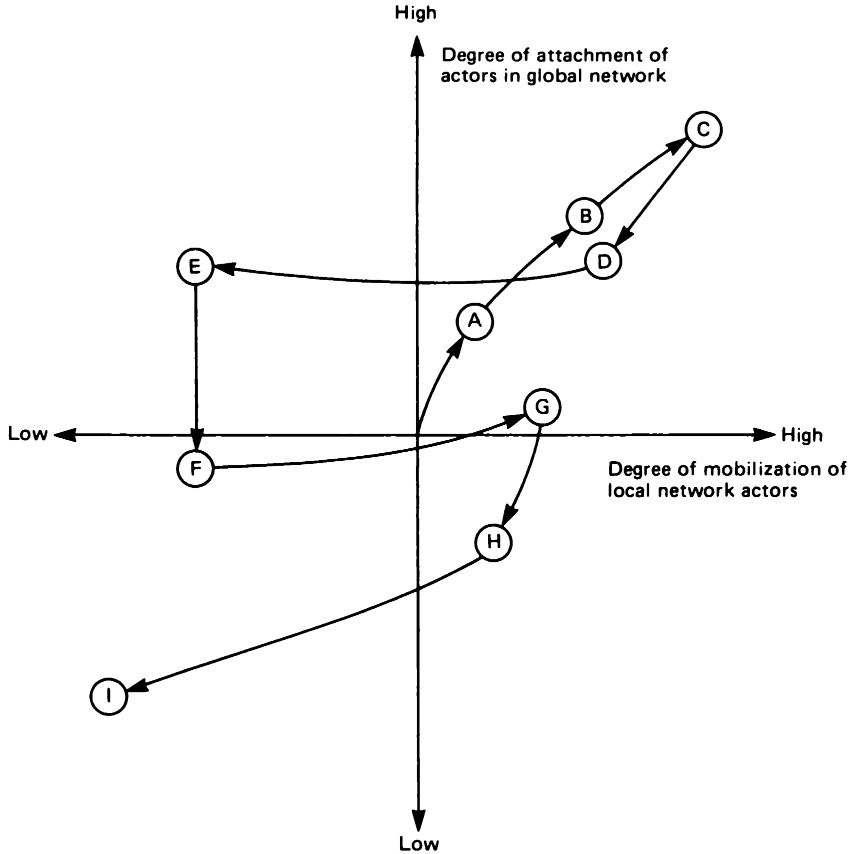

Figure 1.3
The trajectory of TSR.2.

accords to the stereotypical representation of the process of research and development. There is, however, no *necessity* about such progress. If all is smooth, this is because contingency has operated in that way. The kind of erratic progress we have described is far more likely—though such contingencies are often concealed in the Whiggish histories that celebrate the necessity of the successful after the event (see Bowker, this volume).

But our object is to move beyond the claim that outcomes are the product of contingency. Though this is right, it is also unhelpful unless we are content to accumulate specific case studies. Our aim is rather to seek patterns in the case studies. We believe that the case of the TSR.2—like a number of others in this volume—suggests that a crucial strategic move in building many, perhaps all, obdurate sociotechnologies is to create a distinction between inside and out-

Table 1.3
Choices and consequences

	Events/decisions	Local consequences	Global consequences
A	To build a new aircraft	Articulate design	Navy and Treasury blocked
B	Appointment of prime contractor	Articulate weapons	Minimize outside intervention
C	Decision about design	Develop production facilities	Secure funding
D	Support prime contractor's choices	Undermine prime contractor	Permit direct RAF intervention
E	Destruction of engines	Delay, mobilization of new teams and facilities	Expense and increased skepticism
F	Australian purchasing decision	Increasing skepticism by subcontractors	Increased politicization of project
G	Maiden flight	Technical confidence in aircraft and contractor	Strengthens supporters of project
H	Labour party wins election	Increases doubts among subcontractors	Strengthens opponents of project
I	Cancellation	Dissolution of project	Option to purchase F111

side, between backstage and front stage. The methods and materials for building such backstage negotiation spaces and relating them to the front stage are varied, and as the case of the TSR.2 shows, they are certainly not a function of strategy alone. We make use of a network metaphor because we need a neutral way of talking about the barriers that shape, for a time, the seamless web of sociotechnology.

Notes

John Law gratefully acknowledges the award by the Nuffield Foundation of a Social Science Research Fellowship, which made possible the empirical research on which this paper is based.

1. Here we adopt the methodological adage of Latour (1987) and "follow the actors."

2. In an earlier paper (Callon and Law 1989) in which we developed this argument in greater detail, we referred to these neighbors as "preforming networks."

3. Fuller details of this process of design are reported in Law 1987.

4. Little is known about the actual process by which decisions were reached. The best information available to us amounts to little more than hints. It does appear,

however, that the Treasury and the Ministry of Defence were fought off again in February 1958 (Wood 1975, 158). The Treasury was still concerned about the cost of the whole project, and the Ministry of Defence, noting the smaller of the two submissions from Vickers, toyed with the idea of specifying an aircraft that would fulfill some GOR 339 requirements and also be capable of carrier-borne operations (Wood 1975, 156). However, the RAF's need for a large aircraft of the TSR type was pressed both formally and informally, and GOR 339 emerged unscathed.

5. This specified that the TSR.2, as it was coming to be known, should be capable of high-altitude supersonic flight and a 1,000-nautical-mile radius of operations in a mixed sub- and supersonic sortie. It should also be capable of low-altitude treetop-level flight, have a terrain-following radar, display a low gust response, and have a short takeoff capacity, which in turn entailed a high thrust-to-weight ratio. It should have precision, self-contained navigational aids, be capable of delivering both nuclear and high-explosive bombs, have advanced photographic and linescan capabilities, and be reliable in order to minimize losses and permit operation from poorly equipped forward bases. Finally, it should have a ferry range of 3,000 nautical miles and be capable of inflight refueling.

6. In its definitive form the proposed aircraft had 1. a cruising speed Mach 0.9–1.1 at sea level and Mach 2.05 at high altitude; 2. a sortie radius of 1,000 nautical miles, 3. a takeoff capability of 3,000–4,500 feet on rough surfaces; 4. a climbing rate of 50,000 feet per minute at sea level; 5. a takeoff weight of 95,000 pounds for a 1,000-nautical-mile mission; 6. a high-wing delta configuration with large blown flaps but no control surfaces; 7. a large tailplane with all-moving vertical and horizontal surfaces; 8. two internally mounted Olympus 22R engines; 9. an internal weapons bay; and 10. an internal fuel capacity of 5,588 gallons.

7. The development of the engine and the detective work involved in diagnosing the cause of its failure is discussed in detail in Law 1992.

8. In January the government considered an offer from the BAC to manufacture 110 aircraft at a price of £575 million, with the firm picking up the first £9 million of any cost overrun (*Flight International* 87, 2928, April 22, 1965, p. 622). It did not accept this offer primarily because it was not prepared to carry all additional losses.

9. The limits to organizational power are usefully discussed in Clegg 1989.

10. Although it is outside this story, the aircraft went through a further reshaping in 1967 when the F111 was canceled. At that point aircraft number 4—a further version of the Buccaneer—entered the scene.

11. The notion of "translation trajectory" is, of course, ironic. Translations are the product of continual negotiation. They are precisely not the result of momentum imparted at their point of origin. We use the term to indicate the way in which our concerns overlap those of trajectory theorists—see, for instance, Sahal 1981, Dosi 1982, and Nelson and Winter 1982—but offer an analysis of technical change that is quite different in kind.

The De-Scription of Technical Objects

Madeleine Akrich

AKRICH, Madeleine. 1992. The de-scription of technological objects. In: Wiebe E. Bijker; John Law (eds.). Shaping technology/building society: studies in sociotechnical change. Cambridge: The MIT Press, pp.205–24.

Describing the Interaction between Technics and Humans

Although science and technology are often thought to go together, they are concerned with very different subject matters. Science is taken to go beyond the social world to a reality unfettered by human contingency. Perhaps as a result, the sociology of science has studied the ways in which the local and the heterogeneous are combined to create knowledge with the status of universal and timeless truth. By contrast, sociologists have found it difficult to come to terms with technical objects. Machines and devices are obviously composite, heterogeneous, and physically localized. Although they point to an end, a use for which they have been conceived, they also form part of a long chain of people, products, tools, machines, money, and so forth. Even study of the technical content of devices does not produce a focused picture because there is always a hazy context or background with fuzzy boundaries. Thus even the most mundane objects appear to be the product of a set of diverse forces. The strength of the materials used to build cars is a function of predictions about the stresses they will have to bear. These are in turn linked to the speed of the car, which is itself the product of a complex compromise between engine performance, legislation, law enforcement, and the values ascribed to different kinds of behavior. As a consequence, insurance experts, police, and passers-by can use the condition of the bodywork of a car to judge the extent to which it has been used in ways that conform to the norms it represents.

Technical objects thus simultaneously embody and measure a set of relations between heterogeneous elements. However, the process of describing everything about a car in such terms would be a mammoth task.[1] Furthermore, the end product might well be banal. The automobile is so much a part of the world in which we live that its sociography (a description of all the links making it up) would no doubt look like a collection of commonplaces. It would, in other words, look like a set of places where elements of the technical, the social, the economic, and so on were to be found together, and it would leave observers free to switch between one element or register and another as this suited them.[2]

I am arguing, therefore, that technical objects participate in building heterogeneous networks that bring together actants of all types and sizes, whether human or nonhuman.[3] But how can we describe the specific role they play within these networks? Because the answer has to do with the way in which they build, maintain, and stabilize a structure of links between diverse actants, we can adopt neither simple technological determinism nor social constructivism. Thus technological determinism pays no attention to what is brought together, and ultimately replaced, by the structural effects of a network. By contrast social contructivism denies the obduracy of objects and assumes that only people can have the status of actors. The problem is not one of deciding whether a technology should be seen as an instrument of progress or a new method for subjugating people. It is rather to find a way of studying the conditions and mechanisms under which the relations that define both our society and our knowledge of that society are susceptible to partial reconstruction.

To do this we have to move constantly between the technical and the social. We also have to move between the inside and the outside of technical objects. If we do this, two vital questions start to come into focus. The first has to do with the extent to which the composition of a technical object constrains actants in the way they relate both to the object and to one another. The second concerns the character of these actants and their links, the extent to which they are able to reshape the object, and the various ways in which the object may be used. Once considered in this way, the boundary between the inside and the outside of an object comes to be seen as a *consequence* of such interaction rather than something that determines it. The boundary is turned into a line of demarcation traced, within a geography of delegation,[4] between what is assumed by the technical object and the competences of other actants.

However, the description of these elementary mechanisms of adjustment poses two problems, one of method and the other of vocabulary. The difficulty with vocabulary is the need to avoid terms that *assume* a distinction between the technical and the social. Because the links that concern us are necessarily *both* technical and social, I develop and use a vocabulary drawn from semiotics that is intended to avoid this difficulty.[5] The methodological problem is that if we want to describe the elementary mechanisms of adjustment, we have to find circumstances in which the inside and the outside of objects are not well matched. We need to find disagreement, negotiation, and the potential for breakdown.

There are several areas—for instance, in technological innovation and technology transfer—where objects and their supposed functions, or the relationship between supply and demand, are poorly matched. In what follows I describe a number of cases of "technology transfer" to less-developed countries (LDCs) that are drawn from my own fieldwork. These range from the simple transplantation of a piece of technical apparatus widely used in industrial societies to the development of objects specifically intended for use in LDCs.[6] In each case I describe the elementary mechanisms of reciprocal adjustment between the technical object and its environment.

I start by considering the way in which technical objects define actants and the relationships between actants. I show that the ease with which the actants assumed in the design of the object are related to those that exist in practice is partly a function of decisions made by designers. The obduracy or plasticity of objects, something that is established in the confrontation with users, is a function of the distribution of competences assumed when an object is conceived and designed.

In the second part of the chapter I consider the way in which technical objects distribute causes. If most of the choices made by designers take the form of decisions about what should be delegated to whom or what, this means that technical objects contain and produce a specific geography of responsibilities, or more generally, of causes. To be sure this geography is open to question and may be resisted. Nevertheless, it suggests that new technologies may not only lead to new arrangements of people and things. They may, in addition, generate and "naturalize" new forms and orders of causality and, indeed, new forms of knowledge about the world. I will consider this process and illustrate the way in which technologies may generate both forms of knowledge and moral judgments.

Subjects and Objects in the Making

From Script to De-Scription

For some time sociologists of technology have argued that when technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted.[7] Designers thus define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of "*inscribing*" this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a "script" or a "scenario."

The technical realization of the innovator's beliefs about the relationships between an object and its surrounding actors is thus an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the pre-scriptions (notices, contracts, advice, etc.) that accompany it. To be sure, it may be that no actors will come forward to play the roles envisaged by the designer. Or users may define quite different roles of their own. If this happens, the objects remain a chimera, for it is in the confrontation between technical objects and their users that the latter are rendered real or unreal.

Thus, like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act. Sigaut (1984) gives examples of tools whose form suggests a precise description (à la Sherlock Holmes) of their users. The two-handled Angolan hoe is made for women carrying children on their backs. The laborer's stake, with its single point, can only be driven in by two people, and thus presupposes a collective user. However, once one moves away from such simple examples, it becomes more difficult to uncover the links between technical choices, users' representations, and the actual uses of technologies. Thus the method of content analysis, as applied to texts, adopts an individual and psychological approach that has little or no relevance to our problem. Indeed, because it ignores the wide range of uses to which objects may be put, it comes close to technological determinism. It is obvious that it cannot possibly explain the wide variety of fates experienced by technological projects—fates that range from complete success to total failure.

One way of approaching the problem is to follow the negotiations between the innovator and potential users and to study the way in which the results of such negotiations are translated into technological form. Indeed, this method has been widely used in sociological and historical studies of technology. Thus, if we are interested in technical objects and not in chimerae, we cannot be satisfied methodologically with the designer's or user's point of view alone. Instead we have to go back and forth continually between the designer and the user, between the designer's projected user and the real user, between *the world inscribed in the object* and *the world described by its displacement*. For it is in this incessant variation that we obtain access to the crucial relationships: the user's reactions that give body to the designer's project, and the way in which the user's real environment is in part specified by the introduction of a new piece of equipment. The notion of *de-scription* proposed here has to be developed within this framework. It is the inventory and analysis of the mechanisms that allow the relation between a form and a meaning constituted by and constitutive of the technical object to come into being. These mechanisms of adjustment (or failure to adjust) between the user, as imagined by the designer, and the real user become particularly clear when they work by exclusion, whether or not this exclusion is deliberate.[8] The case of the photoelectric lighting kit is an example in which exclusion was explicitly sought by no one.

The Photoelectric Lighting Kit: Or How to Produce a Non-User

The photoelectirc lighting kit was born from the wish of a government agency to promote new energy sources. As part of its cooperative international activities, the agency wanted to work on and and meet the need for lighting—something that well-intentioned informants said was essential for all LDCs. At the same time it wanted to help the French photoelectric cell industry to create a market.

Caught up, as they were, in a specific network involving state support with industry, those involved in its design conceived of the kit as a function of the specific needs and constraints imposed on them by this network. At no point, for instance, did commercial considerations come into play. Accordingly, the shape of the lighting kit can be treated as a description of the way in which this network operated—a network characterized by the circulation of certain types of resources and the exclusion of other actors. The "narrative" patterns and scripts dreamed up by those who conceived the kits were quite specific, a function of their position. Study of the lighting kit (or any other technical object) makes it possible for us to create the "sociology" of the network defined by its circulation.

When I first heard the industrialists and designers talking about the lighting kit, it appeared to be a very simple array with three functional elements. There was a panel for producing electricity, a storage battery, and a lamp that consumed the electricity. However, once I arrived in Africa and started to study the ways in which such kits were actually used, the picture rapidly became more complicated. Those who were responsible for installing and maintaining kits were confronted with considerable difficulties. The first of these was that the wires linking the different components—the panel, the batteries, and the fluorescent tubes—were fixed in length and could not easily be altered because the connections were made with non-standard plugs. This meant that it was difficult to adapt the kits to fit rooms of different sizes. Replacing components with short lifetimes, such as lamps or batteries, represented a second set of difficulties. Neither appropriate fluorescent tubes, nor the watertight batteries chosen to ensure that maintenance problems would not limit the life of the system, were available in markets outside the capital. Local sources of supply were thus of no help to the user. As a result, despite the fact that it was a major element in his or her technical environment, the user lost control over the installation. Suddenly, what had previously been familiar started to become strange (the first question users asked was often "When do I have to add water to the batteries?"). A third factor also worked to prevent the user from appropriating the installation. This was the fact that the contractor who installed the kit forbade him or her to turn to a local electrician in case of breakdown. Instead, the contractor said that he would come to the area twice a year to repair faulty installations. The reason for this embargo on local repairs was the sensitivity of the photoelectric panel. This, as the instructions put it, "converts solar energy directly into electrical energy." However, the fact that this took the form of direct current with non-equivalent poles meant, at least in the view of the contractor, that it would be risky to call in a local electrician who would have experience of alternating but not of direct current. The danger was that if equipment was connected the wrong way, it might be damaged.

The discovery of these difficulties illustrates an important point of method. Before leaving Paris for Africa, the potential significance of nonstandard plugs, direct current, or waterproof batteries had not occurred to me. It was only in the confrontation between the real user and the projected user that the importance of such items as the plugs for the difference between the two came to light.[9] The materialization and implementation of this technical object, like others, was a long process in which both technical and social elements were simultaneously brought into being—a process that moved far beyond the frontiers of the laboratory or the workshop.

The fact that the importance of these characteristics only became evident in the interaction between designers and users was not the result of chance or negligence. Each decision actually taken made sense in terms of design criteria. Direct current is cheaper than alternating current because a transformer consumes a good part of the available power. Watertight batteries and nonstandard connections were chosen to prevent people from interfering with and so potentially damaging the kit. The length of the wiring had to be limited or it would reduce the performance of the equipment. These decisions were intended to ensure that the lighting kit would "work" under all circumstances—an important consideration in the negotiations between the industrialists and their clients. It should be recalled that it was not the latter who were the ultimate users of the kit, but rather the donating agency and the government to which the gift was to be made. Indeed, such was the concern to produce a foolproof kit that the designers decided not to have a separate switch in the circuit because this might become a point of illicit entry into the system. This meant that users often found it difficult to turn the light on or off because the only switch available was attached directly to the light and so was normally out of reach.

So it was that the technical object defined the actors with which it was to interact. The lighting kit (and behind it the designers) worked by a process of elimination. It would tolerate only a docile user and excluded other actors such as technicians or businesspeople who might normally have been expected to contribute to the creation of a technico-economic network. Had the users really been as docile as the designer intended, I would not have seen that the kit represented a large set of *technically delegated prescriptions* addressed by the innovator to the user.

If we are to describe technical objects, we need mediators to create the links between technical content and user. In the case of nonstabilized technologies these may be either the innovator or the user. The situation is quite different when we are confronted with stabilized technologies that have been "black boxed." Here the innovator is no longer present, and study of the ordinary user is not very useful because he or she has already taken on board the prescriptions implied in interaction with the machine. Under such circumstances some prescriptions may be found in user's manuals or in contracts. Alternatively, we may study disputes, look at what happens when devices go wrong, or follow the device as it moves into countries that are culturally or historically distant from its place of origin. In the next section I adopt the last of these methods to describe the use of generators in Senegal.

De-Scription in Technological Transfer: Reinventing and Reshaping Technical Objects in Use

In rural Senegal generators are widely used by "festive groups." An administration buys some small generators, which it distributes to youth groups in the villages. With the generators may come lights, a record player, or a loudspeaker. The youth groups use the generators or lend them to their members who pay for the cost of fuel and oil. Again, they may rent them out to other villagers who are also responsible for the cost of fuel and oil. The money that is made by the rental of generators is shared, with part going to the person who transports the generator and part going to the association. In this way a small collection of actors is involved with the generator—actors that can be seen as so many additions to the components that make up the generator.

The generator's metal trailer means that it is mobile, and so it plays an important part in this process. This is because the field of possible users and the relations between the different actors is defined by the movement of the generator. However, the fuel tank rivals the generator for the starring role because it draws a fundamental distinction between capital costs and operating costs. This distinction is inscribed from the outset in the social setup that brings the generator to the village: there is the administration, which underwrites the investment, and there is the group that actually manages and runs the generator. The technical device reduces negotiations between the two parties to a minimum because it directly suggests a prenegotiated agreement. Obviously things could be arranged differently. This, however, would mean delegating a whole series of tasks to additional (legal, human, and technical) structures external to the generator and its trailer. It might even entail new systems of measurement—in which case it is not clear whether we would still be dealing with the same object.

The situation would be quite different if we were faced with a device whose costs were concentrated exclusively on the side of investment—as, for instance, with the photoelectric kits. What kind of relationship can there be between the buyer and the user under such circumstances? This was a question faced by those promoting the development of photoelectric cells in French Polynesia. Once these cells had been distributed, it was not always possible to insist that these two classes of costs should be distinguished. Not only did the technology itself fail to discriminate between them, but it offered no method of measurement that could be translated into appropriate socioeconomic terms. Thus no matter how it is used, a photoelectric panel generates current as a function of climate and latitude. The "standard" relationship between production and consumption (a reflection of the interdependence of two groups of actors) is replaced by an individual, direct, and indeed arbitary submission to natural forces.

The difference between this and the generator is obvious. In the case of the generator, the fuel tank can be used to measure the relationship between its use and the cost of that use—a relationship embodied in the motor as a whole. The creation of a particular kind of social link, that of renting out, is conditioned by the existence of this relationship, which delocalizes the generator by creating many groups of actors: investors/purchasers, owners/users, associate users, renters, and transporters. The existence of transporters makes the property even "purer," for they free it from servitude. Their payment marks the boundary of group solidarity, for the work of a single person cannot enrich the community. At the same time the generator builds a space and a social geography. Thus the teachers in one of the villages who needed lighting for their evening classes did not even consider renting a generator. The division between the world of the "market" and the "civic"[10] world may not have been brought into being in the village by the social differentiation entailed in electricity and its uses, but it was certainly modified by the latter.

The lighting kit put itself forward as a "hypothetical" object, whereas the generator was just another piece of equipment integrated into the various sectors of economic life. However, we should not overstate the difference between them. This is best seen in terms of differential resistance. It would would take much more effort to (re)dismantle the generator than it would the lighting kit. But in both cases we are dealing with the creation and extension of networks that simultaneously define both the social and the technical. Thus such items as nonstandard plugs and fuses become significant when the real users start to displace projected users. Again, the competence of the youth group, its relations with other elements of village life, the very definition of these elements—all of these are determined at the same time as, and by the same process, that defines the components that make up the generator. If we were to restrict our attention to the "function" fulfilled by this piece of equipment within the youth group, we might imagine that some other technical system (for instance, solar panels or connection to the national grid) would function in the same way. This, however, is not the case, for under such circumstances the relationship between the youth group and others in the village would be different and probably more fluid. In this sense, then, we can say that our relationships with the "real world" are mediated by technical objects.

Prescriptions as a Way of Enrolling Actors: Or How to Make Citizens

So far I have described technologies that appear to exercise relatively weak constraints over those who use them. If the generator and those who sponsor it nudge some who would otherwise be outside economic relations in the direction of involvement, then this effect is relatively small. In the case of the photoelectric lighting kit, the main danger is that no one will use it at all. However, technologies are not always like this. Sometimes their designers and builders use them to obtain access to certain actors, whom they push into specific roles. This is what happened in the case of the Ivory Coast and its electricity network. Here the physical extension of the network was an integral part of a vast effort to reorganize the country spatially, architecturally, and legally. The object was to create such new and "modern" entities as the individual citizen.

Winner (1980) has argued that certain technologies are inherently political—for instance, nondemocratic. If he is right about this, then the approach I have adopted here would lead to a form of technological determinism. However, the case of electrification in the Ivory Coast shows that even in those cases where there are marked political implications, it is first necessary to interest and persuade the actors to play the roles proposed for them.

Until recently village property in the Ivory Coast was collectively owned and under the control of elders, who allocated tracts of land to villagers as a function of their needs. This allocation was not permanent, and people might move to different areas. When the authorities started to think about electrification, they decided that this should be contingent on a more stable allocation of land, and in particular on a distinction between private and public property. Those developing the new electricity network (who also presented themselves as spokespersons for the general interest) assumed that the network would both contribute to this division and depend on it, as it would be installed on public land. In other words, the electricity network made it possible for the state to create its own space (the space of common interests) that could not be appropriated by anyone else. At the same time, it defined those with whom it would interact. Because only the individual would legally exist in this new system, former collective modes of village representation were thus systematically excluded.

To be sure, the creation of a system that allocated land permanently either to individuals or the state was a function of agreement in the village as a whole about the need for such stability. Through the new property system the electricity company was thus asking the villagers to make a *pre-inscription* witnessing their consent to a certain kind of future. Thus, individual villagers had to undertake certain formalities to secure title to fixed property. From the standpoint of the electricity company, legal ownership could be treated as a token for a range of agreements between different bodies about the future of the village. The new system of property was also the foundation for a series of projects by other utilities (the highway department, the water authority, the medical service, the education system). It meant that electrification could be integrated into various modernization programs, and it established economical procedures for consultation and political negotiation. Finally, the construction of the network itself would put the agreement of the village into practice and stablize it by making a durable inscription on the landscape.

But why should the villagers agree to enter into a game in which they would, or so it seems, lose a part of their independence? After all, by so doing they would place themselves under the influence of a central authority that would, by virtue of this very fact, increase its power. There are several answers to this question. The villagers wanted to have access to electricity. But there was the question of the way in which the company negotiated with the village. Indeed, to put it in this way is misleading. The company did not negotiate directly with the village. Rather, it negotiated with a spokesperson—invariably someone who had "succeeded" and moved from the village to the capital. Both this spokesperson, who negotiated with a range of central authorities on behalf of the village, and the villagers themselves knew that a series of indirect benefits would follow from agreement with the electricity company. After electrification the village could hope for better teachers, an improved health service, more financial support, and an increase in the number of development projects. In short, electrification was a method for avoiding direct and specific negotiations between the villagers and a series of external agencies. It was a package whose terms were fixed in advance. Those in the village had a choice. They could accept those terms or they could reject them, and overall the package was attractive.

In general an individual becomes a citizen only when he or she enters into a relationship with the state. In the Ivory Coast this was effected through the intermediary of cables, pylons, transformers, and meters. By contrast, in France individuals are inserted into such a wide range of networks that they have little chance of avoiding citizenship. From the registry office, via obligatory schooling to military service and the welfare state, the mesh of the state with its different superimposed networks draws ever tighter around them. In countries that have been created more recently, specific networks may come to the aid of a weak or non-existent state. The electricity network may create and maintain a relationship between an individual and a place. Thus in the Ivory Coast, where only a minority of salaried workers paid income tax, the electricity bill became the means by which local taxes were collected in recently built towns. Here, then, it was the electricity network that fostered a wider definition of the concept of citizenship.

From Causes to Accusations and Forms of Knowledge

In the examples above I have shown how technical objects define actors, the space in which they move, and ways in which they interact. Competences in the broadest sense of the term are distributed in the script of the technical object. Thus many of the choices made by designers can been seen as decisions about what should be *delegated* to a machine and what should be left to the initiative of human actors. In this way the designer expresses the scenario of the device in question—the script out of which the future history of the object will develop. But the designer not only fixes the distribution of actors, he or she also provides a "key" that can be used to interpret all subsequent events. Obviously, this key can be called into question—consumer organizations specialize in such skepticism. Nevertheless, although users add their own interpretations, so long as the circumstances in which the device is used do not diverge too radically from those predicted by the designer, it is likely that the script will become a major element for interpreting interaction between the object and its users.

Abobo-the-War and Marcory-No-Wire: Where Technology Meets Morality

In this section I focus on one particular process—moral delegation—and discuss devices installed by designers to control the moral behavior of their users. I describe the way in which such devices may measure behavior, place it in a hierarchy, control it, express the fact of submission, and distribute causal stories and sanctions.

As I have indicated, the introduction of the electricity network has established links between individuals in the Ivory Coast. The way in Which the individual/consumer relates to the network, and via the network to the electricity company, is codified and quantified by means of a basic technical tool, the electricity meter. This formulates the initial contract between the producer and the consumer. If one or the other fails to meet its obligations, the meter becomes invalid or inactive. Meters have a symmetrical effect on the producer/consumer relationship. The agreement of both is required if they are to tick over. Accordingly, the *set* of meters is a powerful instrument of control. Taken together, the set of meters measures the cohesion of the sociotechnical edifice materialized by the network. Consider the following story, which appeared in *The Kanian*, the electricity company newspaper, in its February–May 1985 issue:

> OPERATION STRIKEFORCE AT "ABOBO-THE-WAR"
> There is a flashing red light in the DR in Abobo, a lower class suburb of Abidjan, where there are 66,854 subscribers; the network's rate of return (the relationship between the energy put out by the producer and the energy billed to the clientele) has fallen from 0.93 to 0.87 in the space of one year!

Any reduction in the rate of return can be interpreted as an increase in the number of illicit connections, the work of corrupt employees, or a consequence of trafficking in meters. With both human and technical actors involved, the network measures illicit behavior and determines its character.

The definition of social space also extends to non-electrified areas. These are characterized in terms of their degree of deviance from the norm—that is, from electrification. Thus another suburb of Abidjan, Marcory, was split into two by the network. Each was given a name, and characterized in social terms:

> Unlike residential Marcory, Marcory-No-Wire is a Marcory without electricity, without wires. It is well known that Abidjanis have a sense of humour. A suburb with no wires, imagine what kind of a spectacle that offers. For if electricity is a sign of progress, its absence suggests other absences: of hygiene in the streets, of buildings constructed to certain standards, of pharmacists, playgrounds, sportsgrounds and so on. When you add darkness at night to these absences, then the guardians of the peace would say you get a criminal haunt. (Toure 1985)

Even so, the dividing line between the permissible and the impermissible is negotiable. Thus in their strike-force operations, electricity company agents were told to replace so-called Russian meters that had proved defective without penalizing their owners, even though a simple tap on the meter would block it and allow unbilled electricity to be consumed. Unlike the agents, the "Russian" meters found it impossible to distinguish between licit and illicit behavior, between the actions of humans and nonhumans. Accordingly, although the contract between supplier and consumer remained in force, the meter failed in its prescribed role as the material inscription of that contract.

Each *individual* meter intervened as referee and manager of the relationship between supplier and consumer. Taken together, the *set* of meters operated as police in a collective organization, uncovering irregularities. Such irregularities appeared first as deviations in consumption curves that were neither localized nor sanctioned. They could, however, be quickly translated into "social" terms.

Some techniques move closer to "social control." They establish norms and punish those who transgress them. Thus the storage and regulation systems in photoelectric kits take the form of batteries and electronic components. The batteries store the electricity so that it can be given out, for example, for lighting when it is dark. However, the control system lies at the heart of a technical, economic, and social imbroglio. If the battery is allowed to run too low, its lifetime will be reduced. On the other hand, if it is overcharged, electricity may leak back into it and ruin the photoelectric cell. Users might, of course, be given meters with which they could plan their electricity consumption while avoiding both of these dangers. In fact this solution is never adopted because the designers do not believe that users will allow the technical requirements of the system to overrule their immediate wishes. Again, the designers could choose to increase the capacity of the system to cope with the likely demands of the users. This, however, is a costly option. Accordingly, the designers adopt the third option of installing a regulator that cuts off the current to the user when the charge on the battery gets too low, and isolates the photoelectric panel when it gets too high.[11] As a result, a particular mode of consumption is imposed: the user cannot be too greedy, yet neither can he or she hope to compensate for excess consumption by prolonged abstinence. The penalty for breaking the rules—rules that are both social and technical—is immediate and abrupt: the current is cut off and is not reconnected until the battery is adequately recharged.

This method of regulation is designed to "groom" the user. It offers a set of rewards and punishments that is intended to teach proper rules of conduct. However, a flaw in the system is that there is no easy way to measure the charge in the battery. Voltage is only a rough indication. What should be done about this? A general who is not sure of the loyalty of his troops has two options. He may choose to do nothing. Or, like the designers in this case, he may redouble his precautions and disciplinary measures. Accordingly, as I have mentioned, a particularly inflexible system with nonstandard plugs was adopted. Thus while the control device was telling the user not to get too big for his or her boots, the nonstandard plugs were imposing even more draconian limitations on conduct. No bypass of the control device was permissible!

Even so, in French Polynesia the control device proved to be a shaky ally for the designers, because the users felt that its sanctions were arbitrary. The result was that they denounced it and expressed their displeasure by telephoning the electrician every time the system treacherously cut off the current while they were quietly sitting watching television. The electrician, who quickly became tired of doing repairs in the evening, tricked the system by installing a fused circuit in parallel with the control device. When the control device shut off the current, users could bypass it with the fuse, and the electrician would only be called out the following morning. The fused circuit thus marked the submission of electricians to the wishes of their clients and allowed them to be present by proxy instead of being summoned in person by irate users.

The precarious and makeshift character of the fuse makes it plain that some kind of intervention was necessary, even if it only took place after the event. In this particular trial it was the electricians who pleaded guilty. In fitting the fuse, they recognized that the control device and their clients were *both* right and moderated the judgments of the former in favor of the latter.

"The Order of Things and Human Nature": The Stabilization and Naturalization of Scripts

I have described several cases in which technical objects preformed their relationships with actors and vested them with what could be called "moral" content. Because roles and responsibilities are allocated, accusations and trials tend to follow. In principle, no one and nothing is protected from such denunciation. In the case of the electricity network, the users were accused of failing to respect the contract with the meter. However, the electricity company also accused some of the meters of failing to represent that contract. In the case of the photoelectric kits, it was the electricians, and indirectly the manufacturers, who found themselves in the dock through the agency of the control device. Indeed, the story of the kits can be read as a long series of reciprocal accusations. The industrialists tended to argue that if it didn't work (technically), this was because it had been misused (socially). The users, or those who claimed to be their representatives, argued that if it didn't work socially, this was because it had been misconceived *technically*. Here, then, we see an almost perfect "reversible reaction" that reveals the lack of a relationship, through the kit, between designers and users. The users did not interest the manufacturers; they were only important to the extent that they made it possible to go to the ministry of overseas development and seek support for a product that did not yet have a market. And in this interaction the kit did not actually have to do anything. Rather it was the *users* who were treated as an instrument for building a relationship between the manufacturers and the government.

In the case of the electricity network, the situation was quite different. It is difficult to imagine a plausible argument for illegal connection to the network—one in which the electricity network would stand in the dock. This is because the network configured a whole range of relationships. I have already mentioned the meter and the way in which it was related to the allocation of property. But relationships were structured by the network in many other ways. For example, it also tended to stabilize living space. This was because, for reasons of security and as a guarantee of solvency, only "permanent" structures were connected to the grid. And of course, once the grid was in place, new commercial networks for distributing electrical equipment quickly sprang up. Thus once it was established, the network tended to promote both physical and social stability. A wide range of elements were brought together and given substance. A small fringe group of "deviants" could not possibly hope to find the strength needed to outweigh the many actors bound together by the grid. Accordingly, the electricity company could call upon the meters to act as unequivocal spokespeople at will. A double irreversibility had been established—a material irreversibility inscribed in space and practice, and a directional irreversibility where accusations and charges could no longer be reversed. Obviously the two were intimately linked.

In this section I have argued that technical objects not only define actors and the relationships between them, but to continue functioning must stabilize and channel these. They must establish systems of causality that draw on mechanisms for the abstraction and simplification of causal pathways. In the case discussed above, the replacement of the "Russian" meters was very much part of this process—a process designed to make diagnosis automatic. Farther along the same path lies artificial intelligence.[12]

Conclusion: Toward the Constitution of Knowledge

Once technical objects are stablized, they become instruments of knowledge.[13] Thus when an electricity company sets differential tariffs for high- and low-consuming domestic users, for workshops, and for industrial consumers, it finds ways of characterizing and identifying different social strata. If it also chooses categories used in other socioeconomico-political network, then the knowledge it produces can be "exported." "Data" can thus be drawn from the network and transmitted elsewhere, for instance, to economists concerned with the relationship between the cost of energy or GNP and consumption. However, the conversion of sociotechnical facts into facts pure and simple depends on the ability to turn technical objects into black boxes. In other words, as they become indispensable, objects also have to efface themselves. I will illustrate this with an example drawn from Burkino-Faso.

Burkino-Faso is a developing country with a tiny electricity network. Over the past few years it has been government policy to electrify urban centers. The first problem for the engineers and technicians was to judge potential demand and decide how large the network should be. Two different approaches were adopted. The economic studies unit asked potential subscribers what price they would be willing to pay for electricity. This approach assumed that there was a relationship between supply and demand, and that consumption would vary inversely with price. The technical unit adopted a very different method. It drew maps of the towns, marked off the built-up areas, and noted the characteristics of the houses (whether large or small, permanent or temporary, and so on). On the basis of this map they designed a network that would be legally, economically, and technically feasible—a network that would make use of public space and serve only permanent buildings and government facilities.

The results obtained by the two approaches were quite different. In particular, the geographical and legal approach of the technical unit suggested the need for a far larger network than the market-led approach of the economic studies unit. The latter had acted as if there were no need for technical mediation between price and consumption. They assumed, that is, that this relationship was a fact of nature that would be given concrete form by the electricity network. In a sense they were led astray by the naturalization effect, which occurs when technical systems are completely integrated into the social fabric. It is only when the script set out by the designer is acted out—whether in conformity with the intentions of the designer or not—that an integrated network of technical objects and (human and nonhuman) actors is stabilized. And it is only at this point that this network can be characterized by the circulation of a finite number of elements—objects, physical components, or monetary tokens. Disciplines such as economics and technology studies depend on the presence of a self-effacing apparatus that lies outside their domains. Economists extract one kind of information from technical objects, technologists another. They are able to do this because such objects function in stable situations. The introduction of a new device can thus be assimilated, for example by economists, into the price/consumption relationship. The economy is not cut off from technology; there is no radical disjunction.

This is why it makes sense to say that technical objects have political strength. They may change social relations, but they also stabilize, naturalize, depoliticize, and translate these into other media. After the event, the processes involved in building up technical objects are concealed. The causal links they established are naturalized. There was, or so it seems, never any possibility that it could have been otherwise.[14]

We are ourselves no more innocent in this respect than anyone else. For we are able to say that technical objects changed, stabilized, naturalized, or depoliticized social relations only with the benefit of hindsight. The burden of this essay is that technical objects and people are brought into being in a process of reciprocal definition in which objects are defined by subjects and subjects by objects. It is only after the event that causes are stabilized. And it is only after the event that we are able to say that objects do this, while human beings do that. It is in this sense, and only in this sense, that technical objects build our history for us and "impose" certain frameworks. And it is for this reason that an anthropology of technology is both possible and necessary.

Notes

I would like to thank Geoffrey Bowker, who translated this text, John Law, who carefully reviewed the entire text, and Bruno Latour, who helped me arrive at the

more conceptualized form of the conclusions I drew from the various field studies discussed here.

1. Doubtless it could be satisfying to paint on a broad canvas, starting with nuts and bolts, pistons and cracks, cogs and fan belts, and moving on to voting systems, the strategies of large industrial groups, the definition of the family, and the physics of solids. In the case of such an inquiry we would no doubt find a mass of guides (people, texts, objects) ready to suggest ways in which we could extend our network. But such suggestions would be endless. On what grounds would the analyst stop—apart from the arbitrary one of lassitude? Quite apart from the indefinite amount of time such a study would take, there is also the question as to whether it would be interesting.

2. Here we are concerned with what might be called the consensual zone of the automobile, which is defined simultaneously by the major technical elements common to most vehicles and by their generally recognized uses. As is obvious, there are highly controversial zones around the margins, and it is around these points of friction that the battles leading to the establishment of supremacy of such and such a manufacturer or such and such a car are waged.

3. This term is used only as a convenient but imprecise shorthand. Depending on circumstances, the actor (a more general term to be prefered) may be a citizen, a member of a particular social class, a member of a profession, or even a finger or a body with a particular temperature as measured by a system of detection.

4. See Bruno Latour's text (this volume) for further discussion of delegation.

5. This vocabulary is further discussed in Latour's text in this volume and in the joint appendix to our papers.

6. I am aware that the reader may be frustrated by the way in which these examples are used. Within a short article it is not possible to give full details. But as they are intended to exemplify an argument, I hope that the reader will agree that the benefit of using them in this way outweighs the costs.

7. For a striking example of the interrelationship between the definition of technical parameters and the definition of a "world" for which the object is destined, see Callon's article on the electric vehicle in Bijker, Hughes, and Pinch 1987.

8. See, for example, Winner 1980 and Latour 1988a. Winner describes how the height of overpasses on the Long Island Parkway was chosen to prevent the passage of buses, the mode of transport most used by blacks, so that the use of leisure zones was effectively limited to whites. Latour, reinterpreting the example described by Daumas (1977), tells how, in exactly the same way, the radical Paris city council at the end of the nineteenth century decided to build metro tunnels too narrow for standard railway company trains. The objective, which succeeded for seventy years, was to prevent the private railway companies (supported by the right) from getting their hands on the Paris metro, whatever party happened to be in power. Multiple translations are necessary in order to arrive at such results. In Winner's case we need to move from the white/black to the car/bus distinction, and then on to the height of the overpasses. This is only possible because the black/white distinction is already *pre-inscribed* in unequal access to economic resources and, as a consequence, to expensive products such as cars. In Latour's case it is the width of the tunnels that allows the railway (and so the different companies and political parties) to be kept at arm's length from the metro.

9. In the French there is a play of words on *dessein* (design in the sense of plan) and *dessin* (design in the sense of drawing). The two have the same etymology.

10. I am drawing here on the distinction between "marchand" and "civique" discussed by Boltanski and Thevenot (1987).

11. Naturally, the different parts of the system are reconnected automatically once conditions change.

12. The question of "breakdown" is relevant to this issue and deserves further consideration. A "breakdown" relates closely to the definition I have offered of a technical object. This is because it can only be understood as a part of practice—that is, as the collapse of the relationship between a piece of apparatus and its use. A breakdown is thus a test of the solidity of the sociotechnical network materialized by a technical object. The rapidity with which the search for the causes of breakdown can be completed is a measure of this solidity.

13. Perhaps it would be better to say that the stablization of a technical object is inseparable from the constitution of a form of knowledge of greater or lesser significance. This hypothesis is powerfully supported by the case described by Misa (this volume): there an industry, a market, and the notion about what was to count as "steel" were all constructed simultaneously.

14. As is well known, Foucault (1975) has described the links between the technology of the penitentiary, power relations, and new forms of knowledge.

LATOUR, Bruno. 2008. Where are the missing masses? The sociology of a few mundane artifacts. In: Deborah J. Johnson; Jameson M. Wetmore (eds.). Technology and society: building our sociotechnical future. Cambridge: The MIT Press, pp.151-80. [1992]

10 "Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts"

Bruno Latour

One of the most popular and powerful ways of resolving the technological determinism/social constructivism dichotomy in technology studies is the actor network approach. Those advocating the actor network approach agree with the social constructivist claim that sociotechnical systems are developed through negotiations between people, institutions, and organizations. But they make the additional interesting argument that artifacts are part of these negotiations as well. This is not to say that machines think like people do and decide how they will act, but their behavior or nature often has a comparable role. Actor network theorists argue that the material world pushes back on people because of its physical structure and design. People are free to interpret the precise meaning of an artifact, but they can't simply tell an automobile engine that it should get 100 miles per gallon. The laws of nature and the capacities of a particular design limit the ways in which artifacts can be integrated into a sociotechnical system. In this chapter, one of the foremost contributors to the actor network approach, Bruno Latour, explores how artifacts can be deliberately designed to both replace human action and constrain and shape the actions of other humans. His study demonstrates how people can "act at a distance" through the technologies they create and implement and how, from a user's perspective, a technology can appear to determine or compel certain actions. He argues that even technologies that are so commonplace that we don't even think about them can shape the decisions we make, the effects our actions have, and the way we move through the world. Technologies play such an important role in mediating human relationships, Latour argues, that we cannot understand how societies work without an understanding of how technologies shape our everyday lives. Latour's study of the relationship between producers, machines, and users demonstrates how certain values and political goals can be achieved through the construction and employment of technologies.

Again, might not the glory of the machines consist in their being without this same boasted gift of language? "Silence," it has been said by one writer, "is a virtue which render us agreeable to our fellow-creatures."

Samuel Butler (*Erewhon*, chap. 23)

Early this morning, I was in a bad mood and decided to break a law and start my car without buckling my seat belt. My car usually does not want to start before I buckle the belt. It first flashes a red light "FASTEN YOUR SEAT BELT!," then an alarm sounds; it is

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From Wiebe E. Bijker and John Law, eds., *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, Mass.: MIT Press, 1992), pp. 225–258. Reprinted with permission.

so high pitched, so relentless, so repetitive, that I cannot stand it. After ten seconds I swear and put on the belt. This time, I stood the alarm for twenty seconds and then gave in. My mood had worsened quite a bit, but I was at peace with the law—at least with that law. I wished to break it, but I could not. Where is the morality? In me, a human driver, dominated by the mindless power of an artifact? Or in the artifact forcing me, a mindless human, to obey the law that I freely accepted when I get my driver's license? Of course, I could have put on my seat belt before the light flashed and the alarm sounded, incorporating in my own self the good behavior that everyone—the car, the law, the police—expected of me. Or else, some devious engineer could have linked the engine ignition to an electric sensor in the seat belt, so that I could not even have started the car before having put it on. Where would the morality be in those two extreme cases? In the electric currents flowing in the machine between the switch and the sensor? Or in the electric currents flowing down my spine in the automatism of my routinized behavior? In both cases the result would be the same from an outside observer—say a watchful policeman: this assembly of a driver and a car obeys the law in such a way that it is impossible for a car to be at the same time moving AND to have the driver without the belt on. *A law of the excluded middle* has been built, rendering logically inconceivable as well as morally unbearable a driver without a seat belt. Not quite. Because I feel so irritated to be forced to behave well that I instruct my garage mechanics to unlink the switch and the sensor. The excluded middle is back in! There is at least one car that is both on the move and without a seat belt on its driver—mine. This was without counting on the cleverness of engineers. They now invent a seat belt that politely makes way for me when I open the door and then straps me as politely but very tightly when I close the door. Now there is no escape. The only way not to have the seat belt on is to leave the door wide open, which is rather dangerous at high speed. Exit the excluded middle. The program of action[1] "IF a car is moving, THEN the driver has a seat belt" is enforced. It has become logically—no, it has become sociologically—impossible to drive without wearing the belt. I cannot be bad anymore. I, plus the car, plus the dozens of patented engineers, plus the police are making me be moral (figure 10.1).

According to some physicists, there is not enough mass in the universe to balance the accounts that cosmologists make of it. They are looking everywhere for the "missing mass" that could add up to the nice expected total. It is the same with sociologists. They are constantly looking, somewhat desperately, for social links sturdy enough to tie all of us together or for moral laws that would be inflexible enough to make us behave properly. When adding up social ties, all does not balance. Soft humans and weak moralities are all sociologists can get. The society they try to recompose with bodies and norms constantly crumbles. Something is missing, something that should be strongly social and highly moral. Where can they find it? Everywhere, but they too often refuse to see it in spite of much new work in the sociology of artifacts.[2]

I expect sociologists to be much more fortunate than cosmologists, because they will soon discover their missing mass. To balance our accounts of society, we simply

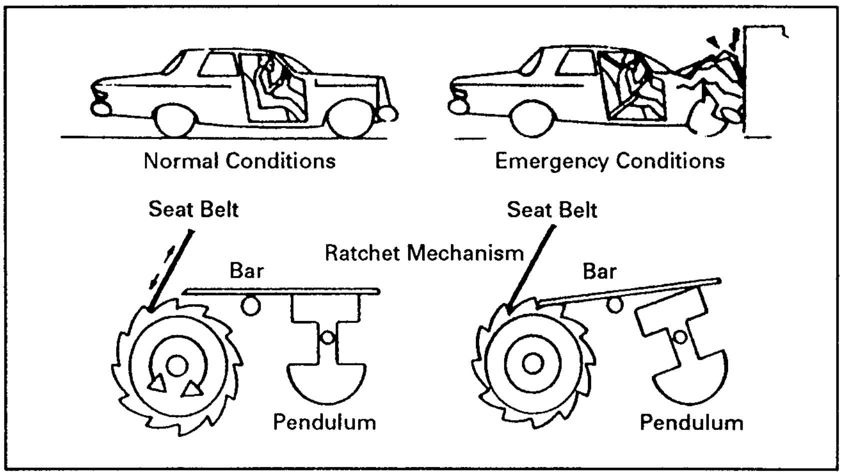

Figure 10.1
The designers of the seat belt take on themselves and then shift back to the belt contradictory programs; the best should be lenient and firm, easy to put on and solidly fastened while ready to be unbuckled in a fraction of a second; it should be unobtrusive and strap in the whole body. The object does not reflect the social. It does more. It transcribes and displaces the contradictory interests of people and things.

have to turn our exclusive attention away from humans and look also at nonhumans. Here they are, the hidden and despised social masses who make up our morality. They knock at the door of sociology, requesting a place in the accounts of society as stubbornly as the human masses did in the nineteenth century. What our ancestors, the founders of sociology, did a century ago to house the human masses in the fabric of social theory, we should do now to find a place in a new social theory for the nonhuman masses that beg us for understanding.

Description of a Door

I will start my inquiry by following a little script written by anonymous hands.[3] On a freezing day in February, posted on the door of La Halle aux Cuirs at La Villette, in Paris, where Robert Fox's group was trying to convince the French to take up social history of science, could be seen a small handwritten notice: "The Groom Is On Strike, For God's Sake, Keep The Door Closed" ("groom" is Frenglish for an automated door-closer or butler). This fusion of labor relations, religion, advertisement, and technique in one insignificant fact is exactly the sort of thing I want to describe[4] in order to discover the missing masses of our society. As a technologist teaching in the School of Mines, an engineering institution, I want to challenge some of the assumptions sociologists often hold about the social context of machines.

Walls are a nice invention, but if there were no holes in them there would be no way to get in or out—they would be mausoleums or tombs. The problem is that if you make holes in the walls, anything and anyone can get in and out (cows, visitors, dust, rats, noise—La Halle aux Cuirs is ten meters from the Paris ring road—and, worst of all, cold—La Halle aux Cuirs is far to the north of Paris). So architects invented this hybrid: a wall hole, often called a *door*, which although common enough has always struck me as a miracle of technology. The cleverness of the invention hinges upon the hingepin: instead of driving a hole through walls with a sledgehammer or a pick, you simply gently push the door (I am supposing here that the lock has not been invented—this would overcomplicate the already highly complex story of La Villette's door); furthermore—and here is the real trick—once you have passed through the door, you do not have to find trowel and cement to rebuild the wall you have just destroyed: you simply push the door gently back (I ignore for now the added complication of the "pull" and "push" signs).

So, to size up the work done by hinges, you simply have to imagine that every time you want to get in or out of the building you have to do the same work as a prisoner trying to escape or as a gangster trying to rob a bank, plus the work of those who rebuild either the prison's or the bank's walls. If you do not want to imagine people destroying walls and rebuilding them every time they wish to leave or enter a building, then imagine the work that would have to be done to keep inside or outside all the things and people that, left to themselves, would go the wrong way.[5] As Maxwell never said, imagine his demon working *without* a door. Anything could escape from or penetrate into La Halle aux Cuirs, and soon there would be complete equilibrium between the depressing and noisy surrounding area and the inside of the building. Some technologists, including the present writer in *Material Resistance, A Textbook* (1984), have written that techniques are always involved when asymmetry or irreversibility are the goal; it might appear that doors are a striking counterexample because they maintain the wall hole in a reversible state; the allusion to Maxwell's demon clearly shows, however, that such is not the case; the reversible door is the only way to trap irreversibly inside La Halle aux Cuirs a differential accumulation of warm historians, knowledge, and also, alas, a lot of paperwork; the hinged door allows a selection of what gets in and what gets out so as to locally increase order, or information. If you let the drafts get inside (these renowned "courants d'air" so dangerous to French health), the paper drafts may never get outside to the publishers.

Now, draw two columns (if I am not allowed to give orders to the reader, then I offer it as a piece of strongly worded advice): in the right-hand column, list the work people would have to do if they had no door; in the left-hand column write down the gentle pushing (or pulling) they have to do to fulfill the same tasks. Compare the two columns: the enormous effort on the right is balanced by the small one on the left, and this is all thanks to hinges. I will define this transformation of a major effort into a minor one by the words *displacement* or *translation* or *delegation* or *shifting*;[6] I will say that we have delegated (or translated or displaced or shifted down) to the hinge the work of reversibly solving the wall-hole dilemma. Calling on Robert Fox, I do not have to do this work nor even think about it; it was delegated by the carpenter to a character, the hinge, which I will call a *nonhuman*. I simply enter La Halle aux Cuirs. As a more general descriptive rule, every time you want to know what a nonhuman does, simply imagine what other humans or other nonhumans would have to do were this character not present. This imaginary substitution exactly sizes up the role, or function, of this little character.

Before going on, let me point out one of the side benefits of this table: in effect, we have drawn a scale where tiny efforts balance out mighty weights; the scale we drew reproduces the very leverage allowed by hinges. That the small be made stronger than the large is a very moral story indeed (think of David and Goliath); by the same token, it is also, since at least Archimedes' days, a very good definition of a lever and of power: what is the minimum you need to hold and deploy astutely to produce the maximum effect. Am I alluding to machines or to Syracuse's King? I don't know, and it does not matter, because the King and Archimedes fused the two "minimaxes" into a single story told by Plutarch: the defense of Syracuse through levers and war machines.[7] I contend that this reversal of forces is what sociologists should look at in order to understand the social construction of techniques, and not a hypothetical "social context" that they are not equipped to grasp. This little point having been made, let me go on with the story (we will understand later why I do not really need your permission to go on and why, nevertheless, you are free not to go on, although only *relatively* so).

Delegation to Humans

There is a problem with doors. Visitors push them to get in or pull on them to get out (or vice versa), but then the door remains open. That is, instead of the door you have a gaping hole in the wall through which, for instance, cold rushes in and heat rushes out. Of course, you could imagine that people living in the building or visiting the Centre d'Historie des Sciences et des Techniques would be a well-disciplined lot (after all, historians are meticulous people). They will learn to close the door behind them and retransform the momentary hole into a well-sealed wall. The problem is that discipline is not the main characteristic of La Villette's people; also you might have mere sociologists visiting the building, or even pedagogues from the nearby Centre de Formation. Are they all going to be so well trained? Closing doors would appear to be a simple enough piece of know-how once hinges have been invented, but, considering the amount of work, innovations, sign-posts, and recriminations that go on endlessly everywhere to keep them closed (at least in northern regions), it seems to be rather poorly disseminated.

This is where the age-old Mumfordian choice is offered to you: either to discipline the people or to substitute for the unreliable people another delegated human character whose only function is to open and close the door. This is called a groom or a porter (from the French word for door), or a gatekeeper, or a janitor, or a concierge, or a turnkey, or a jailer. The advantage is that you now have to discipline only one human and may safely leave the others to their erratic behavior. No matter who it is and where it comes from, the groom will always take care of the door. A nonhuman (the hinges) plus a human (the groom) have solved the wall-hole dilemma.

Solved? Not quite. First of all, if La Halle aux Cuirs pays for a porter, they will have no money left to buy coffee or books, or to invite eminent foreigners to give lectures. If they give the poor little boy other duties besides that of porter, then he will not be present most of the time and the door will stay open. Even if they had money to keep him there, we are now faced with a problem that two hundred years of capitalism has not completely solved: how to discipline a youngster to reliably fulfill a boring and underpaid duty? Although there is now only one human to be disciplined instead of hundreds, the weak point of the tactic can be seen: if this *one* lad is unreliable, then the whole chain breaks down; if he falls asleep on the job or goes walkabout, there will be no appeal: the door will stay open (remember that locking it is no solution because this would turn it into a wall, and then providing everyone with the right key is a difficult task that would not ensure that key holders will lock it back). Of course, the porter may be punished. But disciplining a groom—Foucault notwithstanding—is an enormous and costly task that only large hotels can tackle, and then for other reasons that have nothing to do with keeping the door properly closed.

If we compare the work of disciplining the groom with the work he substitutes for, according to the list defined above, we see that this delegated character has the opposite effect to that of the hinge: a simple task—forcing people to close the door—is now performed at an incredible cost; the minimum effect is obtained with maximum spending and discipline. We also notice, when drawing the two lists, an interesting difference: in the first relationship (hinges vis-à-vis the work of many people), you not only had a reversal of forces (the lever allows gentle manipulations to displace heavy weights) but also a modification of *time schedule*: once the hinges are in place, nothing more has to be done apart from maintenance (oiling them from time to time). In the second set of relations (groom's work versus many people's work), not only do you fail to reverse the forces but you also fail to modify the time schedule: nothing can be done to prevent the groom who has been reliable for two months from failing on the sixty-second day; at this point it is not maintenance work that has to be done but the *same* work as on the first day—apart from the few habits that you might have been able to *incorporate* into his body. Although they appear to be two similar delegations, the first one is concentrated at the time of installation, whereas the other is continuous; more exactly, the first one creates clear-cut distinctions between production, installation, and maintenance, whereas in the other the distinction between training and keeping in operation is either fuzzy or nil. The first one evokes the past perfect ("once hinges had been installed..."), the second the present tense ("when the groom is at his post..."). There is a built-in inertia in the first that is largely lacking in the second. The first one is Newtonian, the second Aristotelian (which is simply a way of repeating that the first is nonhuman and the other human). A profound temporal shift takes place when nonhumans are appealed to; time is *folded*.

Delegation to Nonhumans

It is at this point that you have a relatively new choice: either to discipline the people or to *substitute* for the unreliable humans a *delegated nonhuman character* whose only function is to open and close the door. This is called a door-closer or a groom ("groom" is a French trademark that is now part of the common language). The advantage is that you now have to discipline only one nonhuman and may safely leave the others (bellboys included) to their erratic behavior. No matter who they are and where they come from—polite or rude, quick or slow, friends or foes—the nonhuman groom will always take care of the door in any weather and at any time of the day. A nonhuman (hinges) plus another nonhuman (groom) have solved the wall-hole dilemma.

Solved? Well, not quite. Here comes the deskilling question so dear to social historians of technology: thousands of human grooms have been put on the dole by their nonhuman brethren. Have they been replaced? This depends on the kind of action that has been translated or delegated to them. In other words, when humans are displaced and deskilled, nonhumans have to be upgraded and reskilled. This is not an easy task, as we shall now see.

We have all experienced having a door with a powerful spring mechanism slam in our faces. For sure, springs do the job of replacing grooms, but they play the role of a very rude, uneducated, and dumb porter who obviously prefers the wall version of the door to its hole version. They simply slam the door shut. The interesting thing with such impolite doors is this: if they slam shut so violently, it means that you, the visitor, have to be very quick in passing through and that you should not be at someone else's heels, otherwise your nose will get shorter and bloody. An unskilled nonhuman groom thus presupposes a skilled human user. It is always a trade-off. I will call, after Madeleine Akrich's paper (Akrich 1992), the behavior imposed back onto the human by nonhuman delegates *prescription*.[8] Prescription is the moral and ethical dimension of mechanisms. In spite of the constant weeping of moralists, no human is as relentlessly moral as a machine, especially if it is (she is, he is, they are) as "user friendly" as my Macintosh computer. We have been able to delegate to nonhumans not only force as we have known it for centuries but also values, duties, and ethics. It is because of this morality that we, humans, behave so ethically, no matter how weak and wicked we feel we are. The sum of morality does not only remain stable but increases enormously with the population of nonhumans. It is at this time, funnily enough, that moralists who focus on isolated socialized humans despair of us—us meaning of course humans and their retinue of nonhumans.

How can the prescriptions encoded in the mechanism be brought out in words? By replacing them by strings of sentences (often in the imperative) that are uttered (silently and continuously) by the mechanisms for the benefit of those who are mechanized: do this, do that, behave this way, don't go that way, you may do so, be allowed to go there. Such sentences look very much like a programming language. This substitution of words for silence can be made in the analyst's thought experiments, but also by instruction booklets, or explicitly, in any training session, through the voice of a demonstrator or instructor or teacher. The military are especially good at shouting them out through the mouthpiece of human instructors who delegate back to themselves the task of explaining, in the rifle's name, the characteristics of the rifle's ideal user. Another way of hearing what the machines silently did and said are the accidents. When the space shuttle exploded, thousands of pages of transcripts suddenly covered every detail of the silent machine, and hundreds of inspectors, members of congress, and engineers retrieved from NASA dozens of thousands of pages of drafts and orders. This description of a machine—whatever the means—retraces the steps made by the engineers to transform texts, drafts, and projects into things. The impression given to those who are obsessed by human behavior that there is a missing mass of morality is due to the fact that they do not follow this path that leads from text to things and from things to texts. They draw a strong distinction between these two worlds, whereas the job of engineers, instructors, project managers, and analysts is to continually cross this divide. Parts of a program of action may be delegated to a human, or to a nonhuman.

The results of such *distribution of competences*[9] between humans and nonhumans is that competent members of La Halle aux Cuirs will safely pass through the slamming door at a good distance from one another while visitors, unaware of the local cultural condition, will crowd through the door and get bloody noses. The nonhumans take over the selective attitudes of those who engineered them. To avoid this discrimination, inventors get back to their drawing board and try to imagine a nonhuman character that will not *prescribe* the same rare local cultural skills to its human users. A weak spring might appear to be a good solution. Such is not the case, because it would substitute for another type of very unskilled and undecided groom who is never sure about the door's (or his own) status: is it a hole or a wall? Am I a closer or an opener? If it is both at once, you can forget about the heat. In computer parlance, a door is an exclusive OR, not an AND gate.

I am a great fan of hinges, but I must confess that I admire hydraulic door closers much more, especially the old heavy copper-plated one that slowly closed the main door of our house in Aloxe-Corton. I am enchanted by the addition to the spring of a hydraulic piston, which easily draws up the energy of those who open the door, retains it, and then gives it back slowly with a subtle type of implacable firmness that one could expect from a well-trained butler. Especially clever is its way of extracting energy from each unwilling, unwitting passerby. My sociologist friends at the School of Mines call such a clever extraction an "obligatory passage point," which is a very fitting name for a door. No matter what you feel, think, or do, you have to leave a bit of your energy, literally, at the door. This is as clever as a toll booth.[10]

This does not quite solve all of the problems, though. To be sure, the hydraulic door closer does not bang the noses of those unaware of local conditions, so its prescriptions may be said to be less restrictive, but it still leaves aside segments of human populations: neither my little nephews nor my grandmother could get in unaided because our groom needed the force of an able-bodied person to accumulate enough energy to close the door later. To use Langdon Winner's classic motto (1980): Because of their prescriptions, these doors *discriminate* against very little and very old persons. Also, if there is no way to keep them open for good, they discriminate against furniture removers and in general everyone with packages, which usually means, in our late capitalist society, working- or lower-middle-class employees. (Who, even among those from higher strata, has not been cornered by an automated butler when they had their hands full of packages?)

There are solutions, though: the groom's delegation may be written off (usually by blocking its arm) or, more prosaically, its delegated action may be opposed by a foot (salesman are said to be expert at this). The foot may in turn be delegated to a carpet or anything that keeps the butler in check (although I am always amazed by the number of objects that *fail* this trial of force and I have very often seen the door I just wedged open politely closing when I turned my back to it).

Anthropomorphism

As a technologist, I could claim that provided you put aside the work of installing the groom and maintaining it, and agree to ignore the few sectors of the population that are discriminated against, the hydraulic groom does its job well, closing the door behind you, firmly and slowly. It shows in its humble way how three rows of delegated nonhuman actants[11] (hinges, springs, and hydraulic pistons) replace, 90 percent of the time, either an undisciplined bellboy who is never there when needed or, for the general public, the program instructions that have to do with remembering-to-close-the-door-when-it-is-cold.

The hinge plus the groom is the technologist's dream of efficient action, at least until the sad day when I saw the note posted on La Villette's door with which I started this meditation: "The groom is on strike." So not only have we been able to delegate the act of closing the door from the human to the nonhuman, we have also been able to delegate the human lack of discipline (and maybe the union that goes with it). On strike...[12] Fancy that! Nonhumans stopping work and claiming what? Pension payments? Time off? Landscaped offices? Yet it is no use being indignant, because it is very true that nonhumans are not so reliable that the irreversibility we would like to grant them is always complete. We did not want ever to have to think about this door again—apart from regularly scheduled routine maintenance (which is another way of saying that we did not have to bother about it)—and here we are, worrying again about how to keep the door closed and drafts outside.

What is interesting in this note is the humor of attributing a human characteristic to a failure that is usually considered "purely technical." This humor, however, is more profound than in the notice they could have posted: "The groom is not working." I constantly talk with my computer, who answers back; I am sure you swear at your old car; we are constantly granting mysterious faculties to gremlins inside every conceivable home appliance, not to mention cracks in the concrete belt of our nuclear plants. Yet, this behavior is considered by sociologists as a scandalous breach of natural barriers. When you write that a groom is "on strike," this is only seen as a "projection," as they say, of a human behavior onto a nonhuman, cold, technical object, one by nature impervious to any feeling. This is *anthropomorphism*, which for them is a sin akin to zoophily but much worse.

It is this sort of moralizing that is so irritating for technologists, because the automatic groom is already anthropomorphic through and through. It is well known that the French like etymology; well, here is another one: *anthropos* and *morphos* together mean either that which *has* human shape or that which *gives shape* to humans. The groom is indeed anthropomorphic, in three senses: first, it has been made by humans; second, it substitutes for the actions of people and is a delegate that permanently occupies the position of a human; and third, it shapes human action by prescribing back what sort of people should pass through the door. And yet some would forbid us to ascribe feelings to this thoroughly anthropomorphic creature, to delegate labor relations, to "project"—that is, to translate—*other* human properties to the groom. What of those many other innovations that have endowed much more sophisticated doors with the ability to see you arrive in advance (electronic eyes), to ask for your identity (electronic passes), or to slam shut in case of danger? But anyway, who are sociologists to decide the real and final shape (*morphos*) of humans (*anthropos*)? To trace with confidence the boundary between what is a "real" delegation and what is a "mere" projection? To sort out forever and without due inquiry the three different kinds of anthropomorphism I listed above? Are we not shaped by nonhuman grooms, although I admit only a very little bit? Are they not our brethren? Do they not deserve consideration? With your self-serving and self-righteous social studies of technology, you always plead against machines and for deskilled workers—are you aware of *your* discriminatory biases? You discriminate between the human and the inhuman. I do not hold this bias (this one at least) and see only actors—some human, some nonhuman, some skilled, some unskilled—that exchange their properties. So the note posted on the door is accurate; it gives with humor an exact rendering of the groom's behavior: it is not working, it is on strike (notice, that the word "strike" is a rationalization carried from the nonhuman repertoire to the human one, which proves again that the divide is untenable).

Built-in Users and Authors

The debates around anthropomorphism arise because we believe that there exist "humans" and "nonhumans," without realizing that this attribution of roles and action is also a *choice*.[13] The best way to understand this choice is to compare machines with texts, since the inscription of builders and users in a mechanism is very much the same as that of authors and readers in a story. In order to exemplify this point I have now to confess that I am *not* a technologist. I built in my article a made-up author, and I also invented possible readers whose reactions and beliefs I anticipated. Since the beginning I have many times used the "you" and even "you sociologists." I even asked you to draw up a table, and I also asked your permission to go on with the story. In doing so, I built up an inscribed reader to whom I prescribed qualities and behavior, as surely as a traffic light or a painting prepare a position for those looking at them. Did you *underwrite* or *subscribe* this definition of yourself? Or worse, is there any one at all to read this text and occupy the position prepared for the reader? This question is a source of constant difficulties for those who are unaware of the basics of semiotics or of technology. *Nothing in a given scene* can prevent the inscribed user or reader from behaving differently from what was expected (nothing, that is, until the next paragraph). The reader in the flesh may totally ignore my definition of him or her. The user of the traffic light may well cross on the red. Even visitors to La Halle aux Cuirs may never show up because it is too complicated to find the place, *in spite* of the fact that their behavior and trajectory have been perfectly anticipated by the groom. As for the computer user input, the cursor might flash forever without the user being there or knowing what to do. There might be an enormous gap between the prescribed user and the user-in-the-flesh, a difference as big as the one between the ''I'' of a novel and the novelist.[14] It is exactly this difference that upset the authors of the anonymous appeal on which I comment. On other occasions, however, the gap between the two may be nil: the prescribed user is so well anticipated, so carefully nested inside the scenes, so exactly dovetailed, that it does what is expected.[15]

The problem with scenes is that they are usually well prepared for anticipating users or readers who are at close quarters. For instance, the groom is quite good in its anticipation that people will push the door open and give it the energy to reclose it. It is very bad at doing anything to help people arrive there. After fifty centimeters, it is helpless and cannot act, for example, on the maps spread around La Villette to explain where La Halle aux Cuirs is. Still, no scene is prepared without a preconceived idea of what sort of actors will come to occupy the prescribed positions.

This is why I said that although *you* were free not to go on with this paper, *you* were only ''relatively'' so. Why? Because I know that, because you bought this book, you are hard-working, serious, English-speaking technologists or readers committed to understanding new development in the social studies of machines. So my injunction to ''read the paper, you sociologist'' is not very risky (but I would have taken no chance with a French audience, especially with a paper written in English). This way of counting on earlier distribution of skills to help narrow the gap between built-in users or readers and users- or readers-in-the-flesh is like a *pre*-inscription.[16]

The fascinating thing in text as well as in artifact is that they have to thoroughly organize the relation between what is inscribed in them and what can/could/should be pre-inscribed in the users. Each setup is surrounded by various arenas interrupted by different types of walls. A text, for instance, is clearly *circumscribed*[17]—the dust cover, the title page, the hard back—but so is a computer—the plugs, the screen, the disk drive, the user's input. What is nicely called ''interface'' allows any setup to be connected to another through so many carefully designed entry points. Sophisticated mechanisms build up a whole gradient of concentric circles around themselves. For instance, in most modern photocopy machines there are troubles that even rather incompetent users may solve themselves like ''ADD PAPER;'' but then there are trickier ones that require a bit of explanation: ''ADD TONER. SEE MANUAL, PAGE 30.'' This instruction might be backed up by homemade labels: "DON'T ADD THE TONER YOURSELF, CALL THE SECRETARY," which limit still further the number of people able to troubleshoot. But then other more serious crises are addressed by labels like "CALL THE TECHNICAL STAFF AT THIS NUMBER," while there are parts of the machine that are sealed off entirely with red labels such as "DO NOT OPEN—DANGER, HIGH VOLTAGE, HEAT" or "CALL THE POLICE." Each of these messages addresses a different audience, from the widest (everyone with the rather largely disseminated competence of using photocopying machines) to the narrowest (the rare bird able to troubleshoot and who, of course, is never there).[18] Circumscription only defines how a setup itself has built-in plugs and interfaces; as the name indicates, this tracing of circles, walls, and entry points inside the text or the machine does not prove that readers and users will obey. There is nothing sadder that an obsolete computer with all its nice interfaces, but no one on earth to plug them in.

Drawing a side conclusion in passing, we can call *sociologism* the claim that, given the competence, pre-inscription, and circumscription of human users and authors, you can read out the scripts nonhuman actors have to play; and *technologism* the symmetric claim that, given the competence and pre-inscription of nonhuman actors, you can easily read out and deduce the behavior prescribed to authors and users. From now on, these two absurdities will, I hope, disappear from the scene, because the actors at any point may be human or nonhuman, and the displacement (or translation, or transcription) makes impossible the easy reading out of one repertoire and into the next. The bizarre idea that society might be made up of human relations is a mirror image of the other no less bizarre idea that techniques might be made up of nonhuman relations. We deal with characters, delegates, representatives, lieutenants (from the French "lieu" plus "tenant," i.e., holding the place of, for, someone else)—some figurative, others nonfigurative; some human, others nonhuman; some competent, others incompetent. Do you want to cut through this rich diversity of delegates and artificially create two heaps of refuse, "society" on one side and "technology" on the other? That is your privilege, but I have a less bungled task in mind.

A scene, a text, an automatism can do a lot of things to their prescribed users at the range—close or far—that is defined by the circumscription, but most of the effect finally ascribed[19] to them depends on lines of other setups being aligned. For instance, the groom closes the door only if there are people reaching the Centre d'Histoire des Sciences; these people arrive in front of the door only if they have found maps (another delegate, with the built-in prescription I like most: "*you* are here" circled in red on the map) and only if there are roads leading under the Paris ring road to the Halle (which is a condition not always fullfilled); and of course people will start bothering about reading the maps, getting their feet muddy and pushing the door open only if they are convinced that the group is worth visiting (this is about the only condition in La Villette that is fulfilled). This gradient of aligned setups that endow actors with the pre-inscribed competences to find its users is very much like Waddington's "chreod":[20] people effortlessly flow through the door of La Halle aux Cuirs and the groom, hundreds of times a day, recloses the door—when it is not stuck. The result of such an alignment of setups[21] is to decrease the number of occasions in which words are used; most of the actions are silent, familiar, incorporated (in human or in nonhuman bodies)—making the analyst's job so much harder. Even the classic debates about freedom, determination, predetermination, brute force, or efficient will—debates that are the twelfth-century version of seventeenth-century discussions on grace—will be slowly eroded. (Because *you* have reached this point, it means I was right in saying that you were not at all free to stop reading the paper: positioning myself cleverly along a chreod, and adding a few other tricks of my own, I led you *here*... or did I? May be you skipped most of it, maybe you did not understand a word of it, o you, undisciplined readers.)

Figurative and Nonfigurative Characters

Most sociologists are violently upset by this crossing of the sacred barrier that separate human from nonhumans, because they confuse this divide with another one between *figurative* and *nonfigurative* actors. If I say that Hamlet is the figuration of "depression among the aristocratic class," I move from a personal figure to a less personal one—that is, class. If I say that Hamlet stands for doom and gloom, I use less figurative entities, and if I claim that he represents western civilization, I use nonfigurative abstractions. Still, they all are equally actors, that is, entities that *do* things, either in Shakespeare's artful plays or in the commentators' more tedious tomes. The choice of granting actors figurativity or not is left entirely to the authors. It is exactly the same for techniques. Engineers are the authors of these subtle plots and scenarios of dozens of delegated and interlocking characters so few people know how to appreciate. The label "inhuman" applied to techniques simply overlooks translation mechanisms and the many choices that exist for figuring or defiguring, personifying or abstracting, embodying or disembodying actors. When we say that they are "mere automatisms," we project as much as when we say that they are "loving creatures;" the only difference is that the latter is an anthropomorphism and the former a technomorphism or phusimorphism.

For instance, a meat roaster in the Hôtel-Dieu de Beaune, the little groom called "le Petit Bertrand," is the delegated author of the movement (figure 10.2). This little man is as famous in Beaune as is the Mannekenpis in Brussels. Of course, he is not the one who does the turning—a hidden heavy stone collects the force applied when the human demonstrator or the cook turn a heavy handle that winds up a cord around a drum equipped with a ratchet. Obviously "le Petit Bertrand" believes he is the one doing the job because he not only smiles but also moves his head from side to side with obvious pride while turning his little handle. When we were kids, even though we had seen our father wind up the machine and put away the big handle, we liked to believe that the little guy was moving the spit. The irony of the "Petit Bertrand" is that, although the delegation to mechanisms aims at rendering any human turnspit useless, the mechanism is ornamented with a constantly exploited character "working" all day long.

Although this turnspit story offers the opposite case from that of the door closer in terms of figuration (the groom on the door does not look like a groom but really does the same job, whereas "le Petit Bertrand" does look like a groom but is entirely

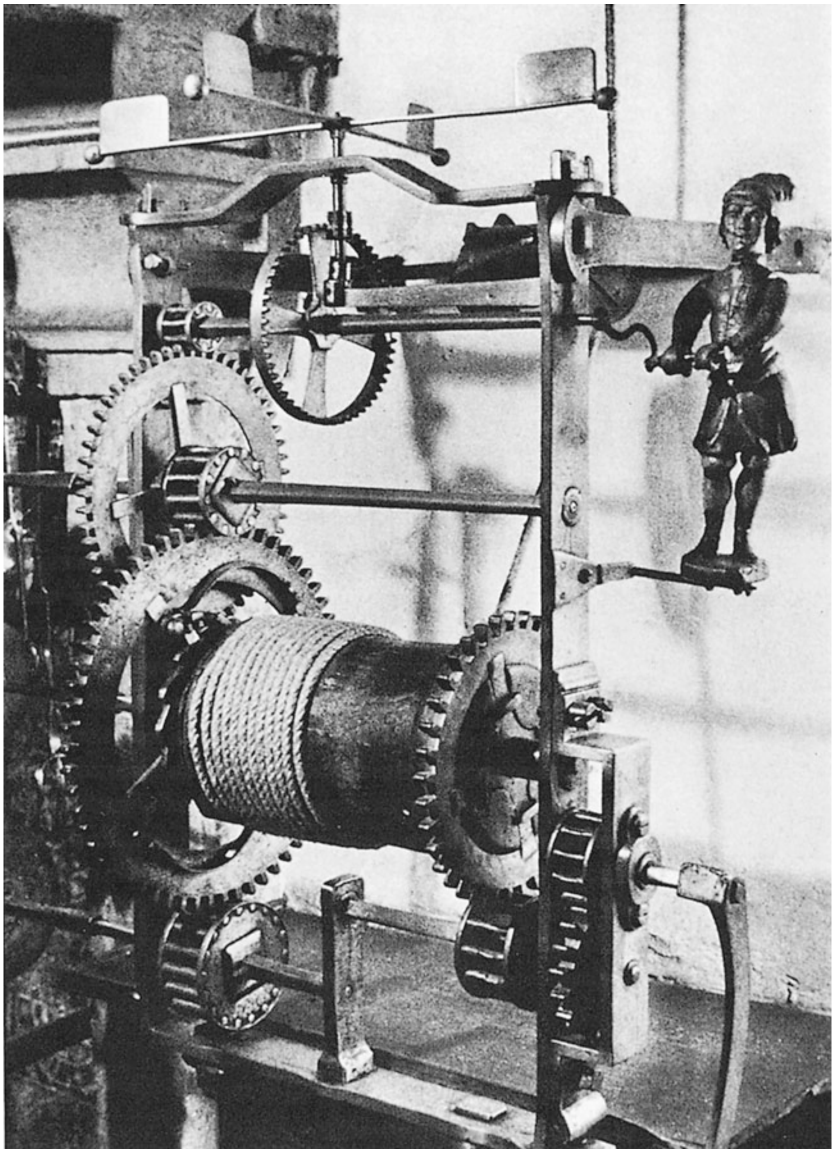

Figure 10.2
Le Petit Bertrand is a mechanical meat roaster from the sixteenth century that ornaments the kitchen of the Hotel-Dieu de Beaune, the hospital where the author was born. The big handle (bottom right) is the one that allows the humans to wind up the mechanism; the small handle (top right) is made to allow a little nonhuman anthropomorphic character to move the whole spit. Although the movement is prescribed back by the mechanism, since the Petit Bertrand smiles and turns his head from left to right, it is believed that it is at the origin of the force. This secondary mechanism—to whom is ascribed the origin of the force—is unrelated to the primary mechanism, which gathers a large-scale human, a handle, a stone, a crank, and a brake to regulate the movement.

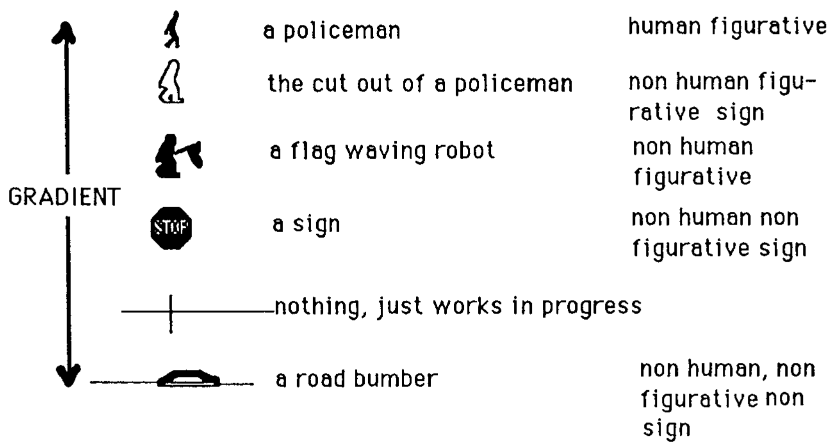

Figure 10.3
Students of technology are wary of anthropomorphism that they see as a projection of human characters to mere mechanisms, but mechanisms to another "morphism," a non-figurative one that can also be applied to humans. The difference between "action" and "behavior" is not a primary, natural one.

passive), they are similar in terms of delegation (you no longer need to close the door, and the cook no longer has to turn the skewer). The "enunciator" (a general word for the author of a text or for the mechanics who devised the spit) is free to place or not a representation of him or herself in the script (texts or machines). "Le Petit Bertrand" is a delegated version of whoever is responsible for the mechanism. This is exactly the same operation as the one in which I pretended that the author of this article was a hardcore technologist (when I really am a mere sociologist—which is a second localization of the text, as wrong as the first because really I am a mere philosopher...). If I say "we the technologists," I propose a picture of the author of the text as surely as if we place "le Petit Bertrand" as the originator of the scene. But it would have been perfectly possible for me and for the mechanics to position *no figurated character* at all as the author *in* the scripts *of* our scripts (in semiotic parlance there would be no *narrator*). I would just have had to say things like "recent developments in sociology of technology have shown that..." instead of "I," and the mechanics would simply have had to take out "le Petit Bertrand," leaving the beautiful cranks, teeth, ratchets, and wheels to work alone. The point is that removing the "Petit Bertrand" does not turn the mechanism into a "mere mechanism" where no actors are acting. It is just a different choice of style.

The distinctions between humans and nonhumans, embodied or disembodied skills, impersonation or "machination," are less interesting that the complete chain along which competences and actions are distributed. For instance, on the freeway the other day I slowed down because a guy in a yellow suit and red helmet was waving

Table 10.1
The distinction between words and things is impossible to make for technology because it is the gradient allowing engineers to shift down—from words to things—or to shift up—from things to signs—that enables them to enforce their programs of actions

	Figurative	Non-figurative
Human	"I"	"Science shows that" ...
Non-human	"le Pelit Bertrand"	a door-closer

a red flag. Well, the guy's moves were so regular and he was located so dangerously and had such a pale though smiling face that, when I passed by, I recognized it to be a machine (it failed the Turing test, a cognitivist would say). Not only was the red flag delegated; not only was the arm waving the flag also delegated; but the body appearance was also added to the machine. We road engineers (see? I can do it again and carve out another author) could move much further in the direction of figuration, although at a cost: we could have given him electronics eyes to wave only when a car approaches, or have regulated the movement so that it is faster when cars do not obey. We could also have added (why not?) a furious stare or a recognizable face like a mask of Mrs. Thatcher or President Mitterand—which would have certainly slowed drivers very efficiently.[22] But we could also have moved the other way, to a *less* figurative delegation: the flag by itself could have done the job. And why a flag? Why not simply a sign "work in progress?" And why a sign at all? Drivers, if they are circumspect, disciplined, and watchful will see for themselves that there is work in progress and will slow down. But there is another radical, nonfigurative solution: the road bumper, or a speed trap that we call in French "un gendarme couché," a laid policeman. It is impossible for us not to slow down, or else we break our suspension. Depending on where we stand along this chain of delegation, we get classic moral human beings endowed with self-respect and able to speak and obey laws, or we get stubborn and efficient machines and mechanisms; halfway through we get the usual power of signs and symbols. It is the complete chain that makes up the missing masses, not either of its extremities. The paradox of technology is that it is thought to be at one of the extremes, whereas it is the ability of the engineer to travel easily along the whole gradient and substitute one type of delegation for another that is inherent to the job.[23]

From Nonhumans to Superhumans

The most interesting (and saddest) lesson of the note posted on the door at La Villette is that people are not circumspect, disciplined, and watchful, especially not French drivers doing 180 kilometers an hour on a freeway a rainy Sunday morning when the speed limit is 130 (I inscribe the legal limit in this article because this is about the only place where you could see it printed in black and white; no one else seems to bother, except the mourning families). Well, that is exactly the point of the note: "The groom is on strike, *for God's sake*, keep the door closed." In our societies there are two systems of appeal: nonhuman and superhuman—that is, machines and gods. This note indicates how desperate its anonymous frozen authors were (I have never been able to trace and honor them as they deserved). They first relied on the inner morality and common sense of humans; this failed, the door was always left open. Then they appealed to what we technologists consider the supreme court of appeal, that is, to a nonhuman who regularly and conveniently does the job in place of unfaithful humans; to our shame, we must confess that it also failed after a while, the door was again left open. How poignant their line of thought! They moved up and backward to the oldest and firmest court of appeal there is, there was, and ever will be. If humans and nonhuman have failed, certainly God will not deceive them. I am ashamed to say that when I crossed the hallway this February day, the door *was* open. Do not accuse God, though, because the note did not make a direct appeal; God is not accessible without mediators—the anonymous authors knew their catechisms well—so instead of asking for a direct miracle (God holding the door firmly closed or doing so through the mediation of an angel, as has happened on several occasions, for instance when Saint Peter was delivered from his prison) they appealed to the respect for God in human hearts. This was their mistake. In our secular times, this is no longer enough.

Nothing seems to do the job nowadays of disciplining men and women to close doors in cold weather. It is a similar despair that pushed the road engineer to add a golem to the red flag to force drivers to beware—although the only way to slow French drivers is still a good traffic jam. You seem to need more and more of these figurated delegates, aligned in rows. It is the same with delegates as with drugs; you start with soft ones and end up shooting up. There is an inflation for delegated characters, too. After a while they weaken. In the old days it might have been enough just to have a door for people to know how to close it. But then, the embodied skills somehow disappeared; people had to be reminded of their training. Still, the simple inscription "keep the door closed" might have been sufficient in the good old days. But you know people, they no longer pay attention to the notice and need to be reminded by stronger devices. It is then that you install automatic grooms, since electric shocks are not as acceptable for people as for cows. In the old times, when quality was still good, it might have been enough just to oil it from time to time, but nowadays even automatisms go on strike.

It is not, however, that the movement is always from softer to harder devices, that is, from an autonomous body of knowledge to force through the intermediary situation of worded injunctions, as the La Villette door would suggest. It goes also the other way. It is true that in Paris no driver will respect a sign (for instance, a white or yellow line forbidding parking), nor even a sidewalk (that is a yellow line plus a fifteen centimeter curb); so instead of embodying in the Parisian consciouness an *intrasomatic* skill, authorities prefer to align yet a third delegate (heavy blocks shaped like truncated pyramids and spaced in such a way that cars cannot sneak through); given the results, only a complete two-meter high continuous Great Wall could do the job, and even this might not make the sidewalk safe, given the very poor sealing efficiency of

China's Great Wall. So the deskilling thesis appears to be the general case: always go from intrasomatic to *extrasomatic* skills; never rely on undisciplined people, but always on safe, delegated nonhumans. This is far from being the case, even for Parisian drivers. For instance, red lights are usually respected, at least when they are sophisticated enough to integrate traffic flows through sensors; the delegated policemen standing there day and night is respected even though it has no whistles, gloved hands, and body to *enforce* this respect. Imagined collisions with other cars or with the absent police are enough to keep them drivers check. The thought experiment "what would happen if the delegated character was not there" is the same as the one I recommended above to size up its function. The same *incorporation* from written injunction to body skills is at work with car manuals. No one, I guess, casts more than a cursory glance at the manual before starting the engine of an unfamiliar car. There is a large *body* of skills that we have so well embodied or incorporated that the mediations of the written instructions are useless.[24] From extrasomatic, they have become intrasomatic. Incorporation in human or "excorporation" in nonhuman bodies is also one of the choice left to the designers.

The only way to follow engineers at work is not to look for extra- or intrasomatic delegation, but only at their work of *re-inscription*.[25] The beauty of artifacts is that they take on themselves the contradictory wishes or needs of humans and nonhumans. My seat belt is supposed to strap me in firmly in case of accident and thus impose on me the respect of the advice DON'T CRASH THROUGH THE WINDSHIELD, which is itself the translation of the unreachable goal DON'T DRIVE TOO FAST into another less difficult (because it is a more selfish) goal: IF YOU DO DRIVE TOO FAST, AT LEAST DON'T KILL YOURSELF. But accidents are rare, and most of the time the seat belt should not tie me firmly. I need to be able to switch gears or tune my radio. The car seat belt is not like the airplane seat belt buckled only for landing and takeoff and carefully checked by the flight attendants. But if auto engineers invent a seat belt that is completely elastic, it will not be of any use in case of accident. This first contradiction (be firm and be lax) is made more difficult by a second contradiction (you should be able to buckle the belt very fast—if not, no one will wear it—but also unbuckle it very fast, to get out of your crashed car). Who is going to take on all of these contradictory specifications? The seat belt mechanism—if there is no other way to go, for instance, by directly limiting the speed of the engine, or having roads so bad that no one can drive fast on them. The safety engineers have to re-inscribe in the seat belt all of these contradictory usages. They pay a price, of course: the mechanism is *folded* again, rendering it more complicated. The airplane seat belt is childish by comparison with an automobile seat belt. If you study a complicated mechanism without seeing that it reinscribes contradictory specifications, you offer a dull description, but every piece of an artifact becomes fascinating when you see that every wheel and crank is the possible answer to an objection. The program of action is in practice the answer to an *antiprogram* against which the mechanism braces itself. Looking at the mechanism alone is like watching half the court during a tennis game; it appears as so many meaningless moves. What analysts of artifacts have to do is similar to what we all did when studying scientific texts: we added the other half of the court.[26] The scientific literature looked dull, but when the agonistic field to which it reacts was brought back in, it became as interesting as an opera. The same with seat belts, road bumpers, and grooms.

Texts and Machines

Even if it is now obvious that the missing masses of our society are to be found among the nonhuman mechanisms, it is not clear how they get there and why they are missing from most accounts. This is where the comparison between texts and artifacts that I used so far becomes misleading. There is a crucial distinction between stories and machines, between narrative programs and programs of action, a distinction that explains why machines are so hard to retrieve in our common language. In storytelling, one calls *shifting out* any displacement of a character to another space time, or character. If I tell you "Pasteur entered the Sorbonne amphitheater," I translate the present setting—you and me—and shift it to another space (middle of Paris), another time (mid-nineteenth century), and to other characters (Pasteur and his audience). "I" the enunciator may decide to appear, disappear, or be represented by a narrator who tells the story ("that day, I was sitting on the upper row of the room"); "I" may also decide to position you and any reader inside the story ("had you been there, you would have been convinced by Pasteur's experiments"). There is no limit to the number of shiftings out with which a story may be built. For instance, "I" may well stage a dialogue inside the amphitheater between two characters who are telling a story about what happened at the Académie des Sciences between, say, Pouchet and Milnes-Edwards. In that case, the room becomes the place *from which* narrators shift out to tell a story about the Academy, and they may or not shift *back in* the amphitheater to resume the first story about Pasteur. "I" may also *shift in* the entire series of nested stories to close mine and come back to the situation I started from—you and me. All these displacements are well known in literature departments (Latour 1988b) and make up the craft of talented writers.

No matter how clever and crafted are our novelists, they are no match for engineers. Engineers constantly shift out characters in other spaces and other times, devise positions for human and nonhuman users, break down competences that they then redistribute to many different actors, and build complicated narrative programs and subprograms that are evaluated and judged by their ability to stave off antiprograms. Unfortunately, there are many more literary critics than technologists, and the subtle beauties of technosocial imbroglios escape the attention of the literate public. One of the reasons for this lack of concern may be the peculiar nature of the shifting-out that generates machines and devices. Instead of sending the listener of a story into another world, the technical shifting-out inscribes the words into *another matter*. Instead of allowing the reader of the story to be *at the same time* away (in the story's frame of reference) and here (in an armchair), the technical shifting-out forces the reader to chose *between* frames of reference. Instead of allowing enunciators and enunciatees a sort of simultaneous presence and communion to other actors, techniques allow both to *ignore* the delegated actors and walk away without even feeling their presence. This is the profound meaning of Butler's sentence I placed at the beginning of this chapter: machines are not talking actors, not because they are unable to do so, but because they might have chosen to remain silent to become agreeable to their fellow machines and fellow humans.

To understand this difference in the two directions of shifting out, let us venture once more onto a French freeway; for the umpteenth time I have screamed at my son Robinson, "Don't sit in the middle of the rear seat; if I brake too hard, you're dead." In an auto shop further along the freeway I come across a device *made for* tired-and-angry-parents-driving-cars-with-kids-between-two-and-five (too old for a baby seat and not old enough for a seat belt) and-from-small-families (without other persons to hold them safely) with-cars-with-two-separated-front-seats-and-head-rests. It is a small market, but nicely analyzed by the German manufacturers and, given the price, it surely pays off handsomely. This description of myself and the small category into which I am happy to belong is transcribed in the device—a steel bar with strong attachments connecting the head rests—and in the advertisement on the outside of the box; it is also pre-inscribed in about the only place where I could have realized that I needed it, the freeway. (To be honest and give credit where credit is due, I must say that Antoine Hennion has a similar device in his car, which I had seen the day before, so I really looked for it in the store instead of "coming across" it as I wrongly said; which means that a) there is some truth in studies of dissemination by imitation; b) if I describe this episode in as much detail as the door I will never been able to talk about the work done by the historians of technology at La Villette.) Making a short story already too long, I no longer scream at Robinson, and I no longer try to foolishly stop him with my extended right arm: he firmly holds the bar that protects him against my braking. I have delegated the continuous injunction of my voice and extension of my right arm (with diminishing results, as we know from Feschner's law) to a reinforced, padded, steel bar. Of course, I had to make two detours: one to my wallet, the second to my tool box; 200 francs and five minutes later I had fixed the device (after making sense of the instructions encoded with Japanese ideograms).

We may be able to follow these detours that are characteristic of the technical form of delegation by adapting a linguistic tool. Linguists differentiate the *syntagmatic* dimension of a sentence from the *paradigmatic* aspect. The syntagmatic dimension is the possibility of *associating* more and more words in a grammatically correct sentence: for instance, going from "the barber" to "the barber goes fishing" to the "barber goes fishing with his friend the plumber" is what linguists call moving through the syntagmatic dimension. The number of elements tied together increases, and nevertheless the sentence is still meaningful. The paradigmatic dimension is the possibility, in a sentence of a given length, of *substituting* a word for another while still maintaining a grammatically correct sentence. Thus, going from "the barber goes fishing" to the "plumber goes fishing" to "the butcher goes fishing" is a tantamount to moving through the paradigmatic dimension.[27]

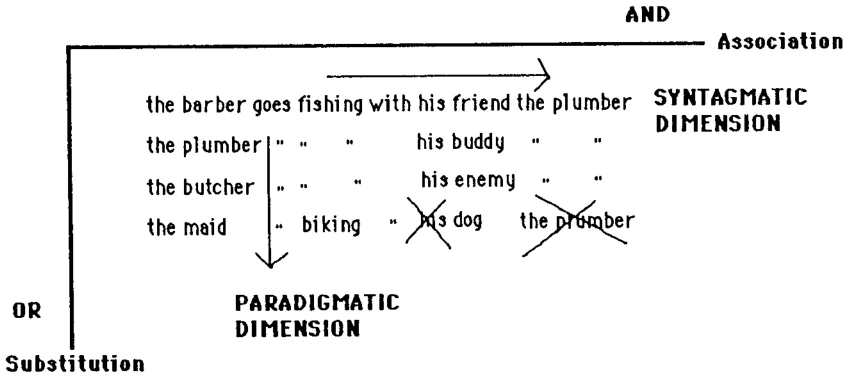

Figure 10.4
Linguists define meaning as the intersection of a horizontal line of association—the syntagm—and a vertical line of substitution—the paradigm. The touchstone in linguistics is the decision made by the competent speaker that a substitution (OR) or an association (AND) is grammatically correct in the language under consideration. For instance, the last sentence is incorrect.

Linguists claim that these two dimensions allow them to describe the system of any language. Of course, for the analysis of artifacts we do not have a structure, and the definition of a grammatically correct expression is meaningless. But if, by substitution, we mean the technical shifting to another *matter*, then the two dimensions become a powerful means of describing the dynamic of an artifact. The syntagmatic dimension becomes the AND dimension (how many elements are tied together), and the paradigmatic dimension becomes the OR dimension (how many translations are necessary in order to move through the AND dimension). I could not tie Robinson to the order, but through a detour and a translation I now hold together my will and my son.

The detour, plus the translation of words and extended arm into steel, is a shifting out to be sure, but not of the same type as that of a story. The steel bar has now taken over my competence as far as keeping my son at arm's length is concerned. From speech and words and flesh it has become steel and silence and extrasomatic. Whereas a narrative program, no matter how complicated, always remain a text, the program of action substitutes part of its character to other nontextual elements. This divide between text and technology is at the heart of the myth of Frankenstein (Latour 1992). When Victor's monster escape the laboratory in Shelley's novel, is it a metaphor of fictional characters that seem to take up a life of their own? Or is it the metaphor of technical characters that do take up a life of their own because they cease to be texts and become flesh, legs, arms, and movements? The first version is not very interesting because in spite of the novelist's cliché, a semiotic character in a text always needs the reader to offer it an "independent" life. The second version is not very interesting

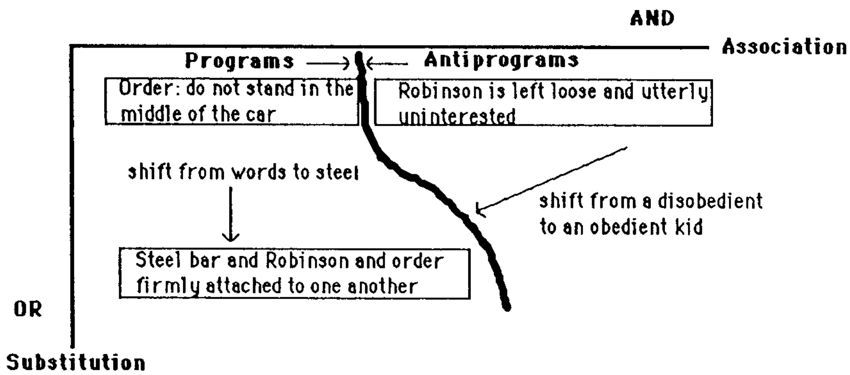

Figure 10.5
The translation diagram allows one to map out the story of a script by following the two dimensions: AND, the association (the latitude, so to speak), and OR, the substitution (the longitude). The plot is defined by the line that separates the programs of action chosen for the analysis and the antiprograms. The point of the story is that it is impossible to move in the AND direction without paying the price of the OR dimension, that is renegotiating the sociotechnical assemblage.

either, because the "autonomous" thrust of a technical artifact is a worn-out commonplace made up by bleeding-heart moralists who have never noticed the throngs of humans necessary to keep a machine alive. No, the beauty of Shelley's myth is that we cannot chose between the two versions: parts of the narrative program are still texts, others are bits of flesh and steel—and this mixture is indeed a rather curious monster.

To bring this chapter to a close and differentiate once again between texts and artifacts, I will take as my final example not a flamboyant Romantic monster but a queer little surrealist one: the Berliner key:[28]

Yes, this is a key and not a surrealist joke (although this is *not* a key, because it is picture and a text about a key). The program of action in Berlin is almost as desperate a plea as in La Villette, but instead of begging CLOSE THE DOOR BEHIND YOU PLEASE it is slightly more ambitious and *orders*: RELOCK THE DOOR BEHIND YOU. Of course the pre-inscription is much narrower: only people endowed with the competence of living in the house can use the door; visitors should ring the doorbell. But even with such a limited group the antiprogram in Berlin is the same as everywhere: undisciplined tenants forget to lock the door behind them. How can you force them to lock it? A normal key[29] endows you with the *competence* of opening the door—it proves you are *persona grata*—but nothing in it entails the *performance* of actually using the key again once you have opened the door and closed it behind you. Should you put up a sign? We know that signs are never forceful enough to catch people's attention for long. Assign a police officer to every doorstep? You could do this in East Berlin, but not in reunited

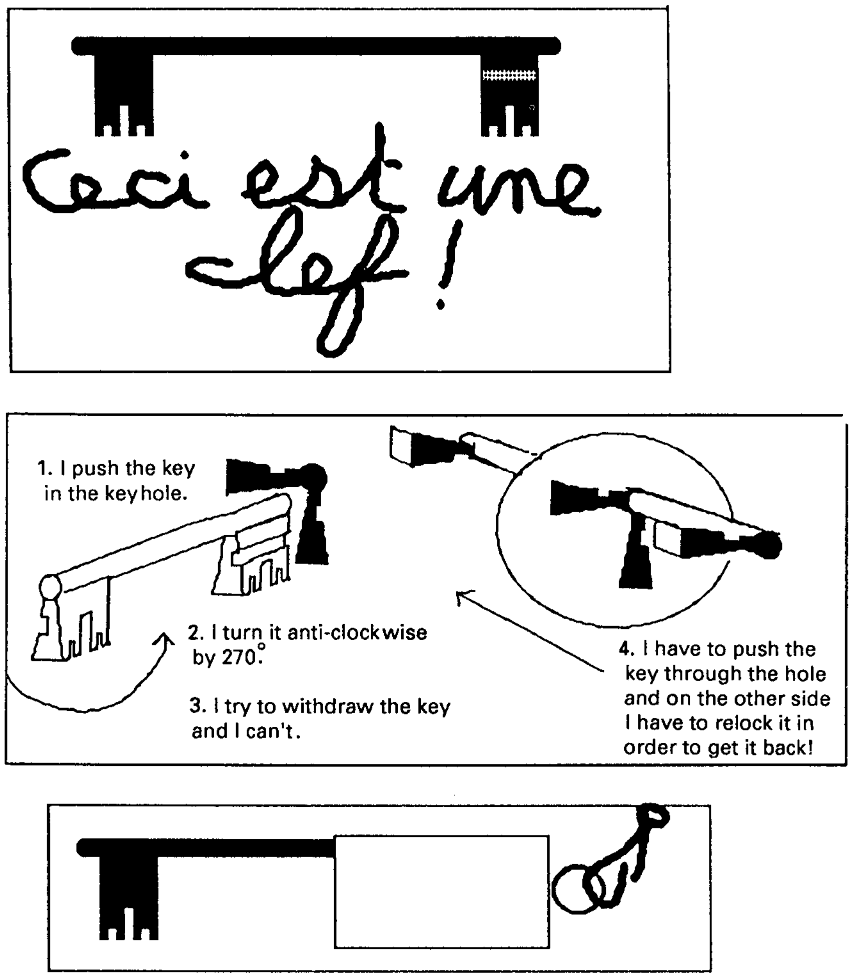

Figure 10.6
The key, its usage, and its holder.

Berlin. Instead, Berliner blacksmiths decided to re-inscribe the program of action in the very shape of the key and its lock—hence this surrealist form. They in effect sunk the contradiction and the lack of discipline of the Berliners in a more "realist" key. The program, once translated, appears innocuous enough: UNLOCK THE DOOR. But here lies the first novelty: it is impossible to remove the key in the normal way; such a move is "proscribed" by the lock. Otherwise you have to break the door, which is hard as well as impolite; the only way to retrieve the key is to push the whole key through the door to the other side—hence its symmetry—but then it is still impossible to retrieve the key. You might give up and leave the key in the lock, but then you lose the competence of the tenant and will never again be able to get in or out. So what do you do? You rotate the key one more turn and, yes, you have in effect relocked the door and then, only then, are you able to retrieve the precious "sesame." This is a clever translation of a possible program relying on morality into a program relying on dire necessity: you might not want to relock the key, but you cannot do otherwise. The distance between morality and force is not as wide as moralists expect; or more exactly, clever engineers have made it smaller. There is a price to pay of course for such a shift away from morality and signs; you have to replace most of the locks in Berlin. The pre-inscription does not stop here however, because you now have the problem of keys that no decent key holder can stack into place because they have no hole. On the contrary, the new sharp key is going to poke holes in your pockets. So the blacksmiths go back to the drawing board and invent specific key holders adapted to the Berliner key!

The key in itself is not enough to fulfill the program of action. Its effects are very severely circumscribed, because it is only when you have a Berliner endowed with the double competence of being a tenant and knowing how to use the surrealist key that the relocking of the door may be enforced. Even such an outcome is not full proof, because a really bad guy may relock the door without closing it! In that case the worst possible antiprogram is in place because the lock stops the door from closing. Every passerby may see the open door and has simply to push it to enter the house. The setup that prescribed a very narrow segment of the human population of Berlin is now so lax that it does not even discriminate against nonhumans. Even a dog knowing nothing about keys, locks, and blacksmiths is now allowed to enter! No artifact is idiot-proof because any artifact is only a portion of a program of action and of the fight necessary to win against many antiprograms.

Students of technology are never faced with people on the one hand and things on the other, they are faced with programs of action, sections of which are endowed to *parts* of humans, while other sections are entrusted to parts of nonhumans. In practice they are faced with the front line of figure 10.7. This is the only thing they can *observe*: how a negotiation to associate dissident elements requires more and more elements to be tied together and more and more shifts to other matters. We are now witnessing in technology studies the same displacement that has happened in science studies during the last ten years. It is not that society and social relations invade the certainty of science or the efficiency of machines. It is that society itself is to be rethought from

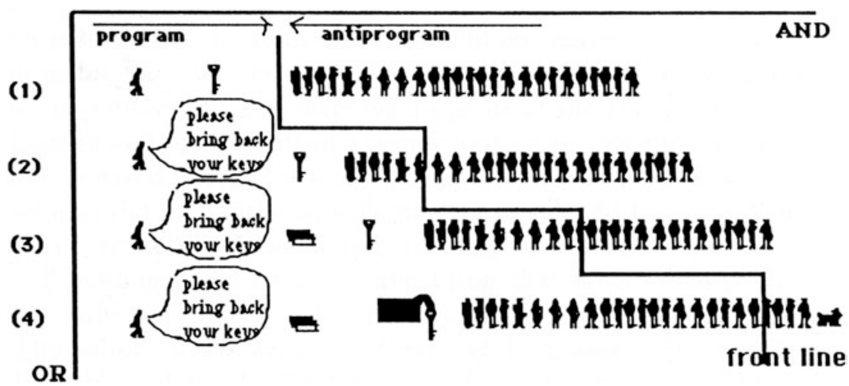

Figure 10.7
The hotel manager successively adds keys, oral notices, written notices, and finally weights; each time he thus modifies the attitude of some part of the "hotel customers" group while he extends the syntagmatic assemblage of elements. From Madelein Akrich and Bruno Latour, "A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies," in Wiebe E. Bijker and John Law, eds., *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge, Mass.: MIT Press, 1992), p. 263.

top to bottom once we add to it the facts and the artifacts that make up large sections of our social ties. What appears in the place of the two ghosts—society and technology—is not simply a hybrid object, a little bit of efficiency and a little bit of sociologizing, but a *sui generis* object: the collective thing, the trajectory of the front line between programs and anti-programs. It is too full of humans to look like the technology of old, but it is too full of nonhumans to look like the social theory of the past. The missing masses are in our traditional social theories, not in the supposedly cold, efficient, and inhuman technologies.

Notes

This chapter owes to many discussions held at the Centre de Sociologie de l'Innovation, especially with John Law, the honorary member from Keele, and Madeleine Akrich. It is particularly indebted to Françoise Bastide, who was still working on these questions of semiotics of technology a few months before her death.

I had no room to incorporate a lengthy dispute with Harry Collins about this chapter (but see Collins and Yearley 1992, and Callon and Latour, 1992).

Trevor Pinch and John Law kindly corrected the English.

1. The program of action is the set of written instructions that can be substituted by the analyst to any artifact. Now that computers exist, we are able to conceive of a text (a programming language) that is at once words and actions. How to do things with words and then turn words into things is now clear to any programmer. A program of action is thus close

to what Pinch et al. (1992) call "a social technology," except that all techniques may be made to be a program of action. . . .

2. In spite of the crucial work of Diderot and Marx, careful description of techniques is absent from most classic sociologists—apart from the "impact of technology on society" type of study—and is simply black-boxed in too many economists' accounts. Modern writers like Leroi-Gourhan (1964) are not often used. Contemporary work is only beginning to offer us a more balanced account. For a reader, see MacKenzie and Wacjman 1985; for a good overview of recent developments, see Bijker et al. (1987). A remarkable essay on how to describe artifacts—an iron bridge compared to a Picasso portrait—is offered by Baxandall (1985). For recent essay by a pioneer of the field, see Noble 1984. For a remarkable and hilarious description of a list of artifacts, see Baker 1988.

3. Following Madeleine Akrich's lead (Akrich 1992), we will speak only in terms of *scripts* or scenes or scenarios, or setups as John Law says, played by human or nonhuman actants, which may be either figurative or nonfigurative.

4. After Akrich, I will call the retrieval of the script from the situation *de-scription*. They define actants, endow them with competences, make them do things, and evaluate the sanction of these actions like the *narrative program* of semioticians.

5. Although most of the scripts are in practice silent, either because they are intra- or extrasomatic, the written descriptions are not an artifact of the analyst (technologist, sociologist, or semiotician), because there exist many states of affairs in which they are *explicitly* uttered. The gradient going from intrasomatic to extrasomatic skills through discourse is never fully stabilized and allows many entries revealing the process of translation: user manuals, instruction, demonstration or drilling situations, practical thought experiments ("what would happen if, instead of the red light, a police officer were there"). To this should be added the innovator's workshop, where most of the objects to be devised are still at the stage of *projects* committed to paper ("if we had a device doing this and that, we could then do this and that"); market analysis in which consumers are confronted with the new device; and, naturally, the exotic situation studied by anthropologists in which people faced with a foreign device talk to themselves while trying out various combinations ("what will happen if I attach this lead here to the mains?"). The analyst has to empirically capture these situations to write down the scripts. When none is available, the analyst may still make a thought experiment by comparing prescence/absence tables and collating the list of all the actions taken by actors ("if I take this one away, this and that other action will be modified"). There are dangers in such a counterfactual method, as Collins has pointed out (Collins and Yearley 1992), but it is used here only to outline the semiotics of artifacts. In practice, as Akrich (this volume) shows, the scripts are explicit and accountable.

6. We call the translation of any script from one repertoire to a *more durable* one transcription, inscription, or encoding. This definition does *not* imply that the direction always goes from soft bodies to hard machines, but simply that it goes from a provisional, less reliable one to a longer-lasting, more faithful one. For instance, the embodiment in cultural tradition of the user manual of a car is a transcription, but so is the replacement of a police officer by a traffic light; one goes from machines to bodies, whereas the other goes the opposite way. Specialists of robotics have abandoned the pipe dream of total automation; they

learned the hard way that many skills are better delegated to humans than to nonhumans, whereas others may be taken away from incompetent humans.

7. See Authicr 1989 on Plutarch's Archimedes.

8. We call prescription whatever a scene presupposes from its *transcribed* actors and authors (this is very much like ''role expectation'' in sociology, except that it may be inscribed or encoded in the machine). For instance, a Renaissance Italian painting is designed to be viewed from a specific angle of view prescribed by the vanishing lines, exactly like a traffic light expects that its users will watch it from the street and not sideways (French engineers often hide the lights directed toward the side street so as to hide the state of the signals, thus preventing the strong temptation to rush through the crossing at the first hint that the lights are about to be green; this prescription of who is allowed to watch the signal is very frustrating). ''User input'' in programming language, is another very telling example of this inscription in the automatism of a living character whose behavior is both free and predetermined.

9. In this type of analysis there is no effort to attribute forever certain competences to humans and others to nonhumans. The attention is focused on following how *any* set of competences is *distributed* through various entities.

10. Interestingly enough, the oldest Greek engineering myth, that of Dacdalus, is about cleverness, deviousness. ''Dedalion'' means something that goes away from the main road, like the French word ''bricole.'' In the mythology, science is represented by a straight line and technology by a detour, science by *epistémè* and technology by the *mêtis*. See the excellent essay of Frontisi-Ducroux (1975) on the semantic field of the name Daedalus.

11. We use *actant* to mean anything that acts and *actor* to mean what is made the source of an action. This is a semiotician's definition that is not limited to humans and has no relation whatsoever to the sociological definition of an actor by opposition to mere behavior. For a semiotician, the act of attributing ''incrt force'' to a hinge or the act of attributing it ''personality'' are comparable in principle and should be studied symmetrically.

12. I have been able to document a case of a five-day student strike at a French school of management (ESSEC) to urge that a door closer by installed in the student cafeteria to keep the freezing cold outside.

13. It is of course another choice to decide who makes such a choice: a man? a spirit? no one? an automated machine? The *scripter* or designer of all these scripts is itself (himself, herself, themselves) negotiated.

14. This is what Norman (1988) calls the Gulf of Execution. His book is an excellent introduction to the study of the tense relations between inscribed and real users. However, Norman speaks only about dysfunction in the interfaces with the final user and never considers the shaping of the artifact by the engineer themselves.

15. To stay within the same etymological root, we call the way actants (human or nonhuman) tend to extirpate themselves from the prescribed behavior *de-inscription* and the way they accept or happily acquiesce to their lot *subscription*.

16. We call *pre-inscription* all the work that has to be done upstream of the scene and all the things assimilated by an actor (human or nonhuman) before coming to the scene as a user or an author. For instance, how to drive a car is basically preinscribed in any (Western) youth years before it comes to passing the driving test; hydraulic pistons were also preinscribed for slowly giving back the energy gathered, years before innovators brought them to bear on automated grooms. Engineers can bet on this predetermination when they draw up their prescriptions. This is what is called "articulation work" (Fujimura 1987).

17. We call *circumscription* the organization in the setting of its own limits and of its own demarcation (doors, plugs, hall, introductions).

18. See Suchman for a description of such a setting (1987).

19. We call *ascription* the attribution of an effect to one aspect of the setup. This new decision about attributing efficiency—for instance, to a person's genius, to workers' efforts, to users, to the economy, to technology—is as important as the others, but it is derivative. It is like the opposition between the primary mechanism—who is allied to whom—and the secondary mechanism—whose leadership is recognized—in history of science (Latour 1987).

20. Waddington's term for "necessary paths"—from the Greek *creos* and *odos*.

21. We call *conscription* this mobilization of well-drilled and well-aligned resources to render the behavior of a human or a nonhuman predictable.

22. Trevor Pinch sent me an article from the *Guardian* (2 September 1988) titled "Cardboard coppers cut speeding by third."

> A Danish police spokesman said an advantage of the effigies, apart from cutting manpower costs, was that they could stand for long periods undistracted by other calls of duty. Additional assets are understood to be that they cannot claim overtime, be accused of brutality, or get suspended by their chief constable without explanation. "For God's sake, don't tell the Home Office," Mr. Tony Judge, editor of the Police Review Magazine in Britain, said after hearing news of the [Danish] study last night. "We have enough trouble getting sufficient men already." The cut-outs have been placed beside notorious speeding blackspots near the Danish capital. Police said they had yielded "excellent" results. Now they are to be erected at crossings where drivers often jump lights. From time to time, a spokesman added, they would be replaced by real officers.

23. Why did the (automatic) groom go on strike? The answers to this are the same as for the question posed earlier of why no one showed up at La Halle aux Cuirs: it is not because a piece of behavior is prescribed by an inscription that the predetermined characters will show up on time and do the job expected of them. This is true of humans, but it is truer of nonhumans. In this case the hydraulic piston did its job, but not the spring that collaborated with it. Any of the words employed above may be used to describe a setup at any level and not only at the simple one I chose for the sake of clarity. It does not have to be limited to the case where a human deals with a series of nonhuman delegates; it can also be true of relations among nonhumans (yes, you sociologists, there are also relations among things, and *social* relations at that).

24. For the study of user's manual, see Norman 1988 and Boullier, Akrich, and Le Goaziou 1990.

25. Re-inscription is the same thing as inscription or translation or delegation, but seen in its movement. The aim of sociotechnical study is thus to follow the *dynamic* of re-inscription transforming a silent artifact into a *polemical* process. A lovely example of efforts at re-inscription of what was badly pre-inscribed outside of the setting is provided by Orson Welles in *Citizen Kane*, where the hero not only bought a theater for his singing wife to be applauded in, but also bought the journals that were to do the reviews, bought off the art critics themselves, and paid the audience to show up—all to no avail, because the wife eventually quite. Humans and nonhumans are very undisciplined no matter what you do and how many predeterminations you are able to control inside the setting.

For a complete study of this dynamic on a large technical system, see Law (1992) and Latour (1992).

26. The study of scientific text is now a whole industry: see Callon, Law, and Rip 1986 for a technical presentation and Latour 1987 for an introduction.

27. The linguistic meaning of a paradigm is unrelated to the Kuhnian usage of the word. For a complete description of these diagrams, see Latour, Mauguin, and Teil (1992).

28. I am grateful to Berward Joerges for letting me interview his key and his key holder. It alone was worth the trip to Berlin.

29. Keys, locks, and codes are of course a source of marvelous fieldwork for analysts. You may for instance replace the key (excorporation) by a memorized code (incorporation). You may lose both, however, since memory is not necessarily more durable than steel.

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A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies

Madeleine Akrich and Bruno Latour

AKRICH, Madeleine; LATOUR, Bruno. 1992. A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies. In: Wiebe E. Bijker; John Law (eds.). Shaping technology/building society: studies in sociotechnical change. Cambridge: The MIT Press, pp.259-64.

Semiotics: The study of how meaning is built, but the word "meaning" is taken in its original nontextual and nonlinguistic interpretation; how one privileged trajectory is built, out of an indefinite number of possibilities; in that sense, semiotics is the study of order building or path building and may be applied to settings, machines, bodies, and programming languages as well as texts; the word sociosemiotics is a pleonasm once it is clear that semiotics is not limited to signs; the key aspect of the semiotics of machines is its ability to move from signs to things and back.

Setting: A machine can no more be studied than a human, because what the analyst is faced with are assemblies of humans and nonhuman actants where the competences and performances are distributed; the object of analysis is called a setting or a setup (in French a "dispositif").

Actant: Whatever acts or shifts actions, action itself being defined by a list of performances through trials; from these performances are deduced a set of competences with which the actant is endowed; the fusion point of a metal is a trial through which the strength of an alloy is defined; the bankruptcy of a company is a trial through which the faithfulness of an ally may be defined; an actor is an actant endowed with a character (usually anthropomorphic).

Script, description, inscription, or transcription: The aim of the academic written analysis of a setting is to put on paper the text of what the various actors in the settings are doing to one another; the de-scription, usually by the analyst, is the opposite movement of the in-scription by the engineer, inventor, manufacturer, or designer (or scribe, or scripter to use Barthes's neologism); for instance, the heavy keys of hotels are de-scribed by the following text DO NOT FORGET TO BRING THE KEYS BACK TO THE FRONT DESK, the in-scription being: TRANSLATE the message above by HEAVY WEIGHTS ATTACHED TO KEYS TO FORCE

CLIENTS TO BE REMINDED TO BRING BACK THE KEYS TO THE FRONT DESK. The de-scription is possible only if some extraordinary event—a crisis—modifies the direction of the translation from things back to words and allows the analyst to trace the movement from words to things. These events are usually the following: the exotic or the pedagogic position (we are faced with a new or foreign setup); the breakdown situation (there is a failure that reveals the inner working of the setup); the historical situation (either reconstructed by the analyst through archives, observed in real time by the sociologist, or imagined through a thought experiment by the philosopher); and finally the deliberate experimental breaching (either at the individual or the collective level). No description of a setting is possible or even thinkable without the mediation of a trial; without a trial and a crisis we cannot even decide if there is a setting or not and still less how many parts it contains.

Shifting out, shifting in: Any displacement to another frame of reference that allows an actant to leave the ego. hic. nunc—shifting out—or to come back to the departure point—shifting in. For narratives there are three shiftings: actorial (from "I" to another actor and back), spatial (from here to there and back), temporal (from now to then and back); in the study of settings one has to add a fourth type of shifting, the material shifting through which the matter of the expression is modified (from a sign FASTEN YOUR SEAT BELT, for instance, to an alarm), or from an alarm to an electric link between the buckle and the engine switch, or, conversely, from an electric current to a routinized habit of well-behaved drivers; the first direction is called shifting down (from signs to things) and the other shifting up (from things to signs).

Program of actions: This term is a generalization of the narrative program used to describe texts, but with this crucial difference that any part of the action may be shifted to different matters; if I write in a text that Marguerite tells Faust, "Go to hell," I am shifting to another frame of reference inside the narrative world itself without ever leaving it; if I tell the reader, "go to page 768," I am shifting already away from the narration, laterally so to speak, since I now wait for the reader-in-the-flesh to do the action; if I then write the instruction, "go to line 768," not to a reader but to my computer, I am shifting the matter of the expression still more (machine language, series of 0 and 1, then voltages through chips); I do not count on humans at all to fulfill the action. The aim of the description of a setting is to write down the program of actions and the complete list of substitutions it entails and not only the narrative program that would transform a machine in a text.

Antiprograms: All the programs of actions of actants that are in conflict with the programs chosen as the point of departure of the analysis; what is a program and what is an antiprogram is relative to the chosen observer.

Prescription; proscription; affordances, allowances: What a device allows or forbids from the actors—humans and nonhuman —that it anticipates; it is the morality of a setting both negative (what it prescribes) and positive (what it permits).

Subscription or the opposite, de-inscription: The reaction of the anticipated actants—human and nonhumans—to what is prescribed or proscribed to them; according to their own antiprograms they either underwrite it or try to extract themselves out of it or adjust their behavior or the setting through some negotiations. The gap between the prescriptions and the subscriptions defines the presence or absence of a crisis allowing the setting to be described; if everything runs smoothly, even the very distinction between prescription and what the actor subscribes to is invisible because there is no gap, hence no crisis and no possible description.

Pre-inscription: The competences that can be expected from actors before arriving at the setting that are necessary for the resolution of the crisis between prescription and subscription.

Circumscription: The limits that the setting inscribes in itself between what it can cope with—the arena of the setting—and what it gives up, leaving it to the preinscription. The glass walls of a bar circumscribe the setting; the word "end" at the end of a novel circumscribes the text; the rigid photovoltaic cell kit circumscribes itself and keeps away "idiots" with whom it cannot cope.

Conscription: It is never clear where the "real" limits of a setting are even though it has inscribed precise walls to itself—a book does not end with the word "end" no more than a bar stops at its glass wall; conscription is the series of actors that have to be aligned for a setting to be kept in existence or that have to be aligned to prevent others from invading the setting and interrupting its existence; it is what makes the pre-inscription more favorable for a setting; it is the network effect of any setting, its tendency to proliferate (the book needs librarians, publishers, critics, and paper, and the bar needs whiskey manufacturers, advertising, a heat spell, socializing buddies, etc.)

Interface or plugs: The many gaps between preinscription, circumscription, and conscription are tentatively limited by plugs, sieves, "decompression chambers," or more generally interfaces; when a setting is largely made of materialized interfaces, it looks like a network in the technological meaning of the word: electricity, telephones, water distribution, and sewage systems are peculiar settings that have a network shape.

Re-inscription: The same thing as inscription but seen as a movement, as a feedback mechanism; it is the redistribution of all the other variables in order for a setting to cope with the contradictory demands of many antiprograms; it usually means a complication—a folding—or a sophistication of the setting; or else it means that the complication, the sophistication is shifted away into the pre-inscription; the choices made for the re-inscription defines the drama, the suspense, the emplotment of a setting.

Redistributing competences and performances of actors in a setting: The new point of departure for observation instead of the divide between humans and nonhumans; the directions of this redistribution are many: extrasomatic, intrasomatic; soft-wire, hard-wire; figurative, nonfigurative; linguistic, pragmatic; the designer may shift the competence IS AUTHORIZED TO OPEN THE DOOR either inside a key (excorporation) or inside a memorized code (incorporation); the code itself may be soft-wired or hard-wired (tied to a nursery rhyme, for instance); the task of opening the door may be either shifted to humans or to nonhumans (through the figurative attribution of electronic eyes); the basic competence for opening the door may either be written down through instructions, (linguistic level) as for airplanes, or shifted to the pragmatic level (emergency one-way exit doors that open when pressed upon by a panicked crowd).

A setting is thus a chain of H(umans) and N(onhumans), each endowed with a new competence or delegating its competence to another: in the chain one may recognize aggregates that look like those of traditional social theory: social groups, machines, interface, impact.

Ascription: The attribution process through which the origin of the activity of the setting is finally decided in the setting itself; it is not a primary mechanism like all the others but a secondary one; for instance, the movement of the setting may be ascribed to the autonomous thrust of a machine, to the Stakhanovist courage of workers, to the clever calculations of engineers, to physics, to art, to capitalism, to corporate bodies, to chance, etc.

Scribe, enscripter, scripter, designer, or author: Who or what is the designer of a setting is the result of a process of ascription

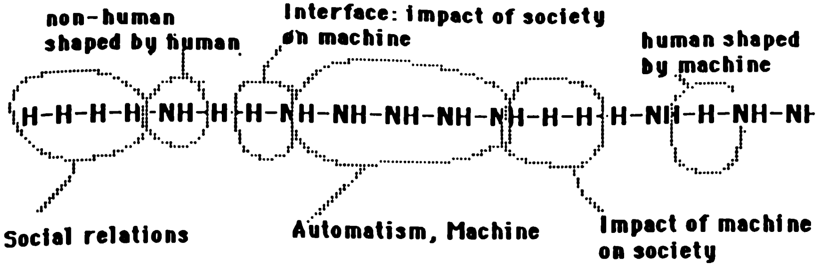

Figure 9.1
The usual categories that sharply divide humans and nonhumans correspond to an artificial cutting point along association chains. When those are drawn, it is still possible to recognize the former categories as so many restricted chains. If we replace H and NH by the name of specific actants, we obtain a syntagm. If we subsitute a specific name for another, we obtain the shifting paradigms.

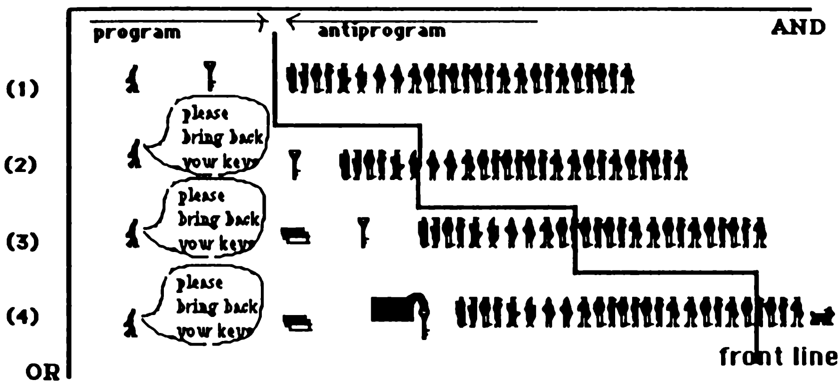

Figure 9.2
The hotel manager successively adds keys, oral notices, written notices, and finally metal weights; each time he thus modified the attitude of some part of the "hotel customers" group while he extends the syntagmatic assemblage of elements.

or attribution; but this origin may be inscribed under many guises in the setting itself—trademarks, signatures, legal requirements, proofs that standards are fulfilled, or more generally what the industry calls "traceability"; the blackest of black boxes are illuminated with such inscriptions.

AND (syntagmatic, association, alliances); OR (paradigmatic, substitution, translation): The two fundamental dimensions for following the reinscription of a setting, hence its dynamic or history; the oral or written message BRING YOUR KEY BACK TO THE FRONT DESK is not necessarily obeyed—antiprogram; the shift from keys to weights ties the clients to the front desk because they have a heavy load in their pockets; other antiprograms will appear that will have to be defeated; the front line between programs and antiprograms maps out the plot of a script and keeps track of its history.

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12

ETHNOGRAPHY OF A "HIGH-TECH" CASE

About Aramis

Bruno Latour

To attempt an ethnography of a "high-tech" case without visiting the places and the times where the techniques are fabricated is like doing armchair anthropology. Since tropical ethnographers may not be familiar with air-conditioned field studies in modern science and techniques, it might be useful to start with the cultural shock any student of rationalized, efficient, productive machines gets when he or she enters the workshop where they are planned and devised.

In March 1988, I was in the middle of an ethnographic study of a revolutionary subway system planned in the south of Paris when one of my informants presented me, at last, with an overview of the whole project.

"Il y a du monde là dedans, hein?" (Lot's of people in there, huh?) he said, unfolding the master plan of the Aramis system (figure 12.1).

Lots of people indeed, but only very few of them were anthropomorphic. Actors called "doublets" had to travel independently along a track ("la voie"); these actors were to be emptied of any human agency and had to be endowed with movement, thought, and a decision-making process of their own. To obtain such a result, a great number of skills had to be delegated to them under the name of "on-board shunt" or "switch." This however was not enough to guarantee a smooth flow of "doublets." Other skills had to be shifted to the track, which was transformed from a longitudinal, continuous ribbon of steel into a highly ritualized discontinuous transversal code of behavior. The track plus the doublets, however, were kept in check by another delegated and delegating entity called "unité de gestion de tronçon et de station" (UGT) (section-station management unit); this entity was immobile but endowed with thought, with the ability to send and receive messages, and with the authority to approve, rubber-stamp and sometimes to overrule decisions taken by the doublets; this entity itself was dominated by a fourth level of organization called the "Poste de Commande Central" (PCC) (Central Command Post); this PCC was fairly powerless, since the doublets and the UGT had to take most of the decisions themselves – and fast – but the PCC could overrule them all, trigger alarms and bring the whole system to a halt. Anthropomorphic humans were to be positioned inside the PCC. But for now they were only humans-on-paper.

The puzzle of this four-tier system became much more complicated when I realized that none of the entities, from the doublets to the humans, were endowed with a complete program of action. Instead of being like Leibniz's monads, unfolding their world-views independently of everyone else and preharmonized by God, their theology was much more like that of Malebranche, except that there seemed to be no God. They had to fumble, negotiate, discuss, sense, touch, see, tell, read, proof-read, encrypt what each other was and wanted. To be able to do this, they had to be equipped with various sensors and antennas (figure 12.1, below).

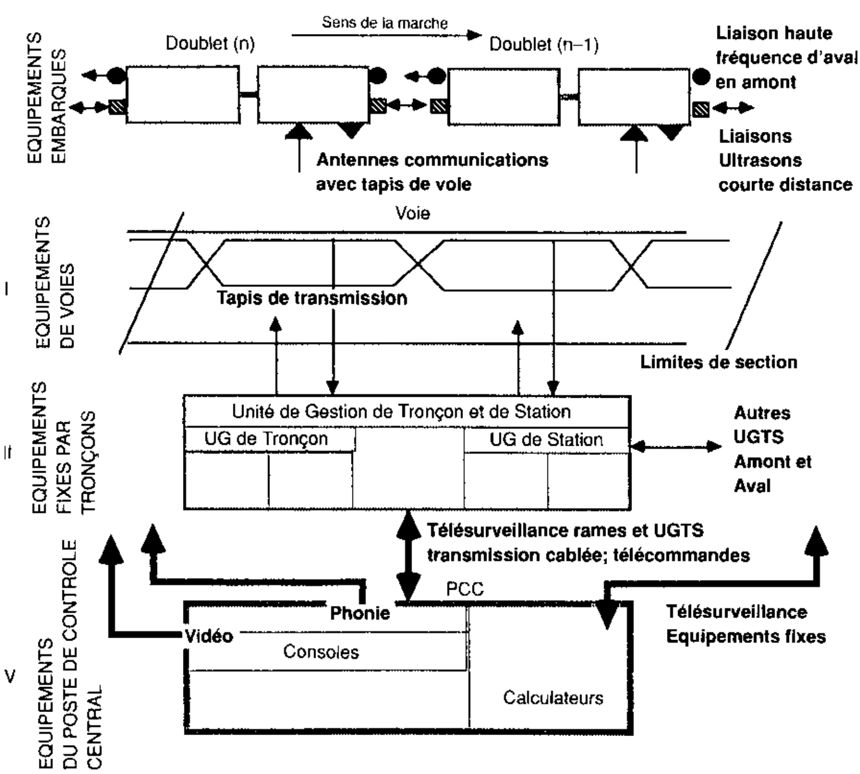

Figure 12.1 The four tier system of the Aramis computer monitoring.

I was accustomed to doing the ethnography of scientific microsocieties; I knew how to map out instruments, credibility, translations, modalities and papers, and to follow long, thin networks of exchanges and relations among scientists and among the things for which they claimed to speak.

This, however was different. The whole principle was to do away with anthropomorphic humans altogether and, instead, to populate the setting with *membra disjecta*, some of which clearly came from a classic repertoire of human action (thinking, authorizing, encrypting), but most of which did not (actuators, tracks, engines, antennas, ultrasound, ultrafrequencies, calculators, videos). Were the methods of ethnography, and especially of the ethnography of science, applicable to a subway system? Could I add notions such as "representation," "symbolic," "social roles," "values" to a technical substratum of efficient action and mechanical behavior? To answer this question I had to turn to ethnographers.

A MEETING WITH TIMID AND NOT-SO-TIMID ETHNOGRAPHERS OF MACHINES

Truth, Efficiency, Profitability are the three sisters who have bewitched all those who have tried to apply ethnographic methods to modern science and technology. Paradoxically, it is Truth, in spite or because of her long philosophical past, who has been first to go. Ethnographic studies of scientific practices (Collins 1985; Latour and Woolgar 1979; Knorr 1981; Lynch 1985; Pinch 1986; Pickering 1992), reversing common epistemology, have swept over the weak programs of the sociology of knowledge and made Truth the *result* and not the cause of the stabilization of scientific controversies. The solidity, robustness, beauty and originality of scientific facts are still there, but so are their artisans, factories, human and non-human allies, accusations and instruments who make these facts hold (Latour 1987). Instead of being naked, Truth is now warmly clothed. Since scientific Truth together with her retinue resemble *more* and not less the sort of objects traditionally studied by anthropologists of parascientific, pseudoscientific, prescientific, or ethnoscientific societies, the Great Divide between ethnographers of Modern worlds and the others has ended (Goody 1977; Horton 1982). The anthropology of science is now a respectable – if not respected – sub-field of anthropology (Shapin and Schaffer 1985; Traweek 1988; Latour 1993).

It is not Truth who limits the anthropology of techniques, since it deals with artefacts no one denies are human-made. But Efficiency, in the case of traditional techniques, and Profitability, for the more modern ones have taken over the guardian role. Most of the so-called social studies of techniques apply to the artefacts the same *dualism* that marked the earlier studies of facts. Their essential intellectual resource is a balanced use of the trope "not only . . . but also." "In addition to" technical factors, which are due to the resistance or constraints of matter, to the relative efficiency of human gestures and to the profitability of the technical system, "there exist symbolic, social and cultural factors *as well*." For instance, one will say that pigs, "in addition" to being a protein source for the Bimin-Kuskusmin of New

Guinea (Poole 1990, personal communication), "also" have a ritual value; or that "in addition" to being dictated by wind tunnels, the aerodynamic shape of Concorde is "also" influenced by political factors such as de Gaulle's quest for prestige or the Green movements' lobbying; or that relativity theory has been shaped "not only" by cognitive factors, "but also" by Einstein's intellectual milieu in turn-of-the-century Switzerland. Exactly as in earlier studies of science, the study of techniques has become a cocktail recipe weighing and mixing *factors* of various origins, resulting, for the same reasons, in just as disgusting a brew.

The problem with "factors," in science as in technique, is that we, anthropologists, are asked to take for granted that we are able to decide *what is* a cognitive, ritual, symbolic, economic, efficient, material factor to begin with. We are asked to decide for ourselves when a Bimin-Kuskusmin is using his stone adze as a cutting instrument and when it is a ritual implement, when an engineer of the Aérospatiale company is dealing with aerodynamic equations and when he is fighting with government lobbies; when Einstein is thinking over accelerated frames of reference and when he is a revolutionary who wants to overthrow the order of things. Even if we are granted that there is no clear dichotomy, we are nevertheless requested to see any mixture as a combination of *pure* forms. Instead of letting the actors themselves make these divisions, and many others, we force on them a definition of "purely" efficient action or of "purely" disinterested truth, the purity of which is precisely what is in question. As far as science and techniques go, most anthropologists, no matter how sophisticated they may be on other subjects, practice the crudest form of ethnocentrism. They regard ethnosciences as the carving out through social categories of what Nature is "out there," without realizing that our (ethno)sciences are doing the carving out of this very Nature, of its unity, of its otherness and of this bizarre notion of "carving out categories"; as for ethnotechnologies, they are seen as so many specific marks *added* by cultures to an efficient action on matter, as if the definition of matter, action and efficiency were not the hallmark of our (ethno)technology! Worse, the only way to prove that culture is at work is often to see it as an "arbitrary" or "conventional" decision projected onto the "necessity" of efficient action.

In reaction to this dualism, the last ten years have seen a flurry of research treating Efficiency with the same resources and with the same principle of symmetry that proved to be so powerful for the treatment of Truth (Bijker and Pinch 1987; Callon 1989; MacKenzie 1990; Bijker and Law 1992). The principle developed from ethnomethodology by Lynch (1985) according to which the only social explanation is to be found in the specific technical resources used by the actors themselves, and that the only metalanguage to use is their language, completely dissolves the "pure factors" which until now were the ingredients used to cook up an explanation of science and technique. Recent anthropologists of technoscience are never faced with the task of allocating what, in a given complex of action, is due to symbol, to religion, to rite, to passion, to politics, and what is due to efficiency, material constraints, basic needs and natural forces as Leroi-Gourhan had to (Leroi-Gourhan 1964). Instead of choosing alternatively from the two lists of human and of non-human ingredients, the anthropologist is now interested in how many lists actors make – and there are rarely only two (Descola 1986)! Instead of knowing in advance what the social and the natural worlds are made of, she follows how all the actors – including those of our societies who have been placed on a level with all the others – invent monstrous hybrids very few of which will look like either humans or non-humans. The loose expressions of "seamless web" (Hughes), "actor-network" (Callon), "heterogeneous engineering" (Law) or "socio-logic" (Latour), all have in common that they erase the Great Divide, reject the dualist explanation, and dethrone the three sisters all at once without allowing any one of them to exert a new hegemony. Even the exit out of the radical relativism thus embraced is left to the actors' own devices – actors clean up their own mess, so to speak, and solve for the analyst the problem of establishing asymmetrical *relations* with one another.

Two completely different research programs are thus now housed under the same label of ethnology and technology. The dualist program *starts from* a list of factors taken from nature, matter, ecology and society, and then goes to a specific setting to *weigh* the relative influence of these factors in shaping artefacts. The other research program *starts from* the distribution and allocation of categories, labels and entities, in a specific setting, and obtains as a provisional and local *achievement* resulting categories, some of which *may* resemble natures, matters, ecologies and societies of old, while others may not look at all like any of the labels we use to order *our* world. This program could be called "monism," as long as it is clear that is a heterogeneous and distributed form of monism.

For example, in the first program, the Kuskusmin's adze might be seen as made up of at least two aspects, one of them being efficient action on matter – it is made to cut wood and fibers – and the other being a ritual and symbolic aspect – it is male and it is to be used only to cut woods for building initiation houses. In the second program, the complex categories used by the Kuskusmin themselves are used to make sense of this very problem of techno-logy (that is the science of techniques as Leroi-Gourhan called it). They have their own sociology of technics, they have their own techno-logy as well as their own epistemology. Indeed it happens that one of their divisions does imply a difference between *profane* implement – which for that reason may have since been replaced by non-sexually marked Western steel axes – and all the others that are more sacred – and which to this day are made of stone. If we now take seriously the metalinguistic resources of the Kukusmin, will the category "profane use" be coextensive with that of our definition of efficiency? Yes, in the first research program, but no, in the second. For the latter, "profane use" is a *coded* category as much as is a male axe or an exchange cowry, and so is our definition of "efficiency" and "material force," which emerges in Europe between the seventeenth and the beginning of the nineteenth century. There is no direct translation between the two. In the second program, we are not allowed to use a recent European scientific definition of "action of force on matter" to reconstitute the world on which the Bimin-Kuskusmin act, no more than we are allowed to consider cowries as being a local type of "money" (Polanyi 1975).

In the first program, everything happens as if all the social marks were added to a *substratum* that is unproblematically defined as part of the material, or natural, or ecological world. In the second program *there is no substratum*, except when traveling observers and scientists "place beneath," as the etymology of substratum ("under-cover") implies, the categories of those they wish to explain. In the first program, society is embedded unproblematically in a material world, and thus the sociology and history of the social and natural sciences that deal with that very world and with that very work of embedding are irrelevant for technology. In the second program, any embedding of society in a material world, including the European one, is to be accounted for, and thus the sociology and history of all sciences, *including* anthropology, are an essential part of any technology. No ethnographer can use notions like "matter," "force," "nature," "world," "arbitrariness," "convention" without studying how they have come about in her society/nature and without taking into account, reflexively, how s/he has come to confront her or his world with those of other societies/natures. This is why it is no accident that most sociologists of techniques come from the sociology of science. If sciences are not made part of the picture, the second research program recedes into the first, and the Great Divide together with the dualist explanation it entails is reinforced instead of being dissolved.

A SYMMETRICAL ANTHROPOLOGY OF TECHNIQUES

The aim of the second research program is to end the partition between materialist and culturalist accounts. This partition is visible in the literature dealing with modern industrialized techniques as well as those dealing with non-modern or non-industrialized ones. Sociologists or semiologists will have no problem in studying the symbolic meaning consumers attach to video players or to cars, but it will be for other scholars far removed from them to study the "substratum" to which the meaning is attached, that is the drafting rooms, the laboratories, the scale models, or the corporate strategy producing the video players and the cars. Similarly, ethnotechnologists will write an account of the material culture of the Bimin-Kuskusmin, where the fifty types of arrowheads will be listed as well as the taro gardens, and the dozens of categories of axes, all being accounted for by transhistorical and transcultural Western categories such as efficiency, impact, force, protein source, energy consumption . . .; and later they or other scholars will *add* the symbolic, ritual, sexual and cultural meanings that supplement this basic economic infrastructure, all of it being accounted for by equally transhistorical and transcultural Western categories such as symbol, rite, religion, society, myth, convention, arbitrariness . . . No matter if they study modern or non-modern practices, they will first describe the video player *as* a machine and the pig *as* an animal, and then will print, paint, mark and ascribe social meaning to them.

There would be nothing wrong with this perfectly reasonable dual research program if it did not make our own techniques and societies entirely opaque – and probably those of the non-modern societies as well. What is a video player? Probably not a machine. At least we should not impose such an a priori crude, unreflected unproblematic category on its manifestations. As for the zoological westernized pig, it is such a latecomer to the series of actions done by "pigs" that it is a very unlikely substratum for meaning. If anything, we should consider the machine-like video player and the zoological pig as two new recent meanings *extracted from* a substratum much more bizarre than these two latecomers. To use a cliché from the debates over relativism, the zoological cassowary is not the substratum out of which the Karam make it a *Yakt* (Bulmer 1967). *Inside* the London zoological collections, nineteenth-century taxonomists make the cassowary part of the Birds, neglecting thousands of other properties the "cassowary" had elsewhere. The objective substratum is no longer the unproblematic matter onto which cultures add their view, *it is another view*, a highly localized and particular view within scientific institutions. As suggested in figure 12.2, when the practice of extraction *is added to the study*, the very notion of "social meaning" fades. It is here that the anthropology of technoscience takes on its most radical meaning: objectivity, objects, natures, efficiency, profitability, truth are shifted *from the outside* (left side of the drawing) *to the inside* of another network of practice whose peculiarity becomes studiable (Star and Griesemer 1989; Latour 1990). Instead of two literatures and two descriptions – one materialist the other culturalist – there exists only one that, in addition to all the others, takes into account the practice, movement, institutions and societies of the zoologists, anthropologists and other miscellaneous empire builders.

By relocating the work of producing truth, efficiency and profitability, it is not only the pre-modern societies but our own world as well that take on a new aspect. To begin with, *our own world stops being modern* because it does no longer differ radically from the others (Latour 1993). The cassowary made a Bird inside the London Natural History Museum is not absolutely different from the *Koptby* made a *Yakt* inside the Karam territory. It is only *relatively* different. The zoological pig in the Jardin des Plantes is no longer ontologically different from the Kuskusmin pig; moreover, the Paris

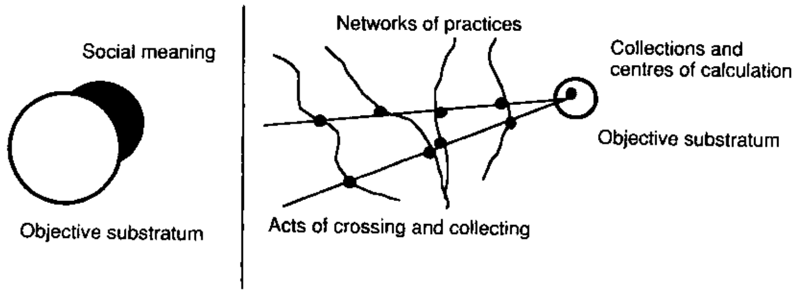

Figure 12.2 The opposition between a dualist interpretation and the one offered by science studies.

zoologist's pig is also relatively different from the pigs on a farm in Brittany; and better still, the Kuskusmin pig that can be eaten only if it dies accidentally is also relatively different from the sacred pig no one is allowed to eat at all. In place of the One a priori unstudiable Great Divide, appear numerous small divides all of which are empirically studiable. Instead of having two literatures, one about the Savages and the other about the Civilized, one about the Pre-modern and one about the Modern, *there is only one anthropology* of science and technology. "They" have many sorts of bizarre pigs, "we" have lots of very queer sorts of pigs (Digard 1990). Then, what we have in common is this bizarre distribution of hundreds of actors whose distribution, diversity and attributes are very poorly accounted for by the invention of this substratum: "the-objective-pig-to-which-cultures-arbitrarily-add-particular-meanings."

Anthropology of science and technology, which deals jointly with the pre-modern and non-modern worlds, is the study of that distribution and of that diversity – and also the study of the efforts of some professions and institutions to unify, limit, extract or purify meanings and natures. Essences have been redistributed back to the networks of actions that shape them through trials.

WHAT IS AN OBJECT? A QUASI-OBJECT. THE CASE OF VAL

What is a high technology in this new symmetrical and "monistic" framework? A shifting network of actions redistributing competences and performances either to humans or non-humans in order to assemble into a more durable whole an association of humans and things, and to resist the multiple interpretations of other actors that tend to dissolve this association (Law 1987). Techniques are not something around which there is a society. It is society considered in its obduracy. It is society *folded*, society made durable, society made complicated in order to resist more tensions by enrolling more non-humans. We seem to get techniques on one side and social relations on the other only when we believe that social or human relations are enough to hold society together. But this is impossible except in very few aspects of a very few cases of some primate societies (Strum 1987; Strum and Latour 1987) where the whole pattern of social relations depends on social skills and "Machiavellian intelligence" (Byrne and Whiten 1988). In human societies skills, competences, obduracy, are shifted down to non-human actors to which or to whom are delegated the task of fulfilling parts of the programs of actions (Latour 1992c). Ironically, they are called *human* societies because the enlisted *non-humans* render them slightly more stable. So every time we are faced with a more *durable* social link, we are in effect faced with techniques (Latour 1992b). No observer of human collectives, for at least the past two million years, has ever been faced with a pure social relation, and none of course, *especially* in high-tech modern settings has ever been faced with a pure technique.

Although this folding, this detour, this shifting down, this embedding is clear in anthropologists' accounts of exotic technologies, it is not so obvious in modern high-tech cases. And because it is not clear in our modern technology, it seems that in exotic ones it applies only to the *meaning* of the artefacts not to the artefacts *themselves*. But this is only because high-technology examples are not studied in detail while they are still *projects*.

Take for example the case of the VAL, the main rival of Aramis (Latour 1992a). In the 1970s, in the northern French city of Lille, where a new town was being built, city planners, inhabitants, developers, started to *talk about* a public transportation system for the new town. At first VAL was a statement, it was an argument, it was a dream that captured or failed to capture the passions, interests, world-views of the people of Villeneuve-d'Ascq. It was like a game: "what about playing at being an automatic public transportation system?" The question now is to follow the trajectory of this dream-passion-interest-game-plan. The first idea of the developers was to make a small public transportation system for the new town alone and to experiment with a new cheap automatic system ("New towns are laboratories for new systems"). But if you want a new automatic system you need to enlarge the group of people who think, pay and are interested in innovations in transportation (at the time there were no automatic subways except as prototypes). The argument, or the token, or the quasi-object is now sent to a larger network of people, the Urban Community of Lille: "Are you ready to help us with our system so that a New Town can be equipped with new attractive high-tech transportation?" Is the token going to be accepted as it is, abandoned or transformed? This question, we know, is the first principle for all studies of sciences and technologies (Latour 1987).

In this case, the statement is completely transformed. "Yes," say the Urban Community, "we are interested, but not if it is limited to your town, only if it becomes the starting point of our Lille Subway." The quasi-object now becomes the focus of interest for the whole conurbation. Are the promoters going to quit because their initial plan is so deeply transformed or will they be able to *re-negotiate* their plan so that it *accommodates* people from Villeneuve-d'Ascq as well as from Lille? This is the crucial question for an ethnography of modern technologies. If the promoters are able to redesign what was a local "bidule" (gadget) into a new subway for Lille, their quasi-objects will now bear the interest of hundreds of people instead of a mere dozen. If they prove unable to tackle so many conflicting interests and to shift them down to the project, they will stick to their local arrangement, but will have to transform it so that they do not need the help of the Urban Community. They might turn to the Government, to the Institutions in charge of promoting innovations in transportation. But then it will be another object, something that will look like a laboratory experiment – it will make the innovators happy, but will it transport the inhabitants of Villeneuve-d'Ascq? In the case of VAL, the promoters did all of that at once. They redesigned the project so that it could interest the whole of the Lille conurbation (it was a real subway), so that it interested the Government (it was a major new development away from Paris in a region that needed help); it fascinated the engineers and the laboratories looking for new systems (it had to be fully automatic) without losing the parochial interest of Villeneuve-d'Ascq (it used the patents and know-how of the local university specialized in automatisms); it remained simple enough to be built in time for the opening of the New Town; and it interested a company, Matra, new to the world of transportation, but specialized in automatism and military weapons and that was seeking to diversify.

Notice that in following the redesign of VAL and the list of interested groups I am not practicing *two different* interpretations – one about the nature of the artefact and the other about the meaning it has for social groups. *It is the same task to define the artefact tying together the various groups or the groups tying together one artefact.* This similarity is all the more visible as the artefact does not yet exist. It is still an argument to which is now added a thick file of drawings, rough calculations, letters of intent, patents and lists of specifications. Each time a new group is recruited, the list of specifications is extended, rewritten, or written off. For instance, as long as it was a local project, the subway was to run along a circle which allowed the cabin to be irreversible (with a head and a tail), and that in turn made the system cheaper and simpler. When the Lille community requested it become a subway line, cabins had to be made reversible, complicating the design and increasing the cost. The reversible cabin is not a piece of machinery "onto which" one could then add a meaning given it by the Mayor of Lille. It is to enlist the Mayor and keep him happy that the cabin "folds" itself and is made more complicated and reversible. Conversely, my analysis is not a social determination of the artefact by the interests of the mayor since there is no direct resemblance between "happiness of the mayor" and "reversibility of the cabin." It is the clever cunning of the engineer and promoter of the project which *translates* "happiness" into "reversibility." This translation is neither obvious, direct nor simple.

At first VAL was not an object, it became so only when, in 1984, VAL was opened and began transporting inhabitants from Lille. Even then it was not an object but a lash-up, an association of humans and non-humans, an institution, parts of which are delegated to pieces of machinery (the cabins, the automatic pilots), parts of which are delegated to collective persons (Matra, VAL) and parts of which are delegated to humans (the users, the inspectors, the maintenance engineers). As long as it was a project it was *not yet* an object. When it was finally realized it was no longer an object but a whole *institution*. So when does a piece of machinery become an object? Never, except when extracted portions of the institution are placed on view inside technical museums! An idle, isolated and useless VAL cabin inside a museum is an object that at last begins to resemble the idea that some people have of a technique isolated from its social context. But even this is still inaccurate, since the display is now part of the museum institution and could not survive long without the assemblage of curators, texts, leaflets, inventory numbers, sponsors, other nearby prototypes, visitors, that keep activating it. It is only once on the scrap heap, when it begins to be dismembered, that a technical object finally becomes an object . . . Even there it is an active entity. No, it is an object, a real object, only when it has disappeared beneath the ground, relegated to oblivion and potentially ready to be discovered by future archaeologists . . . A high-technology object is a myth.

THE ESSENCE OF ARAMIS

Inside the lobby of Matra headquarters in the suburbs of Paris, Aramis is already on its way to a museum display and is beginning to resemble the mythical object of epistemologists. It is a beautiful, idle, isolated white cabin, but no engineer is working on it and no passengers are boarding it. There is no rail and no electricity, no engine and no electronics. Only the nicely designed outer shell is present in the lobby as part of the landscape. Aramis started like VAL, as an argument, as a quasi-object, triggering the enthusiasm of many people. But unlike VAL, it went from being a quasi-object to being a piece of decoration in the lobby of the Matra firm, whereas VAL became the profitable export product of Matra-Transport and the indispensable routinized transportation system of a million Lille residents.

The "distributed monism" I have advocated should be able to tackle symmetrically the failure story as well as the success story. It would be against our principles to say that VAL was more efficient, less costly, more socially accepted, and better technically designed than Aramis, since all of the former's qualities and all of the latter's defects are *results* and not *causes* of the existence of VAL and of the lack of existence of Aramis. An explanation in terms of social forces (pushing VAL and pulling Aramis) or in terms of technical trajectories (mature for VAL and premature for Aramis) are also excluded, since they would be asymmetrical or dualist. And naturally it would fly in the face of the whole field of technology studies to try to explain only Aramis, since it has been a failure, whereas VAL has turned out to be a success (Bloor 1976 (1992)). Such an attitude would be still more asymmetric since it would look for social explanations only when something goes wrong – the straight path of happy technical development being, in contrast, self-evident and self-explanatory.

As a quasi-object, Aramis ties together many interests. Exactly as for VAL, these interests do not exist independently of the Aramis project. They are all bent, seduced, induced by Aramis, which modifies its specification, that is its essence, to tie them all together. Let us read the first page of the specifications written in 1987, a few months before Aramis was dismantled.

Document 1

Basic principles of the Aramis system
Aramis is an entirely automated personal rapid-transit system. The elementary unit of transportation is composed of two cars of limited capacity (ten passengers, all seated) which are mechanically hooked together and which are called "doublets."

Those doublets can be merged into variable trains by means of an electronic coupling that allows their association and dissociation at intersections, change of direction being effectuated by an on-board shunt.

Aramis is the last descendant of the Personal Rapid-Transit movement launched in the United States in Kennedy's day. The idea was to invent a cross between public transportation and the private car in order to decrease air pollution and traffic congestion, and to irrigate loosely populated suburbs with a system that was not too costly. This is a typical case of innovation by hybridization or metaphoric displacement. In the specific Aramis system devised by Matra, the notion of guided systems on tracks was retained from the subway, tramway and train, while the private car contributed the idea of small comfortable vehicles going to the precise place desired by the consumer. Rigid lines imposing a given path on everyone were dropped from the train paradigm, while private ownership and idiosyncratic driving were abandoned from the car paradigm. But in order to abandon the notion of lines, cabins should be endowed with the ability to join a train and to *leave it* at the desired shunt; and in order to abandon the notion of driver, these intelligent cabins should be automated. As a result, the whole work of driving has to be *taken over* by the cabin and by the track, while the whole work of owning, distributing, allocating, cleaning the cabins has to be *taken over* by the public system of transportation. In principle, every automobile driver, every urban planner, every politician should dream of such a system of transportation that would combine all the advantages of individual mobility with none of its dangers and costs. In practice it has become more complicated.

The specific phases of the Aramis system are shown in document 2 and figure 12.3.

Document 2

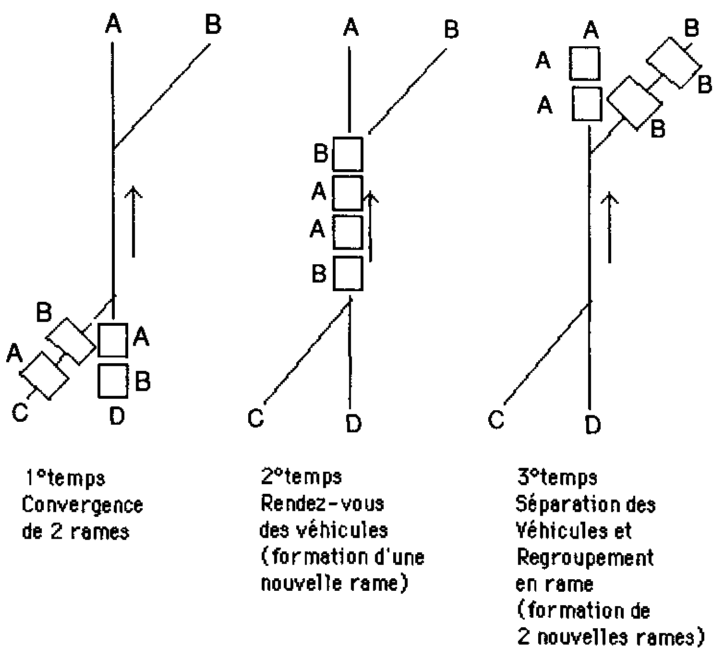

Figure 12.3 The specific phases of the Aramis system and the definition of the core features of the project.

(1st phase: two trains converge; 2nd phase: vehicles rendez-vous and form a new train; 3rd phase: Vehicles separate and form two new trains)

– "rendez-vous" of two trains coming from two convergent roads and merging in order to compose one single train along the common trunk line;
– separation at the intersection of the doublets going to different destinations and reconfiguration of homogeneous trains in each of the two branches.

This principle of making trains of variable length and composition allows:
– to easily adjust the length of the trains to transportation demand, while keeping a good quality service during off-hours by running short but frequent trains on all the branches;
– to exploit connected networks without the user having to change transportation systems or make connections ("ruptures de charge"). This system maintains short intervals on all the smaller branches of the system and may thus provide a fine irrigation of suburbs;
– to offer, in the most sophisticated version of the Aramis system, direct or semi-direct systems by using stations off the main line. Some doublets are thus allowed to short-circuit some stations and to go directly to their destination without intermediary stops.

This is the core of the Aramis project, it is because of this "electronic coupling" or "immaterial tie" that many engineers are so enthusiastic about this innovation, since it allows them to do away with connections ("ruptures de charge") and to let the passenger reach any destination of the network without being bothered with intermediary steps. It also allows them to make public transportation as light and small as cars, since a given vehicle does not have to bear the weight of the whole train. But someone has to think. First the engineers designing the system; then the designed system, which has to allocate destinations, manage the flow of cabins, let the cabins merge into a train, then reshuffle them at each intersection, then come back in order to meet the fluctuations of the demand. The problem is that no mind and no central computer is able to govern a system which, at least in the first project, included 2,200 cabins and, in the last one, 660. So most of the functions have to be delegated locally to the cabins themselves. It is they that must do most of the thinking: checking where they are going, where they are, making sure that their speed is finely tuned with the other cabins ahead and behind, deciding when to activate the "on-board shunt" to switch at an intersection, and when to open the doors to let the passengers in and out.

Document 3

The main advantages of the Aramis innovation
In addition to the specifications described above, two main specifications should be stressed:
– the small size and the easy insertion into most urban sites, the minimum turning radius being 10 m without passengers and 25 m with passengers;
– the very short interval between trains.

Urban designers are also interested in Aramis because it is much smaller than a normal subway and, since it is made of independent cabins not of trains, it can take sharp curves. Ideally it should be able to fit in everywhere in a city and, although it needs a specific track ("site propre"), civil engineering is much less costly than for a subway. The cabins themselves may be made as light as a car, since they never touch or pull each other.

The essence of Aramis is thus to gather about a revolutionary innovation all the people concerned by city congestion and air pollution, all the drivers who want the comfort of their private car but who would prefer not to own and pay for a costly private vehicle, all the city planners and urban engineers who want to implant public transportation without major civil-engineering works, all the companies and scientists interested in furthering automatism, all the big urban networks who wish to do away with unionized and well-paid drivers, government officials who are looking for ways to modernize the world of transportation and discover high-technology export products.

Yet, the ink on the above specifications had not dried when the number of people behind the projects fell to some fifty. A few weeks later, in December 1987, only a dozen or so people lamented the interruption of the project. Since then, I am about the only one left who cares about Aramis. A project that was to excite millions of people was left to the study of one lone ethnographer. I had to dig for the remnants of prototypes, tracks, documents, much as the technologist of traditional technologies lost in the night of time. The half billion francs (£50 millions), the fifteen years invested in the project, was not enough to make Aramis real, that is to turn it from a quasi-object into an institution. On the contrary, it turned it from a quasi-object into a prototype in the south of Paris, and from there into a museum piece, and from there, alas, into an object, lying on a scrap heap.

AGREEING ON AN OBJECT

After 50 interviews and a year of work, I had gathered not only one explanation but at least twenty.

Document 4

The twenty contradictory interpretations offered by the demise of the Aramis project

1 Aramis is technically ready ("au point") for homologation > approval;
2 Aramis is technically ready, but it is too expensive to industrialize;
3 Aramis was almost technically ready, but more studies, and more time, were necessary to complete the experimentation before approval;
4 Aramis was almost technically ready, and would have been completed if it had not been abandoned by politicians, who could have imposed its mass production, and thus decreased the cost per cabin;

5 Aramis was technically ready, but would have been so costly that it would have been unsaleable politically;
6 The Aramis cabin was technically ready, but the system as a whole was not and would have required much more study;
7 The Aramis cabin was technically ready, but even if the system could have been developed, it would have been so expensive that it would have been abandoned on the political front;
8 The Aramis cabin was not technically ready;
9 The Aramis cabin was not technically ready because Matra abandoned it and instead worked on VAL;
10 The Aramis cabin was not technically ready because the RATP (Régie Autonome des Transports Parisiens) requested that Matra respect specifications completely unsuited to such an innovative research prototype;
11 If the RATP had agreed to simplify the specifications, it would have become another VAL instead of Aramis;
12 If Aramis had been simplified and transferred to a region other than Paris, for instance Montpellier, it would have been technically feasible;
13 Whatever the specifications and wherever the prototype, Aramis could not be technically ready because it is unworkable for more than three cabins;
14 Aramis was not technically ready and may have been technically unfeasible, but portions of Aramis could be used in many other transportation innovations, there are many "spin-offs" ("retombées");
15 No portion of Aramis is re-usable, no software, no hardware, everything would have to be started all over, but culturally Aramis has useful spin-offs since it helped Paris unions to accept the idea of subway automation;
16 No portion of Aramis is re-usable, there are no spin-offs technically or culturally, it was a false innovation from the start, an unworkable idea;
17 If the prototype phase had been well managed, it would have been possible to tell whether or not the Aramis cabin, or the Aramis system, was technically feasible and technically ready;
18 It is impossible to tell if Aramis was technically feasible or not, it is a black box, it is unaccountable;
19 There was a cover-up, engineers played their games with the project and now all trace of goals and feasibility are gone;
20 The question of the technical feasibility of Aramis should not be raised.

At one end of the spectrum, some actors in the project believe that the specifications above (documents 1 and 2) were the true essence of a real object called Aramis, while others believe that if Aramis were to be real it would have to become another smaller case of VAL; at the other end, many informants claim that the specifications are those of an absurd, self-contradictory, false innovation that is unfeasible in theory as well as in practice – others going much further and accusing their colleagues of a cover-up. So much for those who believe that technical trajectories are so rationally determined that Cost or Efficiency or Interests are enough to account for their diffusion or demise. On the contrary, the multiplicity of interpretations is a necessary component of projects that slowly cease to exist. Interviews on the history of VAL also show a dispersion of answers, but all the various answers are *points of view* about an institution, the VAL, which exists independently of them. There exists an intersection of the set, and therefore I could find the sum of the points of view *about* VAL. I cannot find the sum of the interpretations of Aramis, since there is no common intersection and hence no distinction between interpretations and the object to be interpreted. The distinction between the two has not *yet* been made. Aramis remains a story, an argument, a quasi-object that circulates as a token in fewer and fewer hands – and now it survives only as a case study among technologists and ethnographers of science, another story to make a point, this time not about transportation, but about the mechanisms of innovation.

"DIALECTICS" OF TECHNICAL OBJECTS

Is it because Aramis ceased to exist that the interpretations diverged so, or because the interpretations are so divergent that the project never became an institution, a stabilized thing, the common intersection of all the arguments for it? I could say that it is both, and close this chapter by saying that it is a dialectical movement between those who tie their fate to the object and those who are tied by the object. "Dialectical" arguments are often used to darken further what is already obscure and to save the dualist paradigm under the pretence of subsuming it. If I want to maintain my "distributed monism" paradigm I have to be more precise than dialecticians and render fully accountable this twofold move of people assembling around things and things forcing people into assent (Latour, Mauguin and Teil 1992).

The process is impossible to follow if we consider social actors that simply press upon or inscribe their wills on inert passive things – or if we decide to see autonomous technologies pressing their fate and aimless goals upon softer human wills. Non-human actors have to be accepted as such, that is as actors endowed with as much complexity, ill will and independence as humans. But even symmetry is not enough. We also need to abandon the idea that *fixed* human actors or *fixed* non-human actors can simply be taken "off the shelf" and inserted into the process. The process becomes accountable if we follow *translations* of human and non-human competence instead of only following the displacements of goals, intentions and intents of the human actors.

The Mayor of Paris, for instance, had been interested in Aramis because the project intended to re-use an abandoned railway line, the "Petite Ceinture," that girds the south of Paris and could irrigate sections where the subway meshes are too far apart. The Mayor had been convinced to pay for the equipment of the Petite Ceinture. He was thus aligned behind Aramis and he linked its fate to the fate of the project. Or is he? Well, not exactly. Aramis's essence is to do away with the notion of line altogether, since the trains are reshuffled at each intersection. However, the Petite Ceinture is a line, as traditional as one can get. It goes from Boulevard Victor straight on to the 13th arrondissement. The Mayor may have supported Aramis, but it could also shift to another object, for instance a VAL, provided it re-uses the Petite Ceinture. The Mayor's support is not aligned behind Aramis, but behind a confusing hybrid: "anything that equips the south and stops citizens from those districts complaining about City Hall." Even this translation is not fixed, however. The citizens from the suburbs and from the north of Paris are now complaining so bitterly about the crowding of another line (line A of the RER), that the Mayor soon lost interest in Aramis – or at least lowered the priority of this "thing on the Petite Ceinture."

To be sure, equipping cheaply the Petite Ceinture with a smaller VAL would be possible and would make the Mayor happy – for a while, but the project's supporters do not agree. An automated subway in Paris would immediately trigger a long strike of the very tough and corporatist subway-drivers' union. They would take it as a long-term threat to their jobs – which it is, especially in the wake of a recent series of bitter strikes. But Aramis is so innovative, so small and so different from a subway that the same unions are indifferent to it, or even like it because it gives a good high-tech image of their company. Same thing with the engineers and the technical structure of the RATP. VAL is their direct enemy that was built by Matra, who short-circuited most of their know-how. Until VAL opened in Lille, RATP engineers were the best subway experts in France. To build a VAL inside Paris would be a provocation. Again, Aramis was so different, so new, and anyway generated so much skepticism that it was not a provocation. It was a good research project on which they could try out new ideas about "immaterial links" and "on-board shunts."

The project leaders inside Matra as well as inside the RATP had literally to "take on board" those various translated interests. The Mayor, the unions and the engineers were behind Aramis, but the first on the condition that Aramis looked like a VAL, the second on the condition that it did not look like the threat of automated subways, and the third on the condition that it would be as different as possible from VAL and as innovative as possible, so that they could regain their lead over Matra. We know the general answer to those quandaries: negotiate, go back to the drawing board and redesign the project so that it folds over and "absorbs" or "swallows" the contradictions of hesitant supporters. Then, once the project itself has been modified, it in turn holds in place all the interests that were at first holding it in place. Non-human mechanisms are now visible where social ties and arguments were before. This is what the project leaders did. So that Aramis looked like the equipment of the Petite Ceinture, the cabins were enlarged to 10 seats – 20 per "doublet" – and the flow of passengers went up – on paper – to 10,000 per hour, later to reach 14,000 per hour. But so that it would *not* resemble a VAL while retaining the shape of Aramis, intersections were added to the Petite Ceinture, intersections that no normal subway, even automated, could accommodate without possessing the competence that made Aramis's charm: "immaterial ties and on-board shunt."

Aramis's chips and software were now bearing the whole weight of the complex negotiations of the project leaders. Nowhere among the lines of the program could one read that the unions, the Mayor, the technostructure, and Matra had to be kept happy. Happiness, here as above for VAL, is being translated by programs of action that are entirely different from the original wording. Not that they are hidden, disguised, covered up, but because the unions, the engineers and the Mayor expect a thing that runs automatically, not words that seduce or please. Negotiation is continuing but this time with non-human actors. Is it possible to endow a cabin, and from there a system of 660 cabins, with the ability to transport in a regular flow 10,000 passengers per hour along a line similar to a subway line, and at the same time to reshuffle all the cabins at the intersection so that a whole network can be irrigated and passengers reach their destination without having to change trains. The work of translation has now assumed the shape of figure 12.1. It not only looks technical, it *is* technical. But by saying this we do not mean something *different* from the discussions between Mayors, unions and technocrats, since the programing languages are now in charge of keeping the negotiation settlement between the human actors. But we are certainly not talking the *same* language either, since it is because the human actors could not agree with one another that the discussion was shifted to non-human actors to which was delegated the task of holding the humans together. This is the reason why we use the key-notion of translation. The chips are not reducible to social ties nor are the social ties reducible to the determination of things. *They are new social ties*. They are social ties continued through the active mediation of "physimorphic" actors that are now playing their own part and trying to reconcile the fuzzy, shifting or contradictory interests of the humans.

They play their part so actively, so freely, that Matra software engineers would like to get rid of most of them. Aramis prototypes have become so full of computers in order to endow the cabins with enough competence to manage the intersections and the merging that there is hardly any place left for passengers! As for the costs, they are skyrocketing, every cabin is now as expensive as a satellite. To be sure, some of the functions of Aramis may be nicely simulated, but Aramis has to be as safe ("en sécurité") as trains and subways, as cheap as the automobile industry, and as sophisticated as the aerospace industry! Now the engineers are trying frantically to reconcile three technical worlds as far apart as the unions, the Mayor and the technocrats were. Automobiles are cheap, but their quality ("disponibilité") is very inferior to that required for public transportation; planes are precise and safe but very expensive; subways are safe, but not at the level of sophistication required for cabins moving at 30 km/hr and adjusting their acceleration hundreds of times a second.

Matra engineers would like to simplify the whole mess and fall back onto the world of VAL they handle so well. But they can't. They have signed a contract and every time they try to loosen the specifications, the RATP is there to insist on their making Aramis, not VAL or some ersatz of it. When at one point they offered to fall back on an ARAVAL, the contractants recoiled in horror at this monstrous hybrid.

I cannot include all the details of the negotiation (Latour 1992a), but the final diagnosis, although paradoxical, may be of some relevance for ethnographers of high-tech projects. It is because Aramis completely isolates the core technical ideas of the project from the rest of the network (exploitation, systems, political vagaries, costs, engineers' skills) that it cannot become an institution and is fated to remain a utopia, a UFO. By contrast, it is because VAL makes no such neat distinctions and swallows up in its technical specifications most of the variations of its human supporters that it gains in reality and, from a mad project, ends up as a respectable institution. The various interests behind Aramis do not intersect any more than do the twenty-odd interpretations of its demise (see figure 12.4). An object cannot come into existence if the range of interests gathered around the project do not intersect. Of course, interests may be modified and so may projects. But, if the two-way movement translating interests and modifying the project is interrupted, then the object cannot become real. Thus the real locus of enquiry for the ethnographer of high technology is neither the technical object itself – that will exist only later as part of an institution or will disappear as part of a scrap heap – nor the social interests – that may be translated and that will later be shaped by the stable objects. The locus of enquiry is to be found in the *exchanges* between the translated interests of humans and the delegated competences of non-humans. As long as this exchange goes on, the project is alive and may become real. As soon as it is interrupted, the project dies, and we obtain, on the one hand, a social assembly of quarreling human actors and, on the other, a stack of documents and a pile of idle and rapidly decaying technical parts.

The irony of the Aramis case is that the main engineers behind the project really believed in the epistemological myth of a technology fully independent from the rest of society. They maintained the basic specifications of the system for fifteen years without a single modification. The same engineers during the VAL story applied a completely different social theory of technology and happily renegotiated the core specifications according to the shifting interests of Lille's main actors.

CONCLUSION: AN ANTHROPOLOGY OF OBJECTIVITY

Many social scientists share the illusion that social actors share the following illusion: "mere actors" believe the intrinsic qualities of art, religion, and techniques to be what oblige them to agree and comply, whereas it is really the force of society projected onto arts, religions and technologies that makes them act and possess meaning. Unable to bear the direct brunt of society, social actors are forced to express it through artefacts and beliefs. Fortunately, social scientists are much wiser than mere social actors, and they see through this illusion and reveal the force of society reflected in the fetish of gods, beauty and technical styles. This way of practicing social science was extremely popular from Durkheim until the irruption of ethnomethodology (Hennion 1991).

What those social scientists never explain is the reason why society constantly needs to be projected onto new objects. Is society so weak that it needs continuous resuscitation? So terrible that, like Medusa's face, it should be seen only in a mirror? And, if religion, arts, styles are necessary to reflect, reify, materialize, embody, society, then are they not, in the end, its co-producers? Is not society built literally, and not metaphorically, of gods, machines, sciences, arts and styles? But then where is the illusion of the actor in the bottom arrow of figure 12.4? Who are deluding themselves if not those same wise social scientists who have simply forgotten that, before projecting itself onto things, society has to be made, built, constructed? And out of what material could it be built if not out of non-social, non-human resources?

We can now detect the origin of the dualist paradigm I discussed earlier and which has for so long paralyzed an ethnography of objects. Social scientists used the Durkheimian model on everything *but* science and technology. They use it on religion, on art, on rites, on style, but not on Truth and not on Efficiency. If, in figure 12.4, you replace the word "object" by the traditional entities about which social scientists are so wise (which means basically the beliefs they do not share), then they criticize the bottom arrow (the false effect) by unveiling the top arrow (the real cause). If, however, you now replace the word "object" by "science and technology," then social scientists occupy the same position as the "mere actors" of figure 12.4. They do indeed believe that objective facts of science and objective constraints of matter force society to agree. The consensus theory so nice for explaining why we believe in gods, in arts or in stylistical differences, is the horror to be

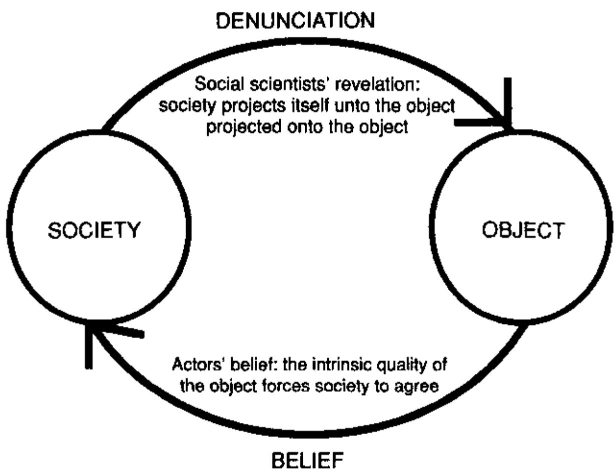

Figure 12.4 The denunciation by social scientists of the naïve belief in objectivity.

avoided at all cost if Truth and Efficiency are concerned. Moreover, it is now the top arrow that becomes the illusion to be eradicated, the illusion of relativism. It is not because a society agrees about something that this thing comes into existence.

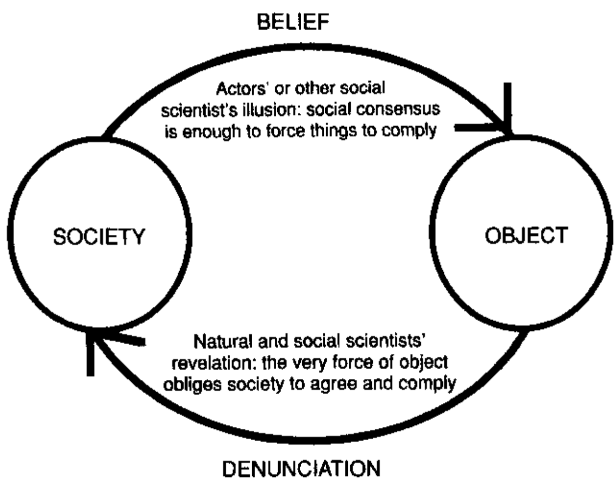

Figure 12.5 The denunciation by social scientists of the naïve belief in freedom.

No wonder that the superposition of the two main resources leads to dualism. How could asymmetrical social scientists resolve the difficulty? Society reflects and materializes itself in all the "false" objects that "mere" actors believe to be the cause of society, but *not* in the real objects that do indeed cause society? If such is the case, then society is becoming a very strange beast indeed, strong enough to be *sui generis* and effectively causes religion, art and styles, but so weak and plastic that science and technology impose consensus on its members without their building any facts and artefacts at all! The result of such a blatant contradiction is dualism. Each object will be divided in two (figure 12.6): one part to which the classical Durkheimian model will be allowed fully to apply, as in figure 12.4, and the other where the no less classic model of figure 12.5 will be applied. "Secondary qualities," to use the old language of philosophy of perception, are socially explainable, but not "primary" ones. The problem with this dualism is that objects and societies are either too weak or too strong. "Society I" is so strong that it is *sui generis* and projects itself on objects which are reduced to being the screen onto which social categories are played. But "objects II" are so powerful that they are able to impose their force onto the pliable matter of society. Either society is too strong and objects too weak, or objects have too much force and society not enough. In both cases it is impossible to grant objects and societies the right solidity and to see both of them in focus.

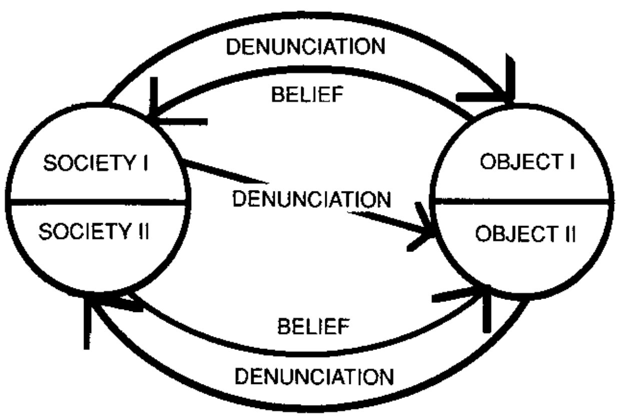

Figure 12.6 The dualism practised by the social sciences renders the locus of technical artefacts difficult to recognize.

To resolve the dualism is now easy. One simply has to apply the first model to the second in order to break *both* into bits. This transformation has occurred in two steps. The first one was to treat science and technology in the same way as art, religion and styles used to be treated by mainstream social science. If, taking over the social scientists' mandate, we now consider their denunciation (bottom arrow of figure 12.6) as a belief which we now denounce (arrow crossing over in figure 12.6), we extend social constructivism to science and technology. I treat the "object II" as if it were the "object I." What social scientists have rightly said of religion, art and style, we now claim, is even truer for the facts of science and the artefacts of technology. They are all made by society through and through, and simply express, reflect, materialize, embody our consensus (Bloor 1976 (1992)).

But no sooner have we taken this step than the whole enterprise falls apart. There is now nothing left with which to make society ("society I"), whereas society is supposed to make and cause everything else *including* the constraints of matter and the objectivity of facts. By *extending* the denunciation program of social scientists to science and technology, we reveal the emptiness of social constructivism, its intrinsic idealism. The impression that it had a meaning was maintained only as long as it did not apply to hard facts. Social constructivism was protected from absurdity only by the dualist paradigm. On the other hand, although some of my colleagues are trying to prolong its life, the extension of social construction to science and technology lasted only a split second, the time to see how badly built a dualist social theory was.

How can the distributed monism I advocated above provide a better social theory? As I indicated in the case of Aramis, the object is not to be positioned at one of the extremities while the social would be at the opposite pole. Society does not exist enough to occupy the position of a pole, nor does technology. The Mayor of Paris does not know what he wants enough to be able to shape Aramis, but the software engineers do not know either if they will be able to accommodate the contradictory wishes (now translated into the form of specifications) of the same Aramis. Where is Aramis? Not on the left side of the diagram (figure 12.6) and not on the right side. A technical object – at least as long as it exists – is the institutionalized transaction through which elements of the actors' interests are reshaped and translated, while non-human competences are upgraded, shifted, folded or merged. Figure 12.7 provides a diagrammatic comparison of the two explanatory models above. There are indeed arrows going from society to technology and back. But these arrows are not the only ones nor do they indicate the most interesting phenomena. What is more important is the *displacement* of goals and properties due to translation – displacements that are indicated by the sharp or shallow turns taken by the lines. Sometimes an element of the social is transposed with very few variations to become a member of the technical world, but sometimes the shift, the metamorphosis, is much greater.

Society does exist, but only as the sum of all the arrows coming from the transaction sites. Technology also exists, but not as the independent entity onto which society could project itself, or which could force society into obedience. When everything is stabilized the smooth transactions indeed give the impression that there exists a technique, faithfully obeying our wishes or coercively forcing us into assent. In times of instability, however, the ethnographer would be wasting her or his time if s/he were sitting at either extremity of figure 12.7, the only viable locus of enquiry being where

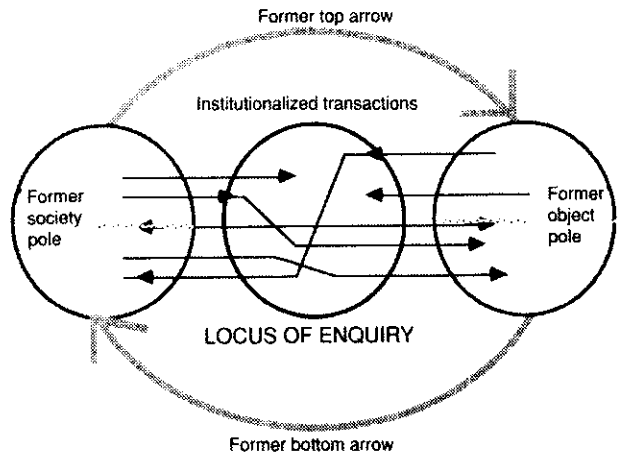

Figure 12.7 By shifting attention to quasi-objects it is possible to locate and analyze technical projects.

translations or transactions are effectuated. This focus was entirely missed – or indeed carefully circumvented – by the two main language games of the social sciences, represented here by the gray arrows from former figures (12.4 and 12.5). Moreover, trying to link the two arrows and to envelop the two poles by dialectical moves would take the ethnographer *still further* from the locus of enquiry. This is the paradox of dialectics, to have so pitifully failed in studying what it claims so arrogantly to reconcile: the subject and the object.

Once again the parallel trajectories of VAL and Aramis are enlightening. VAL remained a site of transactions and has now become an institution. Aramis, unable to maintain the transactions, has drifted into two irreconcilable parts: social interests, on the one hand, techniques on the other. A high technology exists only as long as it remains in the middle part of figure 12.7. As in the old disputes about the connection between soul and body, the locus of enquiry I have tried to picture is the *life* of a technique and of a society.

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On Technical Mediation — Philosophy, Sociology, Genealogy

Bruno Latour

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After Daedalus' escape from the labyrinth, according to Apollodorus, Minos used one of Daedalus' own subterfuges to find his hiding place and take revenge. Minos, in disguise, heralded near and far his offer of a reward to anyone who could thread the convoluted shell of a snail. Daedalus, hidden at the court of King Cocalus and unaware that the offer was a trap, managed the trick by replicating Ariadne's cunning: he attached a thread to an ant and, after allowing it to penetrate the shell through a hole at its apex, he induced the ant to weave its way through this tiny labyrinth. Triumphant, Daedalus claimed his reward, but King Minos, equally triumphant, asked for Daedalus' extradition to Crete. Cocalus abandoned Daedalus; still, the artful dodger managed, with the help of Minos' daughters, to divert the hot water from pipes he had installed in the palace, so that it fell, as if by accident, on Minos in his bath. (The king died, boiled like an egg.) Only for a brief while did Minos outwit his master engineer—Daedalus was always one ruse, one machination, beyond his rivals.

In the myth of Daedalus, all things deviate from the straight line. The direct path of reason and scientific knowledge—episteme—is not the path of every Greek. The clever technical know-how of Daedalus is an instance of *metis*, of strategy, of the sort of intelligence for which Odysseus (of whom the *Iliad* says that he is *polymetis*, a bag of tricks) is most famed.[1] No unmediated action is possible once we enter the realm of engineers and craftsmen. A *daedalion*, in Greek, is something curved, veering from the straight line, artful but fake, beautiful and contrived. Daedalus is an inventor of

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[1]For the myth of Daedalus, I am here following the remarkable book by Françoise Frontisi-Ducroux, *Dédale. Mythologie de l'artisan en Grèce ancienne* (Paris: Maspéro-La Découverte, 1975).

contraptions: statues that seem to be alive, military robots that watch over Crete, an ancient version of genetic engineering that enables Poseidon's bull to impregnate Pasiphae with the Minotaur—for whom he builds the labyrinth, from which, via another set of machines, he manages to escape, losing his son Icarus on the way . . . despised, indispensable, criminal, ever at war with the three kings who draw their power from his machinations. Daedalus is our best eponym for *technique*—and the concept of *daedalion* our best tool to penetrate the evolution of civilization. His path leads through three disciplines: philosophy, sociology, genealogy.

Philosophy

To understand techniques—technical means—and their place in society, we have to be as devious as the ant to which Daedalus attached his thread. The straight lines of philosophy are of no use when it is the crooked labyrinth of machinery and machinations, of artifacts *and daedalia*, we have to explore. That Heidegger's interpretation of technology passes as the deepest of interpretations I find surprising.[2] To cut a hole at the apex of the shell and weave my thread, I need to define, in opposition to Heidegger, what *mediation* means in the realm of techniques.

For Heidegger, a technology is never an instrument, a mere tool. Does that mean that technologies mediate action? No, because we have ourselves become instruments for no other end than instrumentality itself. Man—no Woman in Heidegger—is possessed by technology, and it is a complete illusion to believe that we can master it. We are, on the contrary, framed by this *Gestell*, which is in itself one way in which Being is unveiled. . . . Is technology inferior to science and pure knowledge? No, because, for Heidegger, far from serving as applied science, technology dominates all, even the purely theoretical sciences. By rationalizing and stockpiling nature, science plays into the hands of technology, whose sole end is to rationalize and stockpile nature without end. Our modern destiny—technology—appears to Heidegger radically different from *poesis*, the kind of "making" that ancient craftsmen knew how to obtain. Technology is entirely unique, insuperable, omnipresent, superior, a monster born in our midst.

But Heidegger is mistaken. I will try to show how and in what way he is wrong about technical mediation by using a simple, well-known example.

"Guns kill people" is a slogan of those who try to control the unrestricted sale of guns. To which the National Rifle Association replies with another slogan, "People

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[2]Martin Heidegger, *The Question Concerning Technology and Other Essays*, trans. William Lovitt (New York: Harper Torch Books, 1977).

kill people; not guns." The first slogan is materialist: the gun acts by virtue of material components irreducible to the social qualities of the gunman. On account of the gun, a good guy, the law-abiding citizen, becomes dangerous. The NRA, on the other hand, offers (amusingly enough, given their political views) a sociological version more often associated with the Left: for the NRA, the gun does nothing in itself or by virtue of its material components. The gun is a tool, a medium, a neutral carrier of will. If the gunman is a good guy, the gun will be used wisely and will kill only apropos. If the gunman is a crook or a lunatic, then, with no change in the gun itself, a killing that would in any case occur will be (simply) carried out more efficiently. What does the gun add to the shooting? In the materialist account, everything: an innocent citizen becomes a criminal by virtue of the gun in her hand. The gun enables of course, but also instructs, directs, even pulls the trigger—and who, with a knife in her hand, has not wanted at some time to stab someone or something? Each artifact has its script, its "affordance," its potential to take hold of passersby and force them to play roles in its story. By contrast, the sociological version of the NRA renders the gun a neutral carrier of will that adds nothing to the action, playing the role of an electrical conductor, good and evil flowing through it effortlessly.

The two positions are absurdly contradictory. No materialist claims that guns kill by themselves. What the materialist claims is that the good citizen is transformed by carrying the gun. A good citizen who, without a gun, might simply be angry may become a criminal if he is holding a gun—as if the gun had the power to change Dr. Jekyll into Mr. Hyde. Materialists thus make the intriguing suggestion that our quality as subjects, our competences, our personalities, depend on what we hold in our hands. Reversing the dogma of moralism, the materialists insist that we are what we have—what we have in our hands, at least.

As to the NRA, they cannot maintain that the gun is so neutral an object that it has no part in the act of killing. They have to acknowledge that the gun adds something, though not to the moral state of the person holding the gun. For the NRA, one's moral state is a Platonic essence: One is born a good citizen or a criminal. Period. As such, the NRA account is moralist—what matters is what you are, not what you have. The sole contribution of the gun is to speed the act. Killing by fists or knives is slower, dirtier, messier. With a gun, one kills better, but at no point does it modify one's goal. Thus, NRA sociologists are making the troubling suggestion that we can master techniques, that techniques are nothing more than pliable and diligent slaves.

Who or what is responsible for the act of killing? Is the gun no more than a piece of mediating technology? The answer to these questions depends upon what *mediation* means. A first sense of *mediation* (I will offer four) is the *program of action*, the series of goals and steps and intentions, that an agent can describe in a story like my vignette

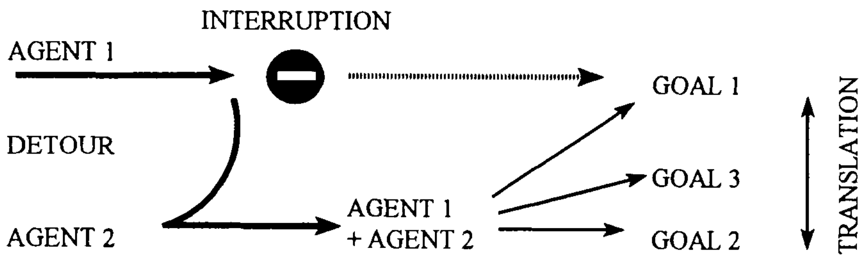

Fig. 1. First Meaning of Mediation: Translation

of the gun (fig. 1). If the agent is human, is angry, wants to take revenge, and if the accomplishment of the agent's goal is interrupted, for whatever reason (perhaps the agent is not strong enough), then the agent makes a detour, a deviation: as we have already seen, one cannot speak of techniques without speaking of *daedalia.* Agent 1 falls back on Agent 2, here a gun. Agent 1 enlists the gun or is enlisted by it—it does not matter which—and a third agent emerges from a fusion of the other two.

The question now becomes which goal the new composite agent will pursue. If it returns, after its detour, to Goal 1, then the NRA story obtains. The gun is a tool, merely an intermediary. If Agent 3 drifts from Goal 1 to Goal 2, then the materialists' story obtains. The gun's intent, the gun's will, the gun's script have superseded those of Agent 1; it is human action that is no more than an intermediary. Note that in the diagram it makes no difference if Agent 1 and Agent 2 are reversed. The myth of the Neutral Tool under complete human control and the myth of the Autonomous Destiny that no human can master are symmetrical. But a third possibility is more commonly realized: the creation of a new goal that corresponds to neither agent's program of action. (You had wanted only to hurt but, with a gun now in hand, you want to kill.) I call this uncertainty about goals *translation.* I have used this term a number of times and encounter each time the same misunderstandings.[3] Translation does not mean a shift from one vocabulary to another, from one French word to one English word, for instance, as if the two languages existed independently. Like Michel Serres, I use *translation* to mean displacement, drift, invention, mediation, the creation of a link that did not exist before and that to some degree modifies two elements or agents.

Who, then, is the actor in my vignette? *Someone else* (a citizen-gun, a gun-citizen). If we try to understand techniques while assuming that the psychological capacity of humans is forever fixed, we will not succeed in understanding how techniques are created nor even how they are used. You are a different person with the gun in your

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[3]In particular, in Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge: Harvard University Press, 1987). My use of the word *translation* comes from Michel Serres through Michel Callon's sociological usage: "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay," in *Power, Action, and Belief: A New Sociology of Knowledge?* ed. John Law (London: Routledge & Kegan Paul, 1986), 196–229.

hand. Essence is existence and existence is action. If I define you by what you have (the gun), and by the series of associations that you enter into when you use what you have (when you fire the gun), then you are modified by the gun—more so or less so, depending on the weight of the other associations that you carry. This translation is wholly symmetrical. You are different with a gun in hand; the gun is different with you holding it. You are another subject because you hold the gun; the gun is another object because it has entered into a relationship with you. The gun is no longer the gun-in-the-armory or the gun-in-the-drawer or the gun-in-the-pocket, but the gun-in-your-hand, aimed at someone who is screaming. What is true of the subject, of the gunman, is as true of the object, of the gun that is held. A good citizen becomes a criminal, a bad guy becomes a worse guy; a silent gun becomes a fired gun, a new gun becomes a used gun, a sporting gun becomes a weapon. The twin mistake of the materialists and the sociologists is to start with essences, those of subjects *or* those of objects. That starting point renders impossible our measurement of the mediating role of techniques. Neither subject nor object (nor their goals) is fixed.

It is, now, possible to shift our attention to the *someone else*, the hybrid actor composed (for instance) of gun and gunman. We must learn to attribute—redistribute—actions to many more agents than is acceptable to either the materialist or the sociological account. Agents can be human or (like the gun) nonhuman, and each can have goals (or functions, as engineers prefer to say). Since the word *agent* in the case of nonhumans is uncommon, a better term is *actant*, a borrowing from semiotics that describes any entity that acts in a plot until the attribution of a figurative or nonfigurative role ("citizen," "weapon").[4] Why is this nuance important? Because, for example, in my vignette, I could replace the gunman with "a class of unemployed loiterers," translating the individual agent into a collective, or I could talk of "unconscious motives," translating it into a subindividual agent. I could redescribe the gun as "what the gun lobby puts in the hands of unsuspecting children," translating it from an object into a collective person, an institution, or a commercial network; or I could define the gun as "the action of a trigger on a cartridge through the intermediary of a spring and a firing-pin," translating it into a mechanical series of causes and consequences.

The difference between actor and actant is exactly the same as in a fairy tale where the sudden performance of a hero may be attributed to a magic wand, or to a horse, or to a dwarf, or to birth, or to the gods, or to the hero's inner competence. A single actant may take many different "actantial" shapes, and conversely the same actor may play many different "actorial" roles. The same is true of goals and functions, the former associated more with humans, the latter with nonhumans, but both can be described as programs of action—a neutral term useful when an attribution of human goals or

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[4]See the definition in A. J. Greimas and J. Courtès, eds., *Semiotics and Language: An Analytical Dictionary* (Bloomington: Indiana University Press, 1982).

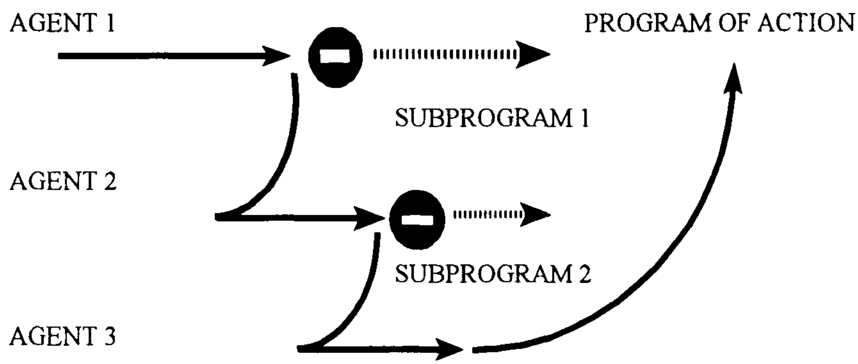

Fig. 2. Second Meaning of Mediation: Composition

nonhuman functions has not been made. Do the guns of *Roger Rabbit* or the clock and candle of Disney's *Beauty and the Beast* have goals or functions? That depends on the degree of anthropomorphism involved.[5]

These examples of actor-actant symmetry force us to abandon the subject-object dichotomy, a distinction that prevents understanding of techniques and even of societies. It is neither people nor guns that kill. Responsibility for action must be shared among the various actants. And this is the first of the (four) meanings of *mediation.*

One might object, of course, that a basic asymmetry lingers—women make electronic chips but no computer has ever made women. Common sense, however, is not the safest guide here, any more than it is in the sciences. The difficulty we just considered in the example of the gun remains, and the solution is the same: the prime mover of an action becomes a new, distributed, and nested series of practices whose sum might be made but only if we respect the mediating role of all the actants mobilized in the list.

To be convincing on this point will require a short inquiry into the way we talk about tools. When someone tells a story about the invention, fabrication, or use of a tool, whether in the animal kingdom or the human, whether in the psychological laboratory or the historical or the prehistoric, the literary structure is the same (fig. 2).[6] Some agent has a goal or goals; suddenly, the access to the goal is interrupted by that breach in the straight path that distinguishes *metis* from episteme. The detour, a

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[5]This position has triggered a lively debate on the difference between agent, actor, and actant. See Harry Collins and Steven Yearley, "Epistemological Chicken," in *Science as Practice and Culture,* ed. Andrew Pickering (Chicago: University of Chicago Press, 1992), 301–26, and the response in the same volume, Michel Callon and Bruno Latour, "Don't Throw the Baby Out with the Bath School! A Reply to Collins and Yearley," 343–68.

[6]See, for instance, Benjamin B. Beck, *Animal Tool Behavior: The Use and Manufacture of Tools* (New York: Garland, 1980).

daedalion, begins. The agent, frustrated, turns in a mad and random search, and then, whether by insight or Eureka or by trial and error—there are various psychologies available to account for this moment—the agent seizes upon some other agent—a stick, a partner, an electrical current—and then, so the story goes, returns to the previous task, removes the obstacle, and achieves the goal. Of course, in most tool stories there is not one but two or several subprograms nested in one another. A chimpanzee might seize a stick and, finding it too blunt, begin, after another crisis, another subprogram to sharpen the stick, inventing en route a compound tool. (How far the multiplication of these subprograms can continue raises interesting questions in cognitive psychology and evolutionary theory.)

Although one can imagine many other outcomes (for instance, the loss of the original goal in the maze of subprograms), let us suppose that the original task is resumed. The *composition* of the action here is interesting—the lines lengthen at each step. Who performs the action? Agent 1 plus Agent 2 plus Agent 3. Action is a property of associated entities. Agent 1 is allowed, authorized, enabled by the others. The chimp plus the sharp stick reach (and not *reaches*) the banana. The attribution to one actor of the role of prime mover in no way weakens the necessity of a *composition* of forces to explain the action. It is by mistake, or unfairness, that our headlines read, "Man flies," "Woman goes into space." Flying is a property of the whole association of entities that includes airports and planes, launch pads and ticket counters. B-52s do not fly, the U.S. Air Force flies. Action is simply not a property of humans but of an association of actants, and this is the second sense of what I intend by technical mediation. Provisional "actorial" roles may be attributed to actants only because actants are in the process of exchanging competences, offering one another new possibilities, new goals, new functions. Thus, symmetry holds in the case of fabrication as in the case of use.

But what does *symmetry* mean? Any given symmetry is defined by what is conserved through transformations. In the symmetry between humans and nonhumans, I keep constant the series of competences, of properties, that agents are able to swap by overlapping each other. I want to situate myself at the stage before we can clearly delineate humans and nonhumans, goals and functions, form and matter, before the swapping of properties and competences is observable and interpretable. Full-fledged human actors, and respectable objects out there in the world, cannot be my starting point; they may be our point of arrival. Does such a place exist? Is it more than a myth?

This principle of symmetry may be used to map out the many well-established myths that tell us we have been made by our tools. The expression *Homo faber* or, better, *Homo faber fabricatus* describes, for Hegel and Leroi-Gourhan and Marx and Bergson, a dialectical movement that ends by making us sons and daughters of our own works.[7] As for Heidegger, the relevant myth is that "So long as we represent technology as an

[illegible] translated into English, by André Leroi-Gourhan, *Le Geste et la* [illegible] instrument, we remain held fast in the will to master it. We press on past the essence of technology."[8] We will see later what can be done with dialectics and the *Gestell*, but if inventing myths is the only way to get on with the job, we should not hesitate to invent new ones.

Why is it so difficult to measure, with any precision, the mediating role of techniques? Because the action that we are trying to measure is subject to "blackboxing," a process that makes the joint production of actors and artifacts entirely opaque. Daedalus' maze is shrouded in secrecy. Can we open the labyrinth and *count* what is inside?

Take, for instance, an overhead projector. It is a point in a sequence of action (in a lecture, say), a silent and mute intermediary, taken for granted, completely determined by its function. Now, suppose the projector breaks down. The crisis reminds us of the projector's existence. As the repairmen swarm around it, adjusting this lens, tightening that bulb, we remember that the projector is made of several parts, each with its role and function and its relatively independent goals. Whereas a moment before, the projector scarcely existed, now even its parts have individual existence, each its own "black box." In an instant, our "projector" grew from being composed of zero parts to one to many. How many actants are really there? The philosophy of technology has little use for arithmetic. . . .

The crisis continues. The repairmen fall back into a well-routinized sequence of actions, replacing parts. It becomes clear that their actions are composed of steps in a sequence that integrates several human gestures. We no longer focus on an object but see a group of people around an object. A shift has occurred between actant and mediator. Figures 1 and 2 showed how goals are redefined by association with nonhuman actants, and how action is a property of the whole association, not particularly of those actants called human. However, as figure 3 shows, the situation is still more confused, since the number of actants varies from step to step. The composition of objects also varies: sometimes objects appear stable, sometimes they appear agitated, like a group of humans around a malfunctioning artifact/quasi-object/quasi-subject. Thus, the projector counts for one, for nothing, for one hundred parts, for so many humans, for no human—and each part itself may count for one, for zero, for many, for an object, for a group. In the seven steps of figure 3, each action may proceed toward either the dispersion of actants or their integration into a single whole (a whole that, soon after, will count for nothing). Some contemporary Western philosophies can account for step 7 or step 2, or both, but what is required, what I propose to develop, is a philosophy that accounts for all seven steps.

Look around the room in which you are puzzling over figure 3. Consider how many black boxes there are in the room. Open the black boxes; examine the assemblies in-

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[8] Heidegger, *Question Concerning Technology*, 32.

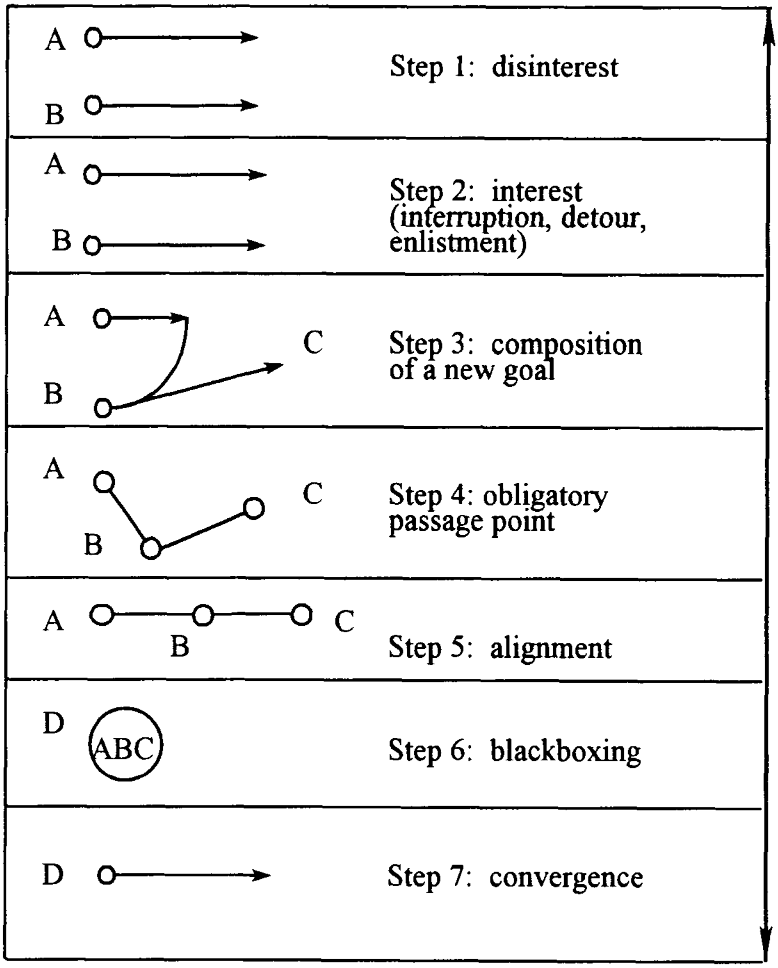

Fig. 3. Third Meaning of Mediation: Reversible Blackboxing

side. Each of the parts inside the black box is a black box full of parts. If any part were to break, how many humans would immediately materialize around each? How far back in time, away in space, should we retrace our steps to follow all those silent entities that contribute peacefully to your reading this article at your desk? Return each of these entities to step 1; imagine the time when each was disinterested and going its own way, without being bent, enrolled, enlisted, mobilized in any of the others' plots. From which forest should we take our wood? In which quarry should we let the stones quietly rest? Most of these entities now sit in silence, as if they did not exist, invisible, transparent, mute, bringing onto the present scene their force and their action from who knows how many millions of years past. They have a peculiar ontological status, but does this mean that they do not act, that they do not mediate action? Can we say that because we have made all of them—who is this "we," by the way? not I, certainly—they should be considered slaves or tools or merely evidence of a *Gestell?* The depth of our ignorance about techniques is unfathomable. We are not able even to count their number, nor can we tell whether they exist as objects or as assemblies or as so many sequences of skilled actions. . . .

Yet there remain philosophers who believe there are such things as objects.

The reason for such ignorance is made clearer in considering the fourth and most important meaning of *mediation.* To this point, I have used the terms *story* and *program of action, goal* and *function, translation* and *interest, human* and *nonhuman,* as if techniques were stay-put denizens of the world of discourse. But techniques modify the matter of our expression, not only its form. Techniques have meaning, but they produce meaning via a special type of articulation that crosses the commonsense boundary between signs and things.

A simple example of what I have in mind: a speed bump that forces drivers to slow down on campus. The driver's goal is translated, by means of the speed bump, from "slow down so as not to endanger students" into "slow down and protect my car's suspension." The two goals are far apart, and we recognize here the same displacement as in our gun story. The driver's first version appeals to morality, enlightened disinterest, and reflection, whereas the second appeals to pure selfishness and reflex action. In my experience, there are many more people who would respond to the second than to the first: selfishness is a trait more widely distributed than respect for law and life—at least in France. The driver modifies his behavior through the mediation of the speed bump: he falls back from morality to force. But from an observer's point of view, it does not matter through which channel a given behavior is attained. From her window, the chancellor sees that cars are slowing down and, for her, that is enough.

The transition from reckless to disciplined drivers has been effected through yet another detour. Instead of signs and warnings, the campus engineers have used concrete. In this context, the notion of detour, of translation, should be modified not only (as with previous examples) to absorb a shift in the definition of goals and functions, but also a change in the very matter of expression. The engineers' program of action, "make drivers slow down on campus," is now inscribed in concrete. Instead of "inscribed," I could have said "objectified" or "reified" or "realized" or "materialized" or "engraved," but these words imply an all-powerful human agent imposing his will on shapeless matter, while nonhumans also act, displace goals, and contribute to their redefinition.[9] The fourth meaning of *translation* thus depends on the three preceding.

Not only has one meaning, in our example, been displaced into another, but an action (the enforcement of the speed law) has been translated into another kind of expression. The engineers' program is inscribed in concrete and, in considering this

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[9]See, for developed examples, Bruno Latour, "Where Are the Missing Masses? Sociology of a Few Mundane Artefacts," in *Shaping Technology-Building Society: Studies in Sociotechnical Change,* ed. Wiebe Bijker and John Law (Cambridge: MIT Press, 1992), 225–59; and, more recently, Bruno Latour, *La clef de Berlin—et autres leçons d'un amateur de sciences* (Paris: La Découverte, 1993).

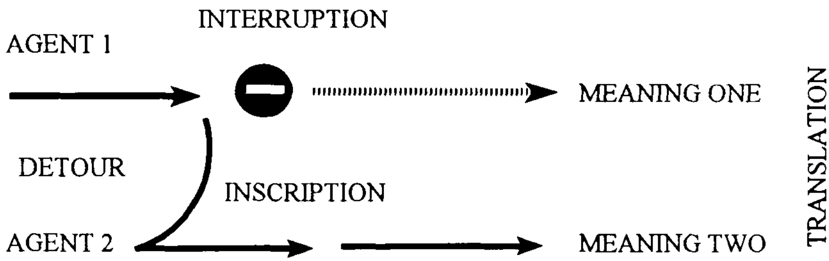

Fig. 4. Fourth Meaning of Mediation: Delegation

shift, we quit the relative comfort of linguistic metaphor and enter unknown territory. We have not abandoned meaningful human relations and abruptly entered a world of brute material relations—although this might be the impression of drivers, used to dealing with negotiable signs, now confronted by nonnegotiable speed bumps. The shift is not from discourse to matter because, for the engineers, the speed bump is one meaningful articulation within a gamut of possibilities among which they choose as freely as one chooses vocabulary in a language. Thus, we remain in meaning *but no longer in discourse;* yet we do not reside among mere objects. Where are we?

Detour, translation, delegation, inscription, and displacement require our better comprehension before we can even begin to elaborate a philosophy of techniques; and understanding these requires that we understand what semioticians call *shifting.*[10] If I say to you, for instance, "Let us imagine ourselves in the campus engineers' shoes when they decided to install the speed bumps," I transport you not only into another space and time but translate you into another actor. I *shift* you out of the scene you presently occupy. The point of spatial, temporal, and "actorial" shifting, which is basic to all fiction, is to make you move without your moving. You made a detour through the engineers' office, but without leaving your seat. You lent me, for a time, a character who, with the aid of your patience and imagination, traveled with me to another place, became another actor, then returned to become yourself in your own world again. This mechanism is called *identification,* by means of which the "enunciator"—I—and the "enunciatee"—you—both contribute to our shifting delegates of ourselves in other composite frames of reference (Fig. 4).

In the case of the speed bumps, the shift is "actorial": the "sleeping policeman," as the bump is known, is not a policeman, does not resemble one in the least. The shift is also spatial: on the campus road there now resides a new actant that slows down cars (or damages them). Finally, the shift is temporal: the bump is there night and day. But the enunciator of this technical act has disappeared from the scene—where are the engineers? where is the policeman?—while someone, something, reliably acts as lieu-

[10]See Greimas and Courtès, *Semiotics and Language.* On shifting, see also Thomas Pavel, *Fictional Worlds* (Cambridge: Harvard University Press, 1986).

tenant, holding the enunciator's place. Supposedly the copresence of enunciators and enunciatees is necessary for an act of fiction to be possible, but what we now have are an absent engineer, a constantly present speed bump, and an enunciatee who has become the employer of an artifact; as if I were to stop writing this article and its meaning would go on being articulated, but more reliably and speedily in my absence.

You may object that this is not surprising. To be transported in imagination from France to Bali is not the same as to take a plane from France to Bali. True enough, but *how* great is the difference? In imaginative means of transportation, you simultaneously occupy all frames of reference, shifting into and out of all the delegated personae that the storyteller offers. Through fiction, *ego, hic, nunc* may be shifted, may become other personae, in other places, at other times. But aboard the plane, I cannot occupy more than one frame of reference at a time. I am seated in an object-institution that connects two airports through an airline. The act of transportation has been shifted *down* and not *out*—down to planes, engines, and automatic pilots, object-institutions to which has been delegated the task of moving while the engineers and managers are absent (or limited to monitoring). The copresence of enunciators and enunciatees has collapsed along with frames of reference. An object stands in for an actor and creates an asymmetry between absent makers and occasional users. Without this detour, this shifting down, we would not understand how an enunciator could be absent: Either it is there, we would say, or it does not exist. But by shifting down, another combination of absence and presence becomes possible. It is not, as in fiction, that I am here *and* elsewhere, that I am myself *and* someone else, but that an action, long past, of an actor, long disappeared, is still active here, today, on me—I live in the midst of technical delegates.

The whole philosophy of techniques has been preoccupied by this detour. Think of technology as congealed labor. Consider the very notion of investment: A regular course of action is suspended, a detour is initiated via several types of actants, and the return is a fresh hybrid that carries past acts into the present and permits its many makers to disappear while also remaining present. Such detours subvert the order of time—in a minute I may mobilize forces locked in motion hundreds or millions of years ago. The relative shapes of actants and their ontological status may be completely reshuffled—techniques act as shape-changers, making a cop out of a bump in the road, lending a policeman the permanence and obstinacy of stone. The relative ordering of presence and absence is redistributed—we hourly encounter hundreds, even thousands, of absent makers who are remote in time and space yet simultaneously active and present. And through such detours, finally, the political order is subverted, since I rely on many delegated actions that themselves make me do things on behalf of others who are no longer here and that I have not elected and the course of whose existence I cannot even retrace.

A detour of this kind is not easy to understand, and the difficulty is compounded by the accusation of fetishism made by critics of technology.[11] It is us, the human makers (so they say), that you see in those machines, those implements, us under another guise, our own hard work. We should restore the human agency (so they command) that stands behind those idols. We heard this story told, to different effect, by the NRA: Guns do not act on their own, only humans do so. A fine story, but too late. Humans are no longer by themselves. Our delegation of action to other actants that now share our human existence is so far progressed that a program of antifetishism could only lead us to a nonhuman world, a world before the mediation of artifacts, a world of baboons.

On the other hand, we cannot fall back on materialism either. In artifacts and technologies we do not find the efficiency and obduracy of matter, imprinting chains of cause and effect onto malleable humans. The speed bump is not made of matter, ultimately; it is full of engineers and chancellors and lawmakers, commingling their wills and their story lines with those of gravel, concrete, paint, and standard calculations. The mediation, the technical translation, that I am trying to understand resides in the blind spot where society and matter exchange properties. The story I am telling is not a *Homo faber* story, where the courageous innovator breaks away from the constraints of social order, to make contact with hard and inhuman but—at last—objective matter. I am struggling to approach the zone where some, though not all, of the characteristics of concrete become policemen, and some, though not all, of the characteristics of policemen become speed bumps. . . .

Daedalus folds, weaves, plots, contrives, finds solutions where none is visible, using any expedient at hand in the cracks and gaps of ordinary routines, swapping properties among inert and animal and human materials. Heidegger is no Daedalus: he sees no mediation, no letting go, no stepping aside, no *poesis* in the technical world, only intermediaries, a terrifying kind of intermediary, eating away at the artisan and the engineer, at all humans, turning them into purposeless instruments for the purposeless goals of technology. In multiplying mediators, am I falling victim to the humanistic illusion ridiculed by Heidegger? Or perhaps I am falling into the materialistic trap of attributing social, ethical, and political mores to artifacts, which they cannot possibly possess. I think that the philosophy of technology forces us to relocate humanism.

Humanism is not to be found at the right pole of Figure 5, where the word *humanism* is found—nor in imagining some demiurgic Prometheus imposing an arbitrary form on shapeless matter, nor in defending ourselves against the invasion of purely objective forces that threaten the dignity of the human subject. Humanism is to be located elsewhere, in the position I am groping to define between antihumanism and

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[11] After Marx, of course, see especially the classic argument by Langdon Winner, "Do Artefacts Have Politics?" *Daedalus* 109 (1980): 121–36.

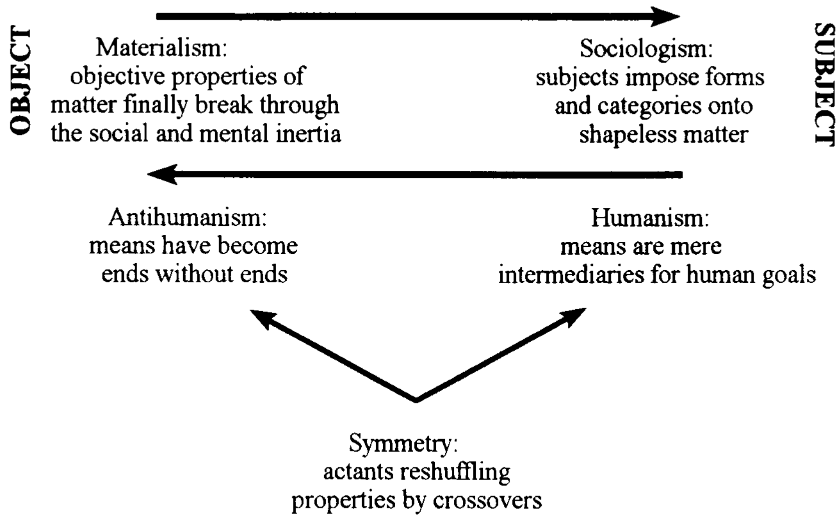

Fig. 5. New Locus for Humanism

"humanism." We must learn to ignore the definitive shapes of humans, and of the nonhumans with which we share more and more of our existence. The blur that we would then perceive, the swapping of properties, is a characteristic of our premodern past, in the good old days of *poesis*, and a characteristic of our modern and nonmodern present as well. One thing Heidegger got right is his critique of the "humanist" NRA story, of the notion that technologies and tools permit humans to hold their projects firmly in hand, to impose their will on objects.[12] But Heidegger added to the dangers of technology: he added the peril of ignoring how much humanity is swapped through the mediating role of techniques—and he added the peril of ignoring the function, genealogy, and history of those sociotechnical imbroglios (to which I now turn) that construct our political life and our fragile humanity.

Sociology

Stanley Kubrick, in *2001: A Space Odyssey*, offers us a modern myth as powerful as that of Daedalus. Unidentified extraterrestrial minds have sent to the primeval earth a huge black box, a monolith, which a band of screaming monkeys now cautiously explore. The film does not indicate what the properties of the box are (apart from blackness—as opaque as the genealogy of techniques I am trying to fathom here), but the box has a mysterious effect on the apes. Is this because they are focusing their attention for the first time on an object or because of what this particular object contains? Whichever the case, they innovate, taking great strides in the direction of humanity. A huge bone

[12]Bruno Latour, *We Have Never Been Modern*, trans. Catherine Porter (Cambridge: Harvard University Press, 1993).

lying at the water hole is suddenly seized by a rapidly evolving ape, transformed into a tomahawk, and used to break the skull of an enemy primate. (Tools and weapons, intelligence and war, commence all at once in this masculine myth.) The Promethean ape, thrilled by this invention and sudden change in the fortunes of war, launches the bone into the sky; the bone whirls around, then—again, suddenly—becomes a vast futuristic station, slowly turning on itself in the depth of space. From tools to high technology, millions of years are summarized in one beautiful cut.

Were scholarship as efficient as the art of film, I would have you progress as rapidly as Kubrick's apes—from a band of primates linked only by social ties to an evolved species of sociotechnical humans who admit their inferior brethren, the nonhumans, to their social thinking. But to bring this about would be quite a miracle, since social theory is as devoid of artifacts as were Kubrick's apes before the monolith arrived. Like the apes, it is on the monolith, precisely, that I will focus my attention: What is a sociology of objects? How did objects come to enter the human collective? Through which entry points? We now understand that techniques do not exist as such, that there is nothing that we can define philosophically or sociologically as an artifact or a piece of technology. To be sure, there is an adjective *technical* that we use in many different situations, and rightly so. Let me briefly summarize its various meanings.

It designates, first, a subprogram, or a series of nested subprograms, like the ones I discussed above. When we say "this is a technical point," it means that we have to deviate for a moment from the main task and that we will eventually resume our normal course of action, which is the only focus worth our attention. A black box opens momentarily, and will become black again, completely invisible in the main sequence of action.

Second, *technical* designates the subordinate role of people, skills, or objects that occupy this secondary function of being present, indispensable, but invisible. It thus indicates a specialized and highly circumscribed task, clearly subordinate in a hierarchy.

Third, the adjective designates a hitch, a snag, a catch, a hiccup in the smooth functioning of the subprograms, as when we say that "there is a technical problem to solve first." Here, the deviation might not lead us back to the main road, as with the first meaning, but may threaten the original goal entirely. *Technical* is no longer a mere detour, but an obstacle, a roadblock. What should have been a means, may become an end, at least for a while.

The fourth meaning carries with it the same uncertainty about what is an end and what is a means. "Technical skill," "technical personnel," designate a unique ability, a knack, a gift, and also the ability to make oneself indispensable, to occupy privileged though inferior positions that I have called, borrowing a military term, obligatory passage points. Technical people, objects, or skills are at once inferior (since the main task will be resumed), indispensable (since the goal is unreachable without them), and, in a way, capricious, mysterious, uncertain (since they depend on some highly specialized and badly circumscribed knack). Daedalus the perverse, and Hephaistos the limping god, are good illustrations of the meaning of *technical.* So the adjective *technical* has a useful meaning that maps in the language the three first types of translation that I defined above.

Technical also designates a very specific type of delegation, of movement, of shifting, that crosses over with entities that have different timing, different properties, different ontologies, and that are made to share the same destiny, thus creating a new actant. Here the noun is often used as well as the adjective, as when we say "a technique of communication," "a technique for boiling eggs." In this case, the noun does not designate a thing, but a modus operandi, a chain of gestures and know-how, bringing about some anticipated result.

Let us compare two pipettes, that which Pasteur used a century ago and the automatic pipette in use today, the trademark of which is aptly "Pipetman." With a traditional pipette, I need to measure quantities precisely, by looking carefully through the transparent glass and checking the correspondence between the level of the liquid and the small calibrated measures engraved on the glass. Thus I need to take special care each time I dip the Pasteur pipette in the liquid before releasing it in another vessel. The calibration of the pipette is now standardized so that I may rely on the engraved measurements. The skills required of me by the new pipette are very different. With the Pipetman, I need only push twice with my thumb on the top of the instrument—once to take up the liquid and then again to release it—and turn the knobs at the top to set the amounts I want to take with each dipping. My point in comparing these two pipettes is that, although both require skills, the distribution of skills is different.[13] With the Pasteur pipette, I require a high degree of coordination and control for each new dipping; with the new pipette, I can rely, for this gesture at least, on force (once I have turned the knob). The new pipette is itself skilled—the program of action is now shared between an upskilled pipette and a relatively deskilled human pipetter.

Technical skill is not a thing we can study directly. We can only observe its dispersal among various types of actants. For instance, one could automate not only the uptake of liquid but its release, and there exist now in biological laboratories many pipetting robots. The total sum of activity—comparing my relation to the Pasteur pipette with my relation to the pipetting robot—is maintained or increased but its distribution has been modified. Some highly trained technicians are made redundant, unskilled workers are recruited, high-tech companies are created in order to produce robots where simple workshops were until recently sufficient. As Marx showed long ago,

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[13]Steven W. Allison, a molecular biologist at Cornell, pointed out to me that it requires, in fact, quite a lot of new skills to push and release the plunger. The real difference, according to him, is the precision obtained with the new pipette, which is one order of magnitude more precise than Pasteur's.

when we talk about something technical, we talk about displacement, conflicts, replacement, unskilling, deskilling, and reskilling; never about a mere "thing." Technical skill is not uniquely possessed by humans and reluctantly granted to nonhumans. Skills emerge in the zone of transaction, they are properties of the assembly that circulate or are redistributed among human and nonhuman technicians, enabling and authorizing them to act.

We must consider, then, who is mobilized by what kinds of action. Our first step is to look for the folding of time, which is a characteristic of technical action. *Once* I have bought the calibrated Pasteur pipette, I can *then* go on with my skilled task. *Once* I have turned the knobs of the automatic pipette, I can *then* fall back on a less skilled task. The enunciator, in other words, may absent itself. Even my own action of a moment ago is now foreign to me, though still present in a new guise. Through my productive detour, my investment, a relative irreversibility is set in place.

But we have also to recognize the role of economic mediation in the folding of time and space. Pasteur could have produced his pipette at the local glassblower's shop. I cannot manufacture an automatic pipette, still less a pipetting robot. Which means that, in the gesture of pushing on an instrument twice with my thumb, I take a long detour through the manufacturing process. Of course, the detour is invisible—except as an item on a long list of supplies I order out of grant monies—unless a crisis, either in my budget or in the pipette, occurs, or if I move my laboratory to Africa or to Bosnia, in which case I will come to realize that, in addition to the simple task of pushing twice with my thumb, pipetting requires that I ensure the reliability of an immense series of other actants. The question known as "the division of labor" may in no sense be differentiated from the question of what is technical.[14]

If ever one comes face to face with an object, that is not the beginning but the end of a long process of proliferating mediators, a process in which all relevant subprograms, nested one into another, meet in a "simple" task (e.g., pipetting). Instead of the kingdom of legend in which subjects meet objects, one generally finds oneself in the realm of the *personne morale,* of what is in English called the "corporate body" or "artificial person." Three extraordinary terms! As if the personality becomes moral by becoming collective, or collective by becoming artificial, or plural by doubling the Saxon word *body* with a Latin synonym, *corpus.* A body corporate is what ~~the~~ pipette and I, in my example, have become. We are an object-institution. The point sounds trivial if applied asymmetrically. "Of course," one might say, "a piece of technology must be seized and activated by a human subject, a purposeful agent." But the point I am making is symmetrical: What is true of the "object"—the pipette does not exist by itself—is still truer of the "subject." There is no sense in which humans may be said to exist as humans without entering into commerce with what authorizes and

[14]Nevertheless, the classic work by Emile Durkheim, *The Division of Labor in Society,* trans. W. D. Halls (1893; New York: Free Press, 1984), does not mention techniques and artifacts at all.

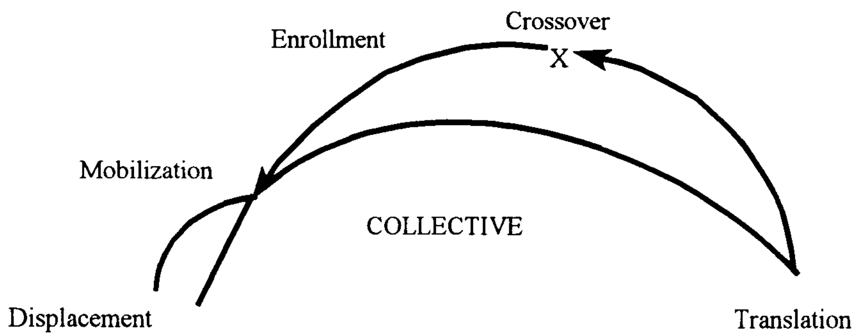

Fig. 6. The Entry Point of Nonhumans into the Collective

enables them to exist (i.e., to act). A forsaken pipette is a mere piece of matter, but what would an abandoned pipetter be? A human, yes (a pipette is only one artifact among many), but not a molecular biologist. Purposeful action and intentionality may not be properties of objects, but they are not properties of humans either. They are the properties of institutions, *dispositifs.* Only corporate bodies are able to absorb the proliferation of mediators, to regulate their expression, to redistribute skills, to require boxes to blacken and close. Boeing-747s do not fly, airlines fly.

Objects that exist simply as objects, finished, not part of a collective life, are unknown, buried under soil. Real objects are always parts of institutions, trembling in their mixed status as mediators, mobilizing faraway lands and people, ready to become people or things, not knowing if they are composed of one or of many, of a black box counting for one or of a labyrinth concealing multitudes. And this is why the philosophy of technology cannot go very far: an object is a subject that only sociology can study—a sociology, in any case, that is prepared to deal with nonhuman as well as human actants.

In the newly emerging paradigm (fig. 6), we substitute *collective*—defined as an exchange of human and nonhuman properties inside a corporate body—for the tainted word *society.* In abandoning dualism, our intent is not to abandon the very distinct features of the various parts within the collective. What the new paradigm attends to are the moves by which any given collective extends its social fabric to other entities. First, there is *translation,* the means by which we inscribe in a different matter features of our social order; next, the *crossover,* which consists in the exchange of properties among nonhumans; third, the *enrollment,* by which a nonhuman is seduced, manipulated, or induced into the collective; fourth, the *mobilization* of nonhumans inside the collective, which adds fresh unexpected resources, resulting in strange new hybrids; and, finally, *displacement,* the direction the collective takes once its shape, extent, and composition have been altered.

The new paradigm provides a basis for the comparison of collectives, a comparison that is completely independent of demography (of their scale, so to speak). What we students of science have all done over the last fifteen years is subvert the distinction between ancient techniques (the *poesis* of artisans) and modern (broad-scale, inhuman, domineering) technologies. The distinction was never more than a prejudice. There is an extraordinary continuity, which historians and philosophers of technology have increasingly made legible, between nuclear plants, missile-guidance systems, computer-chip design, or subway automation and the ancient mixture of society and matter that ethnographers and archaeologists have studied for generations in the cultures of New Guinea, Old England, or sixteenth-century Burgundy.[15]

The difference between an ancient or "primitive" collective and a modern or "advanced" one is not that the former manifests a rich mixture of social and technical culture while the latter exhibits a technology devoid of ties with the social order. The difference, rather, is that the latter translates, crosses over, enrolls, and mobilizes *more elements*, more intimately connected, with a more finely woven social fabric than the former does. The relation between the *scale* of collectives and the *number* of nonhumans enlisted in their midst is crucial. One finds, of course, longer chains of action in "modern" collectives, a greater number of nonhumans (machines, automatons, devices) associated with one another, but one must not overlook the size of markets, the number of people in their orbits, the amplitude of the mobilization: more objects, yes, but many more subjects as well. Those who have tried to distinguish these two sorts of collective by attributing objectivity to modern technology and subjectivity to low-tech *poesis* were deeply mistaken. Objects and subjects are made simultaneously, and an increased number of subjects is directly related to the number of objects stirred—brewed—into the collective. The adjective *modern* does not describe an increased distance between society and technology or their alienation, but a deepened intimacy, a more intricate mesh, between the two: not *Homo faber* nor even *Homo faber fabricatus*, but *Homo faber socialis*.[16]

Ethnographers describe the complex relations implied by every technical act in traditional cultures, the long and mediated access to matter that these relations suppose, the intricate pattern of myths and rites necessary to produce the simplest adze or simplest pot, as if a variety of social graces and religious mores were necessary for humans to interact with nonhumans.[17] But do we, even today, have unmediated access to naked matter? Is our interaction with nature short on rites, myths, and protocols? To believe that would be to ignore most of the conclusions reached by modern sociologists of science and technology. How mediated, complicated, cautious, mannered, even baroque is the access to matter of any piece of technology! How many sciences—the

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[15]See, for instance, Donald A. MacKenzie, *Inventing Accuracy: An Historical Sociology of Nuclear Missile Guidance Systems* (Cambridge: MIT Press, 1990); Bijker and Law, eds., *Shaping Technology-Building Society;* Wiebe E. Bijker, Thomas P. Hughes, and Trevor Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge: MIT Press, 1987).

[16]See Latour, *La clef de Berlin.*

[17]For a recent example, see Pierre Lemonnier, ed., *Technological Choices: Transformation in Material Cultures Since the Neolithic* (London: Routledge, 1993).

functional equivalent of rites—are necessary to prepare artifacts for socialization! How many persons, crafts, and institutions must be in place for the enrollment of even one nonhuman! The time has come for ethnographers to describe our biotechnology, artificial intelligence, microchips, steelmaking, etc.—the fraternity of ancient and modern collectives will then be instantly obvious. What appears symbolic in the old collectives is taken literally in the new; in contexts where a few dozen people were once required, thousands are now mobilized; where shortcuts were once possible, much longer chains of action are now necessary. Not fewer but more, and more intricate, customs and protocols, not fewer mediations but more: many more.

Aramis, an automated metro in the south of Paris, is a choice example of what I mean—a sleek piece of matter confronting the human subject (a passenger) ready to board it.[18] Aramis has no driver. The only human left in the system, the controller, can take over, by remote control, in the event the automatic equipment fails. The only "driver" is one of the six onboard computers. Aramis is a train without tracks and can turn at will like an automobile. The passenger has nothing to do, not even decide on the route to his destination. Aramis does it all. In other words, the ideal Frankenstein myth: a powerless human, boarding an automated train, far from traditional technologies and their rich sociotechnical mix.

But a few years ago, in July of 1985, what ethnographers and archaeologists never see was seen: a technology before it becomes an object or an institution, a technology when it is still a *project.* Aramis was a scale model, little more than a sketch. Assembled around its benign and futuristic shape were dignitaries, spokesmen for conflicting constituencies. A photograph at that time showed the director of the RATP, the Paris rapid-transit system, a communist in love with Aramis, symbol of modernization (though his own technicians are extremely skeptical about the feasibility of the system); then the president and vice-president of the Ile-de-France Region, two men on the right of the political spectrum with no special interest in Aramis as a symbol of anything (all they want is a transportation system, period, to decongest the south of Paris); then Charles Fiterman, Minister of Transportation, another communist—one of the three communists in the first government of President Mitterand (Fiterman is also preoccupied with modernization, with high tech, but lacks the expertise to evaluate the feasibility of the scale model and is anyway about to leave the government); and finally, Jean-Luc Lagardère, the flamboyant symbol of French high-tech capitalism and the builder of Aramis, closely involved with state technocracy, but deeply skeptical of the prospects for Aramis' technical success (he would prefer a simple automated subway like VAL in Lille, but is forced to embrace what Fiterman, the Minister, and Claude Quin, the director of the RATP, consider *the* French symbol of modernization).

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[18]On this example, see Bruno Latour, *Aramis, ou l'amour des techniques* (Paris: La Découverte, 1992), forthcoming from Harvard University Press, trans. Catherine Porter. For a briefer presentation, see Bruno Latour, "Ethnography of a 'High-Tech' Case: About Aramis," in Lemonnier, *Technological Choices,* 372–98.

For two years, the dignitaries have discussed the project, which has been under way for fifteen. They have assembled to sign the contract for the final industrial test of Aramis.

Looking at a project before it is an object, one sees not only the people who inhabit it but also the translation they wish to effect: five spokesmen, five versions of Aramis converging on a scale model whose task is to reconcile their notions of what is politically valuable, technically feasible, efficient, expedient, and profitable. But what of the myth of technology, the Frankensteinian autonomy of design? M. Lagardère, captain of industry, wants a semitraditional subway like the VAL but is obliged to press his engineers for a hypersophisticated system to please the communists—who are worried about a possible strike of the drivers' union against automation and thus want a system that looks as different from a subway as possible. Aramis swallows the contradictory wishes of all involved, absorbs them, and becomes knotted, self-contradictory, and labyrinthine.

Aramis did not exist *enough.* Technical systems have many intermediary degrees of realization. Not long before transporting Jacques Chirac, the former prime minister, Aramis was a construction site in the south of Paris; three or four years after, a home for destitutes; then a sleek cabin in the Museum of Transportation. Aramis ceased to exist. Not one real passenger ever boarded it. From a project it became not an object but a fiction. And even if it had at some point existed as a transportation system, Aramis would have been not an object but an institution, a corporate body including passengers, engineers, controllers, and many nonhumans, all safely "black boxed." The moral of this tale is not that the more advanced technology becomes, the less (and fewer) people have to do with it. On the contrary, in order to move from fiction to project, from project to trial, and from trial to transportation system, ever more people are required. It is because so many abandoned Aramis that it began to cease existing and reversed course: from trial to project, from project to fiction, and from fiction to utopia, the utopia of Personal Rapid Transit that some American cities, blissfully ignorant of Aramis' fate, are now taking up again.

The new paradigm is not without its problems. To view people and nonhumans as interacting within collectives, to define objects as institutions, to fuse subject and object in a corporate body, we need to know what a collective, an institution, and a corporate body are. The difficulty is that we cannot rely on how social theory defines these, since, for many sociologists, a social order is the source of explanation and not what needs explaining. These sociologists begin by delineating social phenomena, long-term social contexts, global institutions, overarching cultures; then proceed with what they take to be their important empirical task, to trace developments and transformations. It is a given, for them, that social order exists. The question of how social order emerges has been abandoned to political philosophy, to the prescientific past out of which Durkheim's descendants have escaped. We are, like the bull dancers of Minos, on the horns of a dilemma: social theory is the way beyond the limits of the philosophy of techniques, but social theorists tell us that the emergence of social order is but a philosophical myth. The definition of social context by the social sciences is of little help since it does not include the nonhumans' role. What social scientists call society represents half of the dualist paradigm that should be jettisoned. A "society" is not the same as the "collective" I am trying to define. Hence, in order to understand technical mediation, we also have to redefine a large part of social theory, bringing back into it, I am afraid, many philosophical questions that it has tried to dispense with too quickly.

Our task, fortunately, is made easier by a radical movement in sociology whose real import and impact has yet to be felt in the study of technology and that is called, rather horribly, "ethnomethodology." What this movement does is take seriously the innocuous assumption that people construct society. Social order, the ethnomethodologists argue, is not a given, but the result of an ongoing practice through which actors, in the course of their interaction, elaborate ad hoc rules to coordinate activities. The actors are helped of course by precedents, but those precedents are not in themselves sufficient to cause behavior, and they are translated, adjusted, reconfigured, invented (in part) to make do in view of shifting and unexpected circumstances. We collectively elaborate an emerging and historical *event* which was not planned by any participant and which is not explainable by what happened before the event or what happens elsewhere. All depends on the local and practical interactions in which we are presently engaging.

The theory seems absurd in view of the claim most reasonable sociologists and historians would make about, for instance, our present circumstance: There exists a broad-scale context that accounts for my writing and your reading this article, for our knowledge of what a scholarly article is, what a journal does, what role intellectuals play in America and France. At most, the reasonable sociologist tells the radical one, the agent can make local adjustments in a context long since and faraway established. So runs the thirty-year debate between ethnomethodology and mainstream sociology, and the still older dispute between agency and structure.

The new paradigm I am proposing for the study of techniques obviates these disputes. Let us admit that the ethnomethodologists are right, that there exist only local interactions, producing social order on the spot. And let us admit that mainstream sociologists are right, that actions at a distance may be transported to bear on local interactions. How can these positions be reconciled? An action in the distant past, in a faraway place, by actors now absent, can still be present, on condition that it be shifted, translated, delegated, or displaced to other types of actants, those I have been calling nonhumans. My word processor, your copy of *Common Knowledge*, Oxford University Press, the International Postal Union, all of them organize, shape, and limit our interactions. To forget their existence—their peculiar manner of being absent and present—would be a great error. When we say that "we" here present are engaged in our local interactions, the sum of those who are summoned must include all the other personae that have been shifted down previously. "We" is not a simple synoptic and coherent category. The notion of a present and local interaction is subverted by an immense crowd of nonhumans, each determined by its own shifts in time, space, and actant.

But to infer, from the conclusion that we are not alone in our interactions, the existence of an overarching society would be an equally great mistake, since it would oblige us to shift attention from the micro to the macro level, as if the macro level existed and was made of other stuff, of material other than the present local interaction. The dispute about the respective role of agency and structure, of "habitus" and "field" (to use Bourdieu's formula), of micro interaction and macro social context, reveals, by its very failure, the presence-absence of technical mediation. Of course, ethnomethodologists are right to criticize traditional sociology with its fanciful macro level, but they are wrong to conclude that there is such a thing as an absolutely local interaction. No human relationship exists in a framework homogeneous as to space, time, and actants. However, the error that traditional sociology makes is as great, when it forgets to ask how a difference of scale is obtained, how power is exerted, irreversibility sets in, and roles and functions are distributed. Everything in the definition of macro social order is due to the enrollment of nonhumans—that is, to technical mediation. Even the simple effect of duration, of long-lasting social force, cannot be obtained without the durability of nonhumans to which human local interactions have been shifted.

The social theory of techniques overhauls sociology, even as it repairs the weaknesses of ethnomethodology. Society is the outcome of local construction, but we are not alone at the construction site, since there we also mobilize the many nonhumans through which the order of space and time has been reshuffled. To be human requires sharing with nonhumans. Social theory may be better at the task of defining what is human than philosophy is, but only when and insofar as it accounts for social complexity, the invention of tools, and the sudden appearance of the black box. I am thinking, still, of Stanley Kubrick, his daring cut that transformed a whirling tomahawk into a silent space station, turning slowly in the depth of space, but I would like, of course, to dispense with an appeal to any extraterrestrial benefactor.

GENEALOGY[19]

11 A.M.: Clairborne sits near Niva, looking around vigilantly. Before Clairborne can make a move, Crook arrives, very nervous. Both Clairborne and Crook want Niva's favors, but Clairborne is her old friend. Crook has just arrived in the group and is so unpredictable that no one trusts him. Clairborne moves toward Niva, but this does

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[19] An earlier version of the following has been published in a special issue of *American Behavioral Scientist*, 37 (1994): 791–808, under the title "Pragmatogonies . . . A Mythical Account of How Humans and Non-Humans Swap Properties."

not stop Crook, who continues to close in. Tension mounts. Niva is caught between conflicting emotions, wanting to flee, yet worried to be on her own so near Crook. She opts to stay near Clairborne, which seems the safer bet. The others watch carefully to see what will happen. Sharman pays special attention since the outcome could affect him. Crook lunges at Clairborne but, instead of running away, Clairborne grabs Niva's infant. The infant clings trustingly to its big friend. Suddenly the action shifts, as if Clairborne had erected a protective shield around himself and Niva. Frustrated, but not daring to make a further move toward them, Crook turns elsewhere to vent his frustration. As he suspected, Sharman becomes the target of Crook's aggression. The two run off exchanging threats, and the small group around Niva relaxes. Clairborne huddles closer to Niva; the infant snuggles in her lap. Now it is Sharman who has the problem. It is 11:05 A.M.

This bit of soap opera does not come from *Dallas* or any of the other programs with which Americans conquer television sets around the world, but from Shirley Strum's study of baboons in Kenya. I want to begin the third part of this discussion not with a technical myth like that of Daedalus or like that of Kubrick's *2001*, but with this exemplary study of a nontechnical but highly complex society. This group of baboons, called Pump-House, which had the good fortune to be studied for twenty years by Strum, offers the best baseline, the best benchmark, to register what we mean by techniques, since, although the social and political maneuvering of baboons is complex, they are, as distinct from chimpanzees, for instance, devoid of tools and artifacts, at least in the wild.[20]

What do human collectives have that those socially complex baboons do not possess? Technical mediation—which we are now prepared to summarize: Technical action is a form of delegation that allows us to mobilize, during interactions, moves made elsewhere, earlier, by other actants. It is the presence of the past and distant, the presence of nonhuman characters, that frees us, precisely, from interactions (what we manage to do, right away, with our humble social skills). That we are not Machiavellian baboons we owe to technical action. To say this, however, entails no *Homo faber* mythology: techniques provide no sort of privileged, unmediated, unsocialized access to objective matter and natural forces. "Objects," "matter," "force," and "nature" are very late comers and cannot be used as starting points. The traditional definition of technique as

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[20]The above passage on baboon behavior is based on conversation during 1994 with Shirley Strum. See also her book, *Almost Human: A Journey into the World of Baboons* (New York: Random House, 1987); and Bruno Latour and Shirley Strum, "Human Social Origins: Please Tell Us Another Origin Story!" *Journal of Biological and Social Structures* 9 (1986): 169–87; Shirley Strum and Bruno Latour, "The Meanings of Social: From Baboons to Humans," *Information sur les sciences sociales/Social Science Information* 26 (1987): 783–802. The section of this article titled "Genealogy" is a continuation of our collaborative work. See also Bijker and Law, *Shaping Technology-Building Society;* Latour, *We Have Never Been Modern;* MacKenzie, *Inventing Accuracy;* Lemonnier, *Technological Choices.*

the imposition of a form consciously planned onto shapeless matter should be replaced by a view of technique—a more accurate view—as the socialization of nonhumans.

The most important consequence of criticizing the *Homo faber* myth is that, when we exchange properties with nonhumans through technical delegation, we enter into a complex transaction that pertains to "modern" as well as traditional collectives. If anything, the modern collective is that in which the relations of human and nonhuman are so intimate, the transactions so many, the mediations so convoluted, that there is no plausible sense in which artifact, corporate body, and subject can be distinguished. In order to take account of this symmetry between humans and nonhumans, on the one hand, and this continuity between traditional and modern collectives, on the other, social theory must be somewhat modified. It is a commonplace, in critical theory, to say that techniques are social because they have been socially constructed. But this pronouncement is vacuous if the meanings of *mediation* and *social* are not made precise. To say that social relations are "inscribed" in technology, such that when we are confronted with an artifact, we are confronted, in effect, with social relations, is to assert a tautology, a very implausible one. If artifacts are social relations, then why must society work through them to inscribe itself in something else? Why not inscribe itself directly, since the artifacts count for nothing? By working through the medium of artifacts, domination and exclusion hide themselves under the guise of natural and objective forces: critical theory thus deploys a tautology—social relations are nothing but social relations—then it adds to it a conspiracy theory—society is hiding behind the fetish of techniques.

But techniques are not fetishes, they are unpredictable, not means but mediators, means and ends at the same time; and that is why they bear on the social fabric. Critical theory is unable to explain why artifacts enter the stream of our relations, why we so constantly recruit and socialize nonhumans. It is not to mirror, inscribe, or hide social relations, but to remake them through fresh and unexpected sources of power. Society is not stable enough to inscribe itself in anything. On the contrary, most of the features of what we mean by social order—scale, asymmetry, durability, power, hierarchy, the distribution of roles—are impossible even to define without recruiting socialized nonhumans. Yes, society is constructed, but not *socially* constructed. Only the Machiavellian baboon, the Kubrick ape, constructs its society socially. Humans, for millions of years, have extended their social relations to other actants with which, with whom, they have swapped many properties, and with which, with whom, they form *collectives.*

But is symmetry between humans and nonhumans really possible? Do not humans always have the initiative? This commonsense objection is not commonsensical, since in most of our activities we do not attribute a causative role to humans. Scientists, for instance, like to claim that they do not speak, that nature speaks (or, more precisely, writes) through the medium of the laboratory and its instruments. It is reality, in other words, that does most of the talking. We find the same conundrum in political theory

(Hobbes's Sovereign acts, but the People write the script) and also in fiction (novelists like to say they are forced to write by the Muse or by the sheer impulse of their characters), while many historians and critics appeal to still another collective force for which novelists play the expressive role of medium, that of society or that of zeitgeist. A second glance at any activity undermines the easy, commonsense idea that humans speak and act. Every activity implies the principle of symmetry between humans and nonhumans or, at the least, offers a contradictory mythology that disputes the unique position of humans. The same uncertainty bedevils techniques, which are human actions that end up being actions of nonhumans. Responsibility for action must be shared, symmetry restored, and humanity redescribed: not as the sole transcendent cause, but as the mediating mediator.

A detailed case study of sociotechnical networks ought to follow at this juncture, but many such studies have already been written, and most have failed to make their new social theory felt. These studies are understood by readers as catalogue examples of the "social construction" of technology. Readers account for the evidence mustered in them with reference to the dualist paradigm that the studies themselves tend to undermine. The obstinate devotion to "social construction" as an explanatory device seems to derive from the difficulty of disentangling the various meanings of the catchword *sociotechnical*. What needs to be done, then, is to peel away, one by one, the layers of meaning and attempt a genealogy of their associations. Moreover, having disputed the dualist paradigm for years, I have come to realize that no one is prepared to abandon an arbitrary but useful dichotomy, such as that between society and technology, if it is not replaced by categories that have at least the same discriminating power as the one jettisoned. We can toss around the phrase "sociotechnical networks" forever without moving beyond the dualist paradigm that we wish to overcome. To move forward, I must convince you that one can discriminate much finer details using the new paradigm, which blurs the distinction between social actors and objects. This in turn requires that I begin from the most contemporary meanings and move down to the most primitive. Each meaning could be loosely defined as sociotechnical, but the novelty is that I will be able in the future to qualify with some precision which sort of properties are swapped or invented at each level of meaning.

For my present story, I have isolated eleven distinct layers. Of course, I do not claim for these definitions, nor for their sequence, any plausibility. I simply want to show that the tyranny of the dichotomy between humans and nonhumans is not inevitable, since it is possible to envision another myth in which it plays no role. If I succeed in opening some space for the imagination, then we are not forever stuck with the boring alternation of humans to nonhumans, and back. It should be possible to imagine a space, that could be studied empirically, in which we could observe the swapping of properties without having to start from a priori definitions of humanity.

Political Ecology (Level 11)

The eleventh interpretation of the crossover—the swapping of properties—between humans and nonhumans is the simplest to define because it is the most literal. Lawyers, activists, ecologists, businessmen, political philosophers are now seriously talking, in the context of our ecological crisis, of granting to nonhumans some sort of rights and even standing in court. Not so many years ago, contemplating the sky meant thinking of matter, or of nature. These days, we look up at a sociopolitical imbroglio, since the depletion of the ozone layer brings together a scientific controversy, a political dispute between North and South, and immense strategic changes in industry. Political representation of nonhumans seems not only plausible now, but necessary, when the notion would have seemed ludicrous or indecent not long ago. We used to deride primitive peoples who imagined that a disorder in society, a pollution, could threaten the natural order. We no longer laugh so heartily, as we abstain from using aerosols for fear the sky may fall on our heads. Like the primitives, we fear the pollution caused by our negligence.

As with all crossovers, all exchanges, this one mixes elements of both sides, the political with the scientific and technological in this case, and the mixing is not a haphazard rearrangement. Technologies have taught us how to manage vast assemblies of nonhumans; our newest sociotechnical hybrid brings what we have thus learned to bear on the political system. The new hybrid remains a nonhuman, but not only has it lost its material and objective character, it has acquired properties of citizenship. It has, for instance, the right not to be enslaved. This first layer of meaning—the last in chronological sequence to arrive—is that of political ecology or, to use Michel Serres' term, "the natural contract."[21] We have literally, not symbolically as before, to manage the planet we inhabit, and must now define a politics of things.

Technologies (Level 10)

Talk of a crossover between technology and politics does not, in the present myth (or pragmatogony), indicate belief in the distinction between a material realm and a social one. I am simply unpacking the eleventh layer of what is packed in the definitions of society and technique. If I descend to the tenth layer, I see that our definition of technology is itself due to the crossover between a previous definition of society and a particular version of what a nonhuman can be. To illustrate: some time ago, at the Institut Pasteur, a scientist introduced himself, "Hi, I am the coordinator of yeast chromosome 11." The hybrid whose hand I shook was, all at once, a person (he called

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[21] Michel Serres, *Le contrat naturel* (Paris: Bourin, 1990); Michel Serres, *Eclaircissements: Cinq entretiens avec Bruno Latour* (Paris: Bourin, 1992).

himself "I"), a corporate body ("the coordinator"), and a natural phenomenon (the genome, the DNA sequence, of yeast). The dualist paradigm will not aid in understanding this hybrid. Place its social aspect on one side, and yeast DNA on the other, and you will bungle not only the data but also the opportunity to grasp how a genome becomes known to an organization and how an organization is naturalized in a DNA sequence on a hard disk.

We again encounter a crossover here, but it is of a different sort and goes in a different direction, although it could also be called sociotechnical. For the scientist I interviewed, there is no question of granting any sort of rights, of citizenship, to yeast. For him, yeast is a strictly material entity. Still, the industrial laboratory where he works is a place in which new modes of organization of labor elicit completely new features in nonhumans. Yeast has been put to work for millennia, of course, for instance in the old brewing industry, but now it works for a network of thirty European laboratories where its genome is mapped, humanized, and socialized, as a code, a book, a program of action, compatible with our ways of coding, counting, and reading, retaining little of its material quality. It is absorbed into the collective. Through technology—defined, in the anglophone sense, as a fusion of science, organization, and industry—the forms of coordination learned through "networks of power" (see below) are extended to disarticulate entities. Nonhumans are endowed with speech, however primitive, with intelligence, foresight, self-control, and discipline, in a fashion both large-scale and intimate. Social-ness is shared with nonhumans in an almost promiscuous way. While on this model (the tenth meaning of *sociotechnical*), automata have no rights, they are much more than material entities; they are complex organizations.

Networks of Power (Level 9)

Organizations, however, are not purely social, because they themselves recapitulate nine prior crossovers of humans and nonhumans. Alfred Chandler and Thomas Hughes have each traced the interpenetration of technical and social factors in what Chandler terms the "global corporation" and Hughes terms "networks of power."[22] Here again, the phrase "sociotechnical imbroglio" would be apt, and one could replace the dualist paradigm by the "seamless web" of technical and social factors so beautifully deployed by Hughes. But the point of my little genealogy is also to identify, inside the seamless web, properties borrowed from the social world in order to socialize nonhumans, and, vice versa, borrowed from nonhumans in order to naturalize and expand the social realm. For each layer of meaning, whatever happens happens as if we were learning, in

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[22] Alfred D. Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge: Harvard University Press, 1990); Thomas P. Hughes, *Networks of Power: Electric Supply Systems in the US, England and Germany, 1880–1930* (Baltimore: Johns Hopkins University Press, 1983).

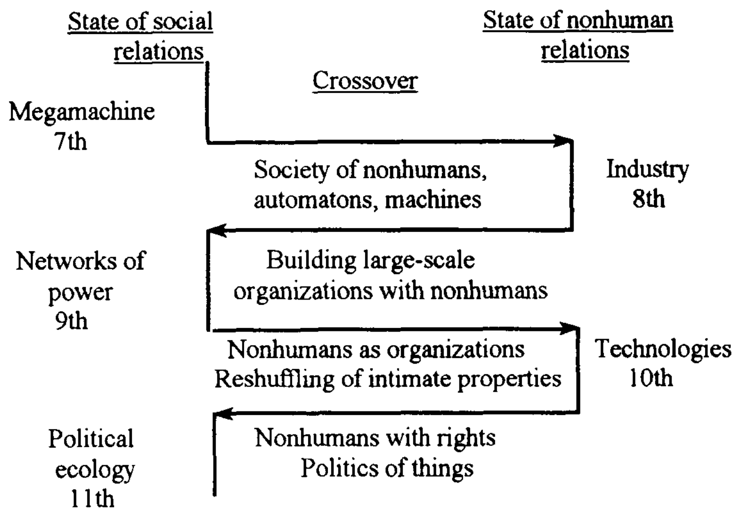

Fig. 7. Five Successive Meaning of Sociotechnical

contact with one side, ontological properties that are then reimported to the other side, generating new, completely unexpected effects (Fig. 7).

The extension of networks of power in the electrical industry, in telecommunications, in transportation, is impossible to imagine without a massive mobilization of material entities. Hughes's book is exemplary for students of technology because it shows how a technical invention (electrical lighting) led to the establishment (by Edison) of a corporation of unprecedented scale, its scope directly related to the physical properties of electrical networks. Not that Hughes in any way talks of infrastructure triggering changes in superstructure; on the contrary, his networks of power are complete hybrids, though hybrids of a peculiar sort—they lend their nonhuman qualities to what were until then weak, local, and scattered corporate bodies. Management of large masses of electrons, clients, power stations, subsidiaries, meters, and dispatching rooms acquires the formal and universal character of scientific laws.

This ninth layer of meaning resembles the eleventh, with which we began, since in both cases the crossover is from nonhumans to corporate bodies. (What can be done with electrons can be done with electors.) But the intimacy of human and nonhuman is less apparent in networks of power than in political ecology. Edison, Bell, and Ford mobilized entities that looked like matter, that seemed nonsocial, whereas political ecology involves the fate of nonhumans already socialized, so closely related to us that they have to be protected by delineation of their legal rights.

Industry (Level 8)

Even philosophers and sociologists of techniques tend to imagine that there is no difficulty in defining material entities because they are objective, unproblematically composed of forces, elements, atoms. Only the social, the human realm is difficult to interpret, we often believe, because it is complexly historical. But whenever we talk of matter, we are really considering, as I am trying to show here, a package of former crossovers between social and natural elements, so that what we take to be primitive and pure terms are belated and mixed ones. Already we have seen that matter varies greatly from layer to layer—matter in the layer I have called "political ecology" differs from that in the layers called "technology" and "networks of power." Far from being primitive, immutable, and ahistorical, matter has a complex genealogy.

The extraordinary feat of what I will call *industry* is to extend to matter a further property that we think of as exclusively social, the capacity to relate to others of one's kind. Nonhumans have this capacity when part of the assembly of actants that we call a machine: an automaton endowed with autonomy of some sort and submitted to regular laws that can be measured with instruments and accounting procedures. From tools held in the hands of human workers, the shift historically was to assemblies of machines, where tools *relate to one another*, creating a massive array of labor and material relations in factories that Marx described as so many circles of hell. The paradox of this stage of relations between humans and nonhumans is that it has been termed "alienation," dehumanization, as if it were the first time that poor and exploited human weakness was confronted with an all-powerful objective force. However, to relate nonhumans together in an assembly of machines, ruled by laws, and accounted for by instruments, is to grant them a sort of social life. Indeed, the modernist project consists in creating that peculiar hybrid: a fabricated nonhuman that has nothing of the character of society and politics yet builds the body politic all the more effectively because it seems completely estranged from humanity.[25] This famous shapeless matter, celebrated so fervently throughout the eighteenth and nineteenth centuries, which is there for Man's—but not Woman's—ingenuity to mould and fashion, is only one of many ways to socialize nonhumans. They have been socialized to such an extent that they now have the capacity of creating an assembly of their own, an automaton, checking and surveying, pushing and triggering other automata, as if with full autonomy. The "megamachine" (see below) has been extended to nonhumans.

It is only because we have not undertaken an anthropology of our modern world that we can overlook the strange and hybrid quality of matter as it is seized on and implemented by industry. We take matter as mechanistic, forgetting that mechanism is one-half the modern definition of society. A society of machines? Yes, the eighth meaning of the word *sociotechnical*, though it seems to designate an unproblematic industry, dominating matter through machinery, is the strangest sociotechnical imbroglio. Matter is not a given, but a recent historical creation.

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[25] Latour, *We Have Never Been Modern.*

The Megamachine (Level 7)

But where does industry come from? It is neither a given nor the sudden discovery by capitalism of the objective laws of matter. We have to imagine its genealogy through earlier and more primitive meanings of the term *sociotechnical.* Lewis Mumford has made the intriguing suggestion that the *megamachine*—the organization of large numbers of humans via chains of command, deliberate planning, and accounting procedures—represents a change of scale that had to be made before wheels and gears could be developed.[24] At some point in history, human interactions come to be mediated through a large stratified, externalized body politic that keeps track, employing a range of "intellectual techniques" (writing and counting, basically), of the many nested subprograms of action. By replacing some, though not all, of these subprograms with nonhumans, machinery and factories are born. The nonhumans, in this view, enter an organization that is already in place and take on a role rehearsed for centuries by obedient human servants enrolled in the imperial megamachine.

In this seventh episode, the mass of nonhumans assembled in cities by an internalized ecology—I will define this expression shortly—has been brought to bear on empire building. Mumford's hypothesis is debatable, to say the least, when our context of discussion is the history of technology; but the hypothesis makes excellent sense in the context of my genealogy. Before it is possible to delegate action to nonhumans, and possible to relate nonhumans to one another in an automaton, it must first be possible to nest a range of subprograms for action into one another without losing track of them. Management, Mumford would say, precedes the expansion of material techniques. More in keeping with the logic of my story, one might say that whenever we learn something about the management of humans, we shift that knowledge to nonhumans and endow them with more and more organizational properties. The even-numbered episodes I have recounted so far follow this pattern: industry shifts to nonhumans the management of people learned in the imperial machine, much as technologies shift to nonhumans the large-scale management learned through networks of power. In the odd-numbered episodes, the opposite process is at work: what has been learned from nonhumans is reimported so as to reconfigure people.

Internalized Ecology (Level 6)

In the context of layer seven, the megamachine seems a pure and even final form, comprised entirely of social relations; but, as we reach layer six and examine what underlies the megamachine, we find the most extraordinary extension of social rela-

[24] Lewis Mumford, *The Myth of the Machine: Technics and Human Development* (New York: Harcourt, Brace & World, 1966).

tions to nonhumans: agriculture and the domestication of animals. The intense socialization, reeducation, and reconfiguration of plants and animals—so intense that they change shape, function, and often genetic makeup—is what I mean by the term *internalized ecology.* As with our other even-numbered episodes, domestication cannot be described as a sudden access to an objective material realm that exists beyond the social. In order to enroll animals, plants, proteins in the emerging collective, one must first endow them with the social characteristics necessary for their integration. This shift of characteristics results in a man-made landscape for society (villages and cities) that completely alters what was until then meant by social and material life. In describing layer six, we may speak of urban life, empires, and organizations, but not of society and/versus techniques—nor of symbolic representation and/versus infrastructure. So profound are the changes entailed at this level that we pass beyond the gates of history and enter more profoundly those of prehistory, of mythology.

Society (Level 5)

What is a *society,* the beginning of all social explanations, the given of social science? If my pragmatogony is even vaguely suggestive, *society* cannot be part of our final vocabulary, since the term had itself to be made, "socially constructed" as the misleading expression goes. But in the Durkheimian interpretation, a society is final indeed: it precedes individual action, lasts very much longer than any interaction does, dominates our lives—*is that in which* we are born, live, and die. It is externalized, reified, more real than ourselves, hence the origin of all religion and sacred ritual, which, for Durkheim, are nothing but the return, through figuration and myth, of what is transcendent to individual interactions.

And yet society itself is constructed only through such quotidian interactions. However advanced, differentiated, and disciplined society becomes, we still repair the social fabric out of our own, immanent knowledge and methods. Durkheim may be right, but so is Garfinkel. Perhaps the solution, as according to the reproductive principle of my genealogy, is to look for nonhumans. (The principle: Look for nonhumans when the emergence of a social feature is inexplicable; look to the state of social relations when a new and inexplicable type of object enters the collective.) What Durkheim mistook for the effect of a sui generis social order is simply the effect of having brought so many techniques to bear on our social relations. It was from techniques that we learned what it means to subsist and distend, to accept a role and discharge a function. By reimporting this competence into the definition of society, we taught ourselves to reify it, to make society stand independent of fast-moving interactions. We even learned how to delegate to society the task of relegating us to roles and functions. Society exists, in other words, but is not socially constructed. Nonhumans proliferate below the bottom line of social theory.

Techniques (Level 4)

By this stage in our speculative genealogy, we can no longer talk of humans, of anatomically modern humans, but only of social *pre*humans. At last, we are in a position to define *technique* with some precision. Techniques, we learn from archaeologists, are articulated subprograms for actions that subsist (in time) and extend (in space). Techniques imply not society (that late-developing hybrid) but a semisocial organization that brings together nonhumans from very different seasons, places, and materials. A bow and arrow, a javelin, a hammer, a net, an article of clothing are composed of parts and pieces that require recombination in sequences of time and space that bear no relation to their natural settings. Techniques are what happen to tools and nonhuman actants when processed through an organization that extracts, recombines, and socializes them. Even the simplest techniques are sociotechnical; even at this primitive level of meaning, forms of organization are inseparable from technical gestures.

Social Complication (Level 3)

But *what* form of organization can explain these recombinations? Recall that at this stage there is no society, no overarching framework, no dispatcher of roles and functions; merely interactions among prehumans. Shirley Strum and I term this third layer of meaning *social complication.*[25] Complex interactions are now marked and followed by nonhumans enrolled for the purpose. Why? Nonhumans stabilize social negotiations. Nonhumans are at once pliable and durable; they can be shaped very quickly but, once shaped, last far longer than the interactions that fabricated them. Social interactions are extremely labile and transitory. More precisely, either they are negotiable but transient or, if they are encoded (for instance) in the genetic makeup, they are extremely durable but difficult to renegotiate. By involving nonhumans, the contradiction between durability and negotiability is resolved. It becomes possible to follow (or "black box") interactions, to recombine highly complicated tasks, to nest subprograms into one another. What was impossible for complex social animals to accomplish becomes possible for prehumans—who use tools, not to acquire food but to fix, underline, materialize, and keep track of the social realm. Though composed only of interactions, the social realm becomes visible and attains through the enlistment of nonhumans—tools—some measure of durability.

The Basic Tool Kit (Level 2)

The tools themselves, wherever they came from, are our only witnesses for hundreds of thousands of years. Many archaeologists proceed on the assumption that the *basic*

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[25] Strum and Latour, "The Meanings of Social."

tool kit (as I call it) and techniques are directly related by an evolution of tools into composite tools. But there is no direct route from flints to nuclear-power plants. Further, there is no direct route, as many social theorists presume there to be, from social complication to society, megamachines, networks. Finally, there is not a set of parallel histories, the history of infrastructure and the history of superstructure, but only one sociotechnical history.

What, then, is a tool? The extension of social skills to nonhumans. Machiavellian monkeys and apes, such as those introduced at the beginning of this section, possess little by way of techniques, but can devise (as Hans Kummer has shown) *social tools* through complex strategies of manipulating and modifying one another.[26] If you grant the prehumans of my own mythology the same kind of social complexity, you grant as well that they may generate tools by shifting that competence to nonhumans, by treating a stone, say, as a social partner, modifying it, then acting on a second stone. Prehuman tools, in contrast to the ad hoc implements of other primates, represent the extension of a skill rehearsed in the realm of social interactions.

Social Complexity (Level 1)

We have finally reached the level of Clairborne, Niva, and Crook, the Machiavellian primates. Here they engage in Garfinkelian interactions to repair a constantly decaying social order. They manipulate each another to survive in groups, each group of conspecifics in a state of constant mutual interference. We call this state, this level, *social complexity*.[27] I will leave it to the ample literature of primatology to show that this stage is no purer from contact with tools and techniques than any of the later stages. Instead I will reconsider the entire genealogy, this seemingly dialectical history that does not rely on dialectical movement. It is crucial to reiterate that the contradiction of object and subject is not the engine of its plot. Even if the speculative theory I have outlined is entirely false, it shows, at the very least, the possibility of imagining a genealogical alternative to the dualist paradigm. We are not forever trapped in a boring alternation between objects or matter and subjects or symbols. We are not limited to "not only . . . but also" explanations. My little origin myth makes conceivable the impossibility of an artifact that does not incorporate social relations, and makes conceivable the impossibility of defining social structures without accounting for the large role of nonhumans in them.

Second, and more importantly, the genealogy demonstrates that it is false to claim, as so many do, that once we abandon the dichotomy between society and techniques, we are faced with a seamless web of factors in which all is included in all. On the

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[26] Hans Kummer, *Vies de singes: Moeurs et structures sociales des babouins hamadryas* (Paris: Odile Jacob, 1993).

[27] Strum and Latour, "The Meanings of Social."

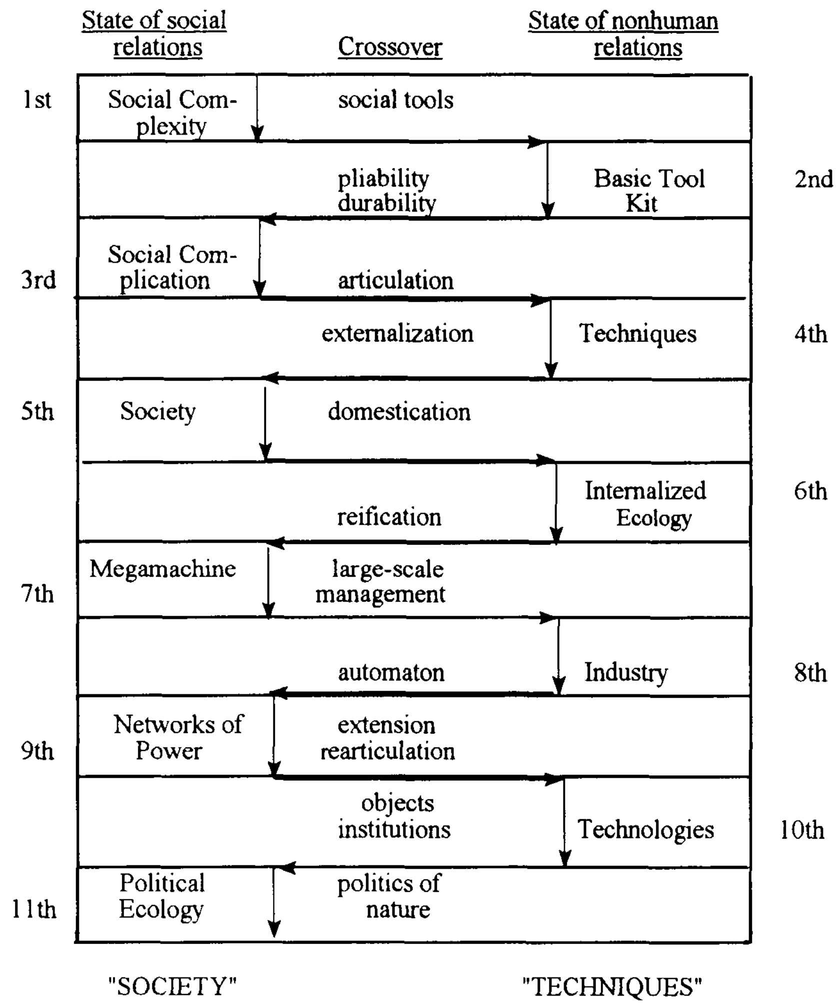

Fig. 8. A Mythical Alternative to the Dualist Paradigm

contrary, the properties of humans and nonhumans cannot be swapped haphazardly. Not only is there an order in the exchange of properties, but for each of the layers I have peeled away, the meaning of the word *sociotechnical* is clarified by considering the exchange: what has been learned from nonhumans and reimported into the social realm, what has been rehearsed in the social realm and exported back to the nonhumans. Nonhumans too have a history. They are not material objects or constraints. Sociotechnical$_1$ is different from sociotechnical$_6$ or $_7$ or $_8$ or $_{11}$. By adding subscripts, we are able to *qualify* the meanings of a term that until now has been hopelessly confused. In place of the great vertical dichotomy between society and techniques, there is conceivable (in fact, now, available) a range of horizontal distinctions between very various meanings of the sociotechnical hybrids. It is possible to have our cake and eat it—to be monists *and* make distinctions.

All this is not to claim that the old dualism, the prior paradigm, had nothing to say for itself. We have indeed to alternate between states of social and states of nonhuman relations, but this is not the same as alternating between humanity and objectivity. The mistake of the dualist paradigm was its definition of humanity. Even the shape of humans, our very body, is composed in large part of sociotechnical negotiations and artifacts. To conceive humanity and technology as polar is to wish away humanity: we are sociotechnical animals, and each human interaction is sociotechnical. We are never limited to social ties. We are never faced with objects. This final diagram (fig. 8) relocates humanity where we belong—in the crossover, the central column, the possibility of mediating between mediators.

At each of the eleven episodes I have retraced, an increasingly large number of humans is mixed with an increasingly large number of nonhumans, to the point where, today, the whole planet is engaged in the making of politics, law, and soon, I suspect, morality. The illusion of modernity was to believe that the more we grow, the more distant objectivity and subjectivity would become, thus creating a future radically different from our past. After the paradigm shift in our conception of science and technology, we now know that this will never be the case, indeed that this has never been the case. Objectivity and subjectivity are not opposed, they grow together, and they grow irreversibly together. The challenge to our philosophy, social theory, and morality is to invent political institutions that can absorb this much history, this huge spiralling movement, this destiny, this fate. . . . At the very least, I hope to have convinced you that, if our challenge is to be met, it will not be met by considering artifacts as things. They deserve better. They deserve to be housed in our intellectual culture as full-fledged social actors.

They mediate our actions?

No, they are us.

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Pragmatogonies

A Mythical Account of How Humans and Nonhumans Swap Properties

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The study of science and technology has been deeply modified in the last 20 years through the use of what has been called a *principle of symmetry* (Bloor, 1991). Truth and falsity, efficiency and irrationality, profitability and waste have been treated in the same terms instead of being partitioned in two incompatible realms. Instead of extracting the three sisters—truth, efficiency, and profitability—from the messy social world, they became mixed into social practice as intimately as possible. Very quickly, however, it appeared that the social theory that had been used to study rationality as well as irrationality in a symmetrical fashion was deeply flawed because it had been devised in contraposition to the world of objects. This birth defect made very difficult the use of the resources of the social sciences to study the natural world.

To get out of this difficulty, it has been necessary to define a generalized principle of symmetry, not between rational and irrational behavior, but between humans and nonhumans (Latour, 1987). The apparent difficulty of this new principle—which is nothing but an extension of the first one—is that it seems to blur the boundaries between the human subject and the nonhuman object. It appears to succumb either to the sin of anthropomorphism (Schaffer, 1991) or to the mechanization of sacred human subjectivity (Collins & Yearley, 1992).

There is no way to answer these critiques as long as we take for granted that we *know* what object and subject, human and nonhuman, mean. In this article, I have no intention of defending or illustrating the principle of symmetry.[1] I simply want to offer an alternative myth to help us suspend our knowledge of what constitutes the human subject and the nonhuman object. Only a myth, at

Author's Note: *This article is a revised version of the last of the three Messinger lectures I gave at Cornell University in April, 1993 entitled "On Technical Mediation." A complete version of those lectures will appear in* Common Knowledge, *Fall, 1994. I thank Sheila Jasanoff and Trevor Pinch for inviting me to deliver them. I also thank Malcolm Ashmore for his assistance with the revision. "Pragmatogonies" is part of a joint project with Professor Shirley Strum of the University of California, San Diego, a project which has been going on for more than 15 years (see Latour & Strum, 1986, Strum & Latour, 1987, Latour & Lemonnier, 1994). A hopefully more reasonable book than this article should come out of this collection.*

this point, may help move the discussion further and point at the common locus from which is produced a certain type of linkage between certain types of humanity and certain types of nonhumanity.

LOOKING FOR THE ENTRY POINT OF OBJECTS INTO THE COLLECTIVE

> 11:00 a m.: Clairborne sits near Niva, looking around vigilantly. Before Clairborne can make a move, Crook arrives, both nervous and brazen Both Clairborne and Crook want Niva's favors, but Clairborne is her old friend. Crook has just arrived and no one trusts him, he is so unpredictable Clairborne moves closer to Niva, but this does not stop Crook, who continues to close in. Tension mounts. Niva is caught between two conflicting emotions, wanting to flee and yet worried to be on her own so near Crook She opts to stay near Clairborne, which seems like the safest bet. Everyone is watching closely to see what will happen. Sharman pays special attention since the outcome could affect him Crook lunges at Clairborne, but instead of running away, Clairborne grabs Niva's infant. The infant clings trustingly to its big friend Suddenly, the action shifts, as if Clairborne had erected a protective shield between himself and Niva Frustrated, but not daring to make a further move toward them, Crook turns elsewhere to vent his frustration. As he suspected he would, Sharman becomes the target of Crook's aggression. As the two run off exhanging threats, the small group around Niva relaxes. Clairborne huddles closer to Niva; the infant snuggles in her lap. Sharman now is the one with the problem. It is 11·05 a m. (Shirley Strum, personal communication, 1994)

This bit of soap opera does not come from *Dallas* or any of those sitcoms with which you Americans conquer our TV sets all around the world, but from primatologists' accounts of baboon life.[2] Such a group of baboons offers the best baseline, the best benchmark, to register how objects enter the collective, because, although baboons are complex in their social and political maneuvering, they are, unlike chimpanzees for instance, devoid of any tools and artifacts, at least in the wild.

To understand the linkages between humans and nonhumans, we have to define techniques in a different way

First, let me define technical action as the form of *delegation* that allows us to mobilize in an interaction movements which have been executed earlier, farther away, and by other actants, as though they are still present and available to us now. Without the presence of the past, the presence of the far away, the presence of nonhuman characters, we would be limited, precisely, to interactions, to what we can manage to do, right now, with our own social skills, like the Machiavellian baboons I have just introduced.

Second, this definition of technical action does not imply any *Homo faber* mythology as if we had through techniques some sort of privileged, unmediated, unsocialized access to objective matter and natural forces. Objects, matter, force, and nature are latecomers and cannot be used as our starting point. The traditional definition of techniques as the imposition of a form consciously planned in advance onto some shapeless matter should be replaced by a much more oblique, although more accurate, definition as the socialization of non-humans (Latour & Lemonnier, 1994).

Third, the most important consequence of criticizing the *Homo faber* myth, is that when we exchange properties with nonhumans through technical delegation, we enter into a complex transaction, which is visible in contemporary collectives as well as in traditonal ones. If anything, as I have shown elsewhere (Latour, 1993b), what we call *modern* collectives are not the ones in which society and technology are finally divorced from each other, but those in which relations are so intimate, transactions so many, and mediations so convoluted, that there is no longer any plausible way to differentiate for good a collective body, an artifact and a subject.

Fourth, to absorb this symmetry between humans and nonhumans on the one hand, and this continuity between traditional and contemporary collectives on the other, social theory has to be somewhat modified. It is nowadays commonplace to say that techniques are social because they have been socially constructed.[3] But this pronouncement remains vacuous if the meanings of *mediation* and of *social* are not made more precise. If we intend to say that social relations are inscribed in technology so that when we are confronted with an artifact, we are confronted, in effect, with social relations, then we say nothing more than a tautology, a very implausible one at that.[4] If artifacts are social relations, then why on earth has society to pass through them to inscribe itself onto something else? Why not inscribe itself directly? After all, the artifacts count for nothing; they are just there to transport domination, exclusion, and power, conducting them like electricity along a wire. I know the answer critical theory will give. By going through the medium of artifacts, power and domination hide themselves under the guise of natural and objective forces They appear naturalized or objectified or reified. Do you see how critical theory functions? First it uses a tautology: Technology is nothing but social relations. Then it adds a conspiracy theory: Society is hiding itself behind the fetish of techniques.

But techniques are not fetishes, they do something more, something unpredictable, they are not means, but mediators, that is, means and ends at the same time, and this is precisely why they are brought to bear on the social fabric. So, in addition to all its other defects, critical theory is also politically weak because it is unable to explain why artifacts enter the stream of our relations through the constant recruitment of socialized nonhumans. This does not happen to mirror, reflect, inscribe, or hide social relations but to remake them anew through fresh and unexpected sources of power. Society is not stable enough to inscribe itself onto anything. On the contrary, most of the features of social order—scale, asymmetry, durability, power, division of labor, role distribution, and hierarchy—are impossible even to define without bringing in socialized nonhumans. Yes, society is constructed, but not just *socially* constructed. Only Shirley Strum's baboons, we could say, construct their society socially (Strum & Latour, 1987). Humans for a few millions of years now have extended their social relations to other actants with which, with whom, they have swapped many properties, and with which, with whom, they form a *collective*.[5] There is no sense in which the notion of a *human* can be disentangled from the nonhumans into whose fate it has woven more and more intimately over the ages.

Such an argument could trigger the objection that symmetry between humans and nonhumans is impossible because the humans seem always to have the initiative. This commonsense objection is not so commonly sensible, however, because in most of our activities we do not attribute the causative role to humans (see Fuller, 1994, this issue). Scientists, for instance, commonly say that they do not speak but that nature speaks—or more exactly, writes—through the medium of the instruments and the laboratory. So who does the speaking? The scientists? Yes, to be sure, but they insist that when they talk they are authorized by the real enunciator of their speech, reality itself, so that in the end reality does most of the talking. You will find the same conundrum in the question of political representation: Hobbes' sovereign, after all, is the *actor* of whom we are the *authors*. And similarly in fiction: Novelists claim that they are forced to write either by the muse or by the sheer impulse of the characters themselves, and, amusingly enough, the literary critics often make fun of this fetishistic belief by appealing to still another collective force for which the novelists play the expressive role of medium, that of society or that of the Zeitgeist. So every activity suspends the easy commonsense idea that humans speak and act. Every activity implies a generalized principle of symmetry or, at the least, offers an ambiguous mythology that disputes the unique position of humans We find exactly the same uncertainty with techniques, where we have a human action ending up in the action of a nonhuman. So who eventually is responsible for the action? Both. The responsibility has to be shared, symmetry restored, and the role of humanity shifted sideways from being the sole transcendant cause to that of *mediating mediators*.

AN UNREASONABLE PRAGMATOGONY

After having quickly summarized what has been learned about techniques by using the principle of symmetry, I could take two different paths, one reasonable, the other unreasonable. The first path would be to describe with as many details as I could some modern sociotechnical imbroglios and to show you in what sense machines and machinations participate in the same deeply renewed Machiavellian politics (Latour, 1992, 1993a; Latour & Lemonnier, 1994; MacKenzie, 1990).

Unfortunately, I am going to take a totally unreasonable and speculative path. Instead of describing sociotechnical networks, I am going to attempt a genealogy of the swapping of properties between humans and nonhumans. Because it will be as unreasonable, implausible, and unempirical as the cosmogonies of the past, and because it will retrace the metamorphosis of the object, I will call it, after Serres (1987), a *pragmatogony*.

The reason I am going to do this is that, no matter how many excellent case studies I and my colleagues are able to produce, they are understood by readers in many instances as a social construction of technology! In other words, readers account for such studies in terms of the dualist paradigm I have criticized so much. The reason for this obstinacy seems to reside in the impossibility of disentangling the various meanings of the catchword *sociotechnical* (Callon, 1986, 1989). What I want to do now is to peel away, one by one, the various layers of meaning that are sedimented in the present packages that we label *society* and *techniques*. Because every time we use the word social, we implicate many types of nonhumans, and every time we speak of techniques, we also bring in definitions of society, the only way out, if we do not want to throw up our hands in despair, is to attempt a genealogy of these associations.

I have another reason to attempt a genealogy. After having disputed the dualist paradigm for years, I now realize that no one is ready to abandon an arbitrary but useful dichotomy, such as that between society and technology, if it is not replaced by analytical categories which have at least the same discriminating power as those just jettisoned (Lee & Brown, 1994, this issue). We can toss around the phrase sociotechnical networks for ages without ever moving beyond the dualist paradigm we wish to overcome. To move on, I need to convince you that I can differentiate *much finer* details with the new paradigm than with the former one. (I am assuming you do not need to be persuaded that there is nothing intrinsically wrong in blurring the distinction between social actors and objects.) To do so, I will traverse all the meanings of sociotechnical I have been able to devise, from the most contemporary to the most primitive. The advantage of this maneuver is that we will be able (in the future) to qualify with some precision which sort of properties are swapped or invented for each of those meanings.

In my present story I have isolated 11 different layers. Of course, I do not claim any plausibility for these definitions, nor for their sequence. I simply want to show that the tyranny of the dichotomy between humans and nonhumans is not inevitable because it is possible to give at least one other myth in which it plays no role. If I succeed in giving some space for the imagination, this would mean that we are not forever stuck with the boring alternation of humans to nonhumans and back. It would be possible to imagine a space, that will later be studied empirically, in which we could observe the swapping of properties without always having to start from a priori definitions of humanity.

PRAGMATOGONIES

I am now going to sketch, in a telegraphic style, the various stages of my myth without even trying to be plausible. I will simply stick to the same principle all along, starting with the latest meaning of sociotechnical and proceeding all the way to the earliest, most primitive layer.

11. POLITICAL ECOLOGY

The eleventh and most recent interpretation of the sociotechnical crossover[6] is, paradoxically, the easiest to define because it is the most literal. Lawyers,

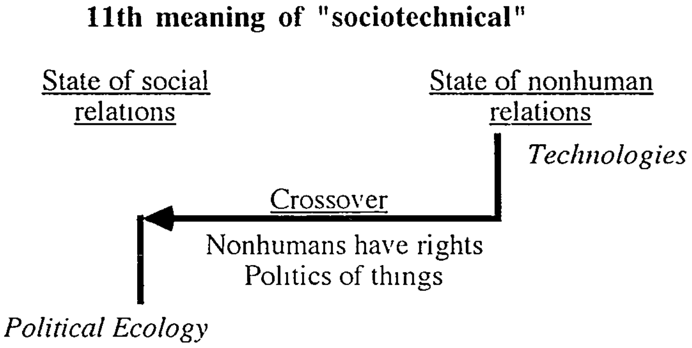

Figure 1: The pragmatogony is told by taking properties learned in social relations and bringing them to bear on the state of nonhuman relations and vice-versa.

activists, ecologists, businessmen, and political philosophers are now seriously talking, because of the ecological crisis, of granting to nonhumans some sorts of rights and some sort of standing in court (see Figure 1).

Not many years ago when we were contemplating the sky above our heads, we thought of nothing but matter and nature. Nowadays, when we look above our heads, we watch a sociopolitical imbroglio, because, for instance, the depletion of the ozone layer brings together a scientific controversy, a political dispute between North and South, and gigantic strategic moves inside industry. The idea of a political representation of nonhumans seems not only plausible but necessary, although it would have seemed ludicrous or even indecent a few years ago. We used to deride primitive people who thought that some disorder in their society, some pollution, could threaten the natural order to the point of letting the sky fall on their heads. We do not laugh anymore when we abstain from pressing the button of an aerosol for precisely the same reason. We too are now afraid that the sky could fall on our heads because of our pollution, our negligence. We have become much more primitive, that is, much more cautious—or, should I say, much more civilized?

How can this crossover between rights and science be defined? Like all crossovers it mixes elements of both sides, those of the political, and those of the scientific or technological orders. But this mixing is not just any haphazard rearrangement. *Technologies* (see below for the definition) have taught us how to manage vast assemblies of nonhumans on a large scale. But this form of management was still conceived as efficient, profitable, rational, and objective, and as a mastery over matter. In the new crossover we bring the property learned through this prior experiment in large-scale management of the planet to bear on the political system. The new hybrid remains a nonhuman, but not only does it lose its material, objective, and rational character, it also takes up some of the properties of citizenship. It has rights, it should be protected, it cannot be enslaved To use Michel Serres's (1990) phrase, we should replace the social contract by the "natural contract." I will call this first layer of meaning—last in chronological order—*political ecology*. We now understand that we must literally and not just symbolically manage the planet and practice the politics of things.

10. TECHNOLOGIES

Do not believe, however, that when I talk of a crossover of technology and politics, I am referring to pure forms, as if techniques were on the material side and politics on the social one. No, I am only defining the eleventh layer of what is packed into the definition of society and techniques. Turning toward the tenth layer, we realize that our definition of technology is itself due to the crossover between a previous definition of society and a particular version of what a nonhuman can be.

To give you an example of what I have in mind, when I met a scientist, a few months ago, he introduced himself by saying, "Hi, I am the coordinator of the chromosome 11 of yeast." What an extraordinary hybrid! Here is a person—"I am"—a corporate body—"the coordinator"—and a truly natural phenomenon—"yeast," whose genome (that is, the complete DNA sequence) this scientist is elucidating! If you were cutting in the middle of this sentence with the dualist paradigm, putting on the one side the social aspect of his organization and on the other the natural truth of yeast DNA, you would not only bungle the data but would also lose any chance of understanding how the yeast genome can become known to an organization and how an organization could become naturalized as a DNA sequence inside a Macintosh hard disk.

We again encounter a crossover here, but it is of a different sort and goes in a different direction, although it can also be called sociotechnical. For the scientist I interviewed, there was no question of granting any sort of rights of citizenship to the yeast. For him, the yeast is a strictly material entity. The industrial laboratory, where new modes of organization of labor elicit completely new features of the nonhumans, would be a good definition of what a technology is in the English sense of the word: that is, a fusion of science, organization, and industry. In technology, the forms of coordination learned through *networks of power* (see below) are extended to disarticulate entities not only on a much larger scale but also in a much more intimate way. Although yeast had, for millenia, already been put to work by the old brewing industry, the yeast now distributed through the networks of 30 European laboratories to have its genome mapped is humanized and socialized in the much more literal sense of becoming a code, a book, a program of action, compatible with our ways of coding, counting, and reading, and no longer retaining any of its material quality, its outsiderness. It has been swallowed within the collective. Through technology, socialness is shared with nonhumans in an almost promiscuous way, automatons being endowed with some sort of primitive speech, intelligence, foresight, self-control, discipline. They have no rights, to be sure, as in the eleventh meaning, but they are much more than material entities: They are complicated organizations.

9. NETWORKS OF POWER

This is not to say that what I call organizations and networks are purely social, because they are themselves recapitulating nine former crossovers of humans and nonhumans. Alfred Chandler and Thomas Hughes have each shown the simultaneous extension of what the former calls the *global corporation* (Chandler, 1990) and the latter calls *networks of power* (Hughes, 1983). Here again, I could talk of a sociotechnical imbroglio and replace the dualist paradigm by the seamless web of technical and social factors so beautifully deployed by Hughes But the point of my little genealogy is to be able to identify inside the seamless web the properties which are borrowed from the social world to socialize the nonhumans, and, vice versa, from the nonhumans to naturalize and expand the social realm. For each layer of meaning, everything happens as if we were learning, through our contact with one side, *ontological properties*, which are then reimported to the other side, generating new, completely unexpected effects.

The extension of networks of power in the electrical industry, in telecommunications, in transportation, are impossible to imagine without the massive mobilization of material entities. The reason why Tom Hughes' (1983) book is so exemplary for the field of science studies lies in his ability to show how a technical invention—that of electric lighting—is brought to bear by Edison on a mode of organization, of management, of law, that creates a corporation without much precedent because its scope and scale, to use Chandler's title, are directly related to the physical properties of the electrical networks. Not that Hughes in any way talks of a material infrastructure triggering changes in the social superstructure. On the contrary, his networks of power are complete hybrids, but hybrids of a peculiar sort: They lend their nonhuman qualities to what were until then weak, local, and scattered corporate bodies. Management of large masses of electrons, clients, power stations, subsidiaries, meters, and dispatching rooms takes on the formal and universal character of scientific law.

Notice that this layer of meaning resembles the eleventh, with which I started, because in both cases the crossover comes preferentially from the nonhumans and is then brought to bear on the corporate bodies. What can be done with the electrons, can also be done with the electors. But the intimacy is weaker in networks of power than in political ecology because the entities which Edison, Bell, or Ford mobilized still look like matter, still seem nonsocial before *industry* (see below) forges them into shape. Political ecology, however, is concerned with the fate of nonhumans which are so socialized and so closely related to us that they have to be protected by rights as if they were our brethren, as if we were primitive again.

8. INDUSTRY

In the philosophy and sociology of techniques, we often imagine that there is no difficulty in defining material entities because they are objective, they just stand there, unproblematically composed of forces, of atoms, of elements. Only the social, the human side, would be difficult to interpret, we believe, because it is so complex, hermeneutic, and historical The principle of my genealogy, however, is that whenever we talk of matter as a given, we are in fact considering a package of multiple layers of former crossovers between social and natural elements so that what we take as primitive and pure terms are belated and mixed ones. Just by retracing the most recent three steps, we can already see that matter is vastly different depending on the different layers I have called political ecology, technology, or networks of power. Far from being a primitive term, always immutable in contrast to a fast changing society, matter has a genealogy too, and nonhumans can in no way be limited to their material definition, which, on the contrary, we should be able to retrace.

The extraordinary feat that I will call *industry* is to grant nonhumans the possibility of being related to one another in an assembly of actants that we call a machine or an automaton, which is endowed with some sort of autonomy and which is submitted to regular laws that can be measured through instruments and accounting procedures. From tools held in the hands of human workers, we shift to an assembly of machines where tools are related *to one another*, creating a massive array of labor and material relations in the new factories that Marx has forcefully described as so many circles of Dante's *Inferno*.

The paradox of this stage of the relations between humans and nonhumans is that it is seen as alienation, dehumanization, as if this was the first time that poor and exploited human weakness was confronted with an all-powerful objective force. However, to relate nonhumans together in an assembly of machines, ruled by laws, and accounted for by instruments, is still to grant them some sort of social life. Indeed, the whole modernist project consists of creating that peculiar hybrid: A fabricated nonhuman that has nothing of the character of society and politics, but that builds the body politic all the more effectively because it seems completely estranged from humanity (Latour, 1993b). This famous shapeless matter, celebrated so fervently throughout the 18th and 19th centuries, which is there for man's—but not woman's—ingenuity to mold and fashion, is only one of the many ways to socialize nonhumans. They are socialized so much that they are granted the possibility of creating an assembly of their own, an automaton, checking and surveying, pushing and triggering one another, as if they had full autonomy. It is the *megamachine* (see below) extended to nonhumans.

It is only because we do not do our own anthropology, the anthropology of our modern world, that we can overlook the strange and hybrid quality of matter as it is seized on and implemented by industry. We treat it as mechanistic, forgetting that mechanism is one half of the modern definition of society. Fancy that, a society of machines! Yes, the eighth meaning of the word sociotechnical, although it seems to designate an unproblematic industry dominating matter through machines, is the strangest sort of sociotechnical imbroglio. The matter of an outside world is not a given, but a recent historical creation.

7. THE MEGAMACHINE

From where does industry come? If it is not a given that it is the sudden discovery of the objective laws of matter by capitalism, then how can we imagine its genealogy? Through which earlier and more primitive meanings of sociotechnical does it emerge? Lewis Mumford has made, in a series of beautiful books, the intriguing suggestion that megamachines are the templates on which machines were then constructed (Mumford, 1966, 1986). First comes the megamachine, that is, the organization of large numbers of humans through chains of command, deliberate planning, and accounting procedures This change of scale through the imperial machinery of legal commands is what has first to be invented. The local interactions of humans are now extended through the large, stratified, externalized body politic, which can keep track of many nested subprograms of action through the invention of such intellectual techniques as writing, counting, and accounting. According to Mumford, before having any notion of wheels, gears, works, and movements, you first need to have set up the very possibility of a large-scale organization. Large-scale management is the template for large-scale technologies. Then and only then, by substituting some but not all of its subprograms by nonhumans, may you generate machinery and factories, industries and automatons. The nonhumans, in this view, enter the organization and take up the role of obedient servant which has already been rehearsed for centuries by humans enrolled in the imperial megamachine. Nonhumans are the understudies of human servants.

In this seventh episode, the mass of nonhumans assembled into cities by *internalized ecology* (see below) has been brought to bear on empire building. No matter how debatable this hypothesis may be in the history of technology, it fits my little pragmatogony nicely. Before being able to delegate action to nonhumans, and before being able to relate nonhumans to one another in an automaton, you first need to be able to nest many subprograms of action into one another without losing track of them. Management, in a way, always precedes the expansion of material techniques. Or rather, if we want to keep with the logic of my story, every time we learn something about the management of humans, we shift this new knowledge to the nonhumans, endowing them with more and more organizational properties.

This is how we could interpret the even-numbered episodes I have recounted so far: Industry transfers to nonhumans the management of people learned in the imperial megamachine, just as technologies do for the large-scale management learned through networks of power. And if we recapitulate the odd-numbered episodes, we see the opposite process at work: What has been learned from the nonhumans is then reimported to reconfigure people, as that which happens in networks of power and political ecology.

From the vantage point of my mythical pragmatogony, it is easy to understand, I hope, why philosophers, sociologists, and historians of techniques have so much difficulty in defining the terms society, human, technology, and material world that they use with such profusion: Every meaning of these words recapitulates a whole pile of significations borrowed, by crossover, either from the humans or from the nonhumans. They look for pure terms and always find mixed ones. Humans pop up in their definitions of matter, and nonhumans are distributed throughout their definitions of human subjects.

6. INTERNALIZED ECOLOGY

Do not believe that the story stops here, or that we have finally stumbled over pure forms as if the megamachine was made of social relations through and through. No, we have only reached the sixth layer of meaning, and if we turn our attention to what the megamachine itself implies, we discover that an earlier extension of social relations to nonhumans has to be postulated. How can we define domestication and agriculture better than by considering it as the granting of socialness and intimacy to nonhuman actants? I will call this process *internalized ecology*; where so many animals, plants, and materials are submitted to such an intense socialization, re-education, and reconfiguration, that they change shapes, functions, and even genetic makeup (Kent, 1989).

Again, as for the other even-numbered episodes, there is no way to describe domestication as a decisive break from *society* (see below) or as the sudden access to a reserve of fresh proteins, existing out there on an objective and material basis. To enroll—so to speak—those proteins in the emerging collective, one first needs to grant them, through another crossover, some of the social attributes necessary to integrate them. The result of this shift of characters is a human-made landscape (gardens, villages, and cities); a development so radical that it completely changed what is meant by social and material life. To speak of material infrastuctures and of symbolic representations, as in the dualist paradigm I have criticized, is obviously not the best way to talk about domestication, urban life, and gardens.

So profound is this break that we touch here the limits of history and enter the darkness of prehistory. But let us not be afraid. If we want to pursue this genealogy of our relation with nonhumans, we must go on, although the firm grounding, the primitive terms, the Origin we seek is beyond all reason. So! Into the mists of pragmatogony we go one step further.

5. SOCIETY

What is a society, this beginning of all social explanations that so many social scientists take as a given? If my genealogy is even vaguely suggestive, it cannot be a primitive term, because it has itself to be made, to be constructed through the mediation of many *techniques* (see below).

In the Durkheimian interpretation, a society is what precedes individual action, what lasts much longer than any interaction, what dominates us, the reality *in which* we are born, live, and die. Society is this corporate body that is so overarching that it socializes us, the humans, giving us a role, a shape, and a function; yes, it domesticates us by teaching us how to behave and to conform. It is externalized, it is reified, it is more real than ourselves. The origin of all religions and sacred rituals, for Durkheim, are nothing but the return, through figures and myths, of what is transcendant over any individual interaction: society.

And yet we build our society solely through interactions. No matter how many roles and functions we have been disciplined into, we still repair the social fabric out of our own knowledge and ethnomethods. Durkheim may be right, but so is Garfinkel.

According to the reproductive principle of my genealogy, we know that the way to proceed is to look for the nonhumans when we cannot understand the emergence of a social feature, and to look for the state of social relations whenever we cannot understand how a new type of object enters the collective.

Where did we get this idea of a long-lasting society that dominates our interactions and forces us into the roles that we then occupy? Certainly not from society, because that would be falling into the trap of tautology Durkheim set for himself. He claimed that society was sui generis, thus transforming it from a strange animal into a completely mysterious one, more opaque indeed than the religion he tried to explain. Instead, the solution may simply be found in yet another incarnation of the word sociotechnical. We are not alone in our interactions. We also bring the long-lasting influence of all the actions which we, or others, have taken in the past through technical mediation. What Durkheim mistook for the effect of a sui generis social order is simply the effect of having brought so many techniques to bear on our social relations. From them, we learned what it was to last longer, to be spread over space and time, to occupy a role, to be dispatched into a function. By reimporting this competence into the definition of society, we learned how to reify it, to make it stand independently of fast-moving interactions. And indeed, we learned how to delegate to this externalized body even the task of delegating us into roles and functions. Yes, society exists for real, but no, it is not socially constructed. Even in this, the most primitive concept of all social theory, nonhumans proliferate rendering it impossible to recognize a "pure" society.

4. TECHNIQUES

Is it possible to retrace our genealogy still further, even beyond what Durkheim took as his starting point? I want to see how far I can go by maintaining the same principle of alternation: To modify the social we are allowed only to use the nonhumans; and to modify those in turn, we are allowed only to re-employ the competences which have been learned through the commerce of humans. But you see how far back I am in my genealogy, so far indeed that we can no longer talk of humans, of anatomically modern humans, but of highly social *prehumans*. Still, I have to go on because a speculative attempt such as this only has any worth if it is pursued to its extreme consequences.

I am now in a position to define techniques with some precision. A technique is far from being a primitive term. As we learn from archaeologists, techniques imply articulated subprograms of action which are spreading in space and time (Leroi-Gourhan, 1964). In other words, they imply not a society, which is a later hybrid, but some sort of social organization to hold together nonhumans extracted from very different seasons, matters, and places. A bow and arrow, a hammer, a net, a piece of clothing, are made of many different bits and pieces which have to be recombined in a time and space sequence bearing no relation to their natural settings. So, techniques are what happened to tools and nonhuman actants when they were processed by a form of social organization that allowed them to be extracted, recombined, and socialized Even the simplest techniques are sociotechnical. Even at this primitive layer of meaning we cannot separate forms of organization from technical practices.

3. SOCIAL COMPLICATION

But what type of social life can explain such a recombination? Remember that there is no society at this stage, no overarching framework, no dispatcher of roles and functions, and that we only have interactions among prehumans. Shirley Strum and I have called this third layer of meaning *social complication* (Strum & Latour, 1987). Complex interactions are now marked and traced by nonhumans brought to bear on social relations. Why would the enrollment of nonhumans be of any use? Because they can *stabilize* social negotiations. At this stage, nonhumans offer an extraordinary feature: They are at once pliable and durable; they can be shaped very fast, but, once shaped, they last much longer than the interaction that has fabricated them. Social interactions, on the other hand, are extremely labile and transitory. More exactly, they are either negotiable but transient, or, if they are encoded for instance in the genetic makeup, they are extremely durable but impossible to easily renegotiate. By bringing in nonhumans, the contradiction of durability and negotiability is solved. It is now possible to trace interactions, to blackbox them, to recombine highly complicated tasks, to nest subprograms one into another. What was impossible for highly complex social animals to do becomes possible when prehumans transfer the use of tools not to gain access to food, but to trace, fix, underline, and materialize their interactions The social realm, although still made only of interactions, becomes visible and gains some durability through its own tracers.

2. THE BASIC TOOL KIT

But those tools themselves, where do they come from? They are our only witnesses for hundreds of thousands of years. Many archeologists try to go straight from what I will call the *basic tool kit* to techniques as if they were

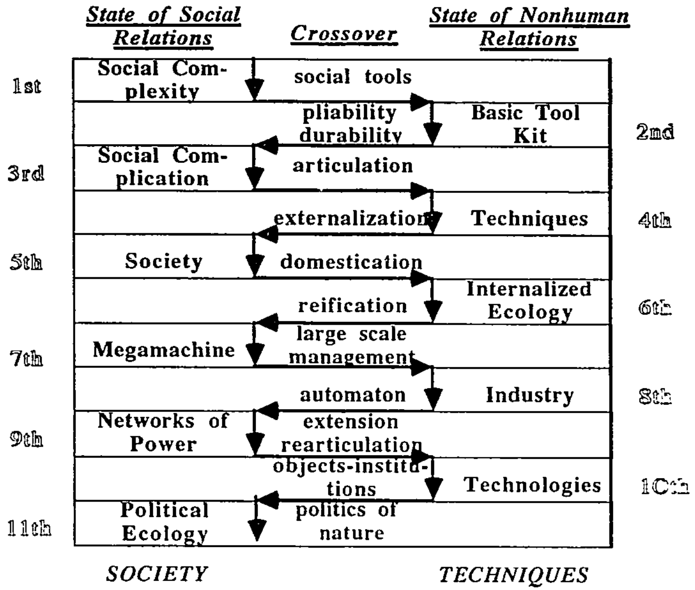

Figure 2: Two opposed spheres of society and techniques are replaced by 11 layers of sociotechnical associations (built in the way described in Figure 1). The most important feature is neither the final result nor the two outside columns but the central one where properties are exchanged.

directly related by a sort of Darwinian evolution of tools into composite tools In the humblest flints some archaeologists are ready to see the first inceptions of techniques, of industry, of technology as if a direct route linked stones and nuclear plants. But look at Figure 2. There is no direct route. It is as if some social theorists wanted to go straight from social complication to society, to megamachines, to networks, as if you could infer from the earliest tool industry the existence of a divison of labor. But there is no direct route in this case either. There are no two parallel histories, the first for the technical infrastructure and the other for the social superstructure, but only one sociotechnical history. There are not two parallel histories, one for the function and the other for the style, one for the material world and the other for symbolic representation. At every stage, according to my pragmatogony, it is through the commerce with nonhumans that the necessary social skills and properties are learned, and it is only by reimporting those skills back to the nonhumans that they are made to do different things and play different roles.

Even the basic tool kit, this epitome of the *Homo faber* myth, cannot be accounted for by a sudden access to objective matter, to the obduracy of stones, straw, and wood. What is a tool, then, in my genealogy? It is the extension of *social* tools to nonhumans! Remember the complex social negotiation that Machiavellian baboons, chimpanzees, gorillas, and vervets are supposed to enter, according to primatologists (Byrne & Whiten, 1988)? They have few techniques, to be sure, but are perfectly able, as Hans Kummer (1993) has shown, to devise social tools through the manipulation and modification of one another in their complex strategies (De Waal, 1982; Strum, 1987). If you grant the prehumans of my own mythology at least the same kind of *social complexity* (see below), you may generate tools simply by shifting this ability, through a crossover, to nonhumans. Just treat pieces of stone and wood as social partners and modify them so that you can act on another. Prehuman tool use, in contrast to the ad hoc use of implements by primates to fulfill a task, would then be the extension of a skill rehearsed in the realm of social interaction. Even the most primitive tools already require some sort of social life, but one which is very different from my earlier episodes (later episodes in terms of the mythical history recounted here).

1. SOCIAL COMPLEXITY

We are now back to the point where I started: to the sitcom of Clairborne, Crook, and Sharman; to the Machiavellian intelligence of primates, engaged in Garfinkelian interactions so as to repair the constantly decaying social order, manipulating one another to survive in groups of many conspecifics who are constantly interfering with one another. We are back to what Strum (1987) calls social complexity. I could go further and show you that even this "primitive term" is no freer from contact with nonhumans than any of the later stages, but I will spare you the rest of my pragmatogony, the rest of this mad pursuit into the logical origin of society and techniques.

BREAKING FREE FROM THE DUALIST PARADIGM

Let me recapitulate our little trip (see Figure 2). Let us consider the meaning of this seemingly dialectical history (which does not rely on any dialectical movement because the contradiction between object and subject is not the engine of its plot). What does it show us?

Even if this very speculative genealogy is entirely false, it shows, at the very least, that it is perfectly possible to imagine an alternative to the dualist paradigm I have criticized so much. We are not forever stuck in the boring alternation between two different substances, one made of objects and matter and the other of subjects and symbols. We are not forever limited to "not only, but also" types of explanation. According to my origin myth, it is impossible even to conceive of an artifact that does not incorporate social relations, or to define a social structure without the integration of nonhumans into it. Every human interaction is sociotechnical.

Second, and more importantly, it is no longer true to say that once we abandon the dichotomy between society and techniques, we are simply faced with a seamless web of factors (Hughes, 1986) in which everything is included in everything else and vice versa, as so many of my critics like to argue (Collins & Yearley, 1992; Schaffer, 1991). On the contrary, the properties of humans and nonhumans cannot be swapped haphazardly. Not only does there exist a strict order in the acquisition of properties, but for each of the layers I have peeled away, the meaning of the word sociotechnical may be clarified by considering the crossover: what has been learned from the nonhumans and reimported back onto the social link, what has been rehearsed in the social realm and exported back to the nonhumans. Nonhumans too have a history. They are not material objects or constraints. Sociotechnical$_1$ is different from sociotechnical$_6$ or sociotechnical$_7$ or sociotechnical$_8$ or sociotechnical$_{11}$. Simply by adding little subscripts we are now able to qualify the meaning of these confusing terms. There is no longer one single big vertical dichotomy between society and techniques, and in its stead we can make many horizontal distinctions between the various meanings of sociotechnical hybrids. It is possible to have our cake and eat it too, that is, to remain monist and still be able to differentiate

Third, it should be clear from Figure 2 that there is a sense, nonetheless, in which the old dualism was right. We do indeed have to alternate between the state of social relations and the state of nonhuman relations, but this is not the same as alternating between humanism and objectivity. The mistake of the dualist paradigm comes from its definition of humanism. The very shape of humans, our very body, is already made in large part of sociotechnical negotiations and artifacts. So, considering the human as that which must be protected against the encroachment of technology, or, symmetrically, considering techniques as efficient material objective forces that have to be purged from the polluted effects of human interests and subjectivity, is tantamount to saying that we want to get rid of our humanity We are sociotechnical animals. We are never limited to social ties. We are never faced with objects. Where should we position humanity, then? Humanity should be positioned in the crossover, in the middle column of Figure 2, as the very possibility of mediating between different mediators.

Fourth, in the pragmatogony I have attempted in this article, I reasoned as if we alternated from the social to the nonhuman repertoire, always through the same move. When we wanted to understand how an object comes to the collective, we looked at what type of social relevance with which it had first to be endowed, and when we wanted to understand how a social interaction could sustain a durable social link, we looked for those nonhumans which could lend their properties so as to render the social order more durable. This meant retracing the creation of a collective by the enrollment of nonhumans. I wanted to demonstrate that it is possible to pay respect to technical mediation without using the dualist paradigm, without inventing those two artifacts, a society, on the one hand, and an objective world, on the other. But *scale* is another feature of that movement. At each of the 11 moves I have retraced, a much larger number of humans are mixed with a much larger number of nonhumans, to the point where, today, the whole planet is internalized in the making of our politics, of our legal system, and, soon, of our morality.

The illusion of modernity was to believe that the more we grew the more distant objectivity and subjectivity would become, thus creating a future radically different from our past. After the paradigm shift in our conception of science and technology, we now know that this will never be the case, indeed that this has *never been* the case. Objectivity and subjectivity are not opposed, they grow together, and they grow irreversibly together, thus breaking the great divide between so-called traditional and modern collectives.

With this pragmatogony, no matter how implausible it might appear, I hope I have convinced the reader, at the very least, that this cannot be done by considering the artifacts with which we share so much of our society as mere things. They deserve better, they deserve to be housed in our intellectual culture as so many fully fledged social actors. They mediate our social action? No, they are *us*.

NOTES

1 See Callon and Latour (1992) and, for a philosophical treatment, see Latour (1993b) For a fascinating critique of the political thrust of the principle of symmetry, see Lee and Brown (1994, this issue)

2. See, for real examples, Strum (1987)

3. For a recent presentation of the various schools of technology studies, see Bijker and Law (1992)

4 For a classical version of this argument, see Winner (1986), for his response to the new symmetrical studies of technology, see Winner (1993)

5. I use the word *collective* as a substantive to mean the tangle (as conventionally understood) of the society (humans-among-themselves) and the objective world (things-in-themselves)

6 This term is borrowed from genetics where it indicates a random reshuffling of genes when chromosomes are duplicatd and then spread apart It is reused here, metaphorically, to indicate an exchange of properties between social and nonsocial entities

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On Interobjectivity

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The Lessons of Simian Societies

The discovery of the social complexity of primate societies other than Homo sapiens, although it was made some 20 years ago, does not yet seem to have been fully taken on board by social theory (De Waal, 1982; Kummer, 1993; Strum, 1987). Violent arguments for or against sociobiology have taken center stage, as if it were necessary to defend the autonomy of the social against the danger of excessive reduction to the biological. In fact, the development of sociobiology, as of ethology, indicates quite another path: the *extension* to animals, even to genes, of classical questions of political philosophy about the definition of the social actor, the possibilities of rational calculation, the existence or not of a social structure standing above the level of interactions, the very definition of interaction, the degree of intelligence necessary for social life, and the role of power and dominance relationships. Far from being displaced from all these questions by a biology presumed triumphant, sociological theory must play its part and must to new ends tackle the problem of the definition of society, extending its comparative base to other than human social lives.[1]

To say that primates other than humans have a rich social life simply means assuming that no primate actor can achieve any goal without *passing through* other interactions with partners. Instead of imagining a presocial being motivated solely by instinct, reactions or appetites and seeking immediate gratification of its goals—assuaging hunger, reproduction, power—the new sociology of simians, on the contrary, depicts actors who cannot attain anything without negotiating at length with others.[2] The simplest case is that of a chimpanzee that does not dare to continue eating at a rich food source it has discovered because the troop is moving on and it cannot stay behind alone. Or again, that of a male baboon that cannot copulate with a female in heat, without first verifying that she will cooperate—a cooperation that had to have been obtained over the course of a period of friendship during times when she was not in estrous. Since each actor's every action is interfered with by others, and since succeeding in one's aims is mediated by continual negotiation, one can talk of this in terms of *complexity*—that is to say in terms of the obligation to take into account a large number of variables at the same time. As described by primatologists, the state of social feverishness, the constant attention to others' actions, the painstaking sociability, Machiavellianism and stress all indicate, then, an

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already complex sociality in the "state of nature."[3] Or, at least, this is the simplified and in part mythical version that can be used as an alternative base line from which to tackle social theory afresh.

Social insects have always served as a means of calibrating models of human sociology. But they offered, at least up until the emergence of sociobiology, the archetypal case of *superorganisms*, in which questions of the individual, interaction, calculation and negotiation could not be posed.[4] The effect of the sociology of primates is quite contrary. It precisely does not permit thinking of the social structure as a superorganism, but only in terms of a chain of interactions. We will find in the state of nature a degree of social complexity that corresponds, more or less, to the forms of sociability described by interactionism. However, there is no language, little technology.[5] It seems that there is not even any representation of self, nor a model of the other,[6] and that the cognitive competencies necessary to bring out this complexity remain very basic. By finding already present "in nature" such a high level of sociability, human sociology finds itself freed from the obligation to found the social, contrary to the hoary tradition in political philosophy and to theories of the social contract. Complex social interaction preceded humanity, and by a long way.

In the sociological literature, social *interaction* presupposes the presence of several constitutive elements. There must be at least two actors; these two actors must be physically copresent; they must be linked by behavior that entails an act of communication; and finally, the behavior of each must evolve as a function of modifications brought to bear on the behavior of the other in such a way that there is an emergence of *unexpected* properties that are more than the sum of the competencies in use by the actors before this interaction.[7] The sociology of simians, in this sense, becomes the limiting case of interactionism, since all the actors are copresent and engage in face to face actions whose dynamic depends continually on the reaction of others. This is a paradise of interactionism; it is a paradise in another sense too, since the question of social order doesn't seem to be able to be posed for simians other than in terms of the progressive composition of dyadic interactions, without any totalizing or structurating effects. Although there are complex interactions, it does not seem that one can say that they live "in" a society, or that they develop a social structure.[8] The question of the exact role of interaction, and its ability to compose *all* society is already posed at the level of primates, and possibly *only* at that level.

The uncertainty of primatologists as to the existence or not of a social structure *beyond* interactions seems to be shared by the monkeys themselves if we grant them the minimal reflexivity needed to be a member and not a "cultural dope" according to Garfinkel's request. For all behavior patterns that presuppose some totalization, primates other than humans have to conduct a series of trials, that need to be ever again begun anew in order to ensure the duration of collective effects. Deciding the direction to be followed by the troop, for example, presupposes an evaluation of the movements of all by all, whence emerges, at the beginning of the day, an order that no one member has given, and that none can claim as their own. The same holds for dominance relationships, which must be put to the test again each time a new event occurs, and for membership relationships, which need to be "repaired" after any, albeit momentaneous, separation. Since the effects of the composition of the social depend on work by individual actors that is continually being started over, one could draw the conclusion that the social life of monkeys is apparently an ethnomethodological paradise.[9] Social construction literally depends solely on the work of the actors themselves to hold things together, and depends crucially on their categories *alone*. Each action is mediated by the action of partners, but to effect this mediation, it is necessary that every actor composes for themselves the totality in which they are situated, a variable totality whose solidity must be reverified each and every time through new trials.

Before there was a significant simian sociology, human sociology made social life begin with humans, or used social insects, even polyps, to demonstrate the universality of forms of aggregation and the ubiquity of superorganisms.[10] But we are now able to count on a chain of complex individual interactions that precedes human sociology. In these interactions, actors have to constantly construct and tend to the collective structures that emerge from their interactions. Society does not begin like Hobbes' with preformed human bodies, with brains capable of calculation, with distinct individuals who choose to agree together through the mythology of the social contract. As far as we can understand through this calibration of our origin stories with the example of primates, the humanization of our bodies and brains was on the contrary shaped by a fine tissue of complex social interactions whose matrix precedes us by several million years. The portmanteau word "socio-biology" has inversed its normal meaning when one takes into account that human life has been immersed for such a long time in a social world, and that we have become physically and intellectually more and more human so as to adapt ourselves better and better to our original environment constituted in a large part by complex sociality.[11]

By allowing us to find already in nature a complex sociality, interactions, individuals and social constructions, simian sociology frees us from the need to make these the province of human sociology alone. Complex social life becomes the shared property of all primates. Just like baboons and chimpanzees, we engage in it, without even thinking, in all our actions. And yet we are neither baboons nor chimpanzees. If the complexity of our social life can no longer suffice to explain this difference, we must find *another source*. For that, we have to understand to what extent the concept of human individual actors engaged in interactions, such as interactionism describes, constructing the social through its own categories that must be regularly tested (the ethnomethodological version) does not account well for most human situations, even though it forms the common basis for our competencies.

Whereas for monkeys it constructs social life step by step, one could say that, for humans, interaction was never more than a *residual category*. Not, as the tenants of the existence of a social structure affirm, because an interaction "takes place in" a society that is greater than it, but quite simply because for an interaction to take place one must first reduce the relationship so that it does not, step by step, mobilize all social life, with which it would otherwise end up being co-extensive. It is only through isolating it by a frame that the agent can interact with another agent, face to face, leaving out the rest of their history as well as their other partners.[12] The very existence of an interaction presupposes a reduction, a prior partitioning. Now how to explain the existence of these frames, partitions, hideaways, fire-doors that are free of contagion from the social? Interactionists are silent about this, merely using the word "frame" metaphorically. Advocates of social structure, the usual opponents of interactionists, cannot explain it any better, since they perceive at all points the total and complete presence of social structure. Now it is just this suspension that one needs to understand, this partial interruption, this cubbyhole within which interaction can be deployed without being interfered with by everyone else. Interactionism's adversaries often reproach it with not being able to compose all of the social—and indeed the very force of interaction lies in its ability to locally and momentarily suspend interference.

That Little "Je ne sais quoi" that Dislocates Interaction

Something prevents human interaction from proliferating *outside* and from being interfered with *inside* by all the other partners. Is this two-way membrane immaterial like a frame (here taken in its metaphorical sense) or material like a partition, a wall, or a framework (here taken in its literal sense)?

In order first to intuitively grasp the answer to this question, one must have seen a troop of some 100 baboons living in the midst of the savannah, looking incessantly at each other so as to know where the troop is going, who is with whom, who is grooming whom, who is attacking or defending whom. Then you must carry yourself away in your imagination to those scenes beloved of interactionists where a few people, most often just two, are interacting in cloistered spots hidden from the view of others. If "hell is other people," as Sartre said, then baboon hell differs from human hell, since the continuous presence of all creates a pressure quite other than that of the closed-doors of interactionism—to such a degree that a distinction must be drawn between two entirely different meanings of the word interaction. The first, as given above (pp. 229, paragraph 2) applies to all primates, including humans, whereas the second applies to humans alone. In order to retain the usual term, it is necessary to talk of *framed interactions*. The only difference between the two derives from the existence of a wall, a partition, an operator of reduction, a "je ne sais quoi" whose origin remains, for the time being, obscure.

There is another difference between simian interaction and what one observes of human interactions. For the latter, it is very difficult to obtain the simultaneity in space and time that are the province of the first. We say, without giving the matter too much thought, that we engage in "face-to-face" interactions. Indeed we do, but the clothing that we are wearing comes from elsewhere and was manufactured a long time ago; the words we use were not formed for this occasion; the walls we have been leaning on were designed by an architect for a client, and constructed by workers—people who are absent today, although their action continues to make itself felt. The very person we are addressing is a product of a history that goes far beyond the framework of our relationship. If one attempted to draw a spatio-temporal map of what is present in the interaction, and to draw up a list of everyone who in one form or another were present, one would not sketch out a well-demarcated frame, but a convoluted network with a multiplicity of highly diverse dates, places and people.[13] Those who believe in social structures often make the same criticism of interactionists, but they draw quite another lesson from it. They suggest that nothing happens in interactions that is not an activation or materialization of what is *already* completely contained elsewhere in the structure, give or take a few minor adjustments. But interaction does more than adjust, it constructs; we learned this from the monkeys as well as from Goffman and from the ethnomethodologists. However, it displays contradictory forms: it is a *framework* (which permits circumscription) and a *network* (which dislocates simultaneity, proximity and personality). Where can those contradictory qualities in humans come from, and why are they so different from interaction as understood by primatologists with respect to naked, co-present monkeys?

It seems impossible to answer this question insofar as one pits interaction against something else, for example social structure, by affirming that the former is local whereas the latter is global. For monkeys, as for example for baboons, this opposition does not hold, since beyond a few dyadic interactions, baboons, just like primatologists, lose trace of interactions and begin to compose the remainder in vaguer terms like "troop," "clan" or "group." It could be rightly said that for baboons social life is composed entirely of individual interactions laid end to end like the successive segments of mechanical solidarity.[14] Interestingly enough, when primatologists go one step further and refer to structure, rank, order, families and caste, they always do this *after* having instrumentalized their observations. This allows them precisely to escape from extreme interactionism through the fabrication of a large number of panoptica and through elaboration, on computers, of a large number of statistical correlations.[15] In doing this they get closer to the human condition, but they doubtless get further away from the manner in which monkeys get to cluster their interactions *without* the benefit of these instruments, panoptica, markers and calculators.

Even though it may not constitute a proof of this, the case of the primatologist's own scientific work constitutes a valuable indication. In order to go from interactions to their sum, you need an instrument, some tool capable of summarizing and summing up. Those who believe in social structures always presuppose the prior existence of that *sui generis* being, society, which is then "manifested" through interactions. Now the only proof that we have for the existence of this being emerges from the impossibility of carrying out a face to face interaction without the immediate arrival with it of a jumble of relationships with other beings from other places and other times. Only the weakness of face-to-face interaction forces the invention of a *framework* defined as that which is always already present in the structure. Now it does not follow from the fact that an interaction presents the contradictory form of a local framework and a network of heterogeneous relationships, that there is thereby a need to leave behind the solid terrain of interactions in order to shift to the "higher level" of society. Even if these two levels really existed, there would be too many steps between them missing. Take the example of dominance relations in male baboons, which quite clearly brings out the flaw in the reasoning here. There are many trials of aggression between males to decide who is strongest. If one wanted in fact to construct an ordered relationship going from the strongest to the weakest, one could not do it except at the price of shortening observation time to a few days![16] But what does it mean to have a hierarchy that fluctuates on a daily basis? How can you say that a baboon has "entered on" or is "ascending a" dominance scale, if that scale has to be recalculated every three days? This probably means that sociology passes too quickly from interaction to structure, in the case of baboons as wells as for humans. Each monkey poses itself the question of knowing who is stronger or weaker than itself, and develops trials that permit it to decide the matter. But as good ethnomethodologists, none uses the concept of rank or hierarchy to do this. The primatologist manages to do so of course, but only with the help of numerous calculations, instruments and graphs. Should we forget the *presence* of this equipment for primatologists and its *absence* for baboons?

There is in all sociological theories a gulf between the (framed) interaction of individual naked bodies and the structural effects that impinge on them in the manner of a transcendent destiny that no one has willed. The question for any theoretician is to decide what social operator best spans this gulf. Is it by means of events induced by interaction itself that would thus transcend the previsions of actors?[17] Can the gulf be spanned by involuntary changes caused by perverse effects emanating from an always bounded rationality?[18] Or through a phenomenon of self-transcendence that brings collective phenomena into play, in the same way as order emerges from chaos?[19] Or do we need to posit a contract, which reduces dispersed actions to a single totalitarian action by a sovereign who is nobody in particular?[20] Or on the contrary, if the gulf cannot be spanned, should we accept the prior existence of a sui generis entity that is always present and which contains interactions like so many specialized cells in an organism?[21] Or again, should we pose that there is between the two extremes a set of intermediaries which permit the transportation into action of the social "field" through the vehicle of the "habitus"; and thus render to structure, by way of individual action, what had been taken from it?[22] There are not very many ways of answering these questions, even if one is allowed to innovate by reworking the small number of available models into new combinations.[23] In any event, these theories presuppose the prior existence of the question that they are seeking to resolve: that there is a yawning gulf separating the agent from structure, the individual from society. Now if there is no gulf, then sociological theory would find itself in the rather odd situation of having tried to provide ever more refined solutions to a non-existent problem.

By setting out before our very eyes the paradise of interactionists and ethnomethodologists, simian sociology demonstrates for us a social life in which interaction and structure are *co-extensive*. There is no framed interaction here, since no relationship is protected from sometimes very rapid contagion from all the others. But neither is there a jot more structure—since each interaction must, locally and on its own account, test all over again the set of relationships without being able to sum, nor to enter into a determined role or function that would hold by itself without the aid of physical bodies. However, monkeys do indeed offer a demonstration of what a *social* society would be—that is to say one conforming to the demands of social theory requiring a passage from the individual to the social "level" by a series of operators that are *themselves* social. But we could not extract from such a group life (framed) interaction or society or agency or structure. All we could get is the impression of an extremely dense and tightly woven but nevertheless plastic and soft tissue that remains always flat. As a consequence, the gulf that, according to sociologists, separates the individual from society is not some primitive given. If we take simian social lives as a partially mythical base line, this abyss remains *invisible*. Something else is needed to have dug it out. Social life, at least in its human form, must depend on something *other* than the social world.

Primatologists attempting to compile structural effects have to instrumentalize their observations with equipment that becomes ever more central to the task at hand. In order to frame an interaction, we need partitions and hideaways. In order to follow an interaction, we need to sketch a quite heterogeneous network that mixes up times, places and actors, and which forces us to ceaselessly traverse the fixed framework. Thus every time that we go from the complex social life of monkeys to our own, we are struck by the multiple causes that at once come into play to dislocate co-presence from social relationships. In passing from the one to the other, we do not go from a simple sociality to a complex one, but we do go from a complex sociality to a *complicated* one. The two adjectives, although they have exactly the same etymology, will allow us to differentiate two relatively different forms of social existence. "Complex" will signify the simultaneous presence in all interactions of a great number of variables, which cannot be treated discretely. "Complicated" will mean the successive presence of discrete variables, which can be treated one by one, and folded into one another in the form of a black box. Complicated is just as different from complex as simple is.[24] The connotations of these two words allow us to fight the evolutionists' prejudices, which always paint a slow progression from monkeys to humans on a scale of increasing complexity. Let us say, to the contrary, that we descend from monkeys to humans, falling from high complexity to high complication. At each point, our social life appears always less complex than that of a baboon, but it is almost always more complicated.

Framed interaction is not local by itself—as if the individual actor, that necessary ingredient for social life with whom one then has to construct the totality, had existed for all time. We will not find that actor amongst the monkeys (who nevertheless live in the paradise, or rather the hell, of interactionism). Amongst humans, on the other hand, an interaction is actively *localized* by a set of partitions, frames, umbrellas, fire-breaks, which permit passage from a situation that is complex to one that is merely complicated. While I am at the counter buying my postage stamps and talking into the speaking grill, I don't have my family, colleagues or bosses breathing down my neck. And, thank heavens, the server doesn't tell me stories about his mother-in-law, or his darlings' teeth. A baboon could not operate such a felicitous channeling. Any other baboon could interfere in any one interaction.

Inversely, structure is not global just by itself, as if it had existed for all time as a sui generis being from whose body individual actor gradually detached itself. We never find among the monkeys (who have no framed interaction) any social structure: the very thing that according to social theory is necessary to balance interactions. For humans, on the other hand, we actively *globalize* successive interactions through use of a set of instruments, tools, accounts, calculations and compilers. These allow us to pass from one complicated and in the end isolatable relationship to other complicated relationships, which are in the end linked to it.[25] In the evening, the post office official can do her accounts and compile summaries that enable an overview of the interesting parts of all the framed interactions that took place at every grill. Baboons cannot calculate such overviews: what is missing is precisely summaries and traces. They only have their bodies with which to compose the social, only their vigilance and the active engagement of their memory to "hold" relationships together.

Since for monkeys there is no difference in kind between interaction and society, there is neither (framed) interaction nor structure. For humans, an abyss seems to separate individual action from the weight of a transcendent society. But this is not an original separation that some social theory concept could span and which might serve to distinguish us radically from other primates. It is an *artifact* created by the forgetting of all practical activities for localizing and globalizing. Neither individual action nor structure are thinkable without the work of *rendering local*—through channeling, partition, focusing, reduction—and without the work of *rendering global*—through instrumentation, compilation, punctualization, amplification. One cannot get anywhere in sociological theory if one is forced to *start* from the substantial existence of either individual action or structure. But, more curiously, one cannot make headway either if, trying to be reasonable, one decides to work simultaneously from the two opposite poles of the actor and the system in order to then work out an intermediary formula for arranging the two.[26] The combination of two artifacts could only produce a third, yet more annoying, one. To take advantage of the comparative basis that simian societies offer us, we don't have to work from interaction or structure or from between the two—but from the work of localization and globalization, which has been up to the present beyond the pale for social theory, which apes and monkeys seem incapable of, and which forces us to have recourse to elements that do not at first sight appear to belong to the social repertoire.

Must Sociology Remain Without an Object?

As against the social interaction of monkeys, the social interaction of humans always appears to be more dislocated. There is no simultaneity nor continuity nor homogeneity. Far from limiting oneself to bodies that are co-present by way of their attention to each other and their continual work of vigilance and construction; for humans one must appeal to other elements, other times, others places and other actors in order to grasp an interaction. Of course for baboons certain relationships can extend over decades and thus demand, in order to be understood, an allusion to past events.[27] But these latter brought to bear other bodies that were present, and are only transported into the current situation by the living memory or the genetic embodiment of those same bodies. For baboons, the social is always woven with the social: hence its lack of durability and the considerable work that is necessary to make it, despite everything, hold together. By contrast, human social life appears to be lopsided. In order to describe this quality, this dislocation, this constant appeal to other elements that are absent form the situation, we often appeal to symbols and the tricky notion of symbolism. Indeed symbols take the place of something else that is not there, but which one can refer to by allusion. Thus the argument goes that the absent structure makes itself felt through symbols. By this means humans distinguish themselves from monkeys, or at least such is the usual line of reasoning. We need, it is said, to supplement primate social links with human symbolic links. However, this hypothesis does not hold, in the literal meaning of the work—for what do symbols hold on to? If the social is not solid enough to make interactions last—as examples from simian societies show—how could signs do the job? How could the brain alone stabilize that which bodies cannot?[28]

In order to get from a complex social life to a complicated one, we need to be able to timeshift, dislocate, make lopsided and delegate the present interaction so as to make it rest provisionally on something else, while waiting to take it up again. But what other thing? On the social itself? Yes, in part, since monkeys do this enthusiastically. The interlacing of interactions certainly offers them that relatively durable matter on which they can in effect base themselves. Could it be based on symbols? This is not very probable, since they in their turn must be held by something other than the memory or the mind or the naked brain of primates. Symbols could not be fundamental. When they are sufficiently sustained, when cognitive capacities are sufficiently instrumentalized heavy enough, then it will be possible to provisionally attach meaning to them, but not before.[29] Why not appeal to something else—to those innumerable objects that are absent for monkeys and omnipresent for humans—whether localizing or globalizing an interaction? How could you conceive of a counter without a speaking grill, a surface, the door, walls, a chair? Do not these, literally, shape the frame of the interaction? How could you compute the daily balance of an office without formulae, receipts, accounts, ledgers—and how can one miss the solidity of the paper, the durability of the ink, the etching of the chips, the shrewdness of staples and the shock of a rubber stamp? Is it not these things that enable totalization? Are not sociologists barking up the wrong tree when constructing the social with the social or patching it up with the symbolic, whilst objects are omnipresent in all the situations in which they are looking for meaning? Why does sociology, in their hands, remain without an object?

It is always difficult to appeal to things in order to explain either durability, extension, solidity and structures or localization, reduction, the framing of interactions. Indeed, for the human sciences, things have become untouchable since, with the exact sciences, they became "objective." After this split, operated in the modern period, between an objective world and a political world, things could not serve as comrades, colleagues, partners, accomplices or associates in the weaving of social life.[30] Objects could only appear in three modes: as invisible and faithful tools, as the determining superstructure and as a projection screen. As tools they faithfully transmit the social intention that traverses them, without taking anything from them or adding anything on to them. As infrastructures, they interconnect and form a continuous material base over which the social world of representations and signs subsequently flows. As screens, they can but reflect social status, and serve as a basis for subtle games of distinction. As a tool, the speaking grill, for instance, would serve only to prevent customers from attacking the staff, and its function goes no further; it does not influence the interaction, only facilitates or hinders it. As an infrastructure, the speaking grill is directly connected to walls, partitions and computers so as to compose a material world that, it is said, completely shapes the remainder of the relationship just as a waffle iron molds a waffle. As a projection screen, the same speaking grill doesn't have any glass or wood or orifice or matter left—it becomes a sign, different from plate glass, barriers, bay windows, landscaped offices and thus signaling a difference in status, or signifying the modernization of public service. Slave, master or substrate of a sign—in each case the objects themselves remain invisible, in each case they are asocial, marginal, impossible to engage in detail in the construction of society.[31]

Do we need to compose the social world with individual actors, or on the contrary begin with a society that is always already there? Do we need to consider objects as determining the social world, or should we, on the contrary, work from interactions alone? These two questions come down to a single one that traces a kind of cross: Structure, Interaction (from top to bottom) and Objective, Social (from left to right). Whence comes then the problem of the actor and the system? From the obligation to choose a point of departure, either in structure or in individual action or from the two extremes at once. But these points of departure *are not primitive*—we learned this from the monkeys, since interaction has to be framed and structure has to be structured, globalized. The point of departure, if there is one, must rather be situated "in the middle," in an action that localizes and globalizes, which dislocates and disperses—an action that simian societies seem to be able to do without. However, in order to situate this locus, we need to be able to share the social with things, which seems equally undoable—not because of the abyss that separates the actor from the system, but because of the no less significant break that separates the objective world from the political world, the exact from the human sciences, nature from culture. As a result of this break, objects cannot irrupt into the social world without denaturing it.[32] And, symmetrically of course, society cannot invade the sciences without corrupting them.[33] One can understand the dilemmas of sociology since it is faced with finding its essential resource at the pit of this double abyss, this double impossibility. It is because it is stretched horizontally between the objective and politics that sociology has no place for things. And *therefore* it finds itself torn vertically between the actor and the system. Forgetting artifacts (in the sense of things) has meant the creation of that other artifact (in the sense of illusion): a society that has to be held in place with just the social. However, the operator, exchanger, agitator, and animator that is capable of both localizing and globalizing sits right in the center of this cross. It can weave the properties of objects with those of the social. But what is it?

Too often sociology remains without an object. Like many human sciences, it has constructed itself so as to resist attachment to objects, which it calls fetishes. It has taken the ancient admonition of the prophets against gods, merchandise, consumer goods and objets d'art to heart: "Idols have eyes and yet do not see, mouths and yet do not speak, ears and yet do not hear." According to them something else animates these lifeless bodies, dead statues: our belief, the social life that we project onto them. The fetishes do not count for anything in themselves. They are merely a projection screen. However, they do indeed add something else to the society that manipulates them: objectification. Like so many overhead retroprojectors, these idols reverse the sense of action—leaving the poor humans who have given them everything they have the impression that their force comes from them alone, and that it is this force that renders humans impotent, which makes them act, which alienates them. The human sciences have for a long time been trying to reverse this reversal. Through a retroprojection symmetrical with the first, they reveal the labor of humans and their multiple animation in the lifeless body of the fetish.[34] The deontology of sociologists demands this anti-fetishism of them. Thus it is clear why reintroducing the objects, speaking again of the weight of things, according inanimate beings real social forces is for them an error: the error of returning to objectivism, naturalism, or belief. However, we cannot make a place for objects without modifying the deontology of the social sciences, and without accepting a certain dose of fetishism.[35] Objects do *do* something, they are not merely the screens or the retroprojectors of our social life. Their sole function is not merely to "launder" the social origin of the forces that we project onto them.

If we want to give a role back to objects in this manufacturing of the social link, then we must of course also abandon anti-fetishist reflexes, just as we must abandon the other role given by the human sciences to objects—the objectivity of natural forces—as well. Everything seems to lead to a position where sociology oscillates between two definitions of the object: the "bad object" or the fetish and the "good object" or the force. The former must be fought by showing that it is nothing but a substrate, an inverter, a dissimulator of beliefs. The latter must be discovered, through the application of appropriate methods, underneath the beliefs, opinions, passions and activity of humans. With these two roles for the object, the human sciences critique popular belief and seek to imitate (what they imagine to be) the natural sciences.[36] Sociology has for a long time alternated between these two roles for the object—neither of which permit it to become a complete social actor. Either objects do nothing except deceive or they do too much. Either they are totally manipulated by humans; or it is them, on the contrary, which manipulate unsuspecting humans. Either they are caused or they cause. "Ordinary" actors are always taken by surprise, whether believing in fetishes or thinking themselves free. In both cases, the science of sociology reveals the actors' peregrinations, and traps them between "bad objects" that they falsely believe in and "good objects" that make them act despite themselves. Critical sociology has been fed for centuries by scientism on the one hand and the denunciation of fetishism on the other.[37]

Toolmaking, constructing the social, acting, interacting, localizing, globalizing, determining, constraining—all these verbs rest not only on a certain model of the individual or collective, human or non-human actor but also on the definition of *action*. If it seems impossible to give objects that remain simply "objective" their place in society, it seems even more difficult to integrate them as the mere fabrication of an all powerful actor. In order to render them usable by sociological theory we must modify on the one hand the objective nature of objects and on the other hand the concept of action. Now normal anthropological usage presupposes in action a "making-be" for which it induces, by extension, a *subject* with appropriate competencies and an *object*, which thanks to the actor has now gone from potentiality to actuality. Nothing in this schema seems to be reusable by a social theory interested in sharing sociality with things. Indeed action cannot be the point of origin except at the price of *stopping* the circulation, or the series of transformations whose movement continually traces the social body. The competencies of the actor will be inferred *after* a process of attribution, pause, abutment or focusing. These must not be confused with the idea that the actor acts, as if actualizing some potentiality. But neither the concept of transformation, nor that of circulation can, without being altered, replace the idea of an action with a point of origin. In order to amend them, we need to consider any point as being a mediation, that is to say, as an *event*, which cannot be defined in terms of inputs and outputs or causes or consequences. The idea of mediation or event enables us to retain the only two characteristics of action that are useful, i.e., the emergence of novelty together with the impossibility of ex-nihilo creation, without in the process conserving anything of the Western anthropological schema that always forces the recognition of a subject and an object, a competence and a performance, a potentiality and an actuality.

The normal theory of the actor is no more salvageable than that of action. As soon as one affirms that an actor, whether individual or collective, cannot be the point of origin of action, then it seems that actors must be immediately dissolved into fields of force. Now to act is to be perpetually overtaken by what one does. "Faire c'est faire." To do is to make happen. When one acts, others proceed to action. It follows that one can never reduce or dissolve an actor into a field of forces, or into a structure.[38] One can only share in the action, distribute it with other actants.[39] This is as true for its manufacture, as for its manipulation. It is a tired old joke against sociologists to pretend that their actors are like puppets in the hands of "social forces." This is a very good example, but it proves the exact contrary of what is generally supposed. If you talk with a puppeteer, then you will find that he is perpetually surprised by his puppets. He makes the puppet do things that cannot be reduced to his action, and which he does not have the skill to do, even potentially. Is this fetishism? No, it is simply a recognition of the fact that we are *exceeded* by what we create. To act is to mediate another's action. But what holds upstream for manufacture also holds downstream for manipulation. Let us suppose that something else is, metaphorically, pulling the strings of our puppeteer—a social actor, the "artistic field," the "spirit of the times," the "epoch," "society" and so forth. This new actant, behind him, can no more master him than he can in turn master the puppet. One can only associate mediators, no one of which, ever, is exactly the cause or the consequence of its associates. Thus it is not the case that there are actors on the one side and fields of forces on the other. There are only actors—actants—any one of which can only "proceed to action" by association with others who may surprise or exceed him/her/it.

How difficult social theory is! Social complexity, once the province of humanity, is now to be shared with other primates, and thus its evolution must be traced over millions of years. Interaction cannot serve as the point of departure, since for humans it is always situated in a framework that is always erased by networks going over in all directions. As for the opposite pole, that famous so-called sui generis society, it only holds together through heterogenesis, and it seems rather to be the ever provisional point of arrival of compilation and summation work that requires a lot of equipment, and weighty tools. The new cognitive capacities owe their extension less to the powers of symbols than to those of the instruments that hold them. It is impossible to work from a—collective or individual—actor, since the attribution of a skill to an actant always follows the realization by that actor of what it can do when others than itself have proceeded to action. Even the everyday usage of "action" cannot serve here, since it presupposes a point of origin and a transport of force, both of which are completely improbable. Not action, nor the actor, nor interaction, nor the individual, nor the symbol, nor the system, nor society, nor their numerous combinations can be redeployed. There is nothing astonishing in this, since sociological theory (no more than physics or geology can) should not expect to find the terms that it needs in everyday usage—above all if, ceasing to be modernist, it reverses the Great Divide and takes responsibility for the "social life of things." Follow the actors themselves, is the slogan of our sociology; indeed, but it is not said *how* to follow them.

From the Study of the Soul of Society to that of its Body

Monkeys almost never engage with objects in their interactions. For humans it is almost impossible to find an interaction that does not make some appeal to technics.[40] Interactions can proliferate for monkeys, calling into play, gradually, the whole troop. Human interaction is most often localized, framed, held in check. By what? By the frame, precisely, which is made up of non-human actors. Do we need to appeal to determination by material forces or to the power of structure to go from interaction to its framework? No, we simply transport ourselves to the places and times where the frame has been conceived and built. The example of the counter will once again serve to elucidate this point. If we let our attention slide from the interaction that is provisionally holding us together, the post-office worker and I, across to the walls, the speaking grill, the rules and formulae then we need to go elsewhere. We do not suddenly land in "society" or in the "administration." We circulate smoothly from the offices of the post office's architect, where the counter model was sketched and the flux of users modeled. My interaction with the worker was anticipated there, statistically, years before—and the way in which I leaned on the counter, sprayed saliva, filled in forms, was anticipated by ergonomists and inscribed in the agency of the post office. Of course they didn't see me standing there in the flesh, any more than they saw the worker. But it would be a serious mistake to say that I was not there. I was inscribed there as a category of user, and today I have just carried out this role and have actualized the variable with my own body. Thus I am indeed connected from the post office to the architect by a slender but solid thread that makes me go from being a personal body in interaction with a worker to a type of user represented on a blueprint. Inversely, the framework sketched out years ago remains, through the intervention of Portuguese workers, concrete, carpenters and fiberglass, the framework that holds, limits, channels and authorizes my conversation with the post office worker. As soon as the objects are added in, it will be seen that we must get used to circulating in time, in space, across levels of materialization—without ever coming across familiar landscapes nor face to face interaction nor some social structure that, it is said, makes us act.[41] Nor, of course, do we encounter the yet more familiar and murky landscape of attempted compromises between these two models of action.

The interactionists are right when they say that we should never leave interactions—but if one follows human interactions then one never stays in the same place, nor ever in the presence of the same actors and never in the same temporal sequence. Herein lies the complete mystery that made their adversaries say that they did not take "structural effects" or "the macro" into account. By dislocating interaction so as to associate ourselves with non-humans, we can endure beyond the present, in a matter other than our body, and we can interact at a distance, which it is difficult for a baboon or a chimpanzee to do. As a common shepherd all I have to do is delegate to a wooden fence the task of containing my flock—then I can just go to sleep with my dog beside me. Who is acting while I am asleep? Me, the carpenters, and the fence. Am I expressed in this fence as if I had actualized outside of myself a competence that I possessed in potential form? Not in the slightest. The fence doesn't look at all like me. It is not an extension of my arms or of my dog. It is completely beyond me. It is an actant in its own right. Did it appear all of a sudden out of objective matter ready to crush my poor fragile, sleepy body with its material constraints? No, I went folding myself into it precisely because it did not have the same durability, duration, plasticity, temporality—in short the same ontology—as me. By folding myself into it, I was able to slip from a complex relationship that demanded my continual vigilance to a merely complicated relationship that didn't demand any more of me than to padlock the gate. Are the sheep interacting with me when they bump their muzzles against the rough pine planks? Yes, but they are interacting with a me that is, thanks to the fence, disengaged, delegated, translated and multiplied. There is indeed a complete actor who is henceforth added to the social world of sheep, although it is one that has characteristics totally different from those of bodies. Any time an interaction has temporal and spatial extension, it is because one has shared it with non-humans.[42]

If we want to analyze not only baboon but also human societies, then we must hear the word *inter*action differently. This expression does not only signify that in all points of society action remains local, and that it always surprises those who engage in it. It signifies that action must be *shared* with other kinds of actants dispersed in other spatio-temporal frameworks and who exhibit other kinds of ontology. At time t, I find myself in contact with beings who have acted at $t-1$, and I fold the situations together so that I myself will act under another form at $t+1$. In situation s, I find myself attached to situations $s-1$, and I act such that downstream situations $s+1$ come to be associated with mine. On top of this disengagement, this dislocation in time and in space, interaction operates an *actantial* shifting-out.[43] Any ego chosen as the reference point finds itself pre-inscribed by the set of egos available to it in the diversified form of durable things. None of these distances proves the existence of another "level," or of a social structure. We always go from one point to another. We never get away from interaction. But this latter forces us to follow numerous instances of shifting out. How can an actor endure in the midst of this diversity? Through the work of narrative creation that permits an "I" to hold together over time.[44] How is this narrative construction itself maintained? By the body, by that old basis of primate sociality that renders our bodies skillful in maintaining interactions.

If interactions are framed by other actants dispersed in space and time, attempts to aggregate are no less so. The life of Parisians, for example, is perhaps made up only of successive interactions, but we should not forget the multiple panoptica that strive each day to sum up Parisian life. Control rooms that manage traffic lights; panels at all points of the water distribution network; huge synoptic tableaux allowing French electricity board officials to calculate down to the second the end of a film being broadcast on Channel First; computers calculating the routes and loads of garbage trucks; sensors permitting a count of the number of visitors to a museum. In a single day and from a single person many small "I"s are collected—statistical "I"s because she has used her car, flushed her toilet, turned off her television set, put out her rubbish bin or visited the Orsay museum. For all that, do those who have collected, compiled and computed constitute a social structure above her? By no means. They work in control rooms that are themselves just as localized, just as blind, just as framed as that person is at any moment of her day. How then can they sum up? In the same way that that person can limit herself at any instant to an interaction. Because sensors, counters, radio signals, computers, listings, formulae, scales, circuit-breakers, servo-mechanisms need to be added in; it is these that permit the link to be made between one place and another, distant, one (at the price of installing some costly equipment). You can't make a social structure without this compilation work. However, you can explain structuration *effects* with it. Thousands of people in Paris strive to locally structure Parisians—each using their own equipment and their own categories. This is the profound truth of ethnomethodology. All that remains is to restore to it what it had itself forgotten: the *means* of constructing the social world.

If you set yourself the task of following practices, objects and instruments, you never again cross that abrupt threshold that should appear, according to earlier theory, between the level of "face-to-face" interaction and that of the social structure; between the "micro" and the "macro." The work of localization, like that of globalization, is always carried out by bodies in times and places far apart from others. Sometimes it is a question of, at great cost, constructing continuity in time for an individual actor; sometimes summarizing, at great cost, the interactions of a more or less large number of actors. You do not have to choose your level of analysis at any given moment: just the direction of your effort and the amount you are willing to spend. Either you can, intensively, know much about little, or, extensively, little about much. Social worlds remain flat at all points, without there being any folding that might permit a passage from the "micro" to the "macro."[45] For example the traffic control room for Paris buses does indeed dominate the multiplicity of buses, but it would not know how to constitute a structure "above" the interactions of the bus drivers. It is *added* on to those interactions. The old difference of levels comes merely from overlooking the material connections that permit one place to be linked to others and from belief in purely face-to-face interactions.

In founding sociology, believers in social structure immediately denied it the practical means of understanding localization and globalization, the shifting out of an individual actor as well as the knitting together of interactions. Or rather, they all saw that it was essential, in order to distinguish ourselves from monkeys, to take material means—things—into account. But they treated these means as mere intermediaries, as mere transfers of a force which had to come from another source—from a sui generis society or from aggregated individual rational humans. This relative contempt for means was exercised three times: firstly on machines, then on control technology, and finally on intellectual technologies. They imagined that at root we were monkeys to which had been added by a simple prosthesis, buildings, computers, formulae or steam engines. However, objects are not means, but rather mediators—just as all other actants are. They do not transmit our force faithfully, any more then we are faithful messengers of theirs. By picturing a social society which had found a material body by chance, they once again exercised, despite their will to be materialist a new form of spiritualism. In speaking of the social body they only spoke in fact about its *soul*. They took humans for monkeys surrounded by things. In order to deal with the social *body* as a body, we need: a) to treat things as social facts; b) to replace the two symmetrical illusions of interaction and society with an exchange of properties between human and non-human actants; c) to empirically follow the work of localizing and globalizing.

Notes

The current version of this paper was translated by Geoffrey Bowker. I also thank him for his efforts in making my social theory less idiosyncratic. A shorter version of this paper has appeared in French: (1994). Une sociologie sans objet? Note théorique sur l'interobjectivité. *Sociologie du travail*, 36(4), 587-607. This article owes a lot to a long collaboration with Shirley Strum and Michel Callon. The baboons of the former and the actor networks of the latter people each page.

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[1] For a first attempt, see Latour and Strum (1986).

[2] See the numerous descriptions of "diffracted" interactions in Strum (1987) and Cheney and Seyfarth (1990).

[3] The expression "Machiavelian intelligence" comes from Byrne and Whiten (1988).

[4] The comparison between Wilson (1971), who still uses the concept of superorganism and Wilson (1975), who does not use it any more is a good marker of the turn in sociobiology that calls for the composition of groups of bodies or ants through individual actions. The assimilation of a body to a marketplace may shock, but it does usefully dispense with metaphors of the social body that we have used profusely since the Roman fable of the "stomach and the organs."

[5] This is the case at least in baboons. The situation is much more complicated with chimpanzees. See McGrew (1992).

[6] This is a disputed question in Cheney and Seyfarth (1990) and Dennett (1987, p. 237).

[7] Such have been the specifications of interaction since at least Goffman (1959).

[8] On this controversial question see Strum and Latour (1987).

[9] See, for instance, the now classic rendering of Heritage (1984).

[10] See the fascinating organicist, or rather sociobiological, metaphors in Durkheim (1984).

[11] This is the meaning of "Machiavellian intelligence": an intelligence born as a secondary adaptation to the hard conditions of social life (Byrne & Whitten, 1988).

[12] See Goffman (1974) for the notion of frame taken as a metaphor of social focusing. It will be taken here also in its literal meaning.

[13] For the dislocation of interaction as soon as one tries to designate the precise network it sketches, see Law (1992) and above all his latest book (1993).

[14] In the classical definition provided by Durkheim.

[15] Few primatologists would accept this way of presenting their work, since they use the same sociological theory for themselves as for their favored subjects. The work of scientific construction is absent from their description. It only becomes visible when certain results from the sociology of science are accepted. For an introduction, see Latour (1987). For a discussion of the advantages of reflexive sociology for the case of dominance relations see Strum (1987).

[16] See Strum (1982). One cannot calculate stable dominance relationships for baboons except for females whose relationships can last several decades. See Fedigan (1982) for a general discussion and Haraway (1989) for the ideological environment of all those debates.

[17] Such is the claim of interactionism (Goffman, 1959) and of symbolic interactionism more generally.

[18] This is the claim of methodological individualism whose most extreme militant expression can be found in Boudon (1992).

[19] See Dupuy (1992), who is using self-organization as the main biological metaphor instead of economics, as is the case of most sociobiology.

[20] As in the powerful metaphor of the social contract of Hobbes (1651/1961).

[21] See Durkheim (1984).

[22] This is of course the solution of Bourdieu (1972; Bourdieu & Wacquant, 1992), which allows him to criticize both types of social theory by using *habitus* as the dialectical operator in the middle.

[23] The rich diversity of these positions is omitted here in order to bring out the common pattern of their reasoning, which necessitates posing first the "problem" of social order and of the individual. See Latour and Strum (1986) for a classificatory principle for these models.

[24] I am here summarizing the main argument of Strum and Latour (1987).

[25] On this theme, which entails considering most structural effects as the performative result of practices of writing and instrumentation, taken widely, see, of course Goody (1977). For science see Latour and De Noblet (1985), and for accounting, Power (1995). For the case of State statistics see Desrosières (1993) and Porter (1995).

[26] This is the limiting case of dialectical solutions like that of Bourdieu's habitus or more recently Friedberg (1993). The dialectic is always impotent in that it hides a problem that needs resolving under the pretense of "overpassing" it; it is even more troubling when trying to overpass an artificial contradiction.

[27] See Strum's article in Latour and Lemonnier (1994).

[28] This argument has taken a new weight from the recent refoundation of cognitive anthropology by Ed Hutchins (1995) since his theory of dissemination of representational states through different media does not require the symbolic definition of symbolism.

[29] Human societies do not permit a study of "naked" cognitive capacities any more than they permit an analysis of a primitive complex social life. It is impossible to study the intellect without looking at "intellectual technologies." See the works of Don Norman (1993), Ed Hutchins (1995), Jean Lave (1988), and those of sociologists of science (see a beautiful recent example in Goodwin [1995]).

[30] I am using here the symmetric anthropology argument made in Latour (1993). The situation is changing rapidly with the end of modernity, thanks to the two pronged attack of the sociology of techniques on the one hand (see, for instance, Bijker and Law, 1992) , and on the other, the reobjectification of economics (see Appadurai, 1986, and more recently, Thomas, 1991). The comparative anthropology of technology is also evolving rapidly; see an excellent state of the art example in Lemonnier (1993).

[31] The debate in archeology between form and function used to reflect this state of affairs. For a recapitulation of the arguments and their recent evolution, see Latour and Lemonnier (1994).

[32] To get an idea of the horror triggered by this position even in smart sociologists, see Collins and Yearley (1992).

[33] This is the classical epistemological position that has been dismantled by science studies, but which makes people believe that science studies are "anti-science" whereas they have, in effect, depoliticized the sciences from the obligation of holding the moral order.

[34] One can recognize here the mechanisms studied by Marx for the economy and Durkheim for religion, which were popularized by Bourdieu for all objects to which common sense could in error become attached. See in particular Bourdieu and Wacquant (1992) for the deontology of the "profession of sociologists." For a partial retort, see Hennion and Latour (1993).

[35] The job of fetishes is precisely to render the two meanings of the word fact compatible: what is fabricated, and what is true. By using the notion of fetish we are forced to always ask our questions as a contradiction: Is it fabricated? or is it true?

[36] The irruption of the sociology of science completely changed this obligation to imitate the exact sciences, since the latter no longer resemble the myths developed by epistemology. On the contrary, since they produce new non-humans to construct the collective with, the sciences become once again imitable, but they are too mixed up with the social sciences to be able to be ordered in a hierarchy with them. They become imitable in their subject matter, not in their form, and, of course, not in their epistemology.

[37] On the recent shift between critical sociology and the sociology of criticism see Boltanski & Thévenot (1991).

[38] The weakness of structuralism is to have sought rules beyond appearances, and to have imagined that some entity could simply "occupy a position" whereas it perpetually recreates one around itself, that it mediates. Hence, the opposition that proved fatal to this system of thought between a subject and the "death of the subject" dissolved into a field of forces (Dosse, 1991, 1995). But there are no subjects to dissolve, nor are there any fields of force to dissolve subjects in, since there exist no transport of force. There are only translations.

[39] The word "actant," which comes from semiology, permits widening the social question to all beings who interact in an association and who exchange their own properties, but it has its own defect. For a critique, see Latour, 1996.

[40] I am using the word here to refer to a modus operandi, where "artifact" or "object" designate the outcome of that operation.

[41] This position has been taken in practice by the work of many symbolic interactionists. See Star (1989 & 1995), especially her notion of boundary objects. What the present theoretical note does is simply to take away the notion of interaction and that of symbolism!

[42] See Latour (1994) on this example and the theory of the social that goes with it.

[43] Semiotics recognizes three kinds of shifting out: in time, in space, and in a new actant. One example is a story that begins with: "Once upon a time, in fairyland, a dwarf was one day walking calmly along. . . ." The notion of shifting out has the advantage of helping us to do away with the idea that technology is "efficient action on matter."

[44] The work necessary to produce the continuity of an ego is especially visible in the narrative theories of Ricoeur (1990).

[45] For the necessity of not choosing a scale to go from the micro to the macro in order to understand relative differences in size, see Callon and Latour (1981).

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LA FIN DES MOYENS

Bruno LATOUR

On admet volontiers que les humains se posent des problèmes moraux « à propos » des techniques (faut-il ou non introduire en Europe les organismes génétiquement modifiés ? Doit-on entreposer les déchets de l'industrie nucléaire en profondeur ou en surface ?) mais les objets en eux-mêmes ne possèdent pas une dimension morale. Telle est la conception courante pour un grand nombre de sociologues[1]. Les techniques appartiennent au règne des moyens et la morale au règne des fins, même si, comme Jacques Ellul en a témoigné il y a bien longtemps, certaines techniques finissent par envahir tout l'horizon des fins en se donnant à elles-mêmes leurs propre lois, en devenant « auto-nomes » et non plus seulement automatiques. Même dans ce cas extrême, affirme-t-on, il n'y a pas d'autre ressource, pour les humains, que de s'extraire de cette domination des techniques, domination d'autant plus perverse qu'elle n'impose pas la dure loi d'un maître mais celle d'un esclave émancipé qui n'a pas la moindre idée des buts moraux propres à l'humain. On sait tout le parti que les Heideggeriens ont tiré de cette idée d'une technique qu'on ne pouvait pas maîtriser puisqu'elle était elle-même pure maîtrise sans maître[2]. Pour redevenir moral et humain, il faut toujours, semble-t-il, s'arracher à l'ustensilité, réaffirmer le règne des fins, redécouvrir l'Etre, bref, aller rattacher dans sa niche le molosse de la technique.

Il n'est pourtant pas si sûr que l'on puisse répartir aussi facilement les moyens et les fins, les transports de force et les rapports de raison, les simples objets et la dimension proprement humaine, l'oubli et le surgissement de l'Etre. C'est à douter de cette distinction que je me suis longtemps efforcé. Certains collègues, sociologues, philosophes ou moralistes, m'ont d'ailleurs reproché d'avoir de ce fait mélangé le rapport moral que les humains doivent entretenir entre eux avec le rapport matériel ou fonctionnel que les objets techniques exercent les uns sur les autres par un transport de force[3]. Pourtant, il suffit de jeter un rapide coup d'œil sur le

1 COLLINS et KUSCH, 1998.
2. ZIMMERMANN, 1990.
3. COLLINS et YEARLEY, 1992.

travail des paléontologues et des préhistoriens pour constater que la question de l'émergence des techniques et celle de l'humain se trouvent mélangées, d'après eux, depuis quelque deux millions et demi d'années[4]. On commence maintenant, après les travaux pionniers sur les « industries » de chimpanzés, à découvrir de longues périodes de la préhistoire où l'habileté technique précède la montée des lignées humaines de centaines de milliers d'années. Il semble de plus en plus que les humains se soient développés dans un nid ou dans une niche peuplés déjà d'habiletés, de savoir-faire et d'objets techniques[5]. Si l'outil, pas plus que le rire, n'est le propre de l'homme, il va devenir de plus en plus difficile de tracer la frontière entre l'empire humain et le royaume des techniques. En tous cas, l'image d'un humain aux commandes manipulant des objets inertes en vue de fins conçus par lui par l'intermédiaire « d'une action efficace sur la matière » se trouve de plus en plus brouillée. Les techniques habitent l'humain selon de toutes autres formes que l'ustensilité, l'efficacité ou la matérialité. Un être que l'on aurait arraché artificiellement à cette demeure, à ce berceau technique, ne pourrait en aucun cas être moral, puisqu'il aurait cessé d'être humain – et d'ailleurs, il aurait cessé depuis longtemps d'être. Techniques et moralités se trouvent indissolublement mélangées parce que, dans les deux cas, la question du rapport des fins et des moyens s'y trouve profondément obscurcie. C'est ce que je souhaite démontrer.

Comment faire pour donner à la technique une dignité égale à celle de la morale afin d'établir ensuite entre les deux un rapport qui ne soit plus celui de l'outillage à l'intention ? En redéfinissant d'abord la technique que je prendrai ici pour un adjectif et non pour un substantif[6]. Il est vain de vouloir définir certaines entités ou certaines situations comme techniques par opposition à d'autres appelées scientifiques ou morales, politiques ou économiques. Il y a de la technique partout, puisque le mot technique se dit d'un régime d'énonciation ou, pour le formuler autrement, d'un mode d'existence, d'une forme particulière d'exploration de l'être – au milieu de beaucoup d'autres. Si l'on ne peut pas distinguer un objet technique d'un autre qui ne le serait pas, on doit pouvoir néanmoins séparer dans une entité quelconque sa dimension technique. Le régime technique, si l'on veut, diffère d'une autre prise (scientifique, artistique ou morale) non pas comme un canton de la réalité différerait d'un autre mais comme une préposition

4. LATOUR et LEMONNIER, 1994.
5. Voir par exemple STRUM et FEDIGAN, 2000 ainsi que les travaux de Frédéric Joulian.
6. LATOUR, 1999a.

d'une autre, comme « dans » se distingue parfaitement du mot « par », bien qu'il n'existe pas un domaine particulier du « dans » que l'on pourrait séparer d'un territoire du « par ». J'aurais envie de définir le régime propre à la technique par la notion de pli, sans lui donner toutes les connotations leibniziennes si bien élaborées par Gilles Deleuze.

Qu'est-ce qui est plié dans l'action technique ? Le temps, l'espace et le type d'actants. Le marteau que je trouve sur mon atelier n'est pas contemporain de mon action d'aujourd'hui : il garde plissés les temps hétérogènes dont l'un a l'ancienneté de la planète, à cause du minerai qui a servi à le fondre, dont l'autre a l'âge du chêne qui a donné le manche, et dont un autre encore renvoie aux dix années passées depuis qu'il est sorti de l'usine allemande qui l'a mis sur le marché. Quand je saisis le manche, j'insère mon geste dans « un bouquet de temps », selon l'expression de Michel Serres, qui me permet de m'insérer moi-même dans des temporalités variées, dans des différentiels de temps, ce qui explique (ou plutôt implique) la solidité relative souvent associée à l'action technique. Ce qui est vrai du temps l'est aussi de l'espace, car cet humble marteau maintient en place des lieux tout à fait hétérogènes et que rien, avant l'acte technique, ne permettait de rassembler : les forêts d'Ardennes, les mines de la Ruhr, l'usine allemande, le camion d'outillage qui propose des discounts chaque mercredi sur les routes du Bourbonnais pour finir par cet atelier d'un bricoleur du dimanche particulièrement maladroit. Toute technique ressemble à ce que les surréalistes appelaient un « cadavre exquis ». Si nous devions, par intention pédagogique, inverser le mouvement du film dont ce marteau n'est que la terminaison, nous devrions déployer des temps lointains et des espaces dispersés, toujours plus nombreux : l'ampleur, la dimension, la surprise des connections aujourd'hui invisibles qui seraient alors rendues manifestes, nous donneraient par contraste l'exacte mesure de ce que ce marteau, aujourd'hui, fait. Rien de moins local, de moins contemporain, de moins brutal qu'un marteau, dès que l'on se met à déplier ce qu'il agence ; rien de plus local, brutal et durable que ce même marteau, dès que l'on replie tout ce qu'il a impliqué.

Mais la simple distance des lieux et des temps ne suffit pas à définir le pliage proprement technique : encore faut-il spécifier la connexion elle-même. Comment garder la trace irréversible de ce pli ? Par un troisième déhanchement, par une troisième dislocation, par une nouvelle hétérogénéité qui va modifier, cette fois-ci, non plus la diversité des temps ni celle des lieux, mais celle des acteurs ou des actants. Sans le marteau je n'aurais, pour enfoncer le clou, que mon poing ou quelque caillou ramassé devant ma porte – et sans le clou, je serais encore bien plus démuni. Par la misère même où je me trouve quand je suis privé de marteau (qu'on se souvienne du bonheur de Crusoé découvrant l'outillage des caisses rejetées par le naufrage), je mesure les êtres dont ce marteau prend la place. Il remplace d'abord la longue série paradigmatique que les technologues ont eu à cœur de recréer, et qui définirait à travers l'histoire tous les substituts possibles de ce marteau-ci[7]. Aux lieux et aux temps invisibles qu'il faudrait déployer afin de rendre justice à ce marteau, nous devrions donc ajouter, si les historiens, les préhistoriens, les paléontologues et les primatologues nous y autorisaient, la stupéfiante variété des formes dont a hérité mon banal marteau. Mais il prend place encore dans une autre série, syntagmatique cette fois, puisqu'il offre à mon poing une force, une direction, une tenue que le bras maladroit ne se savait pas posséder.

Impossible ici de faire comme si le marteau « remplissait une fonction » car il déborde de toute part ce récipient dans les strictes limites duquel il ne saurait se cantonner. C'est de tous les outils (et surtout du marteau) qu'il faut dire que « l'organe crée la fonction ». Avec lui en main, les possibles se multiplient, offrant à celui qui le tient des schèmes d'action qui ne précédaient pas la saisie. C'est ce que James Gibson a si bien documenté avec la notion-clé de « promission » (*affordance*), à la fois permission et promesse : grâce au marteau me voici littéralement un autre homme, un homme devenu « autre » puisque je passe dorénavant par l'altérité, l'altération de ce plissage[8]. Voilà pourquoi le thème de l'outil « prolongation des organes » a si peu de sens. Celui qui croit que les outils sont de simples ustensiles n'a jamais tenu un marteau en main, n'a jamais laissé courir jusqu'à sa conscience le flux de possibles qu'il se sent soudainement capable de trier. On comprend sans peine le singe anthropoïde dans le film de Stanley Kubrick, *2001 l'Odyssée de l'espace*, frappé de stupeur et de surprise devant le monde ouvert devant lui par une mâchoire tenue comme un marteau – et comme une massue bonne à tuer... Si, dans un célèbre mouvement de tourbillon, il la lance si haut et si loin, au point qu'elle devient la station spatiale de l'avenir, c'est parce que toutes les techniques suscitent autour d'elles ce tourbillon de mondes nouveaux. Loin de servir d'abord un but elles commencent par explorer

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7. HAUDRICOURT, 1987.
8. GIBSON, 1986.

des univers hétérogènes que rien, jusqu'ici, ne prévoyait, et derrière lesquels courent des fonctions nouvelles.

On comprend sans peine que la notion de « médiation technique » soit un peu faible pour absorber ce triple plissage des lieux, des temps et des actants. Le mot de médiation court toujours le risque qu'on inverse son message et qu'on fasse de ce qui rend à jamais impossible le transfert d'un sens, d'une cause ou d'une force, ce qui justement ne fait « que » transporter une force, une cause ou un sens. Si l'on n'y prend garde, on ramènera les techniques au rôle de l'ustensile qui ne fait « que » déplacer dans un matériau plus durable des schèmes, des formes, des relations déjà présentes sous une autre forme et dans d'autres matériaux. Pour reprendre un exemple qui m'a beaucoup servi, les ralentisseurs ne sont pas des « gendarmes couchés » simplement faits de béton au lieu d'être de chair et d'os. Si je traite les ralentisseurs comme des médiateurs en bonne et due forme, c'est justement parce qu'ils ne sont pas de simples intermédiaires qui rempliraient une fonction[9]. Ce qu'ils font exactement, ce qu'ils suggèrent, nul ne le sait, et c'est pourquoi leur introduction dans les campagnes ou les villes, commencée sous les auspices innocents de la fonction, finissent toujours par ouvrir une histoire compliquée, par déborder d'affaires, au point de finir parfois au Conseil d'Etat, parfois à l'hôpital. On ne maîtrise jamais les techniques, non pas parce que l'on manquerait de maîtres suffisamment énergiques, non pas parce que les techniques « devenues autonomes » fonctionneraient de leur mouvement propre, non pas parce que, comme le prétend Heidegger, elles seraient l'Etre oublié sous forme de maîtrise, mais parce qu'elles sont une véritable forme de médiation. Loin d'ignorer l'être-en-tant-qu'être au profit de la pure domination, du pur arraisonnement, la médiation technique expérimente ce qu'il faut bien appeler l'être-en-tant-qu'autre.

On pourrait s'étonner de ce que, bien que les techniques n'aient rien à voir avec la maîtrise, ce soit toujours pourtant sous la forme de l'instrument, du service rendu que l'on parle d'elles. Mais en est-il bien ainsi ? Il me semble que l'on parle mieux des techniques sur le mode du détour que sur celui de l'ustensilité. Est technique l'art du courbe, ce que nous avons appelé, après Michel Serres, la traduction. Si l'on va droit, comme l'épistémologie, on n'a guère besoin de technique, on le sait depuis les Grecs. L'ingéniosité commence avec Dédale, prince du labyrinthe, c'est-à-dire avec des

9. LATOUR, 1996.

embranchements imprévus qui éloignent d'abord du but[10]. Lorsque l'on dit qu'il y a un « problème technique » à résoudre, on veut justement introduire l'interlocuteur aux détours, aux labyrinthes qu'il va lui falloir affronter avant de poursuivre ses buts initiaux. Lorsque l'on admire la « technique » d'un spécialiste, on reconnaît justement là un passage que personne ne peut maîtriser, sauf lui et justement lui, qui d'ailleurs ne sait pas ce qu'il fait (tous les spécialistes de système experts s'en aperçoivent à leurs dépens). Comme on est loin de la fonction, de la domination, de l'ustensile ! On se trouve placé, de façon imprévue, devant ce qui permet (sans que l'on comprenne pourquoi) ou qui empêche, sans qu'on le comprenne davantage, d'accéder directement aux buts.

Jamais les techniques n'apparaissent véritablement sous la forme de moyens, et ce trait apparaît encore plus clairement, si j'ose dire, lorsqu'on les traite comme des boîtes noires dont on n'aurait besoin de connaître que les entrées et les sorties. Plus les systèmes techniques prolifèrent, plus ils deviennent opaques, si bien que la croissance de la rationalité des moyens et des fins (selon le modèle usuel) se manifeste justement par l'accumulation successive de couches dont chacune rend les précédentes plus sombres[11]. Si l'on avait oublié cette opacité fondamentale de la technique, les travaux d'archéologues menés depuis dix ans calmement, et depuis deux ans frénétiquement par les informaticiens chargés de nous débarrasser du bogue de l'an 2000, nous le rappelleraient plus nettement que tout effort philosophique d'élucidation. La complication même des dispositifs, par l'accumulation des plissements et des détours, des couches et des retours, des compilations et des réarrangements, interdit à jamais la clarté de la raison droite sous le patronage de laquelle on avait d'abord introduit les techniques.

Pourquoi donc certaines traditions occidentales dominantes parlent-elles malgré tout des techniques comme ce qui est susceptible de maîtrise ? Pourquoi ce qui devrait apparaître comme l'immaîtrisable, se trouve-t-il toujours, en fin de compte, regroupé dans le règne des simples moyens ? C'est là que le conflit avec la médiation morale commence à apparaître. L'apparence modeste que prend la technique vient de l'habitude, laquelle entraîne l'oubli de toutes ces médiations enchâssées. La « figure du labyrinthe », pour reprendre la belle expression de Cornélius Castoriadis, est

10. FRONTISI-DUCROUX, 1975.
11. LATOUR, 1992.

connue de tous les débutants et de tous les innovateurs : chacun découvre, entre lui et ses buts, une multitude d'objets, de souffrances, d'apprentissages, qui l'oblige à ralentir, prendre un détour, puis l'autre, à perdre de vue le but initial, à revenir, à tâtonner, perdre courage, etc. Et pourtant, une fois que le débutant devient expert en montant un à un les apprentissages, une fois que l'invention est devenue innovation grâce à la lente concrétisation exigée par l'industrie et le marché, on finit par pouvoir compter sur une unité d'action tellement fiable qu'elle n'apparaît plus au regard. Les médiateurs techniques ont ceci de propre qu'ils exigent, en fin de compte, l'invisibilité (quoique d'une façon toute différente des instruments scientifiques). Il s'agit là, bien sûr, d'une sorte d'illusion d'optique. En effet, la routine de l'habitude ne doit pas empêcher de reconnaître que l'action initiale, ce fameux « plan » supposé tenir lieu de programme « matérialisé » par la simple implémentation technique, a définitivement muté. Si l'on ne s'aperçoit pas combien l'usage d'une technique, aussi simple soit-elle, a déplacé, traduit, modifié, infléchi l'intention initiale, c'est tout simplement parce que l'on a changé de but en changeant de moyens et que, par un glissement de la volonté, on s'est mis à vouloir tout autre chose que ce qu'on avait désiré au départ. Si vous voulez garder droites vos intentions, inflexibles vos plans, rigides vos programmes d'action, alors ne passez par aucune forme de vie technique. Le détour traduira, trahira vos désirs les plus impérieux.

Non, décidément, par quelque bout que l'on prenne les techniques, jamais le rapport des moyens et des fins n'y paraît aussi simple que le suppose le partage antique entre les moralistes chargés des fins et les techniciens chargés des moyens. C'est des techniques qu'il faut dire, comme Saint Paul : « Je ne fais pas le bien que je veux et commets le mal que je ne veux pas[12]. »

En définissant la prise technique par les notions de pliage et de détour, je crois lui avoir rendu une partie de sa dignité ontologique. Sans les techniques, les humains ne seraient pas tels, puisqu'ils seraient contemporains de leurs actions, limités aux seules interactions de proximité. Incapables de substituer quoi que ce soit à des entité absentes qui en tiendraient lieu, ils resteraient sans médiation possible, c'est-à-dire sans capacité de passer par surprise à travers le destin d'autres êtres complètement hétérogènes dont les possibles s'ajoutent aux leurs, ouvrant ainsi la carrière d'une histoire, au sens propre, multiforme. Je me suis

12. SAINT PAUL, Rom. 7-19.

souvent amusé, avec quelque esprit de provocation, à définir la vie sociale purgée de tout pliage, de tout détour technique, comme la vie rêvée à la fois de certains sociologues, mes collègues, et des babouins de mon amie Shirley Strum : vie passionnante, intense, constamment soumise au renouvellement rapide des coalitions et des relations proprement sociales, mais vie pourtant peu humaine et, partant, peu morale[13]. Sans les détours techniques, il n'y pas de « proprement » humain. Plus sérieusement, on peut le voir dans les innombrables travaux qui vont de l'ergonomie à la technologie, en passant par les remarquables efforts de Laurent Thévenot pour classer les modes d'action[14] : les techniques bombardent les humains d'une offre continuelle de positions inouïes – prises, suggestions, permissions, interdictions, habitudes, positions, aliénations, prescriptions, calculs, mémoires. En généralisant la notion de promission, on peut dire que les quasi-sujets que nous sommes tous deviennent tels grâce aux quasi-objets qui peuplent notre univers de petits fantômes d'êtres semblables à nous et dont nous revêtons ou non les programmes d'action. Si l'habit ne fait pas le moine, on se sent davantage pieux en revêtant la bure.

On hésite toujours à reconnaître dans ce bombardement de positions possibles l'une des sources essentielles de l'humanité, parce qu'il existe beaucoup d'autres sources avec lesquelles on ne souhaite pas la confondre. Une personne, c'est évident, ne se construit pas seulement en tenant un outil dans sa main, en se voyant imposer à l'usine le rythme de la chaîne, en recevant d'un automate de banque l'offre d'une interface, en se coulant sans y penser dans le cours d'action habituel d'une cuisine bien équipée, en se voyant donner une mémoire artificielle par l'arrangement des gondoles d'un supermarché. Pour recevoir la personnalité, il faut bénéficier de bien d'autres régimes d'existence, bien d'autres prises[15]. Pourtant, l'existence d'une multiplicité de modes d'exploration de l'être ne justifie pas que l'on fasse de l'énonciation technique un simple domaine matériel sur lequel flotterait toujours des symboles, des valeurs, des jugements et des goûts, au motif que l'habitude tendrait à faire peu à peu disparaître toutes les médiations. L'erreur serait d'autant plus grande que le corps propre, lui aussi, peut se saisir sous le mode technique et qu'il commence dès lors à proliférer en détours et en pliages[16]. Tout artiste, tout technicien ou artisan, tout chirurgien sait bien qu'il

13. STURM et LATOUR, 1987.
14. THEVENOT, 1994 ; THEVENOT et LIVET, 1997.
15. RICŒUR, 1990 ; LATOUR, 1998.
16. DAGOGNET, 1993.

n'est jamais question dans la technicité que d'une forme nouvelle de répartition entre corps, les uns artificiels et les autres naturels, dont la vascularisation seule permet ces prouesses que l'on attribue ensuite, par paresse, soit aux objets soit au génie humain[17]. Toutes les techniques, en ce sens, selon l'expression de Marcel Mauss, sont techniques du corps.

En quoi, dira-t-on, cette redéfinition, si éloignée de l'usage courant du substantif « la technique » mais si proche de l'adjectif « technique », nous rapproche de la question morale ? J'ai d'abord cru qu'on ferait un grand pas dans la question si l'on reconnaissait qu'une partie non négligeable de notre moralité ordinaire reposait dans les dispositifs techniques. C'est ce que j'avais appelé la question de la « masse manquante de moralité[18] ». Un exemple suffira car le lecteur en trouvera aussitôt vingt autres plus relevés : pour une raison inconnue de moi, le fabricant de mon bureau m'interdit d'ouvrir un tiroir sans que les deux autres soient soigneusement et complètement refermés... Le concepteur a disparu ; la firme a d'ailleurs (avec quelque justice) fait faillite depuis longtemps ; je ne suis pas assez bricoleur pour découvrir l'anti-programme qui mettrait fin à cette aberration ; il n'empêche : vingt fois par jour depuis dix ans, je suis « obligé » d'obéir à cette loi morale tatillonne car je ne suis pas « autorisé » à laisser ouverts les trois tiroirs à la fois. Je peste mais je m'exécute, et j'avoue sans honte que je n'applique quotidiennement aucune autre loi morale avec autant de rigueur inflexible. Dame, c'est que j'y suis « tenu ». La loi morale est dans nos cœurs, certainement, mais aussi dans nos dispositifs. Au sur-moi de la tradition, il faut bien ajouter le sous-moi des techniques afin expliquer la rectitude, la fiabilité, la continuité de nos actions.

S'il est utile de soustraire dans la somme d'un comportement moral la part qui revient aux objets techniques, on ne touche pourtant que la surface du problème puisque l'on prend les techniques et les actes moraux dans leurs phases de routine, d'habitude ou de légers désajustements. Comme le fait justement remarquer Louis Quéré, on ne peut inférer de l'usage courant des expressions en termes de devoir et d'autorisation, que les objets techniques posséderaient en eux-mêmes une éminente dignité morale. Aussi, n'était-ce pas exactement mon intention. C'est surtout le mépris de nombreux sociologues pour la matière et l'innovation technique qui m'avait poussé à

17. AKRICH et BERG, à paraître.
18. LATOUR, 1992.

exagérer quelque peu en parlant naguère des « dilemmes cornéliens d'une ceinture de sécurité »... On reconnaîtra pourtant que je ne me suis pas tout à fait trompé si l'on offre maintenant à la morale la même dignité ontologique qu'à la technique telle que je viens de la redéfinir.

La morale, bien sûr, comme la science ou la technique, est une institution hétérogène faite d'une multitude d'événements, et qui dépend à la fois de tous les modes d'existence – et en partie, comme je viens de le dire, de la tenue des dispositifs techniques, mais aussi de bien d'autres formes d'organisation, véritable capharnaüm comme on peut s'en rendre compte en lisant les dictionnaires de philosophie morale. Je crois pourtant possible de la définir pour elle-même, dans sa façon particulière qu'elle a d'explorer l'altérité de l'être. La morale, elle aussi, est un mode d'existence, une prise sur l'être-en-tant-qu'autre, une préposition, un régime original de médiation. La forme sous laquelle on la reconnaît ordinairement, l'obligation, ne lui appartient pas en propre car celle-ci provient aussi bien des contrats, des événements religieux, des transferts de frayeurs, des chaînes de références, du droit, bref de toute une série composite qu'il serait vain de vouloir démêler pour l'instant. Seul m'intéresse ici le point de friction entre la prise technique et la prise morale sur la question du rapport des moyens et des fins. Qu'il n'y ait pas entre les deux d'harmonie préétablie et qu'elles ne s'ordonnent pas non plus selon le rapport des moyens et des fins, on le voit assez dans leur définition concurrente, contradictoire, de l'altérité. Toutes deux pétrissent l'être-en-tant-qu'autre mais chacune d'une manière différente. Pas plus que la technique, la morale n'est humaine, en ce sens qu'elle proviendrait d'un humain déjà formé et maître de soi comme de l'univers. Disons qu'elle parcourt le monde et que, comme la technique, elle engendre dans son sillage des formes d'humanité, des offres de subjectivité, des modes d'objectivation, des types variés d'attachement. C'est à la qualification de ce sillage qu'il faut maintenant nous intéresser.

Le pliage, le détour technique, je l'ai dit, viennent mêler des êtres à l'existence hétérogène et ouvrir une histoire imprévue par la multiplication des *aliens* qui vont dorénavant s'interposer entre deux séquences d'action, créant brusquement sous nos pas un labyrinthe dont on ne sortira jamais, ou, c'est selon, une routine si habituelle que, pas plus que le lièvre de Zénon, on ne s'apercevra de l'infinité vertigineuse à laquelle on vient d'échapper. Entre le geste d'allumer mon ordinateur et ce que j'écris sur l'écran, je peux soit ignorer l'industrie nucléaire qui me permet ce matin de travailler, soit me trouver plongé dans la destinée incertaine de cette même industrie obligée de tenir compte de l'enfouissement en profondeur des déchets de ses centrales qui n'entraîne pas l'adhésion des Français. Tel est le formidable mouvement d'accordéon propre aux techniques : ou bien j'ai l'accès le plus sûr, le plus silencieux au cours d'action (à tel point que je ne compte même pas dans ma description l'industrie nucléaire réduite au rang, non pas de moyen, mais de rien), ou bien je me retrouve dans un dédale que toute la France se met à parcourir à l'aveuglette en s'écriant « Mais comment s'en débarrasser ? » ! Il y a quelques secondes j'étais dans un moyen tellement moyen qu'il comptait pour zéro ; je me retrouve dans des fins tellement finales que plus personne ne sait comment l'histoire commune va finir.

Ne concluons pas de ce mouvement d'accordéon ou d'éventail passant brutalement du zéro à l'infini que, dans le premier cas, on avait affaire à une « simple question technique » alors que, dans le deuxième, on a posé une question morale « à propos » d'une industrie. Non, c'est dans l'essence même de ce dispositif technique que repose la totale incertitude sur le rapport des moyens et des fins. C'est la forme de respiration propre à la technique que d'alterner brutalement de la modestie à la terreur, de l'outil à l'horizon, de la surprise à la routine. Rien d'étonnant à cela, puisque, avec le pliage de l'industrie nucléaire, nous avons associé le sort de nos ordinateurs à la radioactivité, liant progressivement l'histoire lente de ma carrière d'auteur, aux cadençages par millisecondes des puces informatiques, et le tout au sort de déchets dont la demi-vie (ou plutôt la demi-mort) se compte, pour certains, en centaines de milliers d'années. Ce « bouquet temporel » réside bien là devant moi et il ouvre une histoire qui n'a justement aucune fin. Paradoxe de la technique toujours encensée pour son ustensilité fonctionnelle, ou toujours méprisée pour son irritante neutralité, alors qu'elle n'a jamais cessé d'introduire à une histoire de pliages, de détours, de dérives, d'ouvertures et de traductions qui abolit aussi bien l'idée de fonction que celle de neutralité. Comment peut-on avoir l'audace de qualifier de « neutre » le drame ontologique d'assemblages imprévus d'entités qui peuvent passer, sans coup férir, du zéro à l'infini ? Ce n'est pas pour rien que Vulcain boitait... Derrière le thème ressassé de la neutralité des « techniques-qui-ne-sont-ni-bonnes-ni-mauvaises-mais-ne-seront-que-ce-que-l'homme-en-fera », ou du thème, identique en son fond, d'une « technique-devenue-folle-parce-qu'elle-s'est-autonomisée-et-n'a-plus d'autre-fin-que-son-développement-sans-but », se cache la peur de découvrir cette réalité si nouvelle pour l'homme moderne habitué à dominer : il n'y a pas du tout de maître – pas même les techniques devenues folles.

C'est avec un goût tout différent pour l'altérité que la morale explore les mêmes assemblages d'êtres dont le sort s'est trouvé mêlé par le détour technique (et par bien d'autres formes d'existence dont le contraste ne nous intéresse pas ici). Tout agencement technique paye en création d'intermédiaires la multiplication des médiateurs. Le chêne des Ardennes se dirigeait par sa croissance tout à fait ailleurs que vers la fabrication de mon marteau, même si on l'a planté dans ce but vaguement anticipé. Du chêne, l'outil n'a gardé qu'une portion infime des propriétés, sa solidité, sa chaleur, l'alignement des lignes du lignite. Où allait le chêne pour lui-même et par lui-même ? Dans quel monde prolongeait-il son existence ? Cette question, la technique ne s'y intéresse aucunement, obligée de disloquer toutes les entités qu'elle traverse pour engendrer des mondes possibles et permettre de nouveaux agencements. La morale est taraudée par un tout autre souci : combien de médiateurs les autres formes d'existence maintiennent-elles dans leur sillage ? Ne risque-t-on pas de traiter le chêne comme un simple moyen pour le marteau ? Tout le monde connaît la version simplifiée que la morale humaine, trop humaine, a donné de ce principe : « ne jamais traiter les humains simplement comme des moyens, mais toujours aussi comme des fins ». Kant l'appliquait bien sûr aux seuls êtres humains, et pas aux marteaux, aux chênes ou aux atomes d'uranium radioactif. Ayant repris la fable de l'*Homo faber*, il imaginait vraiment un humain aux commandes travaillant par ses catégories une matière brute et sans droit. Deux cents ans après, cette position nous paraît aussi insoutenable que les récits de chasse à l'éléphant de Théodore Roosevelt ou que les arguties des Grecs sur l'impossibilité d'émanciper des esclaves inférieurs par nature. C'est que la morale depuis ce temps a retravaillé la matière commune brassée par les techniques qui avait associé dans le même sort commun de plus en plus d'entités[19].

On ne peut plus poser aujourd'hui la question morale comme aux temps où les humains avaient à peine gratté la terre sur laquelle ils passaient de la vie à la mort sans que personne d'autre ne s'en aperçoive. La morale comme la technique sont des catégories ontologiques, des modes d'existence comme

19. LATOUR, 1999a.

l'a si bien dit Gilbert Simondon après Etienne Souriau[20], et l'humain provient de ces modes, il n'en est pas à l'origine. Ou plutôt il ne peut devenir humain qu'à la condition de s'ouvrir à ces manières d'être qui le débordent de toutes parts et auxquels il peut choisir de ne pas s'attacher – mais alors au péril de son âme.

La morale, si l'on accepte de la détacher un moment de l'institution complexe qui l'a travaillée de mille manières, apparaît donc comme un souci qui travaille incessamment l'être-en-tant-qu'autre pour empêcher que les fins ne deviennent toutes des moyens, que les médiateurs ne soient transformés en de simples intermédiaires. Elle ne s'interroge pas tant sur le droit des choses pour elles-mêmes (encore que la forme que donne à la question éthique l'écologie profonde ait certainement fait basculer la morale hors de l'anthropocentrisme étroit), mais sur l'existence des choses et sur le sens de cette expression « pour elles-mêmes ». Rien, pas même l'humain, n'est pour lui-même et par lui-même, mais toujours par autre chose et pour autre chose. Tel est le sens même de l'exploration de l'être-en-tant-qu'autre, en tant qu'altération, altérité, aliénation. La morale s'intéresse à la qualité de cette exploration, au nombre de médiateurs qu'elle laisse dans son sillage, voulant toujours vérifier si elle fait pulluler le plus grand nombre possible d'actants qui réclament en leur nom propre d'exister et d'intervenir ou si, au contraire, elle ne s'est pas résignée à les oublier. Partout où l'on veut aller vite en établissant des rails pour qu'un but les parcourre en sifflant comme un TGV, la morale disloque les rails et rappelle à l'existence tous les embranchements perdus. Le train du but s'immobilise bientôt, embarrassé, impuissant. La morale s'occupe moins des valeurs, comme on le dit souvent, que d'empêcher l'accès trop immédiat aux fins.

Ne limitons pas ce ralentissement aux seuls humains. Pour reprendre le cas des déchets nucléaires, personne n'imaginerait plus d'imposer aux maires de petits villages l'implantation sans phrase d'un laboratoire pour étudier la résistance du granit, du sel ou de l'argile. On pouvait traiter les populations comme de simples moyens, il y a cinquante ans, au nom de l'intérêt national : plus maintenant. Il faut dorénavant les prendre avec politesse, et l'on peut lire dans la thèse de Yannick Barthes les trésors de patience que l'ANDRA doit déployer pour les tenir en place ou les séduire[21]. Mais

20. SOURIAU, 1943.
21. BARTHES, 2000.

comment qualifier les autres actants que l'histoire technique a mélangés aux villages humains dans un sort commun, pour le meilleur et pour le pire, par un mariage qu'on n'ose plus dire « de raison » ? Le verre des conteneurs va-t-il tenir plusieurs milliers d'années ? Quelle confiance pouvons-nous avoir dans la géologie des plaques tectoniques dont l'histoire n'a pas cent ans et l'observation fine pas plus de vingt ans ? Que savons-nous des dômes de sel ? D'où la question nouvelle de morale humaine et matérielle : qui est le plus solide à très long terme ? L'argile souple, le sel dur, le granit faillible, ou plutôt le lien fragile mais incessamment renoué des organisations humaines, capables de surveiller, pour les siècles des siècles, une piscine en surface, « monitorée » par des êtres aussi éloignés de nous dans le futur que les néandertaliens dans le passé ?

Une fois que l'on saisit la morale aussi bien que la technique dans sa dignité ontologique au lieu de les rapporter, comme d'habitude, à l'humain seul, on voit que leur rapport n'est plus du tout celui du moyen à la fin, de l'esprit pratique à l'esprit tout court, des faits aux valeurs, de l'obligation symbolique à l'obstination têtue des choses. Les deux modes d'existence disloquent incessamment les agencements, multiplient les inquiétudes, font pulluler les actants, interdisent la voie droite, tracent un labyrinthe – de possibles pour l'un, de scrupules et « d'impossibles » pour l'autre. Le souci des valeurs ne vient pas prendre le relais, une fois résolue la question de la sûreté des dômes de sel et des verres. Elle vient, dans la profondeur même des cavernes, inquiéter l'ingénieur en faisant se multiplier les êtres qu'il avait peut-être traités trop vite en intermédiaires (réseaux réguliers des cristaux de roches, alignement des silices) pour les faire réémerger devant ses yeux comme autant de médiateurs difficiles à mépriser, à maîtriser : lunules, défauts, failles, erreurs microscopiques, dont la multiplication, à l'échelle des éons, vient élargir la faille dans le raisonnement des politiques et semer le doute dans l'opinion frêle et têtue des « populations laborieuses », en surface. La morale vient retravailler exactement les mêmes matériaux que la technique mais en extrayant de chacun d'eux une autre forme d'altérité puisque c'est leur impossibilité de se couler dans le moule de l'intermédiaire qui lui importe avant tout. Bien avant que l'on ne traduise en obligations les exigences morales de la tradition, elles ont résidé d'abord dans cette objectivité massive des médiations qui interdisent d'être prises pour les buts de qui que ce soit, de quoi que ce soit d'autre. La morale, en ce sens là, est bien d'abord dans les choses qui, grâce à elle, nous obligent à les obliger.

Si la technique disloque, c'est pour réagencer ; si elle ouvre devant un but le gouffre des moyens enchâssés les uns dans les autres en un dédale d'inventions nouvelles, c'est pour refermer ce gouffre et créer, soit par l'automatisme de l'habileté, soit par l'automatisme des automates, un cours d'action invisible qui ne compte même plus ; si elle nous introduit à une histoire imprévue, c'est pour que le but initial, déplacé, renouvelé, finisse par coïncider étroitement avec le moyen nouveau qui vient de surgir, au point qu'on se met à parler de l'adéquation de la forme à la fonction comme du gant à la main. Rien de tel avec la morale : pas de boîte noire possible, pas de disparition de millions de buts partiels enchâssés en un seul moyen qui ne compterait plus pour rien et disparaîtrait à la vue. Le travail de la médiation, dans son régime moral, exige au contraire le parcours incessant du souci, le retour mordant du scrupule, la réouverture anxieuse de ces tombeaux où gisent des empilements d'automatismes, le redépliage des moyens en buts partiels et des buts partiels en fins.

Le principe de précaution, si à la mode, ne veut pas simplement dire que l'on s'interdirait d'agir avant d'avoir acquis la certitude de l'innocuité d'un bien, car cela reviendrait encore à conserver l'idéal de maîtrise et de connaissance en exigeant un savoir certain sur une innovation qui, par définition et comme toute technique, échappe définitivement à la maîtrise. Non, le principe de précaution réside dans le maintien permanent d'une impossibilité de plier – ce à quoi la technique aspire justement : d'où le conflit permanent des modes d'être. Maintenir la réversibilité des pliages, telle est la forme actuelle du souci moral dans sa rencontre avec la technique. On le découvre partout actuellement avec les notions de produits recyclables, de développement durable, de traçabilité des opérations de production, dans le souci toujours plus fort de transparence (chercher le transparent en matière de technique, quel paradoxe !), dans l'exigence assez nouvelle en France d'*accountability*, c'est-à-dire de descriptibilité et d'évaluation des choix. C'est en ce sens nouveau que la morale se trouve en conflit permanent et continu avec l'ouverture à l'histoire que la technique ne cesse de proposer[22].

On le voit, le rapport de la technique et de la morale se modifie quelque peu dès que l'on renonce à l'idée de mettre la première du côté des moyens, la seconde du côté des fins. Chacun de ces modes d'existence bouleverse à sa manière propre et distincte le rapport des moyens et des fins : la technique en

22. LATOUR, 1999b, chap. IV.

disloquant les relations entre les entités de telle sorte qu'elles s'ouvrent à une série d'embranchements nouveaux qui forcent au déplacement continu des buts et au pullulement des agents intermédiaires dont le glissement collectif interdit toute maîtrise ; la morale en interrogeant sans cesse les agrégats pour leur faire exprimer leurs fins propres et empêcher que l'on se mette d'accord trop rapidement sur la répartition définitive de ceux qui serviront de moyens et de ceux qui serviront de fins. Si l'on ajoute la morale à la technique, on est obligé de constater, en jouant sur les mots, la fin des moyens. Sans les moyens, une autre histoire commence, puisque morale et technique multiplient les entités à prendre en compte qu'il faudra bien apprendre à rassembler. Ce rassemblement, cette composition progressive d'un monde commun oblige à recourir à une autre forme d'énonciation, politique cette fois, et qui aspire, elle aussi, à retrouver sa dignité ontologique pour sortir de l'état d'abaissement où l'avait précipité un mépris plus long encore que celui où la technique a dû si longtemps se morfondre.

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When things strike back: a possible contribution of 'science studies' to the social sciences

ABSTRACT

The contribution of the field of science and technology studies (STS) to mainstream sociology has so far been slim because of a misunderstanding about what it means to provide a social explanation of a piece of science or of an artefact. The type of explanation possible for religion, art or popular culture no longer works in the case of hard science or technology. This does not mean, it is argued, that science and technology escapes sociological explanation, but that a deep redescription of what is a social explanation is in order. Once this misunderstanding has been clarified, it becomes interesting to measure up the challenge raised by STS to the usual epistemologies social sciences believed necessary for their undertakings. The social sciences imitate the natural sciences in a way that render them unable to profit from the type of objectivity found in the natural sciences. It is argued that by following the STS lead, social sciences may start to imitate the natural sciences in a very different fashion. Once the meanings of 'social' and of 'science' are reconfigured, the definition of what a 'social science' is and what it can do in the political arena is considered. Again it is not by imitating the philosophers of science's ideas of what is a natural science that sociology can be made politically relevant.

KEYWORDS: Epistemology; science and technology studies; method; natural sciences

INTRODUCTION

I forgot who the famous philosopher was who used to quip that all was well with the social sciences except for two tiny words: 'social' and 'sciences'. Although a change of millennium possesses no deep meaning, save for Christians for whom it is a telling event in the history of Salvation, and although thousands of years is much too vast for the juvenile social sciences who never had to celebrate any anniversary longer than a few centuries, the year 2000 might none the less be a good occasion to meditate, once again, about the claims of the social sciences to be just that: sciences of the social.

The time is all the more auspicious since a minuscule sub-field of sociology, called 'science and technology studies' (STS) has for the last

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twenty-five years shed some light on what is a natural science and put into doubt what a 'society' is. Today, it might be possible to ask anew what are the social sciences in the light of the sociology of the natural and social sciences. What fecund areas of research could open up in the near future? The task is not that easy since STS have so far led the same sort of life as early mammals when dinosaurs were roaming the Earth. Hidden in peripheral niches, they were awaiting for better days to explode in many new locations. Although I do not expect (nor hope!) a comet to wipe out the Big Animals, I do think STS will have a more conspicuous place in the delicate ecology of the social sciences, once the demise of a few traditional Big Problems will have left some space for its proliferation. The difficulty is that because of its very invisibility, STS's contribution to mainstream sociology is not easy to grasp (see Jasanoff, Markle, Peterson and Pinch 1995 for an introduction, Biagioli 1999 for a useful reader and Knorr-Cetina 1999 for a recent major contribution).

The official version would have it that STS has contributed to a 'social explanation' of phenomena judged until now irrelevant for sociology because they did not pertain to the social realm at all, namely matter, efficiency, and objectivity. According to tradition, the work of sociologists begins and ends with socially relevant topics. If a cyclist falls off his bicycle because it has hit a rock, social scientists confess, they have nothing to say. It is only if a policeman, a lover, an insurance agent or the Good Samaritan enter the scene that a social science becomes possible, because we are now faced, not only with a causal sequence of occurrences, but also with a string of socially meaningful events. Not so for STS practitioners, who deem sociologically interesting and empirically analysable, the very mechanisms of the bicycle (Bijker 1995), the paving of roads, the geology of rocks, the physiology of wounds and so on, without taking the boundary between matter and society as a division of labour between the natural and the social sciences. Although this equanimity (or 'symmetry' as it is called in the jargon), is fiercely disputed in our subfield, there is complete agreement in STS on the importance of *extending* the research programmes of the social sciences *beyond* the former realm of what was considered until now as the 'social' (Bloor 1991[1976]; Law 1986).

The question I want to tackle here, at the occasion provided by the change of digits in the way that we (in the developed part of some of the richer societies) compute years, is how much of the usual business of the social sciences is to be modified by such an extension to natural phenomena.

NOTHING SUCCEEDS LIKE FAILURE

The first difficulty is to go beyond the boundary of the social in order to grasp natural and material objects. I would be tempted to phrase the situation in the following paradoxical way. If a social explanation of the natural sciences and of technologies succeeds, then it fails and the rest of the social sciences disappears as well. While if it fails, it is interesting but so superficial that we cannot be safe in the hope of becoming real scientists because we have missed the thing under study. In both cases, STS appears as the *fatum* of the social sciences. I will defend this paradox first, before turning, in the next section, to the positive, although counter-intuitive, contribution of STS.

What could it mean, according to mainstream social sciences, to provide a social explanation of a natural phenomenon? It is to show, they believe, that a quark, a microbe, a law of thermodynamics, an inertial guidance system, and so on, are not what they seem to be – incontrovertible objective entities of nature out there – but the repository of something else, which they are hiding, reflecting, refracting or disguising. This 'something else', in the tradition of the social sciences, is necessarily some social functions or social factors. Providing a social explanation, thus, means that someone is able in the end to *replace* some object pertaining to nature by *another one* pertaining to society, which can be demonstrated to be its true substance (see Hacking 1999, for a remarkable feat of analytical clarity).

There are very good reasons for such a research strategy to be efficient since it worked, social scientists believe, in the paradigmatic case of religion during the founding moment of the disciplines in the nineteenth century. At the time, sociologists easily convinced themselves that to explain rituals, faiths, apparitions or miracles, that is, transcendent objects to which the actors attribute the origin of some action, it was perfectly possible (if not always simple) to *replace* the contents of these objects by the functions of society which they were both hiding and impersonating. Those types of objects were called fetishes, that is, place-holders for something else (see Pietz 1985 for a genealogy). Once the *substitution* of the false objects of beliefs with the true objects of society has been effected, there is nothing more to comprehend in religion other than the power of society it so efficiently hides and expresses. So when our colleagues hear that there exist a sub-field dedicated to science and technology, they cannot but imagine that this field has tried to do for materiality and objectivity what has been done first for religion, and later for many other topics such as popular culture, media studies, politics, art, law, gender and so on. What has to be done, it seems, is changing the object of attention wrongly assumed by the actors into the real object which derive from society.

Except of course, that such a substitution cannot be accepted so easily about a topic – science, objectivity, universality – which *alone* is not like *all* the other objects of study in the social sciences. This is because it is something to be looked down and explained, but also something that is to be looked *up* as the *ultimate* source of explanation.

> Science, they say, (and this in itself is the most damning confession) cannot be treated as lightly as the rest (meaning that they would been ready to treat the rest lightly!) because it lies at the heart of what it is to

be a social scientist and is the only goal worth sacrificing one's life: knowledge of what the social is made up.

This is the reason why what could have been warmly welcomed as the expansion of the project of the social sciences to a new domain – STS added to those of religious studies, class studies, urban studies, gender studies and so on – has quickly become a poisoned chalice that decent social scientists would have much preferred not to have received or been offered.

The reason for this uneasiness is not hard to understand. In their hearts, social scientists deeply doubt the quality of their own explanations, so much so that they do not want to be submitted to a treatment they deem deleterious for all the other subjects! Hence the trap of reflexivity so well analysed by STS (Woolgar 1988). We can sociologize everything (including the social sciences) but only as long as we do not sociologize the natural sciences. Why? Because for many sociologists, to provide a social explanation of something means to destroy this object, to debunk the false beliefs that ordinary people entertain about them, and then to replace the idols by a true object of science; or to show that such a replacement is impossible since a certain degree of a not so naive *illusio*, of false consciousness, is necessary for the social order to work (Bourdieu and Wacquant 1992).

This taken for granted assumption about what is the normal *modus operandi* of a social scientist makes one very fidgety when approaching the STS literature. Since social scientists themselves believe that a social explanation destroys its object, what will happen if the natural sciences are undergoing this radical treatment? Are they not going to disappear in the way religion has? Worse: if the natural sciences are submitted to this substitution diet, how long will the objectivity of the social sciences resist? In the same ways as the Revolution kills its children, are we not going to see the whole edifice of science (natural or social) crumble? Even worse: since providing a social explanation means that one replaces an object of belief by a social function, it means that the ultimate source of enlightenment relies entirely on the fragile shoulders of social scientists requested to provide a watertight knowledge of society able to take the place, not only of God (a piece of cake?), but of the laws of nature as well. Are the social scientists really up to the challenge? And if they are not, if their knowledge is weak, will it still be possible to activate the modernist project that requires for the emancipation of the people an absolute bedrock of indisputable objectivity to spur the masses into action? These are the questions agitated in the so-called 'science wars'. If such is the can of worms that STS has opened up, it might be safer to close it, and fast! It seems that by extending the project of the social sciences *to* Reason itself, STS has gone *beyond* reason!

This is why STS's contribution to mainstream social sciences has been so limited: it has always been followed by an evil reputation. You cannot work in this domain without being immediately saddled with huge philosophical problems that are tied to your case-studies. 'Relativism', 'incommensurability', 'subjectivism', 'postmodernism', are shot at you even when you deal with such innocent topics as a mathematical proof, a neurotransmitter, a Monte Carlo calculation or an automated subway. Behind the most innocent field-work, always appear the forked hoof of the devil. Whereas there is no difficulty in showing that Rembrandt was the CEO of a cottage industry playing the speculative market, that cargo cults are the expression of deep colonial frustration, that class interests and product differentiation mark every instant in the carrier of *homo academicus*, it stirs a small scandal to deploy the British Empire in the physics of Lord Kelvin (Smith and Wise 1989), or the whole of imperialism in the setting up of primate visions (Haraway 1989). Somehow, for those topics, and only for those, society and sociality do not seem to be able to meet the bill.

Faced with such opposition, it is not even possible for the STS practitioners to play it safe, because of the second feature of what is a 'social explanation' as traditionally construed: either it destroys its object, or it ignores it altogether! Why, could the wary social scientist ask, not limit STS's claims about scientific practice to the narrow boundaries of the social, as the early founders of the 'sociology of scientists and engineers' (by opposition to that of science and engineering) had very reasonably done in the 1950s (Merton 1973)? All difficulties would evaporate. Yes, that is the point: everything would be vaporized, including the goal of social sciences as well. To be sure, there would be no scandal left if it was generally assumed that the social explanations limited themselves to those elements which, in technology surely and even in science, pertains to the social realm: 'power relations', legitimacy, ideology, biases, money, and some distribution of 'symbolic capital'. But, if only the most superficial aspects of physics, mathematics, neurology or ethology are being touched upon by STS, it means that, when dealing with a hard object, the social sciences have to *give up*. Yes, the problem of accepting STS as a *bona fide* domain of social science will have disappeared, but this neutering of science and technology studies will also have demonstrated that giving a social explanation of *any* object is a tantamount to limiting oneself to what is *not* objective, but *only* social. One can become accepted in the salons of social sciences, only on the condition of not providing an explanation of what one deals with. What was invisible for all the other sub-fields, because their social dimensions seemed to exhaust what there was to know in them, appears in a full light when dealing with the sociology of the facts of natural sciences.

The quandary with which I started this section, may now appear in all its force. If STS's claims are arrogant, they seem to destroy the foundation of what is a science, natural or social, but if they are modest, what they destroy is the very idea of a social explanation of something that escapes the social domain. If STS has succeeded in providing a social explanation, then it is bound to fail or at least to die like Samson under the stones of the temple it has so foolishly shaken. Social scientists may be right, after all, in wanting to have no dealings with a field that destroys the scientificity of all the sciences by explaining all of them socially. If the 'social explanation' fails, however, it is perfectly welcomed inside the rest of the social sciences who, like STS, provide superficial explanations of phenomena whose true substance escape them for ever, be it religion, fashion, popular culture, art, classes or UFOs!

Because of the mere presence of STS, the rest of the social sciences has to confess its deep-seated conviction about its own scientificity. If you do to the natural sciences what we do so efficiently to other fields, then you explode it away, and it is so dangerous that it will backfire. Or, alternatively, if you do to the natural sciences what we do to some other areas, then it is innocuous enough since it does not touch on the important aspects which escape the social. And in this case it also backfires because it reveals that when social scientists claims to comprehend something they have left aside what the *thingness* of this thing actually is! Either they destroy what they study or ignore what it is (see the remarkable case of art history in Hennion 1993). No wonder that STS is rarely read amongst mainstream sociologists.

Fortunately, for the fate of the social sciences generally, and the STS field in particular, in spite of many claims by some of its proponents and most of its opponents, the project was *never* to provide a social explanation of the natural sciences. But by failing to do so on some new harder objects this has revealed what was amiss in the project of a social explanation in general (on the polemics around those points, see Pickering 1992). This is why I have often said, using an evangelical metaphor not out of tune with the millennium occasion, that the failure of STS to provide an explanation of the natural sciences was a *felix culpa*: this original sin that could lead the social sciences to another settlement by rejuvenating the very meaning of those two words, social and science.

HOW TO EMULATE THE NATURAL SCIENCES

Of the resistance of natural objects to social explanations two opposite conclusions can be drawn: the conservative one and the daring one. The conservative would say that the project of a 'social explanation' of nature was doomed to failure because facts escape the confines of the social order. This is the majority opinion of philosophers of science and most 'science warriors'. The other conclusion, held by myself and a few colleagues in philosophy, sociology and anthropology, is that this *felix culpa* has helped point out a general feature of *all* objects which is that they are so specific that they cannot be replaced by something else for which they are supposed to be a stand-in.

The 'unique adequacy' for which ethnomethodologists have fought so strenuously is a very general principle that strictly forbids using any other thing, for instance, a social function, to explain away the insistence, obstinacy or obduracy of a given site (Lynch 1994). We cannot emphasize enough the importance of this feature. If a sociologist abandons the idea of replacing, let us say, the second law of thermodynamics by a social factor this law would be supposed to 'express', it means that the same is probably true of all the other objects for which we try to provide an explanation. They too resist being a stand-in, and that is no less true of miracles (Claverie 1990), fashion, gender, art, than it is of a rotor engine or of a chemical formula. Such is the contribution of STS to social sciences. Another definition of what is an object is called for (Thévenot 1996; Pickering 1995), once sociologists have passed the trial by fire of trying to explain in social terms the very substance of what is not social and have burned themselves out! This contribution would of course be lost immediately, if one was again separating out objects into two pots, one for the *fetishes* which can and should be accounted for as 'mere social constructions' because they are soft, and the other for *facts* which, by definition, escape all social explanations because they are hard (Latour 1996c). Hence, I devised the neologism 'factishes' to remind us of the uselessness of such a dichotomy (see Latour 1999b ch. 9, and for a caricature of the opposition Searle 1998).

This new respect for the unique adequacy of objects has two consequences for the social sciences, the first for the notion of society and the second for what it is that should be imitated when social scientists try to emulate the natural sciences.

I can go quickly on the first point, since several authors in this issue (see Urry, Beck, Castells) are also dealing with the demise of society as a source of explanation. It has become clear over the years that the existence of society is part of the problem and not of the solution. 'Society' has to be composed, made up, constructed, established, maintained, and assembled. It is no longer to be taken as the hidden source of causality which could be mobilized so as to account for the existence and stability of some other action or behaviour (this is at the heart of the systematic effort of actor-network theory, see Callon and Latour 1981; Law 1993). The diffusion of the terms, network (Callon 1992) and fluid (Mol and Law 1994), shows the growing doubts about the notion of an all-encompassing society. In one way, we are witnessing, a century later, the revenge of Gabriel Tarde over Emile Durkheim: society explains nothing but has to be explained (Tarde 1999a, 1999b). If it is to be accounted for, it will be, by definition, through the presence of many other little things that are not social by nature, but only social in the sense that they are *associated* with one another.

The adjective 'social' now codes, not a substance, nor a domain of reality (by opposition for instance to the natural, or the technical, or the economic), but a way of tying together heterogeneous bundles, of *translating* some type of entities into another (translation being the opposite of substitution: Callon 1986; Latour 1988). The great import of technology studies to the social sciences is to have shown, for instance, how many features of the former society, durability, expansion, scale, mobility, were actually due to the capacity of artefacts to construct, literally and not metaphorically, social order (Latour 1996a), including the infamous agent/structure dilemma (Latour 1996b). They are not 'reflecting' it, as if the 'reflected' society existed somewhere else and was made of some other stuff. They are in large part the stuff out of which socialness is made (Latour and Lemonnier 1994). The same is true of the vast literature on the science studies of the social sciences. Here again demography, economics, accounting, politics and of course the various sociologies themselves, appear not as what study society but as what give it flesh, existence, and visibility (more on this below). The old tired theme of social construction has been turned on its head since scholars are now busy trying to show the ingredients with which some lasting order is being maintained. What was the cause is now the provisional consequence. Society is not made of social functions and factors. An interest in the 'social' does not lead to society as a source of explanation (Strum and Latour 1987).

The second aspect, the definition of science, is less well-known and since it might make clearer the definition of the social, I will dwell upon it longer (I follow here Stengers 1996; for an introduction in English, see Stengers 1997b). The imitation of the natural sciences by the social sciences has so far been a comedy of errors.

Having not applied their tools to natural objects and believing what philosophers of science and some scientists were saying about 'the scientific method', social scientists have been paralyzed by a 'physics envy'. They have imagined that the great superiority of natural scientists resided in their dealing with objects that they have fully mastered and dominated. Hence, when studying social entities, most of the enquirers tried to find situations resembling as much as possible this mythical posture of the natural sciences, namely, disinterested scientists gazing over objective entities that they could master at will and they could explain by strictly causal chains. Other social scientists, however, played the emulation game differently. They insisted that social topics requested *another* type of scientificity, a hermeneutic, interpretative nature, that was absolutely different from the one required for chemistry, physics or geology (I leave aside those who have abandoned any hope of providing a social science of anything at all). In brief, those who study social subjects should either try to follow natural scientists as closely, or as far away, as possible. However, both positions, the quantitative and the interpretative (to lump many nuances together), accept the official version of what could be called 'pre-STS' view of the natural sciences.

The model to be emulated by social scientists becomes quite different if one invests some energy in reading the STS literature on scientific practice, as it is going on in the laboratories and the many institutions which have now been subjected to detailed studies by historians, anthropologists or sociologists. Provided, that is, one accepts them as they are, as providing something other than a social explanation of the phenomena in question (although this is missed even by some sociologists of science, see Bloor 1999 and my response Latour 1999a).

Mastery, impartiality, community and disinterestedness are not the hallmarks of those laboratory set-ups. Not that natural scientists and engineers are partial, biased, selfish, agonistic and interested, although that too is part of the process, but because the objectivity that they deal with is of an entirely different nature. Objectivity does not refer to a special quality of the mind, an inner state of justice and fairness, but to the presence of objects which have been rendered 'able' (the word is etymologically so powerful) to *object* to what is told about them (see the striking cases in Rheinberger 1997). A laboratory experiment is a rare, costly, local, artificial set up in which it becomes possible for objects to become relevant for statements made by scientists (this realist social philosophy of science is developed at length in Latour 1999b). Far from being the very example of a complete distinction between subjectivity and objectivity, it is, on the contrary, inside the laboratory (broadly conceived), and because (not in spite) of its artificial and local nature, that the greatest degree of intimacy between words and things can be achieved. Yes, things can be made relevant to language. Those situations are not easy to find, they are so unusual, not to say miraculous, that developing a new protocol, devising a new instrument, discovering a grasp, a trial, a trick, an experiment is often worth a Nobel Prize. Nothing is more difficult than to find a way to render objects able to object to the utterances that we make about them.

The paradox is that when quantitative social scientists imitate the natural sciences they avoid precisely those features that would render their discipline really objective. And the paradox deepens when one realizes that the interpretative schools curse the natural sciences for just the sort of sin that they do not commit, namely treating their objects as 'mere things'! If only, one could say, the social scientists could treat their subjects with the same respect as natural scientists treat theirs (see Strum and Fedigan 2000, for examples in the twilight zone of primate studies). As Stengers (1997a) and Despret (1999) have cogently shown in the case of psychology, the whole misunderstanding relies on the notion of an unknown structure. The argument seems counter-intuitive at first but makes a lot of good sense after one gets habituated to it.

In order to obtain objectivity as they understand it, social scientists try to find cases where their human subjects are as little prone as possible to influence the result. For this, the only solution is to render him or her unaware of what is manipulating his or her behaviour, as for instance in the famous Milgram experiment about the inner cruelty of American students. While the actor is held by forces unbeknownst to him or her, only the scientist is 'in the know', producing what is taken as solid knowledge since it is untainted by the subjective reaction of the participants. The scientist is disinterested and the subject *uninterested* in what is by definition unknown. The set up seems ideal for producing a science of humans as hard as that of natural objects, since human subjects have *no influence* whatsoever on what is said about them.

Unfortunately, although it tastes and smells like hard science, those all-terrain 'scientific methodologies' are a sham and a cheap imitation for a reason that becomes clear if we go back to the definition of objectivity as what allows one entity to object to what is said about it. If we lose the influence of the object in what is said about it, as quantitativists are so proud of saying, we also lose objectivity! If microbes, electrons, rock seams, do not have to be protected against biasing the experiments, it is not because they are fully mastered by their scientists, but because they are utterly *uninterested* in what human scientists have to say about them. It does not mean that they are 'mere objects', but that, on the contrary, they will have no scruples whatsoever in objecting to the scientist's claim by behaving in the most undisciplined ways, blocking the experiments, disappearing from view, dying, refusing to replicate, or exploding the laboratory to pieces. Natural objects are naturally *recalcitrant*; the last thing that one scientist will say about them is that they are fully masterable. On the contrary, they always resist and make a shambles of our pretentions to control. If many more precautions have to be taken with human subjects, it is not because humans should not be treated like 'mere things' devoid of intentionally, consciousness and reflexivity, as interpretative schools would have it; nor is it, as the quantitative schools think, because they would influence the result, but, on the contrary, because they would quickly *lose* their recalcitrance by *complying* with what scientists expect of them. Contrary to microbes and electrons who never abandon their capacity to *object* since they are not easily influenced by the interest of experiments, too remote from their own *conatus* (not to say interest), humans are so easily subjected to influence that they play the role of an idiotic object perfectly well, as soon as white coats ask them to sacrifice their recalcitrance in the name of higher scientific goals (this is what happened in Milgram's lab whose experiment proves nothing more than that a psychologist can indeed be the torturer of his students!).

If social scientists wanted to become objective, they would have to find the very rare, costly, local, miraculous, situation where they can render their subject of study as much as possible able to object to what is said about them, to be as disobedient as possible to the protocol, and to be as capable to raise their own questions in their own terms and *not* in those of the scientists whose interests they do not have to share! Then, humans would start to behave in the hands of social scientists as *interestingly* as natural objects in the hands of natural scientists. One has just, for instance, to compare the pre-feminist sociological literature on housewives and gender-roles with the literature generated after feminism had rendered recalcitrant most of the potential interviewees, to see the difference between a pseudo-objective science which had only the appearance of scientificity, with a startling set of discoveries on gender, which might not always have the trappings of the natural sciences but certainly have its objectivity, its 'objectity', that is, its ability to propel novel entities on the scene, to raise new questions in their own terms and to force the social and natural scientists to retool the whole of their intellectual equipment. Contrary to the worries of the 'science warriors', it is precisely when the objects of study are interested, active, disobedient, fully involved in what is said about themselves by others, that it sometimes happens that a field of a social science begins imitating for good the surprising novelties of some of the best natural sciences. (This is indeed, what STS has done with *their* objects of study that have been made to object, and vociferociously so!). As to the rest of the social sciences that just imitates science but lacks objectivity, it might more charitable to remain silent.

Such an argument (which I call the Stengers-Despret shibboleth because it cuts across disciplines in a very different normative way) is not a vindication of the more interpretative or qualitative schools of the social sciences. This is because their energy would be better spent if, instead of fighting what they imagine to be the natural sciences way of handling 'mere objects', they were actually trying to discover those rare and sometimes dangerous situations where neither intentionality, nor consciousness, nor reflexivity defines humanity. By insisting so much on hermeneutic loops, social scientists have got too easily out of the loop – leaving in the dark the myriad of *non-human* actants, so essential to the very definition of humanity. The incredible amount of work done by hermeneutics to separate out humans and objects is not more ethical (in spite of the high moral stance they always take against natural scientists accused of objectifying humans) than the most blatant apartheid which claims: 'no non-humans in this science' (for the many other types of objectivities that happen in medical settings, see Berg and Mol 1998).

To sum up. As I see it, things are unfairly accused of being just 'things'. More exactly, it might be more rewarding to go back to the etymology of the word (in Anglo-Saxon as well as Roman languages) and to remind ourselves that all things (*res* and *causa* in Latin, see Thomas 1980) also means an *assembly* of a judicial nature gathered around a topic, *reus*, that creates both conflict and assent. After a few centuries of modernism, STS simply brings us back to the normal definition of things as *assemblies*, forcing us to see the divides between nature and society, necessity and freedom, between the relevant domain of the natural sciences and that of the social sciences, as a very peculiar anthropological and historical feature (Latour 1993; Descola and Palsson 1996). One has simply to look at any of the quasi-objects flowing nowadays through our newspapers from genetically modified organisms to global warming or internet commerce, and be convinced that it might be about time for social and natural scientists to forget what separates them and start looking jointly at those 'things' whose hybrid nature has, for many decades now, *already* unified them in practice.

It is to this new political situation, which might prove favourable to the social sciences, that I now turn.

A GOLDEN AGE FOR THE SOCIAL SCIENCES?

For what strange reason have the social sciences tried to imitate the natural sciences so wrong-headedly? Bauman provides an interesting answer when he describes the sociologist as 'legislator' (Bauman 1992). Most of the social sciences were invented, a century ago, to short-cut political process after many years of insufferable civil wars and revolutionary strife. If we have a

Society that is *already composed as one single whole* and which can be used to account for the behaviour of actors who do not know what they are doing, but whose unknown structure is visible to the keen eyes of the trained social scientist, it then becomes possible to embark on the huge task of social engineering in order to produce the common good, without having to go through the painstaking labour of composing this commonality through political means. We find here the genealogy of this famous Society whose demise is now everywhere visible, not so much because of the advent of networks and global markets, but because it has become politically and scientifically scandalous. From Comte to Bourdieu through Durkheim and Parsons, this dream of legislating in order to by-pass an impossibly fractious political arena by using the knowledge of what Society is – what manipulates the people in spite of themselves – has formed the core vocation of most social sciences (apart from the tiny schools of interpretative sociology, ethnomethodology and symbolic interactionism, that Bauman places in a different family).

In this strange political dream of short-cutting politics, we find not only the notion of the social we had to dispute above, but also this extravagant scientism we have also been criticizing throughout.

When social scientists try to find a hidden structure 'manipulating' agents in spite of themselves, they believe they have to imitate the natural sciences' formidable invention of a divide between primary and secondary qualities, to use an old but convenient philosophical vocabulary. Primary qualities define the real stuff out of which nature is made, particles, strings, atoms, genes, depending on the discipline, while secondary qualities defines the way that people subjectively represent this same universe. For instance, this table looks brown, polished and quaint, whereas it is really made up of atoms and a vacuum. This computer is really made of bits and transistors, while I see only a user's friendly interface. The point of this seemingly innocent divide is that it is a formidable political ploy. The common world (of what the universe is really made up) is known by the scientists, but invisible to the eyes of the common people. While what is visible, lived, felt, is, to be sure, subjectively essential but utterly inessential, since it is not how the universe is made up. This means that when the time comes to tackle the political work *par excellence*, namely the definition of what sort of world we have in common, scientists can say that the task is *already completed* since the primary qualities are all summed up in one Nature. There remains, of course, the secondary qualities, but they only divide us into multiple points of view which may be subjectively relevant but are objectively (in the traditional sense) irrelevant. Thus we appear to have one nature, multiple incommensurable cultures (for the complete argument, see Latour 1999c).

We can now understand the extraordinary temptation, for sociologists with a vocation to play the legislator role, to do for Society what natural scientists (they believe) have done for Nature. Instead of composing it bit by bit through some arduous political process, let us suppose instead that there exist for Society too, primary qualities, such as economic infrastructures, power relations, *epistemes*, unconscious, structural constraints, invisible hands, it depends on the discipline, that are detected by the social scientists. And let us further assume that actors themselves are as unaware of the real stuff making up their social life as I am about the atomic composition of this table. When the time comes to compose the world we should have in common, the sociologist can say

> Too late, you cultural dopes! We already have a common world, it is called Society. It has always been there and deployed beneath all your dealings, even if you do not see it. There is also, to be sure, your subjective feelings, but it adds not an iota to the harsh reality of Society. Or, to be more precise, it does add something, the veil of illusion necessary for you to survive without seeing the horrible truth we can see so clearly because we are social scientists.

But one can go even further, and obtain the ideal modernist dream – this dream which recent history, together with the small push of STS, has shattered to pieces. Why not simultaneously use the *two* traditional ways of composing the common world by short-cutting due political process, namely, Nature and Society? Natural scientists deal with the primary qualities of the natural world while social scientists deal with those of Society. The knowledge of what the universe is really like will allow the natural scientists to define all secondary qualities as irrational, private, subjective or culturally respectable (depending on his or her diminishing degree of militancy). While the knowledge of what Society is really like will allow the social scientist to reject all interjections of the actors themselves as so many irrational, subjective, private, distorted, perverse, irrelevant or culturally respectable illusions (depending again on the decreasing level of arrogance). So the quip I started with, comes from a rather sensible philosopher. Yes, the social sciences are excellent except for the words 'sciences' and 'social'. If social means Society and if Sciences means the short-cutting of due process through the already made division of primary and secondary qualities authorizing social and natural scientists to ridicule the common people for their irrationality, then the social sciences are not worth a dime or maybe a Euro.

The social sciences could have, however, an entirely different role if, thanks in part to STS, they abandon this primary/secondary dichotomy (what Whitehead, so tellingly called the 'bifurcation of nature', 1920) and get back to 'things' in the sense defined above. Things (or quasi-objects or risk, the word does not matter) have the peculiar feature of *not* being divisible into primary and secondary qualities. They are much too real to be representations, and much too disputed, uncertain, collective, variegated, divisive to play the role of a stable, obdurate, boring primary qualities, furnishing the universe once and for all. What the social sciences, together with the natural, can do, is to *represent* those things in all of their consequences and uncertainties to the people themselves. This is what Dewey, in one of his most important contributions, offered as a vocation to the social sciences seventy years ago (Dewey 1954[1927]). That is, not to define the unknown structure of our actions (as if the social scientist knew *more* than the actor) but in *re*-presenting the social to itself because neither the 'public', his word for what would be now called risk society, nor the social scientist knows for sure in what sort of experience we are engaged. The good social sciences, in this view, are not those who play the game of the (imagined) natural sciences in inventing infrastructures, but those who are able to modify the representation the public has of itself *fast enough* so that we can be sure that the greatest number of *objections* have been made to this representation. Then the social sciences will begin to imitate the natural ones. Nay, they might begin to bring the 'things' back to what they pertain: this assembly in charge of composing the common world that should rightly be called politics (Latour 1999b; 1999c).

To define the project of 'post-STS' social sciences in this way, could also alleviate the endless talk about fluidity, diversity, multiplicity, fragmentation, open-endedness which is so typical of contemporary discourse (Castells 1996). If we extirpate ourselves from the modernist 'science society' project, it is certainly not to fall back on the postmodern eulogy of networks, fluids and fragments. The 'new spirit of capitalism' to use the damning phrase (Boltanski and Chiapello 1999), might relish in this Nietzschean call for multiplicity, but it is as much of a shortcut of due political process as the former nature/society dichotomy. The first modernist project abandoned the *progressive* composition of the common world, because it possessed a Nature and a Society already made up. The second, postmodernist project of networks, abandons the quest for a *common* world. We would be falling from Charybdis to Scylla, if we were to debase the social sciences again in sounding the clarion call of even more fluid decentered markets. What would be the use of having left the shadow of totalitarianism, to fall into the 'globalonneys' of globalization, 'total' and 'global' being two words for the common world obtained without due process? 'Things', in the sense given to them by the shocking influence of STS on the natural and social sciences, do not have the unity the modernists believed they had, nor do they have the multiplicity postmodernists would like them to retain. They are lying there, in the new assemblies where they are waiting for the due process that will give them their unity, *at the end*, not at the beginning.

CONCLUSION

Throughout this article, I have used the term 'social science' rather than 'sociology'. This was not out of some imperialistic *hubris*, but simply because each social science has its natural science counterpart, *except* for sociology. More exactly, until the advent of STS, each social science was confronted within its own disciplinary boundaries by the issue of what a 'thing' is. Only sociology appeared to have escaped such a fate. There is a physical and a human geography and a physical and a social (or cultural) anthropology. Psychology is divided in an infinite number of layers, from electric sparks in the brain to lacanisms on the couch, to rats running in circles. Linguistics travels in a single department, from computer modelling to speech acts through evolutionary scenarios, etymology and hard-core phonology. Demography, by definition, deals with the most intricate hybrids of genes, sex, statistics, mores and morals. Even economics is internally divided into a naturalization of markets and an economization of nature. It does not mean that life is harmonious in each of these disciplines. On the contrary, it means that each has to be confronted in the same corridor, the same meetings, the same reviews, the same hiring committees, by the scandal of having also to account for things in many different ways.

There is a *social* sociology but where is the *physical* sociology? Sociobiology, alas, does not fit the bill because it is too militantly opposed to the social sciences and too unreflective to produce politically meaningful 'things'. I propose rather that STS should be to sociology this other part which keeps the discipline 'on its toes', which forces colleagues immersed in the 'social' and the 'symbolic' to take seriously the enormous difficulty of accounting for objects, which oblige them to take up the radical hybridity of their topics and which helps makes sociology resemble more closely the rest of the social sciences. The social is not a domain, but only one voice in the assemblies that make up things in this new (very old) political forum: the progressive composition of the common world.

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Morality and Technology

The End of the Means

Bruno Latour, translated by Couze Venn

IT IS readily admitted that although human beings pose themselves moral problems concerning technologies (Should or should we not introduce in Europe genetically modified organisms? Must we dispose of the waste from the nuclear industry in deep or surface silos?) the objects in themselves do not have a moral dimension. Such is the current view of a large number of sociologists (Collins and Kusch, 1998). Technologies belong to the realm of means and morality to the realm of ends, even though, as Jacques Ellul declared a long time ago, some technologies end up invading the whole horizon of ends by setting up their own laws, by becoming 'autonomous' and no longer merely automatic. Even in this extreme case, it is maintained, there is no other resource for human beings than to disengage from this domination by technologies, a domination that is all the more perverse for not imposing the law of a master but that of an emancipated slave who does not have the least idea about the moral goals proper to humankind. We know about the advantage that Heideggerians have drawn from the idea of a technology that could not be tamed since it was itself pure mastery without a master (Zimmerman, 1990). To become moral and human once again, it seems we must always tear ourselves away from instrumentality, reaffirm the sovereignty of ends, rediscover Being; in short, we must bind back the hound of technology to its cage.

Yet it is not so certain that we can so easily allocate their places to means and ends, to the impulses of force and the relations of reason, to simple objects and the properly human dimension, to forgetfulness and the eruption of Being. I have tried for a long time to cast doubt on this distinction. A number of colleagues – sociologists, philosophers, moralists – have besides reproached me for having thereby confused the moral reason which human beings must have among themselves with the material and functional

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relations that technical objects exercise among themselves according to the imperative of a force. However, it is enough to briefly take account of the work by paleontologists and historians of antiquity to recognize that, according to them, the question of the emergence of technologies and that of humanity have been mixed up for about two and a half million years (Latour and Lemonnier, 1994). In the wake of pioneering work on chimpanzeean 'industry', we now begin to discover long periods in pre-history when technical ability preceded the emergence of human language by several hundred thousand years. It increasingly seems to be the case that human self-development appeared within a nest or a niche already inhabited by abilities, by know-how and technological objects (see for example Strum and Fedigan, 2000, as well as the work of Frédéric Joulian, 2000). If the tool is no more proper to humankind than laughter, it will become more and more difficult to trace the border between the empire of the human and the realm of technologies. In any case, the image of a human being at the helm manipulating inert objects to achieve ends through the intermediary of 'efficient action on matter' appears increasingly muddled. Technologies belong to the human world in a modality other than that of instrumentality, efficiency or materiality. A being that was artificially torn away from such a dwelling, from this technical cradle, could in no way be a moral being, since it would have ceased to be human – and, besides, it would for a long time have ceased to exist. Technologies and moralities happen to be indissolubly mingled because, in both cases, the question of the relation of ends and means is profoundly problematized. This is what I would like to demonstrate.

What can we do to give to technology the dignity equal to that of morality so that we may establish between them a relation which would no longer be that of the tool to the intention? First of all, by redefining the technical, which I will here consider to be an adjective and not a substantive. It is pointless to want to define some entities and some situations as technical in opposition to others called scientific or moral, political or economic. Technology is everywhere, since the term applies to a regime of enunciation, or, to put it another way, to a mode of existence, a particular form of exploring existence, a particular form of the exploration of being – in the midst of many others. If we are unable to distinguish between a technical object and a non-technical one, we should nevertheless be able to locate the dimension pertaining to technology in some entity. The regime of technology, if you wish, is different from another standpoint (scientific, artistic or moral) not in the way that a region of reality would differ from another, but in the way prepositions differ amongst themselves, in much the same way as 'in' is clearly distinguishable from 'by', although there is no particular domain of 'in' that we can separate from the territory 'by'. I would like to define the regime proper to technology by the notion of *fold*, without giving it all the Leibnizian connotations that Gilles Deleuze (1993) has elaborated so well.

What is folded in technical action? Time, space and the type of actants. The hammer that I find on my workbench is not contemporary to my action today: it keeps folded heterogenous temporalities, one of which has the antiquity of the planet, because of the mineral from which it has been moulded, while another has that of the age of the oak which provided the handle, while still another has the age of the 10 years since it came out of the German factory which produced it for the market. When I grab the handle, I insert my gesture in a 'garland of time' as Michel Serres (1995) has put it, which allows me to insert myself in a variety of temporalities or time differentials, which account for (or rather imply) the relative solidity which is often associated with technical action. What is true of time holds for space as well, for this humble hammer holds in place quite heterogenous spaces that nothing, before the technical action, could gather together: the forests of the Ardennes, the mines of the Ruhr, the German factory, the tool van which offers discounts every Wednesday on Bourbonnais streets, and finally the workshop of a particularly clumsy Sunday bricoleur. Every technology resembles what surrealists called an 'exquisite cadaver'. If, for pedagogical reasons, we would reverse the movement of the film of which this hammer is but the end product, we would deploy an increasing assemblage of ancient times and dispersed spaces: the intensity, the dimension, the surprise of the connections, invisible today, which would thus have become visible, and, by contrast, would give us an exact measure of what this hammer accomplishes today. There is nothing less local, less contemporary, less brutal than a hammer, as soon as one begins to unfold what it sets in motion; there is nothing more local, more brutal and more durable than this same hammer as soon as one folds everything implicated in it.

But the mere distance of places and times is not sufficient to define the folding which is proper to technology: we still need to specify the connection itself. How would we preserve the irreversible trace of the fold? By means of a third disjunction, a third dislocation, by way of a new heterogeneity that will modify, this time not the diversity of times or that of the places, but that of the actors or actants. Without the hammer, I would have but my fist or some stone picked up outside my door to drive the nail in – and without the nail, I would be even more bereft. The very poverty in which I find myself when deprived of a hammer (let us recall the joy of Crusoe upon discovering the tools in the crates thrown up from the wreck) allows me to measure the beings in the place of which this hammer stands. To begin with, it replaces the long paradigmatic series that technologists have been keen to recreate, which redefine all the possible substitutes of that hammer throughout the course of history (Haudricourt, 1987). Instead of the places and times that we would need to deploy in order to do justice to that hammer, we should therefore add, if historians, historians of antiquity, palaeontologists, and primatologists would authorize it, the astonishing variety of forms which my mundane hammer has inherited. But it finds a place in another series, this time a syntagmatical one, since it provides for my fist a force, a direction and a disposition that a clumsy arm did not know it had.

It is impossible here to proceed as if the hammer 'fulfilled a function', for it overflows the strict limits of this container on all sides. The claim that 'the organ creates the function' can be made about all tools (and of the hammer in particular). With it in hand, the possibilities are endless, providing whoever holds it with schemes of action that do not precede the moment it is grasped. It is what James Gibson has so well documented with the notion of 'affordance', at once permission and promise: thanks to the hammer, I become literally another man, a man who has become 'other', since from that point in time I pass through alterity, the alteration of that folding (Gibson, 1986). This is why the theme of the tool as an 'extension of the organ' makes such little sense. Those who believe that tools are simple utensils have never held a hammer in their hand, have never allowed themselves to recognize the flux of possibilities that they are suddenly able to envisage. One can easily understand the anthropoid monkey in Stanley Kubrick's film *2001*, stupefied and surprised when faced with the world opened up by a jawbone held like a hammer – and as a club handy for killing. If, in a famous swirling movement, he flings it so high and far that it becomes the space station of the future, it is because all technologies incite around them that whirlwind of new worlds. Far from primarily fulfilling a purpose, they start by exploring heterogeneous universes that nothing, up to that point, could have foreseen and behind which trail new functions.

We readily understand how the notion of 'technical mediation' is rather inadequate to encompass this triple folding of places, times and agents. The term mediation always runs the risk that its message could be inverted and that one could turn whatever makes it impossible to transfer a meaning, a cause or a force into precisely what merely carries a force, a cause or a meaning. If we are not careful, we would reduce technologies to the role of instruments that 'merely' give a more durable shape to schemes, forms, and relations which are already present in another form and in other materials. To return to an example which has been very useful to me: traffic calming devices are not 'sleeping policemen' simply made of concrete instead of flesh and bone. If I consider calming devices as *mediators* properly speaking, it is precisely because they are not simple *intermediaries* which fulfil a function (Latour, 1996). What they exactly do, what they suggest, no one knows, and that is why their introduction in the countryside or in towns, initiated for the innocent sake of function, always ends up inaugurating a complicated history, overflowing with disputes, to the point of ending up either at the State Council or at the hospital. We never tame technologies, not because we lack sufficiently powerful masters, not because technologies, once they have become 'autonomous', function according to their own impulse, not because, as Heidegger claims, they are the forgetting of Being in the form of mastery, but because they are a true form of mediation. Far from ignoring being-as-being in favour of pure domination, of pure hailing, the mediation of technology experiments with what must be called *being-as-another*.

It is perhaps surprising that, in spite of technologies having nothing to do with mastery, it is nevertheless always in the form of the instrument, of service rendered, that we speak about them. But is that really the case? It seems to me that it is more adequate to speak about technologies in the mode of the *detour* than in that of instrumentality. Technology is the art of the curve, or what, following Serres, I have called 'translation'. If we go in a straight line, as epistemology does, we do not need it, as we know from the time of the Greeks. Ingenuity begins with Daedalus, prince of the labyrinth, that is, with the unexpected branching-out which at first distances us from the goal (Frontisi-Ducroux, 1975). When we say there is a technical problem to resolve, we precisely wish to introduce the addressee to the detour, to the labyrinth that he will have to confront before pursuing his initial objectives. When we admire the technique of a specialist, we rightly recognize in it the passage that no one can master, except him, and specifically him, who besides does not know what he is doing (all the specialists in systems of expertise recognize this to their cost). How far we are from the function, from domination, from instrumentality! We find ourselves unexpectedly placed in front of what permits us (without understanding why) or what prevents us (without understanding that either) to have *direct* access to the goals.

Technologies never truly appear in the form of means, and that aspect becomes even more clear, I daresay, when one deals with them as black boxes of which we need only know the inputs and the outputs. The more technological systems proliferate, the more they become opaque, so much so that the growth of the rationality of the means and ends (according to the conventional model) is manifested precisely by the successive accumulation of layers, each of which makes the preceding ones more obscure (Latour, 1992a). In case we have forgotten about this fundamental opacity of technology, the quiet archaeological work conducted for the past decade and the frenzied work conducted in the past two years by information technologists in trying to rid us of the millennium bug remind us about it more clearly than all the philosophical attempts at elucidation. The very complexity of the apparatuses, which is due to the accumulation of folds and detours, layers and reversals, compilations and re-orderings, forever denies the clarity of right reason, under the aegis of which technologies have been first introduced.

Why then do certain dominant Western traditions in spite of everything speak of technology as something that is amenable to mastery? Why does that which should appear as unmasterable always in the end find itself regrouped in the realm of simple means? It is here where the conflict with moral mediation begins to appear. The modest appearance assumed by technology comes from *habit*, which prompts forgetfulness about all these interlinked mediations. The 'figure of the labyrinth', to recall Cornelius Castoriadis's nice expression, is known to every beginner and innovator: each discovers between himself and his aims a multitude of objects, sufferings, apprenticeships which force him to slow down, to take one detour after another, to lose sight of the initial aim, to return hesitatingly, to take courage, etc. And yet, once the beginner becomes an expert by going through the apprenticeships one by one, once the invention has become an innovation as a result of the slow concretization which is demanded by industry and the market, we end up by being able to count on a unity of action which is so reliable that it becomes invisible. It is a characteristic of those technical mediators that they ultimately require invisibility (although in an entirely different way from scientific instruments). This is, of course, a kind of optical illusion. Indeed, the routine of habit must not prevent us from recognizing that the initial action, this famous 'plan' which is supposed to stand in for the programme materialized by the simple implementation of technology, has definitely mutated. If we fail to recognize how much the use of a technique, however simple, has displaced, translated, modified, or inflected the initial intention, it is simply because we have *changed the end in changing the means*, and because, through a slipping of the will, we have begun to wish something quite else from what we at first desired. If you want to keep your intentions straight, your plans inflexible, your programmes of action rigid, then do not pass through any form of technological life. The detour will translate, will betray, your most imperious desires.

By whatever end we take hold of technologies, the relations of means and ends will surely never appear as simple as is supposed by the archaic split between moralists in charge of the ends and technologists controlling the means. Like Saint Paul one should say of technologies: 'I do not do the good that I want, and commit the harm that I do not want' (Rom. 7–19).

In defining the hold of technology in terms of the notions of fold and detour, I think I have returned it to its ontological dignity. Without technologies, human beings would not be as they are, since they would be contemporaneous with their actions, limited solely to proximal interactions. Incapable of substituting anything whatsoever for absent entities that would stand in their place, they would remain without possible mediation, that is to say, without the ability to pass unexpectedly through the destiny of other completely heterogeneous beings, the possibilities of which are added to their own, thus inaugurating the progress of *multiple* histories, properly speaking. I have often, in a provocative spirit, toyed with the definition of social life purged of all foldings or technological detours as the shared dream of some sociologists, my colleagues, and of the monkeys of my friend Shirley Strum: a passionate, intense existence, which is constantly subject to the rapid renewal of coalitions and social relations properly so called, but which is nevertheless an existence that is barely human and hence hardly moral (Strum and Latour, 1987). Without technological detours, the properly human cannot exist. On a more serious note, we may detect it in innumerable works ranging from ergonomics to technology, passing through the remarkable efforts of Laurent Thévenot to classify modes of action (Thévenot, 1994; Thévenot and Livet, 1997). Technologies bombard human beings with a ceaseless offer of previously unheard-of positions – engagements, suggestions, allowances, interdictions, habits, positions, alienations, prescriptions, calculations, memories. Generalizing the notion of affordance, we could say that the quasi-subjects which we all are become such thanks to the quasi-objects which populate our universe with minor ghostly beings similar to us and whose programmes of action we may or may not adopt. If the robe does not make the monk, wearing a frock makes us slightly more pious.

We always hesitate before recognizing in this bombardment of possible positions one of the essential resources of humanity, since there exist many other sources with which we would not wish to confuse them. Obviously, a person is not constituted solely in the act of grasping a tool, or when the rhythm of the conveyor belt is imposed upon him, upon receiving the offer of a bridging loan from an automatic machine at the bank, or when he absent-mindedly slips into the habitual course of activity of a well-equipped kitchen, or when he is given an artificial memory through the disposition of goods in a supermarket. To have a personality, one must benefit from a good many other regimes of existence, many other connections (Ricoeur, 1990; Latour, 1998). Yet the existence of a multiplicity of modes of exploration of being does not justify turning technical enunciation into a simple material domain on the surface of which always float symbols, values, judgements and tastes, since that habit would cause all mediations to gradually disappear. The error is all the more serious to the extent that the body itself can grasp itself in the modality of technique and from that point begins to proliferate in detours and foldings (Dagognet, 1993). Every artist, every technician or artisan, every surgeon knows that technicity is never simply a question of a new way of distributing bodies, some being artificial and others natural, the vascularization of which alone allows the feats which we attribute afterwards, through laziness, either to objects or to human genius (Akrich and Berg, forthcoming). In this sense, all techniques are, in Marcel Mauss's terms, techniques of the body.

What in this definition is it, we may ask, which is so remote from the current usage of the substantive 'technology' yet so close to the adjective 'technical', that brings us close to the moral question? At first I thought we would take a giant step forward if only we would recognize that a substantial part of our everyday morality rested upon technological apparatuses. It is what I called the 'missing mass of morality' (Latour, 1992b). One example will suffice, for the reader will readily find 20 other more relevant ones. For reasons unknown to me, the maker of my desk prevents me from opening a drawer without the two others being carefully and completely shut. The designer has disappeared; besides, the firm (with some justice) went bankrupt ages ago; I am not a good enough bricoleur to discover the counterprogramme which would put an end to this aberration; nevertheless 20 times a day for 10 years, I am 'obliged' to obey this meddlesome moral law since I am not 'authorized' to leave the three drawers open at the same time. I rail against it but I get on with it, and I have no shame in admitting that every day there is no other moral law that I apply with such inflexible severity. Blast it, it is because I am bound by it! Of course, the moral law is in our hearts, but it is also in our apparatuses. To the *super-ego* of tradition we may well add the *under-ego* of technologies in order to account for the correctness, the trustworthiness, the continuity of our actions.

If there is something to be gained by subtracting the part pertaining to technical objects from the sum of moral behaviour, this however only touches the surface of the problem, since we are considering techniques and moral action only at the level of their routinized or habitual or slight maladjustment stage. As Louis Quéré (pcrs.com) has rightly pointed out, we cannot infer from the current usage of terms of duty and authorization that technical objects have an obvious moral dignity *in themselves*. Therefore, that has not exactly been my intention. It is mainly the contempt that sociologists have for matter and for technological innovation which has led me previously to exaggerate somewhat in speaking about the 'tragic dilemmas of a safety belt'. Nevertheless, we may recognize that I was not completely mistaken by now granting to morality the same ontological dignity given to technology as I have just redefined it above.

Morality, of course, like science or technology, is an heterogeneous institution constituted from a multiplicity of events, which depends at the same time on all modes of existence – and in part, as I have just said, on the arrangement of technical apparatuses, but equally on a good many other forms of organization, a veritable hotbed of confusion, as one can verify by reading dictionaries of moral philosophy. I believe, however, that it is possible to give it its proper definition, by way of its specific way of exploring the alterity of being. Morality too is a mode of existence, a standpoint on being-as-another, a predisposition, an original regime of mediation. The form in which one usually recognizes it, obligation, does not properly belong to it since the latter derives just as much from contract, from religious events, from transfers (*frayeurs*), from chains of references, from the law, in short, from a whole composite series that it would be futile to unravel for now. The only thing that interests me here is the point of friction between the standpoint of technology and the standpoint of morality regarding the relation between means and ends. It is clear enough from their competing, contradictory definition of alterity that there is between the two neither a pre-established harmony nor an order that accords with the relations of means and ends. They both mould being-as-another but each in a different way. Morality is no more human than technology, in the sense that it would originate from an already constituted human who would be master of itself as well as of the universe. Let us say that it *traverses the world* and, like technology, that it engenders in its wake forms of humanity, choices of subjectivity, modes of objectification, various types of attachment. It is to the qualification of this trajectory that we must now attend.

The folding, the technological detour, as I have said, mingles beings into an heterogeneous existence and inaugurates an unexpected history by the multiplications of *aliens* which henceforth intervene between two sequences of action, suddenly creating in our path a labyrinth from which we can never escape, or alternatively, a routine of such familiarity that, just like Zeno's hare, we would never realise that we had just escaped from a giddying infinity. Between the gesture of switching on my computer and what I write on the screen, I can either ignore the nuclear industry which enables me to work this morning, or find myself immersed in the uncertain destiny of that same industry which forces me to take account of the burial in deep silos of the waste from its stations that the French do not support. Such is the impressive scope of the concertina movement that characterizes technology: either I have the most secure, the most silent access to a course of action (to the extent that I no longer include in my description the nuclear industry reduced to the rank, not of means, but of *nothing*), or else I find myself in the maze which the whole of France blindly traverses shouting: 'but how can we get rid of it?!' A few seconds ago, I was in possession of resources that were so standard that they accounted for nothing; now, I find myself in ends so final that no one knows any longer how the common history will end.

Let us not conclude from this concertina or fan movement switching violently from zero to infinity that, in the former case, we are dealing with a 'simple technical question' whilst, in the latter case, we have posed a moral question 'dealing with' an industry. No, it is in the very essence of this technical apparatus that rests the complete uncertainty about the relations of means and ends. It is intrinsic to the rhythm pertaining to technology to alternate violently from modesty to terror, from the tool to the horizon, from surprise to routine. There is nothing surprising about that, since with the enfolding of the nuclear industry, we have tied the fate of our computers to radioactivity, gradually binding the slow history of my career to the millisecond rhythm of informational fleas, and the whole series to the fate of wastes, the half-life (or half-death) of which can be calculated, for some, in hundreds of years. This 'time garland' has a real existence in my vision and opens onto a history that has *no end*. The paradox of technology is that it is always praised for its functional utility, or always held in contempt because of its irritating neutrality, although it has never ceased to introduce a history of enfoldings, detours, drifts, openings and translations that abolish the idea of function as much as that of neutrality. How dare we qualify as neutral the ontological drama of unexpected assemblages of entities which can pass, without a hitch, from zero to infinity? It is not for nothing that Vulcan limped . . . Behind the tired repetition of the theme of the neutrality of 'technologies-that-are-neither-good-nor-bad-but-will-be-what-man-makes-of-them', or the theme, identical in its foundation, of 'technology-that-becomes-crazy-because-it-has-become-autonomous-and-no-longer-has-any-other-end-except-its-goalless-development', hides the fear of discovering this reality so new to modern man who has acquired the habit to dominate: there are *no masters anymore* – not even crazed technologies.

It is with a quite different feel for alterity that morality explores the same assemblages of beings whose fate has become mingled by the detour of technology (and by a good many other forms of existence whose difference does not interest us here). Every technological initiation pays for the multiplication of mediators in the creation of intermediaries. The growth of the oak from the Ardennes was directed to quite other ends than the production of my hammer, even if it had been planted with this end vaguely in mind. Of the oak, the tool has kept but a minute part of its properties of solidity, of warmth, of the alignment of the lines of lignite. Where was the oak going by itself and for itself? In what world did it prolong its existence? Technology is not interested in such a question, compelled as it is to dislodge all the entities through which it passes in order to engender possible worlds and allow new dispositions. A very different anxiety runs through morality: how many mediators do the other forms of existence maintain in their wake? Do we not run the risk of treating the oak as a simple means for the hammer? Everyone knows the simplified version that human morality, all too human, has given to this principle: 'do not ever treat human beings simply as means, but always as ends as well'. Kant, of course, applied it to human beings alone, and not to the hammer, to oaks or to radioactive uranium atoms. Having reactivated the fable of homo faber, he really imagined human beings in command, putting its categories to work on a raw material without rights. Two hundred years later, such a position appears to us equally indefensible as the accounts of the elephant hunts of Theodore Roosevelt or the quibbles of the Greeks regarding the impossibility of freeing slaves who were considered inferior by nature. It is because morality since that time has reworked the common material blended by technologies that have bound together more and more entities in the same common fate (Latour, 1999a).

We can no longer pose the question of morality in the same way as we would have done at a time when human beings had hardly started to scratch the earth on which they passed from life to death without anyone *else* noticing. Morality and technology are ontological categories, as Gilbert Simondon following Etienne Souriau (Souriau, 1943) has so well expressed it, and the human comes out of these modes, it is not at their origin. Or rather, it cannot become human except on condition of opening itself to these ways of being which overflow it from all sides and to which it may choose to be attached – but then at the risk of losing its soul. Morality, if we agree to detach it for a moment from the complex institution which has shaped it in a thousand ways, appears thus a concern which ceaselessly works upon being-as-another to prevent ends from becoming means, mediators from being transformed into simple intermediaries. It does not so much interrogate itself about the right of things for themselves (even though deep ecology has shaped the ethical question in such a way as to throw morality outside a narrow anthropocentrism), but about the existence of things and the meaning of this expression 'for themselves'. Nothing, not even the human, is for itself or by itself, but always *by other things* and *for other things*. This is the very meaning of the exploration of being-as-another, as alteration, alterity, alienation. Morality is concerned with the *quality* of this exploration, with the number of mediators that it leaves in its wake, always wanting to verify if it proliferates the greatest possible number of actants that claim to exist and intervene in their own name or whether, on the contrary, it has not resigned itself to forgetting them. Wherever we want to go fast by establishing tracks so that a goal can race along them whistling like a high-speed train, morality dislocates the tracks and recalls to existence all the lost sidings. The goal-oriented train soon comes to a stop, burdened, powerless. As it is often said, morality is less preoccupied with values than with preventing too ready an access to ends.

Let us not limit such a slowing down to human beings alone. To go back to the case of nuclear waste, no one would any longer imagine imposing on the mayors of small villages, the implantation, without any discussion, of a laboratory in order to study the resistance of granite, salt, or clay. Fifty years ago, we could treat populations as straightforward means to the national interest: not any more. We must now approach them politely, and we may read Yannick Barthe's thesis for the excess of patience that ANDRA must deploy to keep them in their place or to seduce them (Barthe, 2000). But how do we qualify the other actants that the history of technology has mingled in a common fate with human villages, for better or for worse, by means of a marriage that one no longer dare call 'of reason'? Can the glass of the containers hold for several thousand years? What trust may we have in the geology of tectonic plates, the history of which is hardly 100 years old and the detailed observation of which is but 20 years old? What do we know about the salt domes? Hence the new question of human and material morality: which is the more durable in the very long term? The malleable clay, the hard salt, the fallible granite, or instead the fragile but ceaselessly renewed link among human organizations, able to oversee, for countless centuries, the surface of a pool 'monitored' by beings as far into the future as the Neanderthals are into the past?

Once we have grasped morality as well as technology in its ontological dignity instead of relating them, as usual, solely to what is human, we may see that their relation is not at all that of means to end, practical spirit to spirit *tout court*, facts to values, or symbolic obligation to the stubborn obduracy of things. The two modes of existence ceaselessly dislocate the dispositions of things, multiply anxieties, incite a profusion of agents, forbid the straight path, trace a labyrinth – generating possibilities for the one, and scruples and impossibilities for the other. The worry about values does not disappear once the question of the safety of salt domes and glasses has been resolved. Even in the depth of caves, it comes to trouble the engineer by increasing the beings that he had perhaps too quickly treated as intermediaries (regular networks of rock crystals, the alignment of silicas) to make them reappear in front of his eyes in the shape of just as many mediators that are difficult to scorn, to tame: lunules, defects, breaks, microscopic errors, the multiplication of which, on the scale of eons, widens the fault in the reasoning of politicians and casts doubt upon the weak and stubborn opinion of 'the working classes' – at least superficially. Morality comes to rework precisely *the same materials* as does technology, but by extracting from each of them *another form of alterity* because its primary concern is the impossibility of their fitting into the mould of intermediaries. Well before we are able to translate the moral exigencies of tradition into obligations, they already lie inside that massive objectivity of mediations that forbid them being taken for ends for whoever and whatever else. In this sense, morality is from the beginning inscribed *in the things* which, thanks to it, *oblige us to oblige them*.

If technology causes dislocations, it is in order to readjust; if it opens up in front of an aim the abyss of means enframed within each other in a maze of new inventions, it is in order to close this abyss again and to create, through either the automatism of skill or the automatism of automatons, an invisible course of action which no longer even counts; if it introduces us to an unexpected history, it is to ensure that the initial goal, displaced, renewed, ends up coinciding closely with the new means that have just emerged, to the point that we begin to speak about the adequacy of form to function as we would of the glove to the hand. Nothing of that sort happens with morality: there is no question of a black box here, or the disappearance of millions of partial goals framed within the one means that would no longer matter and would disappear from sight. The work of mediation, in its moral organization, requires instead the ceaseless circuit of concern, the penetrating return of scruple, the anxious reopening of the tombs in which automatisms have been heaped, the redeployment of means into partial aims and aims into partial ends.

The precautionary principle, so much in fashion, does not simply mean that we stop taking action until we are certain about the innocuousness of a good, for that would once again return us to the ideal of mastery and knowledge by demanding certain knowledge about an innovation which, by definition and like any technology, *forever* escapes mastery. On the contrary, the principle of precaution resides in the permanent maintenance of the impossibility of folding – which is precisely what technology aspires to: whence the permanent conflict of ways of being. To maintain the reversibility of foldings: that is the current form that moral concern takes in its encounter with technology. We find it everywhere now in the notion of a recyclable product, of sustainable development, of the traceability of the operations of production, in the ever stronger concern for transparency (to look for transparency in matters of technology, what a paradox!), in the fairly new demand in France for accountability, that is to say, for describability and for the evaluation of options. It is in this new sense that morality finds itself in permanent and continuous conflict with the openness to history that technology constantly suggests (Latour, 1999b: ch. 4).

As one can see, the relation of technology to morality is somewhat modified as soon as we renounce the idea of putting the first on the side of means and the second on the side of ends. Each of these modes of existence upsets in its own distinctive way the relations between means and ends: technology by dislocating the relations between entities in such a way that they open towards a series of new linkages that force the constant displacement of goals and multiply intermediary agents whose collective sliding forbids any mastery; morality, by constantly interrogating aggregates to make them express their own aims and prevent a too hasty agreement about the definitive distribution of those that will serve as means and those that will serve as ends. If one adds morality to technology, one is bound to notice, to make a pun, *the end of the means*. Without means, another history begins, since morality and technology multiply the entities we must consider and must learn to reassemble. This gathering, this progressive composition of a common world, obliges us to return to another form of enunciation, this time a political one, which similarly aspires to recover its ontological dignity in order to escape from the state of abasement in which it had been cast by a scorn that has lasted even longer than that which technology has had to endure for so long.

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REDES QUE A RAZÃO DESCONHECE: LABORATÓRIOS, BIBLIOTECAS, COLEÇÕES [1]

Bruno Latour com a colaboração de Èmilie Hermandt

Aqueles que se interessam pelas bibliotecas falam freqüentemente dos textos, dos livros, dos escritos, bem como de sua acumulação, de sua conservação, de sua leitura e de sua exegese. Eles têm certamente razão, mas há um certo risco do escrito, um risco que Borges ilustrou bem com sua fábula de uma biblioteca total remetendo apenas a si própria. Nessa fábula muito literária, o império dos signos se apresenta como uma fortaleza de intertextualidade. Plena e sólida enquanto nos interessamos somente pelas glosas da exegese, ela parece vazia e frágil a partir do momento em que procuramos ligar os signos aos mundos que os rodeiam. Usuário muitas vezes frustrado das bibliotecas francesas, escolhi enquadrar esses lugares de memória com outros lugares menos freqüentados, como os laboratórios e as coleções, que a história e a sociologia das ciências nos ensinaram recentemente a conhecer melhor. Através desta breve meditação sobre as relações das inscrições e dos fenômenos, espero mostrar que a circulação desses intermediários muitas vezes desprezados fabrica não só o corpo mas também a alma do conhecimento.

risco do escrito

fortaleza de intertextualidade

Neste artigo, pretendo seguir não o caminho que leva de um texto a outro no interior de uma biblioteca, e sim o caminho que leva do mundo à inscrição, a montante e a jusante do que chamarei um "centro de cálculo". Em vez de considerar a biblioteca como uma fortaleza isolada ou como um tigre de papel, pretendo pintá-la como o nó de uma vasta rede onde circulam não signos, não matérias, e sim matéria tornando-se signos. A biblioteca não se ergue como o palácio dos ventos, isolado numa paisagem real, excessivamente real, que lhe serviria de moldura. Ela curva o espaço e o tempo ao redor de si, e serve de receptáculo provisório, de *dispatcher*, de transformador e de agulha a fluxos bem concretos que ela movimenta continua-

do mundo à inscrição

matéria tornando-se signos

A biblioteca curva o espaço e o tempo ao redor de si mente. Apesar de algumas imagens, a viagem para a qual estou convidando o leitor não será tão exótica quanto a de Christian Jacob na Biblioteca de Alexandria, mas talvez permita sair do universo dos signos no qual se quer às vezes – por desprezo como por respeito – confinar a cultura e seu instrumento privilegiado. Talvez o leitor compreenda por meio desse périplo o que os pesquisadores franceses perdem por não se terem beneficiado, até agora, de uma verdadeira biblioteca, e o crime cometido contra o espírito por uma nação que se considera, no entanto, muito espiritual.

Comecemos por subir a montante do signo e por perguntar como definir a informação. A informação não é um signo, e sim uma *relação* estabelecida entre dois lugares, o primeiro, que se torna uma periferia, e o segundo, que se torna um *centro*, sob a condição de que entre os dois circule um *veículo* que denominamos muitas vezes forma, mas que, para insistir em seu aspecto material, eu chamo de *inscrição*. Para tornar esta definição mais concreta, consideremos este auto-retrato do naturalista Pierre Sonnerat (fig.1).

Informação

Informação
relação entre centro e periferia
entre eles, um veículo: inscrição

Fig. 1 - Desenho de P. Sonnerat (auto-retrato),
Voyage à la Nouvelle-Guiné, Paris, 1776

Aqui, não nos encontramos nem numa biblioteca nem numa coleção, mas aquém delas, na costa da Nova-Guiné. O naturalista está em sua terra, mas longe, enviado pelo rei para trazer desenhos, espécimes naturalizados, mudas, herbários, relatos e, quem sabe, indígenas. Tendo partido de um centro europeu para uma periferia tropical, a expedição que ele serve traça, através do espaço-tempo, uma relação muito particular que vai permitir ao centro acumular conhecimentos sobre um lugar que até então ele não podia representar. Nesta gravura muito posada, o naturalista se desenhou a si próprio em plena atividade de transformação de um lugar em outro, registrando a transição entre o mundo das matérias locais e o dos signos móveis e transportáveis para qualquer lugar. Notemos, aliás, que ele se retrata num quase-laboratório, um lugar protegido pela folha de bananeira que o abriga do sol e pelos frascos de espécimes conservados no álcool. Notemos também que o mundo indígena deve fazer-se representar a fim de ser colhido pelo movimento da informação. A escrava de formas generosas exibe o papagaio e permite ao desenhista detectar mais rapidamente os traços característicos do mesmo. O desenho produzido por esse quase-laboratório em breve circulará em todas as coleções reais; quanto aos espécimes, empalhados ou em frascos de álcool, irão enriquecer os gabinetes de curiosidades de toda a Europa.

O que é a informação

O que é então a informação? O que os membros de uma expedição devem levar, na volta, para que um centro possa representar um outro lugar. Por que passar pela mediação de um veículo, de um desenhista, por que reduzir à escrita, por que simplificar a ponto de levar apenas alguns frascos? Por que não levar simplesmente o lugar, em sua integralidade, para o centro? Afinal de contas, era o que faziam os acadêmicos de Lagado que Gulliver visitou. Em vez de falarem, eles se faziam acompanhar por servidores carregando em carrinhos de mão o conjunto das coisas que deviam constituir o objeto de suas conversas, e que lhes bastava apontar. Grande economia de saliva, mas grande gasto de suor! Ora, a informação permite justamente limitar-se à forma, sem ter o embaraço da matéria. Os papagaios permanecerão na ilha com seu canto; levar-se-á o desenho de sua plumagem, acompanhado de um relato, de um espécime empalhado e de um casal vivo, que se tentará

limitar-se à forma sem o embaraço da matéria domesticar para o viveiro real. A biblioteca, o gabinete, a coleção, o jardim botânico e o viveiro se enriquecerão com isso se, no entanto, se entulhar com todos os traços que não teriam pertinência. Verifica-se que a informação não é uma "forma" no sentido platônico do termo, e sim uma relação muito prática e muito material entre dois lugares, o primeiro dos quais negocia o que deve retirar do segundo, a fim de mantê-lo sob sua vista e agir a distância sobre ele. Em função do progresso das ciências, da freqüência das viagens, da fidelidade dos desenhistas, da amplitude das taxionomias, do tamanho das coleções, da riqueza dos colecionadores, da potência dos instrumentos, poder-se-á retirar mais ou menos matéria e carregar com mais ou menos informações veículos de maior ou menor confiabilidade. A informação não é inicialmente um signo, e sim o "carregar", em inscrições cada vez mais móveis e cada vez mais fiéis, de um maior número de matérias.

seleção, extração, redução,

A produção de informações permite, portanto, resolver de modo prático, por operações de seleção, extração, redução, a contradição entre a presença e a ausência num lugar. Impossível compreendê-la sem se interessar pelas instituições que permitem o estabelecimento dessas relações de dominação, e sem os veículos materiais que permitem o transporte e o carregamento. O signo não remete de início a outros signos, e sim a um trabalho de produção tão concreto, tão material quanto a extração de urânio ou de antracito. Um gabinete de curiosidades, um volume de pranchas ornitológicas, um relato de viagem devem, pois, ser tomados como a ponta de um vasto triângulo que permite, por graus insensíveis, passar dos textos à situações e voltar aos livros por intermédio das expedições, da transposição em imagem e das inscrições.

Redução

Entretanto, convém completar este primeiro triângulo isósceles por um segundo, invertido, cujo vértice repousa, desta vez, na situação de partida, e cuja base se expande nos centros de cálculo. Um segundo movimento de amplificação sucede ao primeiro movimento de redução (fig.2).

1º movimento de redução — 2º movimento de amplificação

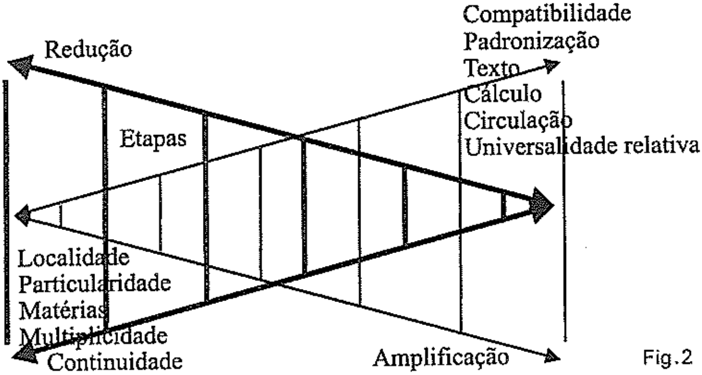


Fig.2

Ilustremos o movimento deste segundo triângulo com outra fotografia, tirada do livro admirável, ilustrado por Pierre Béranger, que Michel Butor consagrou à antiga galeria do Museu de História Natural (fig.3).

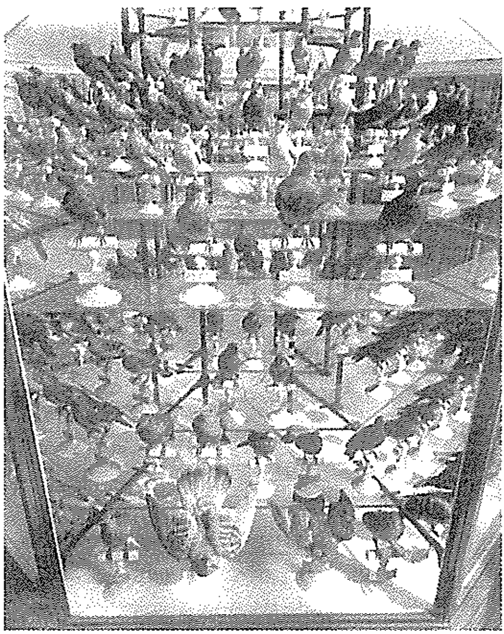


Fig. 3 - P. Beranger. In M. Butor. *Les naufragés de l'arche*. Paris, La Différence, 1981

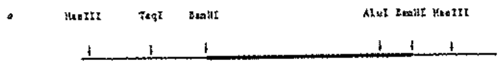
Reencontramos as aves empalhadas de há pouco, mas no meio de todos os seus congêneres, trazidos, do mundo inteiro, por naturalistas dispersos no espaço e no tempo. Em comparação com a situação inicial, em que cada ave vivia livremente em seu ecossistema, que perda considerável, que diminuição! Mas, em comparação com a situação inicial, em que cada ave voava invisível na confusão de uma noite tropical ou de um amanhecer polar, que ganho fantástico, que aumento! O ornitólogo pode então, tranqüilamente, em local protegido, comparar os traços característicos de milhares de aves tornadas comparáveis pela imobilidade, pela pose, pelo empalhamento. O que vivia disperso em estados singulares do mundo se unifica, se universaliza, sob o olhar preciso do naturalista. Impossível, é claro, compreender este suplemento de precisão, de conhecimento, sem a intuição que abriga todas essas aves empalhadas, que as apresenta ao olhar dos visitantes, que a marca por um fino jogo de escrita e de etiquetas, que as classifica por um sistema retificável de prateleiras, de gavetas, de vitrines, que as preserva e as conserva borrifando-as com inseticidas. Aí também, tanto para a amplificação como para a redução, a informação exige uma competência, um trabalho tão material quanto o do empalhador. Talvez o naturalista não pense diferentemente do indígena que percorria sua ilha em busca de um papagaio, mas ele vive, com certeza, num outro ecossistema. A comparação de todas as aves do mundo sinoticamente visíveis e sincronicamente reunidas lhes dá uma enorme vantagem sobre quem só pode ter acesso a alumas aves vivas. A redução de cada ave se paga com uma formidável amplificação de todas as aves do mundo.

Amplifi- cação

Passando do segundo para o terceiro triângulo, também aí não vejo um mundo de signos cortado de tudo e remetendo somente a si próprio. A coleção, o gabinete, o livro ilustrado, o relato, a biblioteca servem, ao contrário, de intérprete, de intermediário, de encruzilhada, de distribuidor, de central telefônica, de *dispatcher*, a fim de regular as relações múltiplas entre o trabalho de redução e o trabalho de amplificação. Todos esses lugares estão repletos de ligações com o mundo, e cada página puxa atrás de si tantas tomadas e fichas quanto a parte posterior de um computador. Ao falar de livros e de signos, não esqueçamos sua "conéctica". Após textos — práticas instituições → situações

quarenta anos de trabalhos sobre a intertextualidade e o esplêndido isolamento do mundo dos signos, convém lembrar que os textos agem sobre o mundo, e circulam em redes práticas e instituições que nos ligam a situações. Segunda evidência, que, com certeza, não nos leva de volta à evidência primeira do realismo e da semelhança ingênua, mas que, assim mesmo, nos afasta um pouco do império da semiótica.

Eis, por exemplo, uma página de revista *Nature* de alguns anos atrás, apresentando uma seqüência de DNA bem como as bases podem codificar (fig.4).



b GAT CCT CAC TTC GTG GTG GTT AAA GAA GCA CTG CTG AAA ACA ATA AAG GAG GCA GTT GGC GAC AAA TGG
c Asp Pro Gln Phe Val Val Val Lys Glu Ala Leu Leu Lys Thr Ile Lys Glu Ala Val Gly Asp Lys Trp
d Asn Pro Glu Phe * Val Val Lys Glu Ala Leu Leu Lys Thr Ile Lys Glu Ala Val Gly Asp Lys Trp
e Asn Pro Glu Phe * Val Val Lys Glu Ala Leu Leu Lys Thr Ile Lys Ala Ser Val Gly Asp Gln Trp
f Asn Pro Glu Phe * Val Val Lys Glu Ala Leu Leu Lys Thr Ile Lys Ala Ala Val Gly Asp Lys Trp

b AGT GAT GAA TTG AGC AGT GCT TGG GAA GTA GCC TAT GAT GAA TTG GCA GCA GCT ATT AAG AAG GCA TTT TAG GATC
c Ser Asp Glu Leu Ser Ser Ala Trp Glu Val Ala Tyr Asp Glu Leu Ala Ala Ala Ile Lys Lys Ala Phe COOH
d Ser Asp Glu Leu Ser Ser Ala Trp Glu Val Ala Tyr Asp Glu Leu Ala Ala Ala Ile Lys Lys Ala Phe COOH
e x Asp Glu Leu Ser Gly Ala Trp Glu Val Ala Tyr Asp Glu Leu Ala Ala Ala Ile Lys Ala Lys COOH
f Ser Asp Glu Leu Ser Arg Ala Trp Glu Val Ala Tyr Asp Glu Leu Ala Ala Ala Ile Lys Ala Lys COOH

Fig. 1 Characterization of the double-stranded cDNA clone, pLb1. *a*, Diagram of pLb1 insert area; heavy line is cDNA sequence, light lines are pBR322 sequences. *b*, Nucleotide sequence of the 145-base pair insert. *c*, Predicted amino acid sequence encoded by *b*. *d*, *e* and *f*, amino acid sequences of soybean Lb c_3, c_1 and a, respectively[9-10]. The amino acids underlined in *e* and *f* are different from those in *d*. cDNA and double-stranded cDNA[16] were synthesized with reverse transcriptase from oligo (dT)-bound RNA isolated from 3-week-old soybean root nodules[17] (*Glycine max* var. Prize infected with *Rhizobium japonicum* strain 61A76). *Sau*3A-cleaved double-stranded cDNA (10–50 ng) was ligated to *Bam*HI-cleaved pBR322 (1 µg) in 5 µl of 20 mM Tris HCl (*p*H 7.5), 10 mM $MgCl_2$, 10 mM dithiothreitol, 0.5 mM ATP and 0.1U T_4 DNA ligase (BRL) at 10 °C for 12 h. *Escherichia coli* strain 490 or HB 101 cells were transformed[18] and ampicillin (25 µg ml^{-1})-resistant and tetracycline (20 µg ml^{-1})-sensitive colonies were selected by replica plating on media containing the appropriate antibiotic. Colonies were screened for leghaemoglobin sequences by hybridizing replica filters[19] with ^{32}P-labelled cDNA in 0.6 M NaCl, 50 mM HEPES (*p*H 7.8), 100 µg ml^{-1} heat-denatured sonicated salmon sperm DNA, 0.5% SDS and 50% formamide at 37 °C. Further characterization of positive clones is discussed in the text. The pLb1 insert, including pBR322 sequences, bounded by *Hae*III sites, was isolated by polyacrylamide gel electrophoresis, cut with *Taq*I, and sequenced by the methods of Maxam and Gilbert[20].

Fig. 4 - Copyright *Natur.* D.R.

Seria absurdo considerar esta página como a expressão transparente, a réplica, na linguagem da seqüência, do gene tal como ele é, desde sempre, na natureza das coisas. No entanto, seria igualmente sensato isolar esta página do conjuto das tomadas referenciais que a ligam à ação de um gene em células vivas, através do laboratório, depois de centenas operações de manipulação. Questão clássica que a filosofia das ciências quis enquadrar por muito tempo, opondo os realistas de um lado e os construtivistas do outro, como se não se tratasse, ao contrário, de compreender a "construção da realidade" bem real dessa gente.

O texto deste artigo comenta a seqüência de genes inscrita como um documento gráfico no interior da prosa. Embora se trate de dois códigos, não nos encontramos aí na intertextualidade. O comentário "faz referência" a um documento que serve de prova e que fundamenta seus dizeres. Esse documento, pela mudança de nível da citação, assegura em parte a veracidade do comentário. Mas aonde nos leva o próprio documento, se seguirmos a série de mudanças de nível que, por sua vez, lhe servem de provas? Chegamos ao gene? Não imediatamente. Chegamos ao programador de genes – instrumento de laboratório –, aos biólogos moleculares manipulando com precaução placas fotográficas irradiadas com produtos radioativos e montando-as numa mesa luminosa como fariam fotógrafos. O gene que acaba se inscrevendo em claro nas páginas da revista não pode ser desligado das redes de transformações, de deslocamento, de traduções, de mudanças de nível, que vai, transversalmente, do texto à manipulação de laboratório. Como no caso do papagaio de há pouco, não é possível situar uma informação sobre o gene sem a rede das instituições, dos aparelhos e dos técnicos que asseguram o duplo jogo da redução e da amplificação. Conforme o lugar em que você se situar para retirar o sinal, você conseguirá: um líquido num tubo de ensaio, o gesto de um tácnico que maneja a pipeta, faixas cinzentas ou pretas num papel prateado, seqüências de ADN na linguagem de um computador, um texto em prosa sobre a localização possível de um gene, um argumento na boca de um homem de branco, um boato que corre no bar da esquina. Nunca se encontra o famoso roteiro de uma linguagem cortada do mundo e de um mundo cortado da linguagem, mas se encontra por toda parte a relação transversal, ao mesmo tempo contínua – que liga centro de cálculos, a montante e a jusante, a outras situações.

rede

cartografia

Como mostrou muito bem Christian Jacob, a cartografia pode servir de modelo para todo este trabalho de transformações que inverte a relação entre um lugar e todos os outros.

Nesta imagem (fig.5), o cartógrafo desenha, em local abrigado e no plano, a paisagem que ele domina com o olhar. Inversão

Fig. 5 - D.R.

propriamente fantástica, pois aquele que seria dominado, na paisagem desenhada ao fundo, torna-se o dominante assim que entra em seu gabinete de trabalho e desdobra os mapas para rasurá-los. Para compreender esta inversão, não devemos esquecer, bem entendido, a conéctica, que liga este lugar a todos os outros, por intermédio das expedições, das viagens, dos colóquios, das academias, pela mediação das vias comerciais tratadas a fogo e sangue, da matemática pura, que permite experimentar vários sistemas de projeção, e pela dos gravadores em cobre e dos impressores. Prestemos atenção por um instante à inversão das relações de força entre aquele que viaja numa paisagem e aquele que percorre com o olhar o mapa recém-desenhado. Da mesma forma que as aves do museu ganhavam, pelo empa-

Coerência ótica

lhamento, uma coerência que as tornavam todas comparáveis, assim também todos os lugares do mundo, por mais diferentes que sejam, ganham, através do mapa, uma coerência ótica que os torna todos comensuráveis. Por serem todos planos, os mapas podem ser sobrepostos, e permitem, portanto, comparações laterais com outros mapas e outras fontes de informação, que explicam esta formidável amplificação própria dos centros de cálculo. Cada informação nova, cada sistema de projeção favorece todos os outros.

comparação

amplificação

centro de cálculo

Compreende-se melhor, então, a expressão "centro de cálculo". A partir do momento em que uma inscrição aproveita as vantagens do inscrito, do calculado, do plano, do desdobrável, do acumulável, do que se pode examinar com o olhar, ela se torna comensurável com todas as outras, vindas de domínios da realidade até então completamente estranhos. A perda considerável de cada inscrição isolada, em relação com o que ela representa, se paga ao cêntuplo com a mais-valia de informações que lhe proporciona esta compatibilidade com todas as outras inscrições. O mesmo mapa pode encobrir-se de cálculos; é possível sobrepor a ele mapas geológicos, meteorológicos, pode-se comentá-lo num texto, integrá-lo num relato.

Nesta imagem do serviço da "Météo-France", por exemplo (fig.6), pode-se ver como, graças à coerência ótica do mapa, se superpõem tipos de informações diferentes, uns, provenientes de

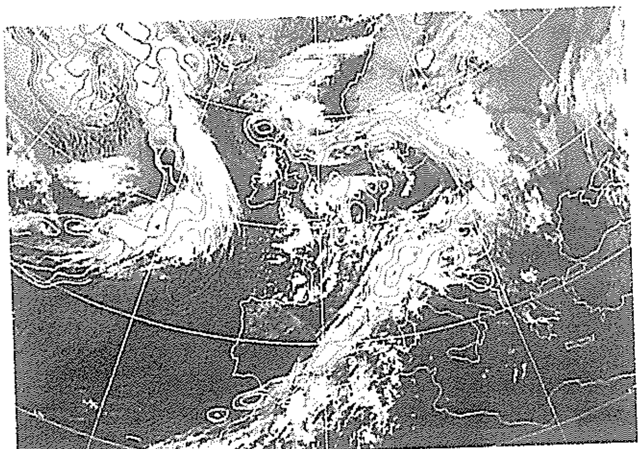


Fig. 6 - Copyright *Méteo-France.*

um cálculo numérico, e outros, de uma imagem em infravermelho tomada por satélite. Hoje compreendemos melhor esta compatibilidade, pois todos utilizamos computadores que se tornam capazes de remexer, religar, combinar, traduzir desenhos, textos, fotografias, cálculos ainda agora fisicamente separados. A digitalização prolonga esta longa história dos centros de cálculo, oferecendo a cada inscrição o poder de todas as outras. Mas este poder não vem de sua entrada no universo dos signos, e sim de sua compatibilidade, de sua coerência ótica, de sua padronização com outras inscrições, cada uma das quais se encontra sempre lateralmente ligada ao mundo através de uma rede.

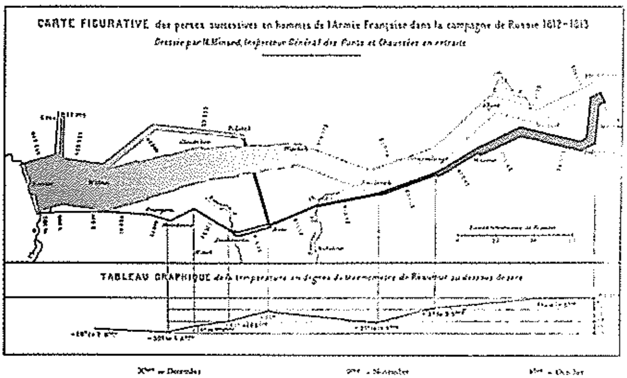


Fig. 7 - Mapa estabelecido por M. Minard. In E. J. Marey. *O método gráfico*. Paris, 1885

Nesta imagem (fig.7) que Tufte considera como um dos diagramas científicos mais "eficazes", compreende-se a origem desta aposta dupla que faz o cientista ganhar cada vez que parece ter perdido o contato direto com o mundo. No mesmo desenho, Marey, o grande fisiologista (e inventor do inverso do cinema!), pôde superpor o mapa da Rússia, a medida das temperaturas, o percurso da *Grande Armée*, a data de seus deslocamentos e, mais tragicamente, o número de soldados sobreviventes em cada bivaque! Informações diferentes, procedentes de instrumentos separados, podem unificar-se em uma só visão, porque suas inscrições possuem todas a mesma coerência ótica. Sem a superposição das inscrições móveis e fiéis, seria impossível apreender as relações entre os lugares, as datas, as temperaturas, os movimentos estratégicos e as vítimas do general Inverno. Neste "lugar-comum", oferecido pela roteirização do gráfico, cada dado se liga, por um lado, a seu próprio mundo de fenômenos, e, por outro lado, a todos aqueles com os quais se torna compatível.

lugar-comum! cada dado se liga a seu próprio mundo e aos outros

Quando Mercator utiliza pela primeira vez a palavra Atlas, para designar não mais o gigante que carrega o mundo em seus ombros, e sim o volume que permite segurar a terá entre as mãos, ele materializa a inversão das relações de força que a cartografia torna tão claramente visíveis – mas que se encontram, em graus diferentes, em todas as disciplinas que entram sucessivamente na "via direta de uma ciência". Resumo notável da história das ciências, este frontispício em que Atlas não tem mais nada a fazer, senão medir a bola que segura sem esforço nos joelhos (fig.8).

Ora, essa inversão das relações de força se realiza por uma inversão literal das proporções, dos tamanhos respectivos, entre o geógrafo e a paisagem. Quando se usa a metáfora astronômica da "revolução copernicana", sempre se esquece um pequeno detalhe:

Fig. 8 - Foto de B. Latour

o que chamamos "dominar com o olhar" permanece impossível enquanto não nos tornarmos Gulliver no país dos liliputianos. Não existe ciência, rígida ou flexível, quente ou fria, antiga ou recente que não dependa desta transformação prévia, e que não acabe por expor os fenômenos pelos quais ela se interessa numa superfície plana de alguns metros quadrados, em volta da qual se reúnem pesquisadores que apontam com os dedos os traços pertinentes, discutindo entre eles. O controle intelectual, o domínio erudito, não se exerce diretamente sobre os fenômenos – galáxias, vírus, economia, paisagens – mas sim sobre as inscrições que lhe servem de veículo, sob a condição de circular continuamente, e nos dois sentidos, através de redes de transformações – laboratórios, instrumentos, expedições, coleções.

O dedo apontado sempre permite aos realistas afirmar seu ponto de vista, antes de dar um murro na mesa exclamando, num tom de camponês do Danúbio: "Os fatos estão aí, teimosos". Ora, os dedos destes cientistas, fotografados antes de sua partida para a floresta amazônica, não designam a floresta e sim a sobreposição dos mapas e das fotos de satélites que lhes permitirão determinar onde estão (fig.9).

Fig. 9 - Foto de B. Latour

Paradoxo do realismo científico, que só pode designar com o dedo a ponta extrema de uma longa série de transformações no interior da qual circulam os fenômenos. Mas este paradoxo, a final de contas, não é menor que o do anjo pintado por Fra Angélico (fig.10).

Sua mão direita designa, para a surpresa das mulheres, o túmulo vazio ("ele não está mais aqui"), enquanto sua mão esquerda designa a aparição do ressuscitado, que as mulheres também não vêem, mas que o monge em oração pode contemplar com devoção, sob condição de compreender bem o duplo gesto do anjo: "Não é uma aparição, Jesus, aqui na pintura, não está aqui, no túmulo, mas está presente porque ressuscitado, não o procurem entre os mortos, mas entre os vivos". Paradoxo deste dêitico que designa também, como o das ciências, uma ausência. Em outras palavras, as ciências não são mais imediatas do que as imagens piedosas nem menos

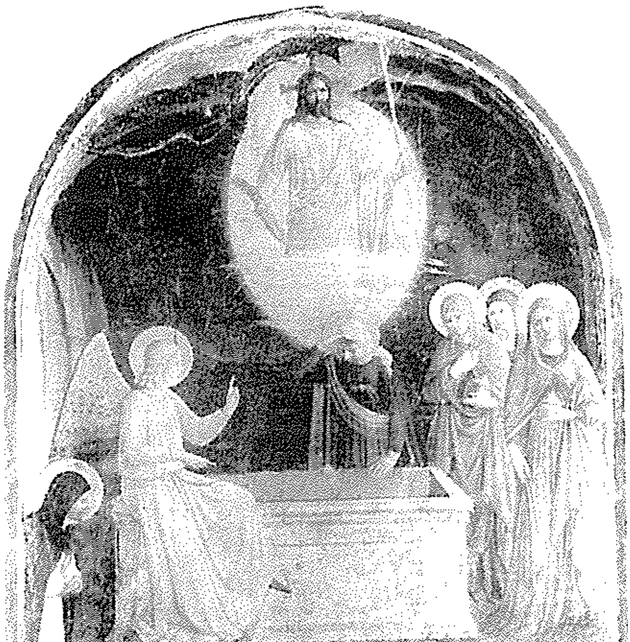


Fig. 10 - Fra Angelico. *Ressurreição.* Florença, Museu de San Marco, Cl. Giraudon

redes de transformações

transcedentes que elas. Tanto Deus quanto a natureza circulam através de redes de transformações. Haveria impiedade em crer que se pode ver diretamente a floresta amazônica ou pôr diretamente, como São Tomé, os dedos nas chagas do Salvador.

Para compreender um centro de cálculo é preciso pois apreender o conjunto da rede de transformações que liga cada inscrição ao mundo, e que liga em seguida cada inscrição a todas as que se tornaram comensuráveis a ela pela gravura, o desenho, o relato, o cálculo ou, mais recentemente, pela digitalização. Se quisermos compreender a imagem do geógrafo trabalhando em seu gabinete, não devemos esquecer a imagem tirada do mais belo romance verdadeiro da história das ciências (fig.11).

* centro de cálculo: cada inscrição ao mundo e às outras inscrições) rede de transformações

Fig. 11 - In F. Trystram. *Le process des étoiles*. Paris Seghers, 1979. Doc. Serviços Culturais da Embaixada da França no Equador, D. R.

Numa bruma dos contrafortes andinos, os infelizes geógrafos da expedição La Condamine esforçam-se por avistar as balizas que com grande dificuldade levantam, mas que os índios de noite derrubam, ou que os tremores da terra ou as erupções vulcânicas deslocam ligeiramente, arruinando assim a precisão de seus alinhamentos. Para que o mundo termine no gabinete do geógrafo, é preciso que expedições tenham podido quadricular os Andes com balizas bastantes para obter, por triangulações sucessivas, o meridiano de Quito e visar em seguida as mesmas estrelas fixas nas duas extremidades. Que tenham sido necessários vinte anos de duros trabalhos e de inverossímeis aventuras para obter este meridiano (fig.12), eis o que não se deve esquecer, sob pena de crer que o signo representa o mundo sem esforço e sem transformação, ou que ele existe à parte, num sistema

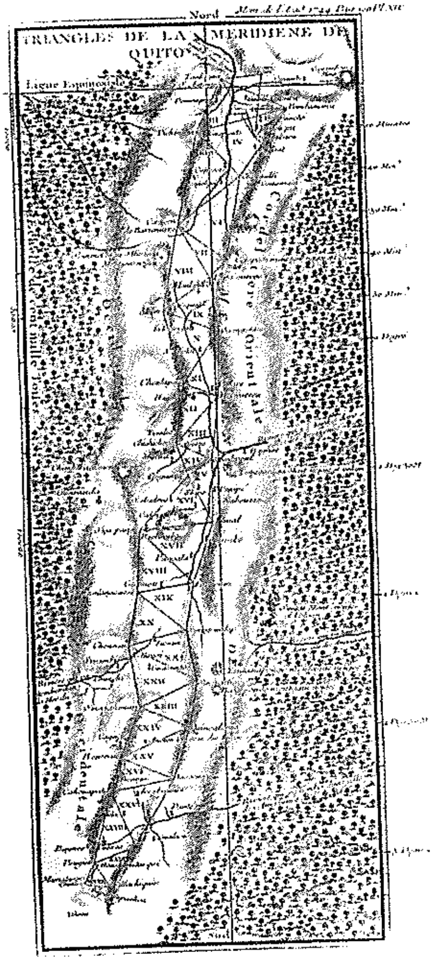


Fig. 12 - O Meridiano de Quito. In F. Trystram. *Le process des étoiles*. Paris Seghers, 1979. Doc. Biblioteca do Institut, Cl. Lauros-Giraudon.

astronômico que lhe serviria de referência. Mito científico oposto ao mito literário, e que dissimula tanto o labor dos construtores de redes como o dos centros de cálculos. Com efeito, os estudiosos de literatura, como os de ciência – sem falar nos teólogos –, têm alguma dificuldade, mas por motivos opostos, em reconhecer o papel das inscrições, em se interessar pelo corpo da prática instrumental.

Eu já disse o suficiente para que se possa agora considerar a topologia particular dessas redes e centros. Redes de transformações fazem chegar aos centros de cálculos, por uma série de deslocamentos – redução e amplificação –, um número cada vez maior de inscrições. Essas inscrições circulam nos dois sentidos, único meio de assegurar a fidelidade, a confiabilidade, a verdade entre o representado e o representante. Como elas devem ao mesmo tempo permitir a mobilidade das relações e a imutabilidade do que elas transportam, eu as chamo de "móveis imutáveis"* entre nós, para distingui-las bem dos signos. Com efeito, quando as seguimos, começamos a atravessar a *distinção usual entre palavras e coisas*, viajamos não apenas no mundo, mas também nas diferentes matérias da expressão. Uma vez nos centros, outro movimento se acrescenta ao primeiro, que permite a circulação de todas as inscrições capazes de trocar entre si algumas de suas propriedades. A coerência ótica dos fenômenos relatados autoriza de fato essa capitalização, que parece sempre tão incompreensível quanto a do dinheiro (fig.13).

topologia das redes e centros

inscrições

móveis imutáveis

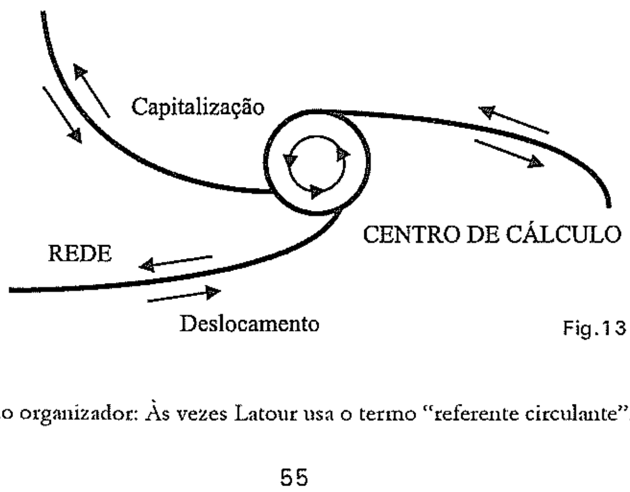


Fig.13

* Nota do organizador: Às vezes Latour usa o termo "referente circulante".

O conjunto desta galáxia emaranhada – redes e centro – funciona como um verdadeiro laboratório, deslocando as propriedades dos fenômenos, redistribuindo o espaço-tempo, proporcionando aos "capitalizadores" uma vantagem considerável, uma vez que eles estão ao mesmo tempo afastados dos lugares, ligados aos fenômenos por uma série reversível de transformações, e aproveitam o suplemento de informações oferecido por toda e qualquer inscrição a todas as outras. Uma biblioteca considerada como um laboratório não pode, é evidente, permanecer isolada, como se ela acumulasse, de modo maníaco, erudito e culto, milhões de signos. Ela serve antes de estação de triagem, de banco, representando para o universo das redes e dos centros o papel de Wall Street ou da City para o capitalismo. Para dar outro exemplo, ela se apresenta, nesta descrição, como um grande instrumento de física, como os aceleradores do "Centre Européen de Recherche Nucléare" (CERN), obtendo em seu interior condições extremas, que redistribuem as propriedades dos fenômenos submetidos a provas que não existem em nenhum outro lugar, e que detectores gigantes expressamente construídos para isso sabem colher, localizar, amplificar.

Onde se encontram os fenômenos?, perguntar-se-á. "Fora, na extremidade das redes que os representam fielmente", dirão uns. "Dentro, ficção regulada pela estrutura própria do universo dos signos", dirão outros. Tanto os realistas como os construtivistas, tanto os epistemólogos como os leitores de Borges, todos gostariam de dispensar o conjunto traçado pelas redes e pelos centros, e se contentar seja com o mundo seja com o signos. Infelizmente, os fenômenos circulam *através do conjunto*, e é unicamente a sua circulação que permite verificá-los, assegurá-los, validá-los. Não esqueçamos que as belas palavras de conhecimento, exatidão e precisão perdem seu sentido fora destas redes, dessas transformações, dessas acumulações, dessas mais-valias de informação, dessas inversões de relações de força. Seria como querer separar a eletricidade doméstica das redes atendidas pela Electricité de France (EDF) ou as viagens de avião das linhas da Air France.

através, entre, rede

Compreende-se então a obsessão da geometria, da matemática, da estatística, da física, da meteorologia, pela noção de constante.

Com efeito, trata-se sempre, pela inversão de instrumentos cada vez mais sutis, de conservar o máximo de formas e forças através do máximo de transformações, deformações, provas. Ah, deter-se num ponto e, por uma série de simples transformações, de simples deduções, recriar todos os outros, à vontade! Os melhores espíritos se entusiasmaram com essas invenções que, no entanto, não os afastavam, muito pelo contrário, da busca pelo poder e da criação de coletivos cada vez mais vastos e cada vez mais bem "dominados".

Para compreender esta esquisitice, é preciso interessar-se pelo traço mais curioso dessas redes de transformação, isto é, por sua relatividade. Tomemos o exemplo simples da perspectiva, bem estudado por Ivins e por Booker. Nos desenhos feitos sem perspectivas, o leitor não pode deduzir o conjunto das posições do objeto no espaço (fig.14).

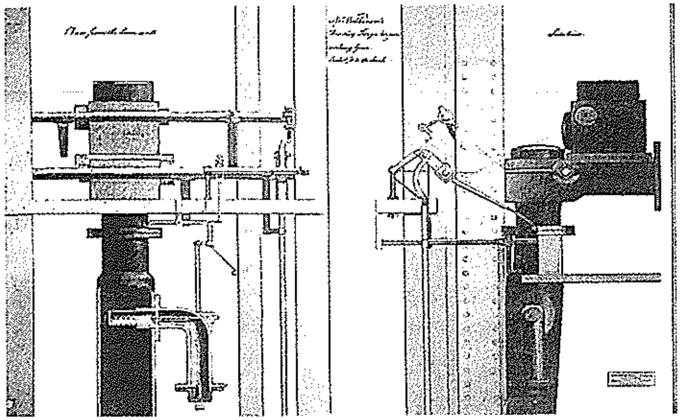


Fig. 14 - Mr. Wilkinson's Bradly Forge Engine Working Gear. Escala: 1/8 por polegada, c. 1782. In K. Baynes e F. Pugh. *The art of the enginner.* Guilford, Sussex Lutherword Press, 1981. D. R.

Como diz Edgerton: "Não se gira por trás de uma Virgem de Cimabue". Num desenho em perspectiva à moda italiana, é possível imaginar outras posições do objeto no espaço, mas o sujeito, quanto a ele, deve ocupar a posição privilegiada que o pintor lhe reservou. Num desenho técnico, que obedeça às regras da geometria projetiva – e às convenções relativas às sombras, às cores e aos símbolos –, é possível ao leitor (competente) reconstituir a peça em todas as suas posições através do espaço. Com o desenho industrial a maneira de Monge, a relatividade dá um passo gigante. O documento gráfico permite recalcular – como num mapa, mas em três dimensões – a totalidade das posições, bem como a totalidade dos pontos de vista do espectador. Todas as posições do sujeito e todas as posições do objeto são equivalentes, tanto que se pode transportar o desenho técnico através do espaço sem modificar em nada as relações entre as partes que o compõem. Não há mais nem observador nem perspectiva privilegiados.

De fato, como na relatividade de Einstein, existe sim um observador privilegiado, aquele que, no centro de cálculo, pode capitalizar o conjunto dos desenhos, dos dados, dos levantamentos, dos mapas, das observações, enviados por todos os observadores despojados de qualquer privilégio, e pode também, por uma série de correções, de transformações, de reescritas, de conversões, torná-los todos compatíveis. É justamente porque os observadores delegados ao longe perdem seu privilégio – o relativismo – que o observador central pode observar seu panóptico – a relatividade – e encontrar-se presente ao mesmo tempo em todos os lugares onde, no entanto, não reside. É essa negociação prática entre os observadores da periferia e os do centro que dá carne e sentido à expressão, sem isso vazia, de "leis universais". A partir do momento que um observador, um instrumento, um investigador se torna muito específico, muito particular, muito idiossincrático, ele interrompe o deslocamento dos móveis imutáveis, acrescenta ruído à linha, enfraquece o centro de cálculo, impede o observador privilegiado de capitalizar, isto é, de conhecer. Como se vê, os fenômenos não se situam nem no exterior nem no interior das redes. Eles residem numa certa maneira de se deslocar que otimiza a manutenção das relações constantes, apesar do transporte e da diversidade dos observadores. A perspectiva, a teoria da relatividade, a geometria são alguns dos veículos que asseguram às inscrições seja sua mobilidade, seja sua imutabilidade. Existem muitos outros, menos grandiosos, como o empalhamento, a imprensa, o modelo reduzido, a conservação no azoto líquido ou a perfuração para a extração de amostras.

os fenômenos
nem fora
nem dentro das
redes,
mas no
caminho

Todos estes meios juntos permitem reter os fenômenos, com a condição de transformá-los, procurando para cada caso o que se mantém constante através dessas transformações. A veracidade não vem da superposição de um enunciado e de um estado do mundo, mas procede antes da manutenção contínua das redes, dos centros e dos móveis imutáveis que aí circulam. A palavra verdade não ressoa quando uma frase se prende a uma coisa como um vagão a outro vagão, conforme o modelo comum da *adequatio rei et intellectus*. Deve-se ouvi-la antes como o ronronar de uma rede que gira e que se estende. Compreende-se então que as instituições como as bibliotecas, os laboratórios, as coleções não são simples meios que se poderiam dispensar facilmente, sob pretexto de que os fenômenos falariam por si mesmos à simples luz da razão. Adicionados uns aos outros, eles compõem os fenômenos que só têm existência por esta exposição através das séries de transformações.

No entanto, tal visão, que parece muito afastada do realismo à moda antiga, não nos leva de volta ao simples jogo dos signos, pois essa série de transformações tem justamente como particularidade atravessar continuamente e reversivelmente os limites dos signos e das coisas. A obsessão pela constante, pela manutenção das relações estáveis através de transformações mais extremas, não se manifesta apenas entre as inscrições, como no caso da perspectiva ou do desenho técnico. Ela se manifesta ainda mais claramente quando é preciso manter um fenômeno através das transformações que o fazem passar da matéria à forma, ou, inversamente, da forma à matéria.

atravessam os limites entre os signos e as coisas

Voltemos ao exemplo simples da cartografia. Como verificar a adequação do mapa ao território? Impossível aplicá-lo diretamente ao mundo – a menos que se refaça o trabalho colossal que permitiu aos Cassini, aos La Condamine, aos Vidal de La Blache inverter a proporção entre dominantes e dominados, o que suporia outras instituições, outros meios, outros instrumentos. Na prática, aplicamos o texto do mapa a uma baliza, inscrita na paisagem (fig.15 e 16). Reencontramos os dedos apontados de há pouco e o mesmo jogo sutil da ausência e da presença. Esse viajante apressado mostra com o dedo o mapa do metrô, e pode ler em letras grandes o nome da estação que corresponde àquele, menor, do mapa. Essa moça aponta com o dedo o nome da rua, e põe em correspondência, com um

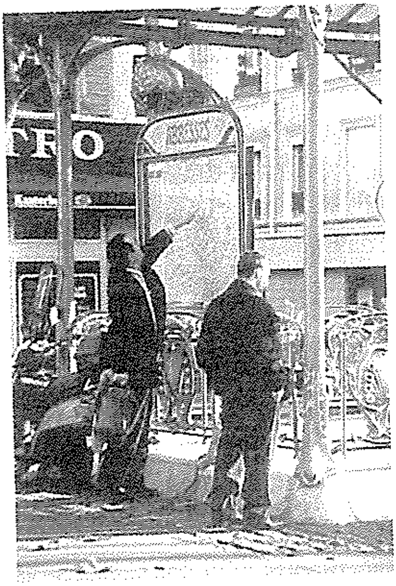


Fig. 15 - Foto de S. Lagoutte

Fig. 16 - Foto de S. Lagoutte

rápido movimento de cabeça, o nome que se encontra em sua planta de Paris e nas placas de rua. As duas inscrições – a primeira no mapa, a segunda na placa – serão ambas signos? Certamente, mas numa relação que nos afasta da intertextualidade. Essas duas espécies de signos, mapas e placas, alinhados uns aos outros e mantidos ambos por grandes instituições (o Instituto Geográfico Nacional, o "Ponts et Chaussées", o Ministério do Interior) que nos permitem passar do mapa ao território, negociando com cautela a enorme mudança de nível que separa um pedaço de papel, que dominamos pelo olhar, de um lugar onde moramos e que nos cerca por todos os lados. Naturalmente, a série não pára aí. A posição da placa depende de um regulamento do ministro do interior; a marcação das ruas se baseia, por sua vez, através de outra mudança de nível, nos marcos geodésicos que se encontram cravados nas calçadas, ou recém-pintados. Podemos enfim passar para o solo argiloso? Ainda não, pois os triângulos da rede nacional nos afastam logo do lugar balizado para nos alinhar em outras balizas a vários quilômetros de distância, ou em satélites a vários milhares de quilômetros de distância, geridos por outras instituições. As inscrições não remetem no vazio a outros signos, uma vez que, a cada mudança de nível, elas se carregam de matéria e servem de validação uma à outra. E, no entanto, não se pode percorrer sua cadeia sem encontrar, atrás da matéria anterior, outras marcas, outras instituições que já "prepararam o terreno", a fim de que sua leitura se torne compatível, apesar da mudança de nível, com o mapa que eu seguro na mão. Se desejamos entender como chegamos, às vezes, a dizer a verdade, devemos substituir a antiga distinção entre a linguagem e o mundo por essa mistura de instituições, formas, matérias e inscrições.

verdade *

Às vezes, pretende-se dispensar bibliotecas, laboratórios, coleções, sem com isso perder nem o saber nem a razão. É acreditar na "natureza se desvelando aos olhos da ciência", como nessa estátua de Ernest Bramar, que se encontra no Conservatório das Artes do Ofício (fig.17).

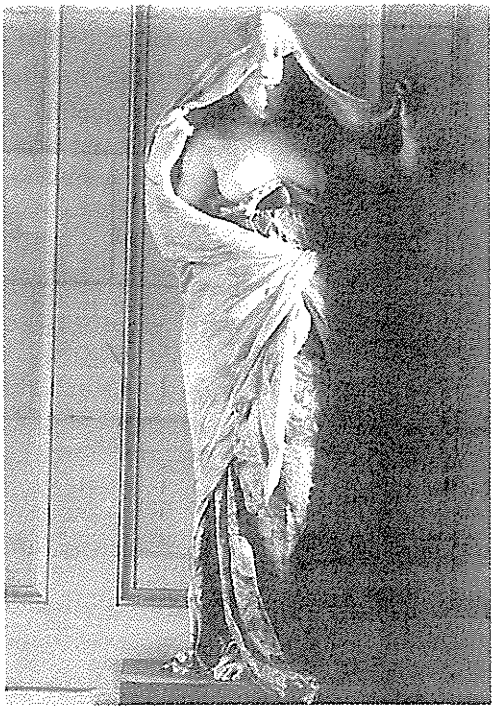


Fig. 17 - E. Bramar. *A Natureza se desvelando à ciência.* 1985. Foto de Bruno Latour

Esse mito não é criticável apenas por seu sexismo, mas também pela nudez terrificante na qual deixa sobreviver a Natureza, como a Verdade saindo gelada de seu poço. Tudo o que aprendemos recentemente das ciências, e que eu lembrei muito rapidamente, nos mostra, ao contrário, a verdade vestida, equipada, gorda, instrumentada, custosa, exposta, rica, e os pesquisadores fazendo uma coisa bem diferente de contemplar o mundo num derrisório *peep-show*. Os estudiosos de letras como os de ciências, por razões opostas, porém, não parecem reconhecer ao mesmo tempo o papel dos lugares fechados, onde se elabora o conhecimento, e as redes ampliadas e violentas, através das quais circulam os fenômenos. Os estudiosos de letras consideram a linguagem autônoma e livre de fazer referência a qualquer coisa, os estudiosos de ciências gostariam de dispensar o miserável intermédio das palavras, a fim de terem acesso direto às coisas. Ora, esses lugares silenciosos, abrigados, confortáveis, dispendiosos, onde leitores escrevem e pensam, se ligam por mil fios ao vasto mundo, cujas dimensões e propriedades transformam.

Tomemos, para acabar, um último exemplo, extremo, reconheço (fig.18). Eis um dos *War Rooms* em que Winston Churchill

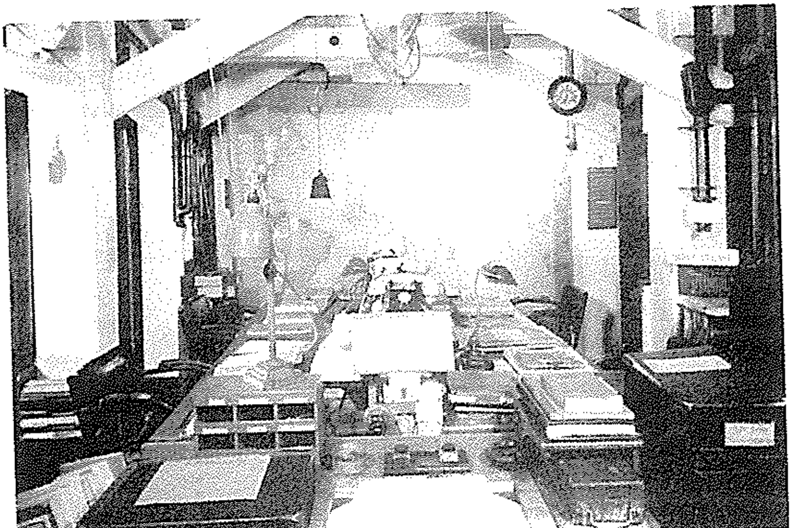


Fig. 18 - Foto do Imperial War Museum, Londres

conduzia a última guerra, abrigado das bombas num *bunker* cavado por baixo de Westminster, que foi aberto ao público depois de restaurado. Neste lugar abrigado, só se vêem nas paredes inscrições, compilações estatísticas e demográficas sobre o número de comboios afundados, de soldados mortos, de fornecimentos militares em produção. Entretanto, este lugar não está isolado da grande batalha planetária. Ao contrário, ele a resume, a mede, serve-lhe, literalmente, de modelo reduzido. Com efeito, como saber se o Eixo ganha ou não dos Aliados? Ninguém pode sabê-lo com segurança sem construir um "dinamômetro" que meça a relação das forças por meio de uma série de instrumentos estatísticos e de contagens. Como o gabinete do nosso cartógrafo, esta sala baixa e protegida das bombas se aplica, através de mil intermediários – dossiês, fichas, listas, relatórios, avaliações, fotografias, contagens, estoques –, a colher informações sobre a batalha que se desencadeia lá fora, mas cujo sentido global ficaria perdido sem este panóptico, sem esta compilação notarial. Apesar de seu caráter marcial, eu afirmo que esta situação se parece mais com o laço que liga o leitor, curvado sob a auréola amarela da lâmpada, ao mundo que o cerca, que os mitos perversos de uma verdade desvelada pela ciência ou que a biblioteca interminável de Borges. É porque os laboratórios, as bibliotecas e as coleções estão ligados em num mundo que, sem eles, permanece incompreensível, que convém mantê-los, se nos interessarmos pela razão. Segundo Christian Jacob, parece que a Biblioteca de Alexandria teria servido de centro de cálculo para uma vasta rede da qual era a fonte abastecedora. Não é à toa que os Ptolomeus eram gregos. O império de Alexandre sabia muito bem as forças que podem ser derrubadas com o império dos signos.

[1] Tradução de Marcela Mortara.

LATOUR, Bruno. 2007. Can we get our materialism back, please? Isis 98:138-42.

Can We Get Our Materialism Back, Please?

*By Bruno Latour**

ABSTRACT

Technology is epistemology's poor relative. It still carries the baggage of a definition of matter handed down to it by another odd definition of scientific activity. The consequence is that many descriptions of "things" have nothing "thingly" about them. They are simply "objects" mistaken for things. Hence the necessity of a new descriptive style that circumvents the limits of the materialist (in effect idealist) definition of material existence. This is what has been achieved in the group of essays on "Thick Things" for which this note serves as an afterword.

SOMETHING HAS HAPPENED to materialism. In many ways, it seems that we have come full circle from the early modern controversies over the various abilities of material entities. For a short while, materialism seemed to be a foolproof appeal to a type of agency and a set of entities and forces that allowed analysts to explain, dismiss, or see through other types of agencies. Typically, for instance, it was possible to explain conceptual superstructures by means of material infrastructures. Thus an appeal to a sound, table-thumping materialism seemed an ideal way to shatter the pretensions of those who tried to hide their brutal interests behind notions like morality, culture, religion, politics, or art. But that's precisely the point: it was an *ideal* and not a *material* way of making a point. Materialism, in the short period in which it could be used as a discussion-closing trope, implied what now appears in retrospect as a rather idealist definition of matter and its various agencies. I am not enough of a historian to put dates on this short period where the materialistic *explanans* had its greatest force, but it might not be totally off the mark to say that it persisted from the era of post-Marxism (Marx's own definition of material explanation being infinitely more subtle than what his successors made of it) all the way to the end-of-the-century sociobiologists (who tried without much success to insert their own simplistic mechanisms into the glorious lineage of Darwin).

Why does this materialism appear to us in retrospect as much too idealist? The reason has been worked out only recently in various commentaries on Alfred North Whitehead's

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philosophy.[1] Under the rubric of "matter," two totally different types of movement had been conflated: first, the way we move knowledge forward in order to access things that are far away or otherwise inaccessible; and, second, the way things move to keep themselves in existence. We can identify matter with one or the other, but not with the two together without absurdity. Of course, we might marvel at the miracle of a "correspondence" between the geometrization of the ways we know and the geometrization of the things that are known, but this is because we commit, wittingly or unwittingly, a little sleight of hand and explain this spurious correspondence by the fact that the "primary qualities" of the objects known are themselves geometrical. That is easy to do when all the other qualities—those that will become the "secondary qualities"—have been carefully eliminated, one after the other.

The application of this point to *technical entities* is rather straightforward, but it is well worth insisting on, since the history of technology has for so long been a bastion of the idealist materialism I've just mentioned. We can still understand James Watt's beautifully drawn designs of his steam engine without any difficulty, even though steam engines themselves have all but vanished. For any piece of machinery, to be drawn to specs by an engineer, on one hand, or to remain functional without rusting and rotting away, on the other, requires us to accept two very different types of existence. To exist as a part *inter partes* inside the isotopic space invented by the long history of geometry, still-life painting, and technical drawing is not at all the same as existing as an entity that has to resist decay and corruption. Obvious? Yes, of course—but then why do we so often act as if matter itself were made of parts that behave just like those of technical drawings, which live on indefinitely in a timeless, unchanging realm of geometry? Why, in the name of "mechanical philosophy" (itself an exceedingly complex affair, as historians of science have shown), do we still take this view of technical artifacts so seriously—as if the ontological qualities of matter itself were the same as the ontological qualities of drawing and moving parts around in geometrical space?

This is why the materialism of the recent past now looks so idealistic: it takes the idea of what things in themselves should be—that is, primary qualities—and then never stops gawking at the miracle that makes them "resemble" their geometrical reproduction in drawings. . . . And this miracle is idealist a second time because it ignores entirely the difficulty of producing drawings and the whole network of engineering practices necessary to identify the features, follow the lines, and assemble the whole institution necessary for any mechanism to function. Technical drawing is an extremely difficult activity to sustain and calibrate. The whole notion of *mechanism* is a twice-idealized definition of the way we know and of the behavior of what we know. No wonder, then, that when it is transported to the fields of economics or genetics or used to supply biological or social "explanations" it creates so much trouble.

The problems with this idealized materialism can be clearly seen in Damián Ortega's fascinating installation *Cosmic Thing*, which John Tresch discusses in his essay. This piece, which presents what is in effect the "exploded view" (in French, "*écorché*") of a VW Beetle, offers a deceptive transparency that the following essays refuse to accept. Of course, the great irony of the installation is that if the exploded view—rendered familiar to us by the invention of technical drawing, projective geometry, and innovations all the

[1] Isabelle Stengers, *Penser avec Whitehead: Une libre et sauvage création de concepts* (Paris: Gallimard, 2002).

way to computer-aided design—is a great way to draw parts, order their fabrication, stabilize specifications, verify standards, maintain inventories, and render all these operations traceable and accountable, it is nevertheless decidedly not what defines the "thingness" or the "cosmicity" of techniques. The visual imaginary space in which an exploded view is made possible is infinitely distant from the way any VW Beetle inhabits the world—or, rather, the cosmos.

In other words, whereas *res extensa* is a way to draw technical parts side by side, those parts themselves do not assemble or gather or survive as if they were "in" *res extensa* or "made of" matter. Or, rather, we are now faced with two different definitions of "matter": one (the idealist one) in which the reproduction of the parts through geometry is confused with the reproduction of the parts themselves, and another in which those two pathways are clearly distinct. The first gives way to *objects*, the description of which is always *thin*; the second gives way to *things*, which are the topics, as Ken Alder says in his introduction, of *thick* description. Thin objects, on one hand, with an *ideal* definition of matter; thick things, on the other, with a *material* definition of matter: this seems to me the choice offered to the reader of the pieces in this Focus section.

This does not mean that reproduction through geometry is "abstract," "cold," and "dead" while reproduction through steel, brass, or wood is "concrete," "warm," and "alive," but simply that geometry is what allows engineers to draw and know the parts, while the parts themselves go their own ways and follow, so to speak, their own directions. . . . If Ortega had really wanted to provide a view of the VW Beetle that would do justice to his title—*Cosmic Thing*—he would have to redo his installation entirely and do for the Beetle what Gabrielle Hecht and Wiebe Bijker and Ken Alder have done here for "their" uranium rocks, dams, and lie detectors: that is, first prodigiously *extend* the number of parts necessary for the gathering of the Beetle and then *multiply* the number of assembling principles that gather them together in a functioning whole. The suspension of the parts side by side with nylon thread is a nice way of reminding us of the gathering aspect of every technical "whole," but it is much too restricted a census of which parts are necessary and of the process through which they might coalesce together. To the *assemblage* of parts, Ortega should have added an *assembly* of entities that would have made his installation really worthy of the name *Cosmic Thing*.

This is why I always find it baffling that people would take Heidegger's "philosophy of technology" seriously. Not only would Heidegger see no difference whatsoever between an atomic bomb, a dam, a lie detector, and a staple—all being mere examples of the same "enframing"—but when he finally gives some respect to a shoe or a hammer it is only to see it as the assembly of *four* elements—his "fourfold." To be sure, such tools may be beautifully made, and it is much better to call on the gods and the mortals, heaven and earth, to account for their emergence than to dismiss them as the thinnest of "mere" objects. But look again at the VW Beetle: just four elements, really? That's a very small list indeed. . . . According to Hecht, there are many more than four existing deities, or dimensions, or factors, brought simultaneously into play in order to define what it is for "uranium" to be "nuclear." Any technical imbroglio forces us to count *way* beyond four. But it is true—and here Heidegger sends the inquiry in the right direction—that any artifact is a form of assembling, of gathering, of "thinging" entities together and that it is absurd to forget the mortals and the gods when describing a piece of hardware, even the most hypermodern ones. But I am sure that Heidegger would refuse to comment on Ortega's exploded view. And Ortega himself, by offering, as I have just said, such a limited number of parts and types of assembling, betrays the title he gave to his piece—or else he is enjoying himself with a very modernist irony that follows the same pattern as Heidegger's spite for modernity.

What is so promising about extricating material materialism from its idealist counterpart—of which the concept of "enframing" is a typical example—is that it accounts for the surprise and opacity that are so typical of techniques-as-things and that techniques-as-objects, drawn in the *res extensa* mode, completely hide. The exploded-view principle of description makes it possible to overcome one of the main aspects of bringing an artifact into existence: opacity. In other words, it draws the object as if it were open to inspection and mastery while it hides the elementary mode of existence of technical artifacts—to take up Gilbert Simondon's title.[2] Parts hide one another; and when the artifact is completed the activity that fit them together disappears entirely. Mastery, prediction, clarity, and functionality are very local and tentative achievements that are not themselves obtained inside the idealized digital or paper world of *res extensa*—even though it would be impossible to carry them forward without working upon and with technical drawings and models. But, again, it is not the same thing to work *upon* a model—mathematical, analogical, digital—as it is for a technical assemblage to *be* a model. As every engineer knows, scaling up (or scaling down, in the case of miniaturization and industrialization) is a tough, surprising adventure filled with twists and detours. As soon as one assimilates mechanisms to the *res extensa* mode, one is no longer prepared to encounter any of the tricky, clever innovations that go with every technical gathering. Nor is there any room left for a Daedalus or a Viktor Frankenstein, though aspects of these mythological figures abound in the tales recounted in these essays: the demiurgic ambitions of Brazilian positivists; the monstrous and protean power of "nuclearity"; the rivalries, twists, and disappointments involved in powering and watering the Indian subcontinent; the labyrinths of bluff and double bluff that come to define both lie detection and the arms race.

Finally, what one is no longer prepared to encounter either are the various meddlers, known in an earlier period of our disciplines as the "social context" that surrounded artifacts that were otherwise essentially imperturbable. After having remained for so long rather politely at a safe distance *around* the techniques, now meddlers of all sorts—not only engineers, of course, but also "members of the public," those who suffer various "unwanted consequences" of technology, militants, dreamers, activists, lawyers—are part and parcel of the gathering of techniques. Each of the essays in this Focus section shows this major shift in our understanding of technological things; it was also strikingly revealed in 2003 when, after the explosion of the shuttle *Columbia*, hundreds of hitherto-unknown actors had to be drawn into the discussion—a legal dispute, a "thing" in the etymological sense.[3] Suddenly, everyone discovered that the shuttle was actually encased in an organization, NASA, and that many "parts" of *Columbia* could not be seen in an Ortega-style exploded view of the shuttle. And yet those parts were indeed elements of the process of assembly necessary for the final assemblage of parts to function safely. But no more than the stakeholders in so many of the projects reviewed by Bijker did they have any way to be literally "drawn together" within the conventions of technical representation now entrenched into CAD digital files.

[2] Gilbert Simondon, *Du mode d'existence des objets techniques* (Paris: Aubier, 1958).

[3] Graham Harman, *Tool Being: Heidegger and the Metaphysics of Objects* (Chicago: Open Court, 2002); and Bruno Latour and Peter Weibel, eds., *Making Things Public: Atmospheres of Democracy* (Cambridge, Mass.: MIT Press, 2005).

Perhaps this is where we meet the limit of the "thick description of things." We know how to provide a "thin description" of an entity's idealized material aspects; as these essays show, we are finally starting to learn how to give a *post hoc* narrative thick description of what should have been visible in the gathering that brings a thing together (similarly, after the shuttle's explosion a tough inquiry was pursued). And yet we still don't know how to assemble, in a single, visually coherent space, all the entities necessary for a thing to become an object—Ortega's installation notwithstanding. When we have learned how to do that, we might finally get our (material) materialism back—and our cosmic things to boot. That's when the plot will really thicken.

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PRENDRE LE PLI DES TECHNIQUES

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MODE D'EXISTENCE ET INSTAURATION

Il existe, dans le voisinage du pragmatisme de James et de la philosophie spéculative de Whitehead, une tradition qui porte sur les prépositions définies comme des *modes d'existence*. On trouve ce terme, dans le livre assez bien connu, même s'il n'a guère trouvé de continuateurs, de Gilbert Simondon sur le cas particulier de la technique. *Du mode d'existence des objets techniques* est un livre de philosophie qui sait compter au-delà du sujet, de l'objet et de leur combinaison. Il va même, comme on le sait, jusqu'à sept, enchaînant les modes d'existence dans une sorte de généalogie – qu'il appelle « génétique » – largement mythique mais qui a l'immense avantage de ne pas réduire à deux (ou à trois) les solutions possibles : pour Simondon, la saisie du monde n'exige pas que l'on commence par partager les réalités en objet et sujet. Une citation suffira pour dessiner la trajectoire qu'il s'efforce de capter : « *Nous supposons que la technicité résulte d'un déphasage d'un mode unique, central et originel d'être au monde, le mode magique ; la phase qui équilibre la technicité est le mode d'être religieux. Au point neutre entre technique et religion, apparaît au moment du dédoublement de l'unité magique primitive la pensée esthétique : elle n'est pas une phase mais un rappel permanent de la rupture de l'unité du mode d'être magique et une recherche d'unité future* » (p. 160).

En dehors de l'intérêt qu'il y a pour lui à réhabiliter la magie, à faire de la technique le pendant du religieux, et, plus tard, à extraire l'éthique de la technique, la science du religieux et, enfin, la philosophie de l'esthétique, c'est la notion même d'une pluralité de modes d'existence dont chacun doit être respecté pour lui-même, qui fait toute l'originalité de cette étrange aventure intellectuelle. Bien qu'elle soit restée sans lendemain (la philosophie des techniques continuant à prendre les goûts et dégoûts de Heidegger pour une profonde pensée (Simondon, 1989), Simondon a saisi que la question ontologique pouvait s'extraire de la recherche d'une substance, de la fascination pour la seule connaissance, de l'obsession pour la bifurcation entre sujet et objet, et se poser plutôt en termes de *vecteurs*. Pour lui, sujet et objet, loin d'être au début de la réflexion comme les deux crochets indispensables auxquels il convient d'attacher le hamac où va pouvoir somnoler le philosophe, ne sont que des effets assez tardifs d'une véritable histoire des modes d'existence : « *Ce déphasage de la médiation en caractères figuraux et caractères de fond traduit l'apparition d'une distance entre l'homme et le monde ; la médiation elle-même, au lieu d'être une simple structuration de l'univers, prend une certaine densité ; elle s'objective dans la technique et se subjective dans la religion, faisant apparaître dans l'objet technique le premier objet et dans la divinité le premier sujet, alors qu'il n'y avait auparavant qu'une unité du vivant et de son milieu : l'objectivité et la subjectivité apparaissent entre le vivant et son milieu, entre l'homme et le monde, à un moment où le monde n'a pas encore un complet statut d'objet ni l'homme un complet statut de sujet* » (p. 168).

Simondon, pourtant, demeure classique, obsédé qu'il est par l'unité originelle et l'unité future, déduisant ses modes les uns dans les autres, d'une manière qui pourrait en fait rappeler plutôt Hegel. Il n'aurait compté jusqu'à sept que pour mener, en fin de compte, jusqu'à l'un… Le multiréalisme ne serait au fond qu'un long détour pour revenir à la philosophie de l'être, le septième des modes dont il a tracé l'esquisse.

C'est vers un autre livre, celui-là tout à fait oublié, d'un philosophe qui n'a même pas connu le respect poli qu'on accorde quand même à Simondon, qu'il faut se tourner. Quand Étienne Souriau publie cet apax *Les différents modes d'existence*, en 1943, en pleine guerre, ce n'est pas pour parler de géopolitique, pour chercher les causes de la défaite ou pour remonter le moral des troupes (Souriau, 1943). Non, c'est pour explorer, avec une audace inouïe, une invention métaphysique toute fraîche ainsi qu'une stupéfiante liberté d'expression, la question du multiréalisme : de combien de façons différentes peut-on dire que l'être existe ? Si l'on pouvait faire à nouveau retentir cette expression si banale, on pourrait suggérer que Souriau s'intéresse aux *manières d'être*, en prenant certes très au sérieux le mot « être », mais en conservant aussi l'idée de *manière*, d'étiquette, de protocole, comme si le philosophe voulait inventer enfin, après plusieurs siècles de bifurcation (Whitehead, 1920), une politesse respectueuse des *bonnes manières* de se comporter avec les êtres.

Pour comprendre ce qu'il définit explicitement comme une enquête empirique et systématique, il convient de s'armer de deux notions essentielles. La première nous est déjà familière, puisque Souriau rattache directement son projet à une citation de James dans laquelle celui-ci définissait l'empirisme comme un respect de l'expérience donnée par les prépositions : « *On sait* *quelle importance W. James attachait, dans la description du courant de la conscience, à ce qu'il appelait 'un sentiment de ou, un sentiment de car'. Nous serions ici dans un monde où les ou bien, ou les à cause de, les pour et avant tout les et alors, et ensuite, seraient les véritables existences. (...) Ce serait une sorte de grammaire de l'existence que nous déchiffrerions ainsi, élément par élément* » (p. 108).

Le point capital, c'est que cette ontologie des prépositions nous éloigne d'emblée du type d'enquêtes si fréquentes jusqu'ici dans les philosophies de l'être : la préposition ne désigne pas un domaine ontologique, une région, un territoire, une sphère, une substance. Il n'y a pas de région du *si* ou du *et.* Mais, comme son nom l'indique parfaitement, la préposition *prépare* la *position* qu'il va falloir donner *à ce qui suit*, offrant à la recherche du sens une inflexion décisive qui va permettre de juger de sa direction, de son vecteur. Comme la préposition, le régime d'énonciation prépare ce qui suit, sans empiéter en rien sur ce qui est effectivement énoncé. À la façon des partitions en musique, le régime indique seulement dans quelle tonalité, dans quel *clef*, il va falloir se préparer à jouer ce qui suit. Il ne s'agit donc pas de rechercher ce qui subsiste *sous* les énoncés, leurs conditions de possibilité, ou leur fondement, mais, chose à la fois décisive et légère, leur mode d'existence. « *What to do next ?* », comme le dirait Austin dont la notion de *force illocutoire* pourrait d'ailleurs servir d'utile synonyme (Austin, 1970). La force illocutoire, on s'en souvient, ne dit rien de l'énoncé mais elle annonce *comment* l'on doit accueillir ses conditions de félicité afin d'éviter les erreurs de catégorie et ne pas prendre par exemple pour une description, ce qui est un récit de fiction, ou pour une interdiction ce qui est une demande. Qu'il s'agisse de préposition, de régime d'énonciation, de mode d'existence ou de force illocutoire, la vection est la même : peut-on enquêter de façon sérieuse sur les relations comme on l'a fait si longtemps sur les sensations, sans les obliger à s'aligner aussitôt dans la seule et unique direction d'avoir à mener soit vers l'objet (en s'éloignant du sujet) soit vers le sujet (en s'éloignant alors de l'objet) ?

Toutefois, en prenant comme synonymes de mode d'existence des termes proches de la sémiotique ou de la linguistique (métaphores que Souriau utilise d'ailleurs aussi), je risque de faire déraper le projet avant même qu'il ait repris la bonne direction : nous sommes en effet habitués à poser *soit* des questions de langue *soit* des questions d'ontologie – habitude qui est évidemment la conséquence de cette bifurcation à laquelle nous souhaitons mettre fin en apprenant à compter sur nos doigts au-delà de deux ou de trois. Il faut donc ajouter une précaution : nous devons non seulement différencier la recherche des prépositions de celle des substances ou des fondements, mais aussi chercher un terme qui autorise à joindre les questions de langue et celle d'être, et cela malgré l'interdit qui oblige à les distinguer.

C'est là l'innovation philosophique la plus importante de Souriau celle qu'il désigne du beau mot d'instauration. Comment saisir « l'œuvre à faire » en évitant de devoir choisir entre ce qui vient de l'artiste et ce qui vient de l'œuvre, voilà ce qui l'intéresse avant tout (Souriau, 1956). Pour comprendre l'obsession de Souriau, prenons une des nombreuses descriptions qu'il fait de l'acte de création : « Un tas de glaise sur la sellette du sculpteur. Existence réique[1] indiscutable, totale, accomplie. Mais existence nulle de l'être esthétique. Chaque pression des mains, des pouces, chaque action de l'ébauchoir accomplit l'œuvre. Ne regardez pas l'ébauchoir, regardez la statue. À chaque action du démiurge, la statue peu à peu sort de ses limites. Elle va vers l'existence – vers cette existence qui à la fin éclatera de présence actuelle, intense et accomplie. C'est seulement en tant que la masse de terre est dévouée à être cette œuvre qu'elle est statue. D'abord faiblement existante, par son rapport lointain avec l'objet final qui lui donne son âme, la statue peu à peu se dégage, se forme, existe. Le sculpteur d'abord la pressent seulement, peu à peu l'accomplit par chacune de ces déterminatons qu'il donne à la glaise. Quand sera-t-elle achevée ? Quand la convergence sera complète, quand la réalité physique de cette chose matérielle et la réalité spirituelle de l'œuvre à faire se seront rejointes et coincideront parfaitement ; si bien qu'à la fois dans l'existence physique et dans l'existence spirituelle, elle communiera intimement avec elle-même, l'un étant le miroir lucide de l'autre *» (p. 107-108)*

L'erreur d'interprétation serait évidemment de croire que Souriau décrit ici le passage d'une forme à une matière, l'idéal de la forme passant progressivement à la réalité, comme une potentialité qui deviendrait simplement réelle à travers le truchement de l'artiste plus ou moins inspiré[2]. Il s'agit au contraire d'une instauration, d'un risque pris, d'une découverte, d'une invention totale : « *Mais cette existence croissante est faite, comme on voit, d'une modalité double enfin coincidente, dans l'unité d'un seul être progressivement inventé*

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1. « Réique » est un néologisme pour parler de la chose phénoménale d'abord puis objective ensuite.
2. Opposition classique introduite par Deleuze entre le couple potentiel/réel et le couple virtuel/actuel. C'est le second qui intéresse Souriau, ce qui explique d'ailleurs l'intérêt que lui porte Deleuze.

au cours de ce labeur. Souvent nulle prévision : l'œuvre terminale est toujours jusqu'à un certain point une nouveauté, une découverte, une surprise. C'est donc cela que je cherchais, que j'étais destiné à faire ! » (p. 109).

Ce qui fascine Souriau dans l'art (comme ce qui me fascine dans le laboratoire), c'est le *faire faire*, c'est le *faire exister*, c'est-à-dire la réplication, la redondance, le rebondissement de l'action par l'artiste (ou par le chercheur) et le recueil de l'œuvre (ou l'autonomie du fait). Instaurer et construire sont évidemment synonymes, mais l'instauration a l'insigne avantage de ne *pas* réutiliser tout le bagage métaphorique du constructivisme – qui serait pourtant d'un emploi facile et presque automatique dans le cas de l'œuvre si évidemment « construite » par l'artiste. Parler d'« instauration », c'est préparer l'esprit à engager la question de la modalité à l'envers exact du constructivisme. Dire, par exemple, qu'un fait est « construit », c'est inévitablement (et je suis bien payé pour le savoir) désigner à l'origine du vecteur le savant, selon le modèle du Dieu potier. Mais à l'inverse, dire d'une œuvre d'art qu'elle est « instaurée », c'est se préparer à faire du potier celui qui accueille, recueille, prépare, explore, invente – comme on invente un trésor – la forme de l'œuvre.

Prenons bien garde : malgré le style si daté, il ne s'agit en rien d'un retour à l'Idéal du Beau dont l'œuvre serait le creuset. Dans les deux cas, aucun doute là-dessus, aucune hésitation chez Souriau : sans activité, sans inquiétude, sans main-d'œuvre, pas d'œuvre, pas d'être. Il s'agit donc bien d'une modalité active. Mais l'accent résonne tout autrement dans le cas du constructivisme et dans celui de l'instauration : l'appel au constructivisme sonne toujours critique parce qu'on croit entendre derrière la désignation du constructeur ce Dieu capable de créer *ex nihilo*. Il y a donc toujours du nihilisme dans le Dieu potier : si les faits sont construits, alors le savant les construit *de rien* ; ils ne sont eux-mêmes que de la boue saisie par le souffle divin. Mais s'ils sont *instaurés* par le savant ou par l'artiste, alors les faits comme les œuvres tiennent, résistent, obligent – et les humains, leurs auteurs, doivent se *dévouer* pour eux, ce qui ne veut pourtant pas dire qu'ils leur servent de simple conduit.

DU MODE D'EXISTENCE TECHNIQUE

L'un des plus étonnants traits des Modernes, c'est le peu de place qu'ils accordent à ce qui les définit le plus nettement aux yeux de tous les autres depuis le début des grandes découvertes : l'art et la manière de déployer la *technique.* Ceux qui se vantent d'être de « solides matérialistes », n'ont pas donné deux pensées à la solidité des matériaux. Qu'on méprise la religion, cette figure qui n'a pas su tenir son rang ontologique devant la compétition des sciences, je veux bien ; que l'on se méfie des tripatouillages de la psychologie, je le comprends sans peine : ils contaminent toujours assez dangereusement ceux qui les manipulent. Mais les outils ? les automates ? les machines ? le paysage même que l'on n'a cessé de retourner et de labourer depuis des centaines de milliers d'années, les inventions qui dans les trois derniers siècles ont bouleversé nos vies plus que toutes les autres passions ? Pour mille ouvrages sur les bienfaits de la connaissance objective – et les risques mortels que ferait courir sa mise en cause –, il n'y en a pas dix sur les techniques – et pas trois pour signaler le danger mortel que l'on courrait à ne pas les *aimer*. Je veux pour preuve de cet abaissement que, dans le mot d'épistémo*logie*, nous entendions toujours une connaissance *sur* la connaissance, alors que dans le mot de techno*logie*, malgré les efforts d'André Leroi-Gourhan et de ses disciples, nous ne parvenons plus à nous souvenir que gît emprisonnée une réflexion quelconque *sur* cette technique. Nous n'hésitons pas à dire de la plus humble machine pleine de puces qu'elle est une « technologie », mais nous n'attendons d'elle aucune leçon ; à un « technologue » nous demandons seulement qu'il vienne réparer ladite machine mais pas qu'il nous en offre une connaissance. Qu'en ferions-nous ? Il n'y a rien à penser dans la technique. Ce n'est qu'un tas de moyens compliqués. Tout le monde le sait.

Même la philosophie politique, pourtant si peu prolixe, peut se flatter d'avoir engendré plus d'ouvrages que la philosophie des techniques, on peinerait à les compter sur ses dix doigts. C'est que l'on s'est servi de ce que j'appelle l'information double-clic (le déplacement sans transformation) pour étalonner une manière d'être pour laquelle elle est aussi peu faite que pour juger du cheminement des faits, des démons, des anges ou des moyens de droit. Mais comme toujours, au lieu de rejeter un étalon si manifestement inadéquat, on a choisi de faire rentrer la technique aussi dans ce lit de Procuste. Alors que toute l'expérience s'insurgeait contre une telle mutilation, on a fait comme si la technique, elle aussi, transportait sans déformation de simples informations. Il est vrai que les ingénieurs n'ont pas protesté, se donnant tout le mal du monde pour ressembler à l'image de savants butés qu'on voulait donner d'eux !

On dira que là, vraiment, c'est impossible, que j'exagère, que je suis victime d'occidentalisme, que tout dans la pratique des artisans, des ingénieurs, des technologues, des bricoleurs même, manifeste au contraire la multiplicité des transformations, l'hétérogénéité des combinaisons, la prolifération des astuces, le montage délicat des savoir-faire fragiles. Si l'on peut hésiter sur le mode d'existence de la reproduction (à cause de la persistance qui en résulte) (Latour, 2007)[3], hésiter encore sur celui des chaînes de référence (comme on accède bien aux lointains, on peut omettre à la fin les instruments qui ont permis cet accès), on ne peut pas douter que la technique émerge d'une longue série de transformations risquées. Par cette objection, le lecteur prouverait à quel point il a mal compris la capacité des Modernes à s'aveugler grâce à leur obsession pour le transport d'identité à identité par une identité. Si l'on veut mesurer l'abîme qu'ils sont capables de creuser entre la pratique et la théorie de la pratique, ce n'est pas seulement dans l'épistémologie, dans la psychologie ou dans la théologie qu'il faut aller, mais aussi dans la technologie (j'utiliserai toujours le terme dans son sens de réflexion *sur* la technique). Même quand ils parlent de « construction », les Modernes sont parvenus à cet exploit vraiment admirable de ne pas être constructivistes ! Pour ne rien dire de l'instauration.

Comment pourrait-on imposer un transport sans transformation dans l'acte technique quand tout indique le contraire ? Ô c'est très simple : il suffit d'y ajouter *l'utilité*, *l'efficacité* ou, d'un mot plus savant, *l'ustensilité*. L'efficacité est à la technique comme l'objectivité à la référence : le moyen d'avoir le beurre et l'argent du beurre, le résultat sans le moyen, je veux dire sans le chemin de médiations appropriées (il en est d'ailleurs de même avec *la rentabilité*, troisième Grâce de cette archaïque mythologie). Tous les tourbillons et les trublions des transformations techniques peuvent être oubliés, si vous dites qu'on ne fait que transporter par *l'objet* technique la *fonction* qu'il doit *fidèlement* remplir. Si vous parvenez à voir dans toute technique un transport d'efficacité à travers un outil « parfaitement maîtrisé », et si, en plus, vous lui accolez un fabricateur qui possède dans sa tête une forme préalable qu'il applique à une matière inerte et informe, alors vous allez pouvoir, par un geste de prestidigitation, faire disparaître le monde matériel tout en donnant l'impression de le peupler d'objets dont la matérialité aura le même caractère fantomatique que la nature ! La voiture ? Elle « correspond » exactement au « besoin de déplacement » et chacune de ses formes « découle » de ses besoins. L'ordinateur ? Il « remplit efficacement » la fonction pour laquelle il a été conçu. Le marteau ? Lui aussi provient d'une réflexion sur la « meilleure façon » de balancer le bras, le levier, le bois et l'acier. Donnez-moi des besoins et des concepts : la forme en sortira et la matière suivra. La technique ? De

3. J'appelle ici reproduction le mode d'existence qui assure la continuité dans l'être des phénomènes (mode entièrement distinct de celui de la référence).

la pensée appliquée à de la matière elle-même conçue comme forme, si bien que, à nouveau, forme et pensée se répètent l'une l'autre. Entrée en scène de l'*Homo faber* qui moule ses besoins à travers des outils par une « action efficace sur la matière » (l'expression est malheureusement de Leroi-Gourhan), cinq mots aussi parfaitement innocents que parfaitement inadéquats.

Le mépris dans lequel on tient les techniques vient de ce qu'on les traite sur le même modèle que celui qui a déjà servi à mécomprendre le travail de la référence scientifique (Latour, 2001). De même qu'il existe en épistémologie une théorie de l'objectivité comme « correspondance » entre carte et territoire par le truchement de la forme, il y a en technologie une théorie de l'efficacité comme *correspondance* entre la forme et la fonction. On croit que la technique est une action venue de l'homme – mâle d'ailleurs le plus souvent – et qui porte ensuite « sur » une matière conçue elle-même par confusion de la géométrie et de la persistance. La technique devient alors une application d'une conception elle-même erronée de la science !

Comme on le voit, il n'y a pas que les anges qui souffrent d'être incompris : les techniciens non plus n'ont pas de chance, on les prend pour des savants simplement de rang inférieur – en se trompant sur eux après s'être trompé sur les savants… Ce n'est pas la technique qui est vide, c'est le regard du philosophe : dans le plus beau barrage sur le Rhin, Heidegger ne parvient à rien voir d'original quant à l'Être. Il se contente de redoubler le mouvement universel d'occultation de la chose savante en le prolongeant un coup plus loin : la Science n'est qu'un avatar de la Technique, après que celle-ci ait été préalablement mécomprise comme *Gestell*. Magistrale méprise sur la maîtrise. Beau cas d'oubli de l'être en tant que technique. Manque de générosité ontologique ! S'il est vrai que le lent déluge de la *res extensa* a submergé la Vierge et les saints, elle a noyé beaucoup plus obscurément encore « le mode d'existence de l'objet technique ». Simondon aussi s'était indigné qu'un phénomène aussi massif puisse échapper à la conscience lettrée. J'y vois une preuve supplémentaire du manque de fiabilité des modernistes sur leur propre civilisation : comment ont-ils pu rater l'étrangeté, l'ubiquité, l'humanité des techniques ! Rater leur somptueuse opacité ! Mais surtout, ce qui m'a toujours stupéfié, manquer leur *transcendance*. Décidément, c'est de la technique et pas de la nature qu'il faut dire « qu'elle aime à se cacher ».

On dira que tous les modes d'existence sont transcendants puisqu'il y a toujours un saut, une faille, un décalage, un risque, une différence entre une étape et la suivante, une médiation et la suivante, n et n + 1 le long d'un chemin d'altérations – ce que la notion d'instauration cherche justement à cerner. La continuité manque toujours. Rien de plus transcendant, par exemple, que les repères géodésiques par rapport aux relevés inscrits sur le carnet du géomètre arpenteur ; rien de plus transcendant que la question d'une seule ligne posée au jury d'un procès par rapport aux milliers de pages d'un lourd dossier roulé grâce à un diable jusqu'au greffe du tribunal ; rien de plus transcendant que le rapport entre la tiédeur d'une prière rabâchée et le saisissement d'en avoir compris le sens comme pour la première fois ; rien de plus transcendant que le rapport entre la scène de carton pâte et l'envol des personnages de théâtre qui semblent en sortir. Les transcendances abondent puisque entre deux continuités il y a toujours une discontinuité dont elle forme, en quelque sorte, le prix, le chemin et le salut, bref l'être-en-tant-qu'autre.

Ce qui manque le plus, c'est l'*immanence*. Faut-il rappeler qu'il n'y a pas deux mondes, le premier immanent et plein *au-dessus* et *au-delà* duquel il faudrait en ajouter un autre – le surnaturel – et *en deçà* duquel, pour faire bonne mesure et loger les représentations, il faudrait en creuser un autre –l'intériorité ? Il n'y a que des êtres sous-naturels – nature comprise ! (Stengers, 2002) – tous *légèrement* transcendants par rapport à l'étape précédente le long de leur chemin particulier. Ils forment réseau et ces réseaux s'ignorent le plus souvent sauf quand ils se croisent et doivent composer les uns avec les autres en évitant autant que possible les erreurs de catégorie. Le monde est donc plein de, ou plutôt non, le monde est constamment *évidé* par des circulations de transcendances qui le creusent tout au long par un fin *pointillé* laissé par les sauts et les seuils qu'il faut franchir de proche en proche pour exister quelque peu davantage. Une course d'obstacles, en somme.

LE TYPE DE TRANSCENDANCE DE L'ACTE TECHNIQUE

Si la technique est transcendante comme tous les autres modes, par conséquent, ce doit être *à sa façon*. Mais laquelle ? Comment comparer les êtres avec pour seul outillage des objets et des sujets ? Tout bricoleur sait bien que son habileté s'accroît s'il dispose, au lieu de quelques outils rudimentaires, d'une panoplie de tournevis et de clefs anglaises, de scies et de pinces. C'est le génie de Simondon d'avoir vu qu'on ne pouvait préciser le mode d'existence de l'objet technique qu'en le *titrant* grâce à ceux de la magie, de la religion, de la science, de la philosophie. C'est le seul usage rationnel qu'il faut donner, d'après moi, au proverbial rasoir d'Occam. On s'en sert maladroitement si l'on se met à couper à tort et à travers pour limiter arbitrairement le nombre d'êtres. Je crois au contraire qu'il convient d'en faire usage comme d'un nécessaire de scalpels de tailles et de formes diverses luxueusement logés sur un lit de satin dans un coffret de bois verni pour découper selon les articulations même de l'animal *tous* les modes d'existence, sans accepter de rompre le cou d'aucun…

Quelle est donc l'*abaliété* propre au mode d'existence technique – pour emprunter à Souriau l'un de ces beaux vocables qu'il oppose à la seule recherche de *l'identité* ? Pas de doute, il s'agit bien d'un saut, d'une faille, d'une cassure même, d'une rupture dans le cours des choses, ce qu'on appelle une *invention* humble ou géniale peu importe. Il suffit pour s'en convaincre de regarder autour de soi et de commencer à prendre la mesure de ce que la technique a fait subir aux êtres qu'elle se donne comme point de départ.

Les pierres de votre maison gisaient dans une carrière fort loin d'ici ; le bois de votre meuble en tek allait son chemin quelque part en Indonésie ; le sable de votre vase en cristal dormait au fond d'une vallée de la Somme ; et ainsi de suite. Mais n'est-ce pas aussi le mode d'altération des métamorphoses, cette stupéfiante habilité à changer de forme ? C'est en effet qu'il y a de la *magie* dans la technique – tous les mythes le disent et Simondon l'a saisi mieux que personne. Regardez de nouveau autour de vous : vous ne pourrez établir aucune continuité entre la carrière, la forêt tropicale, la sablière et les formes qu'elle ont su suggérer à leurs fabricants en devenant quelques-unes des composantes de votre demeure. Il y a donc bien eu *métamorphose*, et ce n'est pas par hasard si l'on parle, à propos de la technique, de ruse, d'habileté, de détour, de *mètis*. On sent bien des harmoniques entre la subtilité nécessaire pour déjouer les pièges des démons et celle qu'il faut mettre en œuvre pour trouver « le truc ». En tout cas, les deux *biaisent* parce que, selon l'admirable expression populaire, « il y a toujours le moyen de moyenner ». Si Ulysse est « plein de ruses », si Vulcain boite, c'est parce que, à l'approche de l'être technique, rien ne va droit, tout se fait de biais – et même parfois *tout va de travers.* Mais en même temps, ma table, les murs de ma maison, mon vase de cristal demeurent. Contrairement aux êtres de la métamorphose, et donc de la magie, une fois radicalement transformés, les êtres de la technique imitent ceux de la reproduction par leur persistance, leur obstination, leur *conatus*. C'est comme si la technique avait arraché à la reproduction comme aux métamorphoses une partie de leurs secrets en croisant les deux espèces. Pas étonnant qu'on ait vu dans le feu de Prométhée ce qui fluidifie toutes choses et, en même temps, ce qui leur procure une durée, une dureté, une consistance nouvelle. Pas une archéologue digne de ce nom qui ne s'émeuve devant les poteries qu'elle déterre et qui, même fracassées, dureront autant que notre Terre.

Si le mode d'existence de l'objet technique n'est qu'un mélange astucieux de deux autres modes, n'aurait-il rien en propre ? Aucun doute qu'il soit difficile à saisir, encore plus labile, peut-être, que les êtres de la magie suivis par Simondon. C'est en effet qu'il est *rare* et que le terme d'« objet » technique risque de nous égarer. Ni le mur, ni la table, ni le vase – ni la voiture, ni le train, ni l'ordinateur, ni l'animal domestiqué – ne sont « techniques » *une fois laissés à eux-mêmes*. Ce qu'il y a d'objet en eux dépend de la présence des composés dont chacun a été arraché par des métamorphoses à la persistance des êtres choisis comme point de départ – inertes ou vivants – dont chacun prête certaines de ses vertus, bien sûr, mais sans qu'on puisse le plus souvent durablement profiter de leur initiative et de leur autonomie. Les ingrédients de ces mélanges demeurent étrangers les uns aux autres. Ils acceptent d'être traduits, détournés, disposés, agencés, mais ils n'en restent pas moins sur leur « quant à soi », prêts à lâcher à la moindre occasion. Si l'on n'y veille pas, le mur s'écroule, le bois taraudé par les vers tombe en poussière, le cristal s'opacifie ou se brise – la voiture tombe en panne, le train déraille, le cheval redevient sauvage ; quant à l'ordinateur, je préfère ne pas en parler tant il est fragile (le mien vient de tomber en panne au retour de vacances, par une sorte de dépression maléfique…). C'est des techniques bien plus que des textes qu'il faut dire *traduttore, traditore.* On ne trouvera donc jamais le mode d'existence technique *dans l'objet lui-même* puisqu'il laisse partout des *hiatus* : d'abord, entre lui-même et le mystérieux mouvement dont il n'est que le sillage ; ensuite, à l'intérieur de lui-même entre chacun des ingrédients dont il n'est que l'assemblage momentané[4]. Il n'y a jamais en technique de *solution de continuité* ; ça ne « fait jamais raccord ».

L'épreuve est facile à mener : il suffit de se retrouver les bras ballants devant un « machin », un « truc » dont le sens vous échappe totalement, peut-être un cadeau qu'on vous aura fait, ou un dispositif dont le mode d'emploi est opaque, ou encore un caillou du Châtelperronien dont les tailleurs ont disparu depuis quarante mille années : tout est là, et pourtant rien n'y est visible. Comme si l'objet n'était qu'une partie seulement d'une trace, d'un tracé, d'un mouvement dont le sens vous échappe. On prêche dans les Églises que la lettre des Écritures reste inerte sans l'Esprit qui souffle où il veut ; c'est bien plus vrai encore des os blanchis de l'objet technique, qui attendent que l'esprit de

4. C'est ce que je me suis efforcé de suivre dans *Aramis, ou L'amour des techniques* (1992).

la technique vienne les soulever, les recouvrir de chair, les agencer à nouveau, les transfigurer, le mot n'est pas trop fort : les ressusciter.

L'objet technique a ceci d'opaque et, pour tout dire, d'incompréhensible, qu'on ne peut le comprendre qu'à la condition de lui ajouter les *invisibles* qui le font exister d'abord, puis qui l'entretiennent, le soutiennent et parfois l'ignorent et l'abandonnent. – Encore des invisibles ? N'est-ce pas trop fort, comme si j'avais un penchant obsessionnel pour ajouter de l'irrationalité même au cœur de l'efficacité la plus matérielle et la plus rationnelle ! – Mais non, sans les invisibles pas un objet ne tiendrait et surtout pas un automate ne parviendrait à ce prodige de *l'automation*. De même que l'on oublie d'ajouter à la connaissance objective les chemins de la référence, on omet toujours d'ajouter aux objets techniques ce qui les instaure sous prétexte, ce qui est vrai aussi, qu'ils se *tiennent tout seuls* une fois lancés, sauf qu'ils ne peuvent jamais demeurer seuls et sans soin – ce qui est vrai aussi. Décidément, la technique est mieux cachée que la fameuse *aletheia*.

Ah, vous voulez dire qu'il y a des techniciens, des ingénieurs, des inspecteurs, des surveillants, des équipes d'intervention, des réparateurs, des régleurs, *autour* et *en plus* des objets matériels ? Bref, des humains et même un contexte social ? Mais non, je n'ai rien dit de tel et pour la bonne raison que les techniques *précèdent* les humains par des centaines de milliers d'années et que, de toutes façons, je ne sais rien de ce qu'est « l'humain » ; par quoi vous voulez dire, je le subodore, le « sujet qui maîtriserait la matière », cet *Homo faber* de la mythologie moderniste laquelle ne respecte même pas dans ce qu'elle célèbre le sens du courbe, du biaisé, du déhanché, la marche en crabe de la technique. Si la pornographie tue l'érotisme, le « *hype* », comme disent les Américains, tue le désir d'objet technique encore plus sûrement. Si l'on ne comprend rien à la cure en se donnant un sujet angoissé, si l'on ne comprend rien à la connaissance en se donnant un *cogito*, on ne comprendrait rien au mode d'existence technique en supposant qu'un fabricant serait aux commandes. Il y a bien plus dans les fabrications et les artifices qu'un fabricateur et un artificier. En ajoutant un constructeur aux constructions on ne comprendrait rien de plus, puisque c'est le (dé)constructivisme même qui manque de sens. Les êtres techniques viennent au technicien et non l'inverse. Mais comment ?

SAVOIR PRENDRE LE PLI DES TECHNIQUES

Au lieu de changer les connotations d'un vocable, mieux vaut en changer. C'est de nouveau au beau terme d'*instauration* qu'il faut recourir. L'artiste, nous a dit Souriau, n'est jamais le créateur, mais toujours l'instaurateur d'une œuvre qui vient à lui mais qui, sans lui, ne viendrait jamais à l'existence. S'il y a une question que ne se pose jamais le sculpteur, c'est la question critique : « Est-ce moi ou est-ce la statue qui est l'auteur de la statue ? ». Si je parle d'invisibles, c'est pour suivre rationnellement le fil de ce labyrinthe, je veux dire du vrai labyrinthe : celui que l'architecte Dédale a construit pour le roi Minos. Si rien dans la technique ne va droit, c'est parce que le cheminement logique – celui de *l'épistemè* – est toujours interrompu, dévié, modifié et qu'on va de déplacements en déviations – rappelons-nous que le *daedalion*, en grec, c'est le détour astucieux hors de la voie droite. C'est ce qu'on veut dire, fort banalement, quand on affirme qu'il y a là « un problème technique », un obstacle, un « os », un « bogue » ; ce que l'on désigne en disant de quelqu'un qu'il est le « seul techniquement capable » de résoudre cette difficulté : « il a le coup de main », le « *knack* ». « Technique » n'est pas un substantif mais un adjectif : « ça c'est technique » ; un adverbe : « c'est techniquement faisable » ; soit enfin mais plus rarement un verbe : « techniciser ». Autrement dit, « technique » ne désigne pas un objet mais une différence, une exploration toute nouvelle de l'être-en-tant-qu'autre, une nouvelle déclinaison de l'altérité, une *abaliété* propre. Simondon lui aussi se moquait du substantialisme qui, là encore, là comme toujours, manquait l'être technique.

Rien à faire, demeurer fidèle à ce genre d'existence, c'est accepter sa rareté, sa fulgurante invisibilité, sa profonde et constitutionnelle opacité. Rien de plus courant, de plus quotidien, de plus expérimental : vous alliez au bureau en montant dans votre voiture, et soudain, sans avoir bien compris, vous vous retrouvez dans un garage, cherchant obscurément à saisir ce que marmonne un technicien en bleu de travail, accroupi sous le châssis, qui semble désigner de sa main noircie par l'huile de vidange une pièce dont le nom et la fonction vous échappe tout à fait sauf que (vous commencez à le deviner) de la disponibilité de cette pièce de rechange et de l'habileté de ce garagiste, vous vous mettez « à attendre des miracles », sachant qu'il « faudra y passer » si vous voulez retrouver le chemin de votre bureau – et qu'en plus vous « allez le sentir passer ». Voilà, le souffle de la technique a passé sur vous quelque temps jusqu'à ce que le ronronnement sous le capot vous fasse aussitôt tout oublier. Les êtres techniques seraient-ils donc, eux aussi, à occultations ? Aucun doute là-dessus, *l'oubli* qu'il laisse derrière eux fait partie intégrante de leur cahier des charges. La technique aime à se faire oublier. On a autant de peine à la saisir en plein vol que les oiseaux migrateurs, il y faut de bonnes jumelles et un bon guide.

J'ai eu la chance, pendant les vingt-cinq ans passés au CSI, de photographier bien des fois *l'éclair* des innovations techniques. Grâce à d'imprévisibles détours, des êtres totalement éloignés dans l'ordre de la reproduction deviennent la pièce manquante d'un puzzle dont on ne savait pas qu'il demandait tant d'intelligence. Par une longue série de détournements, tous plus ingénieux et imprévisibles les uns que les autres, voilà que la physique atomique se retrouve au service d'un hôpital pour y soigner le cancer. Par un autre détournement, le bois et l'acier s'impliquent l'un l'autre dans la balance d'un marteau. Par un autre détournement, les couches successives d'un programme, d'un compilateur, d'une puce parviennent à se compliquer et à s'aligner au point de remplacer cette vieille machine à écrire IBM dont la boule pourtant me paraissait si nouvelle quand elle a fait son apparition dans les années 1960 – on pouvait même faire des gras et des italiques à condition de la changer par un petit clic !

Et ce n'est souvent pas la peine d'aller très loin dans les géniales innovations techniques, pour en saisir le détour, la totale originalité. On retrouve cette fulgurance dans l'humble geste du bricoleur qui trouve une cale pour empêcher une porte de se refermer trop vite. « Trouver le truc », tout est là. Quel mode va plus loin dans *l'altération* que celui-ci ? Le risque de la reproduction est admirable bien sûr, mais jamais les êtres de la reproduction ne sautent dans l'existence de façon aussi vertigineuse que les composants de la plus humble technique. Toutes les galaxies peuvent tourner les unes sur les autres, elles ne feront pas tourner la roue d'un char à bœuf sur son moyeu ; vous pouvez m'impressionner dans la Galerie d'histoire naturelle par la profusion des êtres vivants, oui, mais moi c'est la série des bicyclettes dans le Musée du Conservatoire des Arts et Métiers, ou l'entrée d'une locomotive électrique glissant sans bruit le long de ses rails éclatants jusqu'au quai de la gare, qui m'émeuvent. Par la technique, l'être-en-tant-qu'autre apprend qu'il peut être encore plus infiniment *altéré* qu'il ne le croyait jusque-là.

S'il y a une chose vraiment que le matérialisme n'a jamais su célébrer, c'est la multiplicité des matières, cette altération infinie des puissances cachées que l'astuce seule va y chercher. Comme on la comprend mal en prétendant faire des techniques les simples « applications de la Science » et la seule « domination de la Nature ». L'idée que l'on pourrait *déduire* tous les tours et détours du génie technique par des principes a priori a toujours bien fait rire les ingénieurs. Isabelle Stengers avait imaginé de réduire, par une expérience de pensée radicale, toutes les inventions techniques aux seuls « principes de base » reconnus par les savants et dont on enseigne dans les écoles qu'ils forment leur « indiscutable fondement » : réduites au cycle de Carnot, les locomotives s'arrêtaient aussitôt ; limités à la physique de la portance, les avions s'écrasaient au sol ; ramenée au dogme central de la biologie, l'industrie biotechnologique tout entière suspendait ses cultures de cellules. En s'envolant, les invisibles de la technique – détour, dédale, astuces, trouvailles – auraient réduit à néant l'effort des sciences. Plus d'invisibles, plus de domination. Cataclysme universel aux effets bien plus effroyables que la chute de quelques gratte-ciel. Vulcain le boiteux se moque bien de la prétention d'Athéna à lui dicter ses lois. Tout dans la matière est esprit pour l'ingéniosité. Comment a-t-on perdu ce contraste au profit d'un rêve de maîtrise et de domination ? Comment a-t-on pu ignorer cette *matériologie* qu'a honorée pourtant tout un courant assez caché de la philosophie française de Diderot à François Dagognet en passant par Bergson et bien sûr Simondon (Dagognet, 1989 ; Bensaude-Vincent, 1998) ? Perte aussi effarante que celle du religieux. Inversion tout aussi tragique, puisque les techniques vont si peu droit qu'elles laissent dans leur sillage bien d'autres invisibles : les conséquences inattendues, les surprises, les déchets, tout un nouveau labyrinthe ouvert sous nos pas et dont l'existence même continue à être niée par ceux qui pensent pouvoir aller d'un coup, sans médiation, sans le péril d'aucun long détour, « droit au but » (Beck, 2003). « *The magic bullet* », « *the technical fix* », il faut bien parler américain pour comprendre cette étrange cécité de Modernes sur la source la plus précieuse de toutes les beautés, de tous les conforts, de toutes les efficiences. Quelle manque de politesse pour notre propre génie. Il est bien tard pour parler enfin des *précautions* qu'il faudrait prendre pour apprendre à les aimer avec toute la délicatesse requise.

Comment nommer ce mode d'existence que l'on manquerait tout à fait si l'on faisait l'erreur de le limiter aux objets laissés dans son sillage sans en reproduire le mouvement si particulier ? Je l'appellerai tout simplement *le pliage technique*. Ce terme nous évitera la bévue de parler de la technique de façon irrévérencieuse comme d'une masse d'objets. La technique, c'est toujours « pli sur pli », implication, complication, explication. Il y aura pliage technique à chaque fois que l'on pourra mettre en évidence cette transcendance de deuxième niveau qui vient interrompre, courber, détourner, détourer les autres modes d'existence en introduisant ainsi, par une astuce, un *différentiel* de matériau, de résistance, quel que soit par ailleurs le type de matériau. On pourra parler de pliage technique pour le montage si délicat d'habitudes musculaires qui font de nous, par apprentissage, des êtres compétents doués d'un fin savoir-faire, aussi bien que pour parler de la fonte en fusion qui sort des hauts fourneaux de Mittal, ou encore pour désigner la distinction entre un logiciel et son compilateur, ou enfin pour célébrer la « technique » juridique qui permet de relier un texte un peu plus durable avec un dossier qui le sera moins. Là ou est le différentiel de résistance, là aussi est la technique. C'est d'ailleurs cette ubiquité qui explique probablement son opacité : elle est partout, dans toutes les chaînes et réseaux, chaque fois qu'il y a ce détour, ce pliage, ce gradient et ce maintien des assemblages hétérogènes. De même que la technique se plie dans les êtres de la reproduction et de la métamorphose, tous les autres modes vont se loger, se lover, s'abriter, s'appuyer dans les dispositifs que l'astuce technique va laisser derrière elle – en disparaissant modestement.

On dira qu'en parlant du mode d'existence technique, j'ai omis de prendre en compte ce qui devrait sauter le plus aux yeux : les techniciens, les ingénieurs, les humains qui la fabriquent. Or c'est volontairement que j'ai parlé des techniques et peu des humains auxquels elles sont advenues. Je ne voulais pas qu'on se précipite pour partir des humains en allant ensuite vers leurs objets. Sur ce point de préséance, nous bénéficions d'ailleurs du témoignage de la paléontologie : sans ces techniques invisibles et opaques, ce sont les humains qui seraient demeurés invisibles sur la surface de la terre ; la trace de leurs pas eût été plus discrète encore que celle des éléphants ou des chimpanzés – sans parler des vers de terre. Disons, au contraire, qu'il est arrivé quelque chose à ceux qui ont avivé le contraste de la technique. Tout se passe comme si les humains avaient été instaurés par les techniques (Sloterdijk, 2005). L'humanité, c'est le choc en retour des techniques. *Homo fabricatus* : nous sommes bien les fils de nos œuvres.

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