

Technology is society made durable

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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

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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

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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 *transport* a statement and the succession of *transformations* 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.

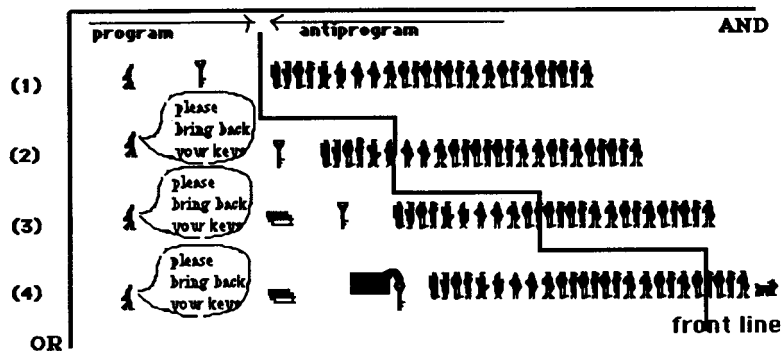
We wish to be able to follow both the *chain* of speakers and their statements and the *transformation* of speakers and their statements. We thus define two dimensions: association (akin to the linguist's syntagm) and substitution (or paradigm for the linguists). To simplify even further, we can think 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

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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!

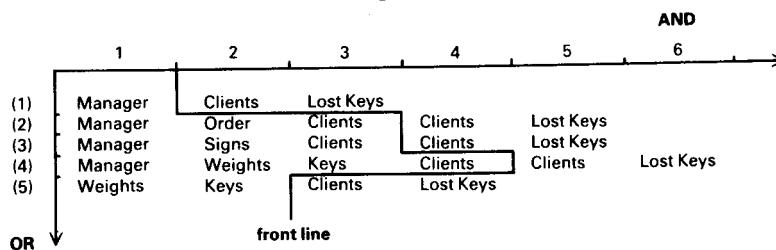
We notice in the diagram that the social group of the hotel customers finds itself transformed little by little. The accumulation of elements – the will of the manager, the hardness of his words, the multiplicity of his signs, the weight of his keys – ends up trying the patience of some customers, who 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

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'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 technician 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

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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** -/-

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(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

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(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-//-

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 super-structure, 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

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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.

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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

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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

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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.

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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

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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

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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

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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-

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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

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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.

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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 cryptogamic 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.

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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

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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

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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 transcendent 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

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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 indifferenciation. 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 transcendence, it loses none of its acuity.

Notes

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- 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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