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The De-Scription of Technical Objects

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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 compli-

cated. 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 nonstandard 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, elec-

tricity 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 simplifi-

cation 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.