The automation process and its social forms the sociological paradigm

Michel Freyssenet
CNRS-IRESCO-CSU [1]

This is a study of the design of production techniques in the context of the social conditions under which they are developed and implemented. It begins by distinguishing the presuppositions which have oriented choices of automation methods made by a series of companies, and seeks to reveal their origins. It then underlines the contradiction between these presuppositions and the objectives assigned to new forms of work organization adopted in these companies. It reveals how this contradiction transforms forms of work organization which are supposedly "skilling" into the opposite of this. Finally, referring to the author's participation in the design of several automated installations, the study suggests a social form of automation which is indeed capable of bringing about a real and durable inversion of the division of knowledge from work, but whose generalization meets with major obstacles.*

---

[1] Institut de Recherche sur les Societies Contemporaines, Centre de Sociologie Urbaine, 59-61 rue Pouchet, 75849 Paris Cedex 17, France. This translation, by Sybil H. Mair, taken from the French version published in *Sociologie du Travail* (4/92: 469-496): all quotation marks around words are in original text. Translator's notes marked with asterisks.
* [Translator's note: from French *qualifiante*: adjective meaning *skill-increasing*.]

Freyssenet M., **The automation process and its social forms: the sociological paradigm**, Communication at the SASE Congress (Society for the Advancement of Socio-Economics) Paris, 15-16 Juillet 1994. **English** version of: Freyssenet M., “Processus et formes sociales d’automatisation. Le paradigme sociologique”, *Sociologie du Travail*, n° 4/92, pp 469-496. Digital publication, freyssenet.com, 2007, 428 Ko.

The debate on the place and status of production techniques in the process of the division of labour has progressed through three phases [1]. A fourth one is beginning now. In the 1950s and 1960s an idea was advanced, in opposition to the ideas of Friedman, of a production technique which both determined the evolution of work and was autonomous in its own evolution. During the 1970s, this was followed by the claim that machines are designed with the goal of imposing a form and a norm onto human work, a thesis backed up by examples which are suggestive rather than conclusive. At the beginning of the 1980s, the two preceding perspectives were wrongly confused in the same critique of the "technological paradigm". The variety of forms of the organization of work noted in companies from different countries -- though using similar machines -- led to a conclusion that the division of labour was autonomous in relation to production techniques, and to the possibility of moving it in various directions by acting upon the factors that might condition it, namely hierarchical social relationships and national structures of education. The discovery that a variety of forms of work organization were combined with identical production techniques not only within the same country but within the same company, even the same factory, has since then demanded more detail or more moderation as far as exclusively societal explanations are concerned. In the eyes of many, the autonomy of the content and organization of work in relation to productive techniques has been confirmed yet more clearly.

At the same time, however, growing questions and doubts on the part of company managements concerning the modalities of design and the well-foundedness of choices their engineering departments have made regarding automation allowed, during the second half of the 1980s, social science research on the reasons why automated installations were not attaining target performance levels, and on the origin of the conflicts that these installations were bringing about between engineering departments and production managers[2]. It has since then become possible to study the design process

---

1 . This article is a modified and final version of a presentation given under the title "Processus et formes sociales d'automatisation" at the international conference "Maitrise sociale de la technologie", 9th-12th Septermber 1991 at Lyon, organized by the Maison Rhone-Alpes des Sciences de l'Homme and the Groupement de Recherche en Economie Industrielle of the CNRS. It has benefitted from questions and comments from the editorial committee of the journal *Sociologie du Travail* and from participants at the seminar series "The emergence of new production models" organized by "GERPISA international network", "Automathomme" organized by ANACT (the national agency for improving work conditions) and the Research Ministry, "Les rationalisations du travail. Cinquièmes Journées de sociologie du travail" and "Approches multidisciplinaires des technologies" of the CNRS-associated research unit "Work and mobility" at the University of Paris X.

2. After 1978, many companies, and this was especailly true in France, launched large programmes of investment in production automation, with the goal, they hoped, of rapidly increasing the productivity of work, the quality of products, and the flexibility of production. The expected results have not been achieved. This has had made small contribution to the worsening competitive and financial situation of these companies. On this subject see: Michel Berry (ed) "Pour une automatisation raisonnable de l'industrie" *Annales des Mines* n° special, janvier 1988, 125p; and Michel Freyssenet and Jean-Claude Thenard "Choix d'automatisation, efficacité productive et contenu du travail", *Cahiers de recherche du GIP Mutations Industrielles*, n° 22, 15 décembre 1988, 68p.

Freyssenet M., **The automation process and its social forms: the sociological paradigm**, Communication at the SASE Congress (Society for the Advancement of Socio-Economics) Paris, 15-16 Juillet 1994. **English** version of: Freyssenet M., “Processus et formes sociales d’automatisation. Le paradigme sociologique”, *Sociologie du Travail*, n° 4/92, pp 469-496. Digital publication, freyssenet.com, 2007, 428 Ko.

as well as to understand production techniques [1] for what they are, that is to say as social "products", just as anthropology has done for a long time regarding the tools of pre-industrial societies. The results of these studies allow the debate to be reopened.

A tool has always been the materialization of the intelligence of producers with a view to attaining their goal; more efficiently from their point of view. However, the end pursued, the social conditions under which it must be attained, and the social modalities of the constitution and of the materialization of the intelligence necessary, that is to say the type of division of labour which is at work, have not remained unchanged throughout history, and neither are they the same in different societies. Aims, conditions and modalities have varied and do vary -- this is the hypothesis that we bear in mind -- depending upon the type of social relationship that links those participating to the activities under consideration, and depending upon the history of this relationship within each society that has allowed its development. This explains why the material form of the means of work not only carries the stamp but also symbolically represents and delimits practically (if it is not modified or diverted towards other kinds of goals) the use that can be made of these means in the social relationship at the heart of which and for which they were conceived. And in our case here, that means the wage relationship[2].

Anthropology has the advantage of comparing tools from several clearly distinct societies and therefore being able to identify more easily what their material forms and uses owe to the social relationships that characterize each of them. The means of production in our own societies possess a homogeneity of design, that goes beyond their appearance, which makes it more difficult to show that they might have been designed differently, under certain social conditions.

In reconstituting or following the design process and utilization of several automated installations (machining lines, robotized welding lines, railway points and signalling posts, mechanical assembly lines, bottling lines, automatic testing equipment, and expert control and maintenance systems) [3], we started by making a point of identifying and questioning the objectives, principles, presuppositions, social images, which oriented the technical choices characterizing these installations, and searching for their organizational and social origins and as a consequence their history or evolution.

---

[1] We refer here to machines and other installations that are actually involved in productive activity. We do not mean techniques in general (mechanics, hydraulics, computing) and still less scientific and technical development. These too of course might be subjected to a sociological analysis and they are not unrelated to the demands of production. But their analysis is obviously yet more complex. It cannot be reduced, in fact, either to simply showing their links with the dominant social relationship, currently the wage relationship, even if this relationship is no less likely for all that to play an important role in their evolution, nor to reconstructing the social history of the actors or institutions which invented, developed and applied them, even though this is an indispensible research step. In the problematic suggested here, analysis must establish the links between the processes of creation and diversification of the technical or scientific disciplines and the social structures that these processes articulate and traverse in the course of their development.

[2] By social relationship we mean not social relationship as popularly understood, but the the few kinds of social relationship which structure our societies, like for instance the wage relation (which is divided into several types). Cf Michel Freyssenet and Suzanna Magri (ed) *Les rapports sociaux et leurs enjeux,* Seminar at the Centre de sociologie urbaine 1986-1988, Paris, CSU, vol 1, 208p.; 1991, vol 2, 210p.

[3] The corresponding publications are listed at the end of the article. The cases studied concern both so-called "continuous process" industries and so-called "discrete process" or "manufacturing" industries. There is no difference between them in the social forms taken by automation.

This does not suffice, however, to demonstrate that other technical forms are possible. It is still necessary to verify that by pursuing different social objectives and by changing presuppositions, one is in fact defining other processes and other social forms of automation. Now the real world certainly offers examples that would allow us to test this. One method might have consisted of looking for and analyzing them. The "research relationship" [1] agreed with the companies in which the investigations cited were carried out led us to proceed differently. Once the presuppositions and principles behind current forms of automation were revealed, it was possible to show that they contradicted the objectives behind new forms of work organization set up in these companies, that paradoxically they were transforming (as we shall see, only in appearance) these forms of work organization, in a single step and with one technical change, towards a deepened division of labour. In view of these results, three companies agreed an exploration of what a change of principles might bring by way of modifications to the technical specifications of machines, materials and automated installations, and consequently to the use that can be made of them.

THE ECONOMIC AND SOCIAL PRESUPPOSITIONS BEHIND CURRENT FORMS OF AUTOMATION, AND THEIR POSSIBLE ORIGINS

Here we discuss those presuppositions which, in the cases studied, have had the most important implications for technical choices. These have been identified by seeking to make explicit the reasons behind choices of automation successively made over the course of a project, and by an analysis of the counter-productive results and dysfunctioning of the resulting installations, with the actors concerned: engineering staff, manufacturers of machines, top management, management accountants, quality staff, production and purchasing managers, operating and maintenance workers and technicians.

The actual functioning of an installation should and could correspond to its theoretical function

The designers of automated installations consider that those who are in charge of their utilization must and can ensure that the conditions and rules which guarantee their sound operation are adhered to. Yet, reciprocal ignorance remains such that, today, the former often are unaware of actual conditions in production, and postulate other conditions which the latter are incapable of satisfying and keeping to. As a consequence it is impossible to attain the expected theoretical results. This rupture may go as far as explicit refusal to acknowledge conditions and the way work is conducted in the factories, on the basis of the principle that what happens there arises out of empiricism and a latitude of action that ought to be condemned and therefore certainly should not

---

[1] On this idea see the preliminary statement in "Rapport d'activite scientifique 1986-1990 du GIP Mutations Industrielles", *Cahiers de recherche du GIP Mutations Industrielles,* Paris, n° 50, 30 juin 1990, pp 21-22.

be taken into account. To this argument is added another, according to which automation may in no circumstances consist of imitating what already exists and certainly not the way things are currently done, but should, on the contrary, replace them with different frameworks and actions compatible with the principles according to which the machine operates. What is forgotten in this line of reasoning is that the prior analysis of work and the conditions in which it takes place is not aimed as much at getting to know the ways employees do things currently in order to reproduce these, as at identifying the concrete problems that these behaviour resolve in their own way, and which the automated machine will itself have to address if it is not also to prove insufficiently adapted to its conditions of utilization.

The long, difficult and costly task of modification during the phase of implementation and ramping up to full production in part compensates for the lack of interaction between the engineering department and the factory when the machine's desired characteristics are being specified, when the studies are completed, and when the project is launched. However, everything cannot be caught up. In the utilization phase the operators and maintenance workers are obliged to make up for the insufficient adaptation to conditions of utilization and deficiencies of the installation by undertaking operations which are often fragmented and subject to time constraints, and by stepping in to tackle recurring breakdowns or problems.

The severing of design and production is widely presented as one of the characteristic traits of Taylorism. In fact this is not so. Taylor recommended distinguishing between functions, not segmenting them. On the contrary, the detailed analysis of work and the conditions in which it is undertaken is fundamental to his method and to his philosophy of production. Moreover, for many years, the engineers who designed the means of production came out of a manufacturing background and possessed a good knowledge of the terrain. However, changes to their recruitment and to their career paths within the company over the past twenty years, and the overvaluation of the scientific contribution in relation to the practical, have led to a generalization of the type of design process which consists of starting from a blank page and defining a "norm" which the actual producers only have to keep to. The counter-productive results of this mode of design together with the Japanese example are these days leading certain companies to revise their recruitment methods and the career paths of their engineers as well as the ties between the "manufacturers" and the engineering staff.

The profitability of investment would be higher to the extent that workforce reductions were significant and rapid

Decreasing the numbers of workers in manufacturing and maintenance is considered the favoured means to immediately increase financial performance. Even though other criteria to justify automation have appeared in reports on investment since the mid 1980s, reduction of labour "costs" remains the determining variable in formulae for calculating profitability. As a result, planners are preoccupied with fully "occupying" the personnel in order to limit their numbers.

Among all the activities to be undertaken, surveillance by humans is quite often perceived as a highly unproductive activity advantageously and easily replaceable by automatic signals and stops in the event of faults or difficulties. The operator, thus released from being tied to direct or indirect observation of the functioning of the installation, can be assigned either to associated tasks of quality control, noting down information, preparing tools and doing preventive maintenance (and this, even more easily since meanwhile these tasks are themselves simplified and shortened by other types of automation) or to surveillance of several automated lines from a centralized control cabin.

The elimination of human surveillance and anticipation requires several conditions if it is not to be counter-productive. Firstly the greatest possible number of faults, difficulties and breakdowns must be foreseen during the design process and must be able to be spotted automatically, and at reasonable cost. Then the signals and stops must be neither too frequent nor simultaneous. And finally, the identification of the primary causes of these faults and difficulties, necessary in order to rapidly and definitively eliminate them, must be possible when the machines are not working. Experience shows that these three conditions are rarely fulfilled. The medium-term performance of an automated installation in fact depends more upon ability to eliminate primary causes of stoppages and faults than upon rapidly repairing or correcting them. Now, what this capability really requires is the availability of operators and maintenance personnel, quickly and in sufficient numbers, to observe and analyze the actual functioning of the machines under their charge [1].

The calculation of the productivity of work and of the profitability of investments by taking into account the size of the manufacturing workforce, multiplied by a fixed coefficient to take account of the indirect workforce, has lost its usefulness, with indirect costs far surpassing direct costs in an increasing number of industries. It is therefore being challenged today, and we are witnessing attempts, as yet unsuccessful, to substitute other modes of calculation. It does not seem, however, condemned in principle. Certain of the current forms of work reorganization, compatible, as we shall see, with the form of automation being described here, include the deployment of a growing proportion of the indirect workforce to different production lines, when they do not actually lead to a single new category "exploitants"[*] who undertake functions previously divided between direct and indirect workers. At this point the idea of new direct costs, or costs that can be so designated, resumes meaning, as does the reasoning which is designed to reduce them with the aid of the kind of automation currently being designed.

Rapid repair is fundamental to the availability of automated lines

In cases of stoppages due to faults, problems or breakdowns, automated production would depend, for its output, quality and timing upon the speed with which operating and maintenance staff intervened. Out of this springs the preoccupation with acting on all the time fragments which make up an intervention.

---

[1] This process of automation is one of the sources of current unemployment. It increases constant-volume employment reductions above that which is necessary, without however leading to a sufficient or lasting increase in performance.

* [Translator's note: French word meaning worker or cultivator newly in use to describe workers now undertaking both direct and indirect tasks.]

The amount of time needed for pinpointing an incident is thus shortened with the automatic and instantaneous display of the problem location on a screen. The amount of time needed for diagnosis of the problem, which is the longest, the most risky, and which varies the most from one person to another, is shortened and evened out by recourse, depending upon the case, to "automatic testing equipment" or to expert systems which indicate the underlying cause of the problem. The amount of time needed for dismantling, repair, and re-assembly is greatly reduced by improving accessibility to parts and mechanisms, but above all by a standard exchange which allows repair of the faulty part to take place off site, while production continues, or even, when standard exchange is not possible, by limiting the repair to exactly what is necessary in order to resume production. Treatment of breakdowns which requires the shut-down of the means of production is postponed until the night-shift or the weekend, ie outside periods of production. Moreover, operations to increase reliability are only undertaken after analysis of automatic recordings of the amount and nature of downtime, as well as of documents completed by operating and maintenance staff concerning the apparent or immediate causes of the problems. It is thus possible for a specialized department to determine which stoppages are the most troublesome in length and frequency and thereby prioritize what actions are to be undertaken.

Automatic instruments for recognizing, diagnosing and recording problems, as well as the modularization of machines and the standardization of parts, all designed for rapid repair, allow identification and clear distinction between four levels of maintenance, as a function of the length and complexity of interventions, and the allocation of each level to a particular category of staff.

Brief and simple interventions (maximum two to three minutes), removing products that are blocked, cleaning production cells, and restarting the production cycle following automatic stoppages make up the first level. They are assigned to line operators, whose proximity and continuous presence ensures that the interventions will be as short as possible.

Second-level interventions must be as rapid as possible. They consist of diagnosis of the immediate cause of the breakdown by automatic identification of the part, of the mechanism, of the electrical circuits, or of the electronic boxes out of service, with the aid of automatic testing equipment or expert systems. There follows a standard exchange or a limited repair. Maintenance workers, electricians, electrician-mechanics, fitters, are now allocated to this type of breakdown work, which excludes what used to be their job: namely looking for the causes of breakdowns, and in-depth repair.

Repairs are carried out at the third stage, off site, in centralized workshops or on-site outside production periods. The electronic boxes and circuit boards are automatically tested in centralized workshops to identify the faulty components. Parts and mechanisms are appraised there in order to select between repair or replacement with new parts, depending upon the cost of each.

Searching for and resolving the primary causes of breakdowns, the fourth level of maintenance, are activities which are increasingly deferred. They are initiated when a part or mechanism is too frequently changed or repaired and when automatic recordings of stoppages reveal repetitive and costly breakdowns. They are undertaken by an engineering department, and may or may not involve liaison with maintenance staff or workshop technicians.

The priority given to rapid repair over analysis of causes and increasing reliability is only profitable in appearance. If it allows machine utilization rates to increase in the short term, this soon reaches a ceiling due to postponement of work to increase reliability, and then tends to regress because of the premature wearing of materials and the increased number of problems and breakdowns.

The "long circuit" to making machines reliable implied by this maintenance philosophy is in the final analysis costly, discouraging, and not very efficient. It is costly because breakdowns will recur as long as their primary causes are not eliminated. Down-times, the time for dismantling and re-assembling, even when very short, represent a considerable period of inactivity when added together. The stock of mechanisms, of modules and parts in rotation increases. The repetition of stoppages itself leads to other problems, faults and breakdowns. It is discouraging for the staff because they have to live with constant and repeated problems. They become discouraged from seeing the problems ever properly resolved, tiring of correctly "documenting" them for the engineering departments, and this all the more as they are often reduced to having to draw up a summary or "blind" description, ie without knowing what is significant. Finally, it is not very efficient, because in the final analysis no one group, no one person, possesses concentrated practical knowledge of the real functioning of the installations. Not surprisingly, the solutions envisaged, away from the real conditions of production, to eliminate the causes of breakdowns, turn out to be insufficiently adapted to their conditions of utilization often needlessly complicated.

Dialogue and breaking down barriers between the factory, maintenance functions and engineering departments, advocated and introduced in certain companies, are often only palliative measures for the consequences of a technical design process rarely questioned.

This maintenance philosophy is not specifically "Taylorist" in nature. It does not imply analysis of time and actions to establish and prescribe the best way to work, the method which is at the heart of Taylor's doctrine and which constitutes its original contribution. On the other hand, it does form part of the now two-hundred year old development of the separation of knowledge from work.

Seeking a "good compromise" as an optimization strategy

Optimization of the functioning and utilization of an automated installation is thought to be like seeking a good compromise between demands considered to be contradictory.

The integration of machines into automated production lines creates the problem of a general stoppage of production whenever there are problems or breakdowns on one segment of the line. Engineering departments generally interpret this problem as the question: what size of buffer stocks are necessary between these sections, so that they "absorb" stoppages at one of them, at the same time avoiding stocks that are too large and therefore costly? The answer has been, and this remains true in a number of companies, to work out a "financial" compromise between the cost of a general stoppage and that of buffer stocks. To do this, the frequency and duration of stoppages of each machine are calculated on the basis of observations of identical or similar machines, in order to work out the volume of stock to prepare upstream and downstream.

Conversely, taking the time to fully repair and eliminate the primary causes of breakdowns so that they never again recur, and as a result eventually attaining a steady flow, effectively without buffer stocks -- including "unauthorized" ones -- is beginning to be seen as a possible, efficient and at last reasonable strategy, given the performance of Japanese companies which have adopted it. This strategy, however, reveals so many hidden problems, which raise questions of procedures, structures and distributions of power, that much time is necessary before the result can be attained.

One finds a similar opposition in the conceptualization of how to optimize the man-machine relationship. Thus the automation of guidance and control (whether this is of a "process" or of a means of transport) in normal situations creates the problem of the inability of the operator to resume manual control in abnormal situations, and of his fear of not possessing the appropriate immediate reaction. The ability to guide or control diminishes when it is no longer continually exercised. Moreover, attentiveness to exceptional incidents demanding quick decision-making also diminishes when it is transformed into passive surveillance. The "compromise" has been to periodically give operators "manually assisted" control, or even to place them in simulated abnormal situations during training, in order to maintain their abilities and their attentiveness. Another formula consists of equipping their command stations with expert systems which filter and synthesize the numerous types of information which they have to deal with in these situations.

In such cases the idea that a compromise must be found derives from the fact that the process of automation and the form it takes, which create these types of problems, are not called into question. The presence of the operators has been transformed into passively and agonizingly awaiting a problem,[1] instead of being utilized to permanently observe and analyse the actual operation of their machine and its outputs, and thus to contribute to the elimination of the causes of problems, and therefore to a form of automation that is under control.

Demands judged to be irreconcilably contradictory, between which a "compromise" is found, therefore dictate precise technical choices. But the demands can be actually reconciled if the presuppositions behind the process and social form of automation which give rise to these contradictions are investigated and called into question.

The origin of the normal way of conceptualizing the compromise is more difficult to identify. It may result, in the case of the optimization of stocks, from the autonomous workings of, and internal divisions between, departments responsible for manufacturing, maintenance, design of the means of production and production management, still common in numerous companies. With each one asserting its demands (unavoidable stoppages and incompressible repair time on the one hand, and indispensable intermediary stocks on the other), all that remains is to find the compromise which is the least costly in terms of the regularity of production flows. This situation is in the process of changing in certain companies. On the other hand, in the case of automatic control and guidance, an understanding of the situation has not yet come about, in spite of the risks that are run and the accidents that have resulted. To do this would above all presuppose relocating the operator at the centre of the production process, and that goes against the current philosophy of automation.

---

[1] In these conditions, accidents are often viewed as being of human origin, whereas it is the situation in which the operators are placed by the current form of automation that leads to their "errors".

The superiority of the technical solution over every other

The technical solution is in fact still considered as being more efficient, "clearer", more definite and more "moving with the tide of history" than organizational, social or managerial types of solutions, whether it is a matter of rapidly increasing productivity and quality, guaranteeing the safety of equipment and personnel, improving work conditions, filling in for an absence of skill, decentralizing knowledge, or even resolving social problems.

Thus, during the 1970s, the "problem of the unskilled worker" could only be rapidly and definitively solved, in this vision of the future, by a forced march towards automation. The reorganization of work, infinitely less costly and more immediate in its results for the unskilled worker and for the company, would however have had the advantage of preparing the minds and skills of workers for a more progressive, productive, and skilling form of automation.

Moreover, the growing rarity of workers who still possess the knowledge and skills necessary in specialized areas immediately finds a technical solution in the introduction of prescriptive expert systems for operations of maintenance, instead of provoking reflection on the reasons for this increased rarity and on organizational, social, and technical measures that can be taken to recreate the necessary skills.

The complete automation of an activity which has no immediate justification other than to remove a professional category which had become socially unmanageable because of behaviour considered to put the company at risk, will be allowed, recommended even, in the name of the idea that the activity will in any event have to be automated one day or another. The search for a social solution to a problem of a social nature, by bringing to light the conditions which lead a professional group to adopt rigid rules about what tasks they will do and who is allowed to do their work, is often perceived as a risky, ambiguous, or naive procedure.

This presupposition is typically technicist, in the sense that technical progress, perceived as a whole, homogeneous and indivisible, would be by its very nature or in its details a bearer of social progress. This vision is still frequently held by the design engineers. It is also widely shared by their management colleagues who, although critical of the installations designed by the former, do not really question them. It may be the case, however, that the vision is in retreat within the companies, if only for the fact that with investments becoming expensive, it has proved possible to be equally efficient while being restricted to organizational, management or social measures.

The greatest uncertainties about production are human and social

This presupposition is probably the most important. Technicist in formulation, it is connected to the fundamental preoccupation of the company which, committing its own capital or that of its shareholders, needs to reduce uncertainty in all areas and make the production process transparent in order to control it. In its own way it expresses what is at stake in the wage relationships and in the division of knowledge from work which is linked to it.

The efficiency of the technical system is said to be constantly threatened by the major elements of uncertainty comprised of, on the one hand, the productive worker himself, as human being, subject to faults, and as an employee motivated by his own strengths and interests, and on the other hand the social life of the factory, characterized by toleration, arrangements and compromises which call into question the rationality of the system.

Hence the tendency, during the design process, to limit the field of possibilities and to concretely pre-determine the operations to be undertaken. As a consequence, we see for example the preference for technical solutions with results that are average but dependable, to the detriment of another technical choice with better results but more dependent upon the operator. Flowing too from this mistrust of the reliability of humans and the refusal to wager on the collective professional competence and conscientiousness, is the tendency to design a concrete framework for work which makes it only necessary for the operators to understand that part of the automated installation which the designers consider necessary and sufficient, and which constrains them to intervene, as far as they possibly can, according to the modalities considered *a priori* to be logical and coherent with the theoretical principles of the functioning of the system. The more a system prescribes and reduces human intervention, the more it is "all tied up", the more it is deemed certain and perfect. It is then logical to "externalize" the operator.

The preceding economic and social presuppositions lead, therefore, to a process and social form of automation which appears to the operating and maintenance staff as prescribing, externalizing, excluding, and substituting. If some presuppositions are likely to disappear, others, however, appear more likely to last.

How, then, are we to understand that current forms of automation are accompanied by new forms of work organization considered almost unanimously to entail the "reskilling" of work?

COMPATIBILITIES/INCOMPATIBILITIES BETWEEN CURRENT FORMS OF AUTOMATION AND NEW FORMS OF WORK ORGANIZATION

The process and the social form of current forms of automation are compatible with certain new forms of work organization and are in contradiction with others. Not all new forms of work organization are in fact, and despite appearances and discourse concerning them, skilling forms of organization.

Organizations that "enrich"

These are the forms of organization in which the operators of automated installations have confided in them primary maintenance, quality control, tool change and watching over production, and are sometimes asked to organize themselves autonomously to fulfil these functions. The project of socio-technicians during the 1960s to "reorganize" work and to create autonomous groups thus arose at the same time that automation was taking place. What happened in fact? The new activities confided in the operators were first simplified by automation designed to that end.

We have already seen how current forms of automation, presupposing that human surveillance means no more than waiting for a problem to occur, and is therefore unproductive (and in fact automation has often rendered it unproductive, only allowing such knowledge of the functioning of the installation as is judged *a priori* necessary and sufficient by the designers), "frees" the operator from having to wait, thanks to automatic signals and stops. The operator becomes available to undertake other tasks. Now, the priority given to rapid intervention to restart production as soon as possible leads to division between the tasks of maintenance, repair, quality control, setting up, tool change, and watching over production, with one part of the knowledge that is necessary incorporated in the automation (notably recording and diagnosing), and sometimes to dividing the remaining operations between several categories of staff, according to how long the operations take and their complexity, as we saw above in the case of machine repair. As far as quality control is concerned, the automatic detection of faults reduces the activity of the operator either to extracting the product or to "marking" it for rework downstream, or to reworking it immediately, if this last can be done simply and within the time of the work cycle. Moreover, changing tools is today limited, following an automatic halt after *X* cycles, to positioning a jig holding the tool which has already been set up in the factory or elsewhere with the aid of set-up tools.

These new tasks, frequently considered to be bringing about a "reskilling" of work, moreover in fact often leading to "training" and classification at a higher level, indeed to the title of skilled worker, are in fact the juxtaposition of operations that have become partial, whose implementation does not in itself allow an understanding of the real functioning of the installation as a whole and a learning of practical knowledge about it, a condition of all real and lasting reskilling.

This type of transfer of tasks to operators, which has allowed elimination of the jobs of setters, inspectors and of rework staff, continues. The automation of breakdown diagnosis -- a part of maintenance work which is skilled *par excellence* -- with the aid of automatic testing equipment or prescriptive expert systems, as well as the generalization of standard exchange, in effect allow the future transfer of a growing part of second-level repair activity to installation operators to be envisaged, without this transfer requiring a true skilling for the operators. A deepening division of labour is in gestation with, on the one hand, the training of an undifferentiated category of polyvalent "operator-repairers" and on the other hand the constitution of a smaller group of specialists to deal with rare or new breakdowns that cannot be automatically diagnosed and to enrich the basic knowledge and "rules" of the expert systems.

Prescriptive and externalizing automation, linked with new forms of work organization which are limited to "enriching" the work of operators, leads to a deeper division of labour. Now, it is this linkage which is today the most widespread. The whole process is happening as if the scenario observed when "specialized mechanization" and Taylorism began were being repeated. At that time we saw, on the one hand, the "reskilling" of labourers by their reassignment to "operating" specialized machine-tools, and on the other hand, the creation of the category of maintenance workers, replacing the skilled workers who operated, set up, and maintained the universal machine tools on which they worked [1].

There was a "real reskilling" for the labourers, in the sense that, at the beginning, decomposition of tasks and specialization of machines were still far from what they would later become [2]. This reskilling was accompanied, moreover, by an increase in salaries for those concerned, and later by the creation and allocation of a higher classification, that of specialized worker.* But this reskiliing was relative and temporary, as will be that of the operators of automated installations, if the techno-organizational model which has just been described, and which is the most widespread one today, prevails.

Organizations that "skill"

Forms of work organization which are really skilling are characterized by the formation of teams for operation and maintenance which organize themselves autonomously and have effective responsibility not only for achieving the production programme, but above all for improving the performance of the installation in their charge, in output, in quality, and in timing. These forms of work organization stand in contradiction, in principle and in practice, with automation as it is currently designed.

Improving the performance of an automated line by using a basic team implies that the team has an understanding of the actual functioning of the line beyond that which is visible from the installation itself. Now automated lines and the machines which compose them are frequently constructed in such a way that anybody, skilled or

---

[1] F.W. Taylor points this out in *Scientific Management* (Westport, Conn.: Greenwood Press, 1947 edn.). On page 146, he notes: "It is true, for instance, that the planning room, and functional foremanship, render it possible for an intelligent laborer or helper in time to do much of the work now done by a machinist. Is not this a good thing for the laborer or helper? He is given a higher class of work, which tends to develop him and gives him better wages. In the sympathy for the machinist the case of the laborer is overlooked." It is interesting to note that he adds "This sympathy for the machinist is, however, wasted, since the machinist, with the aid of the new system, will rise to a higher class of work which he was unable to do in the past, and in addition, divided or functional foremanship will call for a larger number of men in this class, so that men, who must otherwise have remained machinists all their lives, will have the opportunity of rising to a foremanship." We know since that this was the case for only a small proportion of them. Today we are beginning to hear the same argument made regarding maintenance workers and technicians who are replaced by polyvalent maintenance staff or by the operators of automated installations, formerly unskilled workers, when automated installations equiped with automatic error or breakdown diagnostic systems are put in service.

[2] F.W. Taylor, in 1902, did not imagine the machine-tool operator reduced to what he later became. In *Scientific Management* p. 101-102, he writes: "The repair boss sees that each workman keeps his machine clean, free from rust and scratches, and that he oils and treats it properly, and that all of the standards established for the care and maintenance of the machines and their accessories are rigidly maintained, such as care of belts and shifters, cleanliness of floor around machines, and orderly piling and disposition of work." In short, F.W. Taylor recommends that the operator should do what is today called primary maintenance, which for the person undertaking it deserves classification as a skilled worker, whereas the worker whose activity he describes is trapped in the labourer category and will keep that label until the inter-war period! On this classic phenomenon of the opposite development of the classification of individuals and the real skill required by the work they do, see Michel Freyssenet, "Peut-on parvenir a une definition unique de la qualification?" in *La division du travail,* Paris: Galilee, 1978, pp.67-79.

* [Translator's note: *ouvrier specialise*: normally today translated as *unskilled worker*, for reasons the text is explaining at this point.]

otherwise, would find it physically impossible to observe, during production, likely problem-areas, mechanisms that might fail, tools that can shift from their settings, and movements leading to desynchronization. The working parts, the parts which drive the machines, and the transfer of the product within the machines are no more visible than the overall kinematics (mechanical movements) are readable.* Electronic and electro-mechanical screens at command and signaling stations permit representation of only the running of the installation upon which the operator is expected to act if necessary. Now, the transparency, the intelligibility, the "analysability" of machines while actually functioning, are pre-conditions for the team in charge to improve their performance. The paradox is that it is just at that point that machines become even more compact and opaque. Their design even discourages or dissuades efforts to understand their weaknesses and their deviations while they are being utilized, and thus to anticipate breakdowns and problems by preventive action on their causes. This is true even for operating and maintenance teams composed exclusively or mostly of skilled maintenance staff.

The discourse on skilling organizational forms and on calls for worker initiative and autonomous organization lose their credibility in the eyes of those who are supposed to benefit from them and take part in them. The conviction that production techniques are socially neutral is widely accepted by the promoters of these forms of work organization and prevents them from perceiving the contradictory situation in which the operating and maintenance staff are placed [1]. They interpret the reticence of the latter and the merely average or short-lived results of these new forms of organization to result from the deep-rootedness of "Taylorist mentalities" and from insufficient financial compensation offered for the effort being expected, without perceiving the need to make the principles behind technical design and organizational form coherent if a skilling process is to begin.

It may occur, however, that despite the material obstacles encountered, staff in charge of the installation arrive, by making modifications that are more or less authorized and by transgressing their orders, at acquiring a good knowledge of their line, and at improving its results. But the pursuit of automation in its current social form, and notably the inclusion of expert systems for operating and prescriptively diagnosing breakdowns, which substitutes for the abilities of operators, then arrives and undermines their motives for participating.

The very design of automation, as it currently takes place, is thus clearly placed in doubt. Are alternative processes and forms of automation conceivable and achievable? That is what we wanted to find out by participating in the design of several automated installations.

---

* [Translator's note: French *lisible:* literally, *readable*. Here and later the metaphor *read* is used as in *reading machines* (ie being able to understand how machines work by looking at them).]

[1] The critique of "technological determinism", without making the distinction between the thesis of determinism by the technique itself as an autonomous force, and the thesis of the determinism of productive techniques because these are themselves socially determined, has contributed greatly to the belief that it suffices to change the organization of work to invert the division of labour.

AN AUTOMATION PROCESS AND SOCIAL FORM OF AUTOMATION AIMED AT FINANCIAL PERFORMANCE AND SKILLING OF WORK ARE CONCEIVABLE AND ACHIEVABLE IN A LOCALIZED WAY, BUT CAN THEY BE GENERALIZED?

We have tried to see what the consequences would be of a skilling form of organization, as it has been characterized above [1], for the process of automation and for the technical characteristics of automated installations. The general lessons of these experiments are presented here. The application of the new design principles that have been developed has only been partial, because of difficulties, some of which can be overcome, but others of which probably originate in the wage relationship as we know it, and therefore present major obstacles. These latter difficulties make us doubt the chances of generalizing the process and social form of automation described below, even though they are probably achievable in some places and temporarily. For now, we will often use the conditional tense to signify that what we are able to state today is still far from being achieved and even further from being generalized.

Giving priority to increasing reliability over rapid repair: a strategy for financial performance and for skilling work, under certain social conditions

The automation of machines and their integration in production lines make their rate of utilization and the stability of their settings essential components of their performance in terms of output, quality, and timeliness. Now it is more efficient and more profitable to foresee or add a staff member, if their work contributes to increasing the actual utilization rate of the automated installation, than to try to eliminate a work post in order to raise the theoretical ratio of output produced over workforce necessary. We were able to show this in the case of bottling lines. The gap represented by two percentage points in the rate of utilization, at the level of production these lines operated at, corresponded to the cost of a skilled employee for a year.

In the current state of technical control over automation, and above all of knowledge of the concrete conditions of production and of primary causes of breakdowns, the staff who design the means of production cannot guarantee (at the moment, and in most cases) -- and only by the intrinsic qualities of the installations they are planning -- a high rate of utilization, and define *a priori* a programme of systematic preventive maintenance able to keep it up over time. Moreover, the rate of utilization can only be substantially increased by restarting production rapidly and postponing the analysis of

[1] Sharing some of the above viewpoints, and interested in the exploration of new directions, the human resources management of the group BSN, along with the management of one of the companies within the group, agreed to an attempt to redesign the automation of a bottling line, with a view to confiding the process of increasing its reliability to the operating and maintenance team itself. A succinct summary of this experiment, which took place in 1988, can be found in "Le contenu organisationel de l'innovation technique; le cas de la conception d'une ligne automatisee a BSN, *Entreprises et chercheurs, a la recherche d'un partenariat*, Cahiers de Cargese, L'Harmattan, Paris, 1991, pp. 85-96. Similar work is currently taking place at RATP for the design of new trains, and at Renault for the design of assembly lines.

Freyssenet M., **The automation process and its social forms: the sociological paradigm**, Communication at the SASE Congress (Society for the Advancement of Socio-Economics) Paris, 15-16 Juillet 1994. **English** version of: Freyssenet M., “Processus et formes sociales d’automatisation. Le paradigme sociologique”, *Sociologie du Travail*, n° 4/92, pp 469-496. Digital publication, freyssenet.com, 2007, 428 Ko.

faults, problems and breakdowns until later and by a specialized department. This last is obliged, in effect, to draw up a hierarchy of emergencies according to its own logic of functioning, which is not the same as the factory's logic, even if under the same authority as the factory. It is then subject to budgetary decisions that it often does not control. It ends up by intervening in an installation whose conditions of utilization may meanwhile have changed. We have seen how this "long circuit" to increasing reliability, apparently rational and "economic", turns out in fact to be costly for the company, de-motivating for the manufacturing and maintenance workers, and insufficiently efficient, due to the leakage of knowledge and concrete understanding to which it leads.

Implementing a "short circuit" for increasing reliability

The rapid analysis and elimination of the primary causes of faults, problems and breakdowns by an operating and maintenance team whose essential role and responsibility this would be, and which would possess the material and budgetary means and technical support necessary, might be the method to continuously and permanently increase the rate at which automated lines are utilized. The establishment of such a "short circuit" for increasing reliability might also be the starting point of a process of real inversion of the division of labour, under certain social conditions as we shall see later on. The operating and maintenance team would in effect become an indispensable and respected partner of the engineering department, because it possesses new knowledge absolutely necessary for designing installations that are properly adapted to their conditions of utilization.

A progressive and non-excluding process

From this kind of viewpoint, the reduction in working time, and eventually the size of the workforce, which accompanies automation at a given output level, can be accomplished progressively as the team manages to increase the reliability of the line it is in charge of. The agreement of the parties involved is of course fundamental, and requires, as we shall see, conditions that are difficult to achieve. Moreover, the complete substitution of one type of workforce by another which often takes place today is not only unnecessary but turns out to be counter-productive. The activity of increasing machine reliability in fact necessitates good knowledge of how products and machines behave as well as of the concrete conditions of production, a knowledge which is generally possessed by the operating and maintenance staff who have worked on previous installations. In such a process, one can even imagine that the automation of a function or of an operation would only be decided when the team is able to identify, with the aid of the engineering department, the relevant parameters and the unexpected events that occur while accomplishing this function or that operation. We then have a process of automation which is much more economically and socially "smoothed", in which the basic team is obliged to become an active party in practice as well as in theory. Above all, if the political will is maintained, this process leads to an alternative social form of automation.

The workers are no longer thought of as the unreliable elements in a technical system but rather, on the contrary, as the means to increase its reliability. For this to be so, for them to acquire -- beyond indispensable professional knowledge -- the practical knowledge of the actual functioning of the production line they are assigned to and the faults that might occur, the organization of work must lend itself to this, and above all the technical design of the installation must allow for it by being readable and intelligible, capable of being tested and analysed, adapted and modified.

The availability of staff as the basis for the availability of machines

The "short circuit" of increasing machine reliability that characterizes this scenario implies in the first place that staff are available to observe, placed at positions of complexity and possible difficulty. In opposition to the current philosophy of production and maintenance, it can be said that the availability of the installation is proportional to the availability of staff to ensure a permanent surveillance permitting the primary causes of maladjustments, anomalies and problems to be traced back. In order to do this, two problems must be solved.

The staff must be freed from content-less, time-constrained operations, automation of these having been made a priority. Moreover, difficulties due to lack of conformity of materials to machine tolerances must be, if not resolved, dealt with to the extent that the operator is not obliged (as is often the case today) to stand permanently at the head of the line in order to remove or quickly correct products which visibly do not conform and are likely to be damaged or to block the flow. Automatic surveillance and ejection methods, if they were adopted, would only be a costly item of sophistication and a palliative to a problem which ought in fact to be treated at source. If this is not done, operators will find it difficult to distance themselves from the beginning of their section of the line in order to concentrate on how the line is functioning and on the quality of the operations on, and manipulation of, the product. On the other hand, if the product is sufficiently "hygienic", the operators can devote themselves to active surveillance.

At this point, the value of automatic stops, whose only reason for existence is to relieve the operator of a passive and unproductive surveillance task in order to attend to other related tasks, would have to be reconsidered. Their elimination would be possible to the extent that the causes of the problems they detect were resolved completely and exhaustively. Not only is it thus possible to "desophisticate" the production equipment, but also to eliminate additional problems due to failure of the automatic detection system itself, which causes "unjustified" stops (which may be numerous) or failures to stop with consequences of varying seriousness.

Machines that are readable and intelligible

If the essential function of members of the basic team is to prevent faults, problems and breakdowns and to eliminate their causes, then the primary attribute of the machines and the lines they make up must be visibility, using all available and possible means, of their actual functioning during utilization, so they are readable, understandable as a whole, and intelligible. This is an essential pre-condition for the staff, individually or collectively, to acquire knowledge of the functioning of the machines that no prior classroom training can replace.

First, the very structure of the machines must be aimed at transparency. The clarity of their kinematics, that is to say of the different mechanical movements and their sequences, facilitates the reconstruction of sequences of events when problems occur. The visibility of the functioning areas, that is to say the areas where mechanisms, parts, and of course, tools, have most demands placed upon them and are most likely to become maladjusted or broken, jeopardizing product quality, is often a requirement for finding the original deviation and its explanation. Understanding maladjustments is the pre-condition for designing apparatuses that ensure stability and thus succeed in producing high quality rather than having to test for it *a posteriori* and carry out rework. Physical separation between operations and operating areas, rather than their grouping around the same work station, a tendency observable on numerous pieces of equipment to save space; reducing the time taken to transfer products and limiting in-process stocks; these may ultimately be more profitable, if, as a result of the visibility they ensure, they permit the anticipation of maladjustments or, even better, elimination of their causes. It is not until a very high level of control is reached, which may happen more quickly if the basic team is responsible for it, that the grouping of operating areas is no longer counter-productive. The parts that drive the installation are usually relegated to the least visible and least accessible places, even though dysfunctioning has direct repercussions on them and makes their evenness and length of their life vary considerably. Finally, the areas in between operating posts, usually considered to be areas with no transformative action taking place on the product and therefore not worthy of special attention, are usually completely invisible, even though dirtying, jamming, scratching, warping, breaking, and so on frequently take place there. That invisibility in turn makes it a difficult and lengthy process to spot this type of problem and even more difficult to anticipate it.

As long as a high level of reliability has yet to be been reached, there are therefore no economic reasons to make machines compact and opaque. On the contrary, to get to that point, it is necessary to proceed via "extraverted" and "transparent" machines. Neither are there any reasons for compactness and opaqueness to do with safety. Beyond the fact that there is no logical connection with opaqueness, it is known that the active safety of the staff (which does not exclude "passive" safety measures) is first of all based upon their understanding of moving machinery and the events that can result from it. This understanding allows them to acquire automatic motions under normal circumstances and reflex actions in abnormal circumstances which are fundamental to their safety.

In the scenario developed here, there is no more reason to limit, to channel the interventions of the operators and to allow them only a picture of the functioning of the machine reduced to what is judged appropriate by the designer. On the contrary, when the operating staff play their part in improving reliability, they can, if they wish, visualize on a board or screen (or even see directly) each elementary movement of the machine, and if necessary control it, in order to be able to trace back sequences of events and to undertake inspections and "dynamic tests".

. . . testable and analysable . . .

It is impossible to predict *a priori* all the places, the mechanisms, the movements which should be recorded or sampled in order to pin-point the primary causes of problems. They must all therefore be accessible and able to be fitted by the tools used to analyse and test. The overall structure of the installation must, moreover, not only be "open" to make its functioning readable and intelligible, but must make it possible to physically "listen to" -- as with a stethoscope -- the component parts and to "analyse" products which pass through it, this in the places which practice shows to be relevant, and moreover during the course of production.

Making the search for primary causes of breakdowns a priority also dispenses with the distinction between known types of breakdowns, that can be diagnosed by automatic testing equipment or by expert systems whose prescriptions have to be followed by staff, and new or rare types of breakdowns, whose analysis is the reserve of specialist technicians. All breakdowns, simple or complex, frequent or rare, receive the same treatment: elimination of their causes. The function and the design of automatic testing equipment and expert systems is thus modified.

By definition, these instruments could not be prescriptive, since their function would be to help find causes as yet unknown. As a first approximation, they would first have to memorize the most diverse forms of information, measured automatically or entered in by the operators, about conditions around and functioning of lines of machines, especially at their points of weakness, complexity and susceptibility to exterior forces. They might be able to supply examples of breakdown event sequences having some relationship with that under examination. They should be able to reconstruct the logic, the methodological rules, the theories, and the relationships which were appropriate in the past to the subject under investigation, in order to help see, think, and discover. But available formalisms and "systems of inference rules", resulting from research into artificial intelligence, do not seem to meet these specifications.

. . . adaptable and modifiable . . .

Increasing reliability often comes about through adaptation to the particular conditions in which a given installation is utilized. It follows that the complete modularization of machines as well as the systematic standardization of parts cannot be imposed, above all when the object of these is simply to permit rapid repairs.

Finally, increasing reliability comes about through modifications which are only big and costly because they increasingly require a process of dismantling, rebuilding, rewiring and re-writing that is long and complex, due to the mechanical or electronic structure of the line. An alternative type of modularization could be designed which meets the requirement of adaptation and modification necessary to achieve the targeted increases in reliability rather than the requirement of rapid and limited repair.

Giving priority to increasing reliability over rapid repair, which is the pre-condition of, and first stage towards a real inversion of the intellectual division of labour, therefore has significant consequences both for the automation process and for the design of automated installations.

The technical choices that result are limited neither to ergonomic adaptation of work stations to reduce arduousness and enrich the content of work, nor to arrangements to promote a more collective and autonomous form of work organization. They affect the structure and arrangement of machines and production line and the very function and purpose of automation. They are not merely the material form of an alternative organizational plan, unless this term is loaded with so many elements that it loses all analytical interest. They are the expression, the framework, the vector, the constituents and the conditions of a socio-productive model, which is not simply new, but which is also alternative. They cannot result from the rapprochement of "design" and "production" alone. This rapprochement may eliminate the grossest errors resulting from the most flagrant misunderstandings of the conditions of production on the part of the engineering departments. It does not resolve the political problem of the social and economic process that we want to set in motion when making a skilling organization and the form of automation coherent, because it depends upon a decision that neither the designers, nor the "producers" are able to take, nor, in many cases, dream of taking.

How far has it been possible to go in the projects in which we have participated towards application of the principles for design and operation of automation just described?

THE DIFFICULTIES OF IMPLEMENTATION, AND THE SOCIAL PRE-CONDITIONS FOR GENERALIZATION OF THE PROCESS AND SOCIAL FORM OF AUTOMATION WE HAVE DESCRIBED

Surmountable implementation problems

These were sufficient in the experiments that were completed, and this remains the case in the experiments currently under way, to prevent certain technical recommendations from being adopted. However, while very important, these difficulties are logically surmountable in time. Just three will be mentioned here.

Companies generally purchase their machines and equipment from suppliers' catalogues. All modifications mean heavy excess costs. Now, the scenario proposed implies more than simple modifications. It requires nothing less than a complete rethinking of the equipment. It requires, then, convincing the suppliers that they have an interest in doing this. But suppliers will not be convinced until the day that a sufficient number of client companies ask them to do it. In fact, for the automated installations whose design we were involved in, it was possible to retain only those recommendations of readability, of analysability and of adaptability that did not mean revising the overall mechanical and electronic structure of the machines, in other words modifications that were too limited to allow operating staff to really take charge of analysis and of increasing reliability. The principles of technical design spelt out above are therefore more likely to materialize in the short term in individual production installations.

The cost of creating a new technical family of automated machines is not the only point at issue. Even when intellectually convinced, the engineers hesitate to proceed beyond improving the man-machine interface or increasing the social acceptability of automation.

Their prudence is reinforced when they note that management in production and maintenance, which was initially most critical of their original ideas for the automation, has begun to worry about the technical aspects of the new projects which entail real autonomy and delegate real power to the operating and maintenance teams. They judge the social conditions needed for the process and social form of automation described have a chance of being accepted and being able to develop to be unrealistic, at least right now. And such are indeed the social and "political" stakes involved in this scenario.

Implications and social conditions that might destabilise the wage relationship

Operating and maintenance teams which are permanently analysing the real functioning of their installations and increasing their reliability, are creating original knowledge that nobody else truly possesses. This "situated" knowledge, which can henceforth be expressed very precisely, is indispensable to the design of the next generation of machines, and may enter into either complementary or contradictory relationship with the theoretical knowledge of the engineer. The workers are no longer just solicited by the design department to ask for their comments or suggestions and so that they can be prepared to operate and maintain the new installation, as happens today in the best cases. They are in a position to participate on an equal footing. A real inversion of the division of labour can then, and then only, be set in motion. It is possible to envisage a transition from knowledge that is socially divided to a social shared knowledge, founded on cooperation without subordination. Is the capitalist company in a position to accept this and to bear the weight of its social dynamic and consequences? The practical power that wage-earners would acquire, unless it is strongly "satisfied", will very logically be "cashed in", literally or figuratively, by requests for compensation.

It will moreover be reinforced by the social conditions that have to be achieved. Employees will not participate in increasing reliability, and therefore will not work to directly reduce the number of jobs needed to achieve a given output level, unless they are guarantied not only employment but employment in which the new abilities they have acquired through their work of increasing reliability can be reutilized and further developed. An anticipatory type of employment management will have to take into account not only the ages and careers of the personnel, but above all the varied abilities that will compose the personnel. To do this, companies will have to plan their future not only in terms of the development of their market and ways to ensure returns on their capital, but also in terms of the development of the abilities of their employees, a development liable to lead the employees far from their original "profession". If this ability dynamic opens up possibilities of professional and geographical mobility, making the categorical "rigidities" that are denounced from time to time meaningless, it in fact gives the employees a right to knowledge, to speak, and a power to intervene in the strategic choices made by the company regarding the development of the products it makes and its diversification.

What kind of company would be suitable for this? Could the wage relationship as we know it survive? The example of Japanese companies which have followed this path[1] shows that they are very careful to minimize the risks of opaqueness* connected to this scenario (autonomy is accompanied by an insistent demand for "loyalty", for transparency, and for making new knowledge explicit). They have also succeeded in "containing" the dynamic in such a way that the objectives of the company itself and its strategic choices remain out of bounds. Historical circumstances have enabled this. There is nothing to show that matters will continue to be this way in future, or that alternative conditions or circumstances would also permit this, there or elsewhere.

Finally, this scenario is very destabilizing, economically and social. Companies that were successful at one way or another mobilizing all the knowledge shared by their employees, thanks to a real and lasting inversion of the division of labour, would have a devastating competitive ability, assuming of course that the other factors of competitiveness were also present. Certain Japanese companies, while they have yet to reach this level, permit a glimpse of it. Other countries are reduced to political negotiations to limit the destructive effects of their competitive ability and are forced to demand that Japanese employees work less and consume more.

The illusion that there is an automatic link between performance and skilling forms of automation/organization

The economic superiority of this scenario, so perfect that one wonders why nobody thought of it previously, is only therefore a reality under certain social and political conditions. Now, these conditions seems only to be met in specific historical circumstances. That means that there is no necessary and automatic linkage between financial performance and skilling forms of automation/organization.

Conversely, the current scenario, prescriptive automation and "enriching" forms of organization, in other words the "long circuit" for design and increasing reliability, may in the end lead, after years of mediocre performance and excess investment and running costs, to results which while not optimal are satisfactory, as can begin to be seen here and there. The more time passes, the more the initial level of reliability of the new automated installations is raised. Designers and suppliers end up learning from their failures. Finally, the current scenario permits a saving in terms of avoiding expensive and risky learning of an alternative production philosophy, alternative professional relationships and an alternative social structure, and perhaps a social crisis over the wage relationship itself.

---

[1] There are far fewer of them than is often thought. Only in a few sectors is there "significant" participation by factory staff in design, and there its character remains subordinate. The theories developed by various Japanese writers are *a posteriori* systematizations which do not claim to describe the whole reality and which present a coherence that industrial life is far from possessing. For further development of this argument, see Michel Freyssenet, "Formes sociales d'automatisation et expériences japonaises" in Helena Hirata (ed.) *Autour du modèle japonais*, Paris: L'Harmattan, 1992.

* [Translator's note: *opaqueness* in the sense of a social institution that is not fully *transparent* (clearly understandable).]

It is important not to yield to the view, which ignores history but is widely shared today, that technical efficiency necessarily requires a systematic skilling of the work force, as if the division of knowledge from work which has been taking place up to now had merely been a giant historical error. It might reasonably be thought that the impossibility of achieving the social and political conditions spelled out above in a lasting way was at the origin of the division of labour which has separated what we have agreed to call conception from execution (which is not, it must be recalled, specific to Taylorism and did not begin with him: all he did was to propose, in a given historical period, one way, among many others, to pursue a separation that had begun a century earlier and which had already progressed through several stages).[1]

CONCLUSIONS

It has therefore become possible today to conceive of and describe a process and social form of automation which bring about a real and lasting inversion of the division of knowledge from work, even if the type of company that this implies causes doubts about its generalization in the absence of a thorough transformation of the wage relationship itself, the abandonment of Taylorism not being sufficient in itself.

From a scientific perspective the exercise has the advantage of confirming that production techniques are sociologically, economically and culturally conditioned in their development and diffusion, just as much research has indicated. But it also shows moreover, that these techniques are also socially "constructed" and "constituted" by a set of objectives, principles, images, economic and social presuppositions which are at their root, and which are themselves rooted in the wage relationship and the division of knowledge from work which has been tied to it for two centuries.

The division of knowledge from work has two sides: one material, the other organizational. Nowadays, it is transmitted more efficiently via production techniques, because most of the necessary knowledge has been incorporated into them, than via the organization of work in the factory, which only distributes -- differently according to the forms it takes -- what remains of knowledge, to arrive at the goal given in this framework. Production techniques are not simply marked by the social conditions of their design. They are also, in the context for which they were designed, an active instrument in the type of division of labour which is at work there.

---

[1] Simplifying historical abridgements (notably in B. Coriat, *L'atelier et le chonometre*, Paris: Christian Bourgois, 1979, and more recently J.P. Womack, D.T. Jones, D. Roos, *The Machine that Changed the World*, New York: Maxwell Macmillan, 1990, give the impression that prior to Taylorism craft workers dominated, and that the division between "conception" and "execution" began with the application of Taylorist principles. Beyond Taylor himself saying that, if he inserted his method within this type of division of labour, he did not invent it, and that his contribution was elsewhere, historical studies confirm that Taylorism was one moment and one path among others in the division of knowledge from work. On this subject see Patrick Fridenson "Le tournant taylorien de la societé francaise: 1904-1918" in *Les Annales*, Paris: A. Colin, vol 42, n° 5, pp. 1031-1060; Michel Freyssenet, "Division du travail, taylorisme et automatisation: confusions, différences et enjeux" in *Le Taylorisme,* M. de Montmollin, O. Pastre (eds), Paris, La Découverte, 1984, pp. 321-333; Michel Freyssenet, *La division capitaliste du travail*, Paris, Savelli, 1977.

Techniques are obviously "malleable" if their principles are considered abstractly, and if this means that they can assume different forms and therefore have different uses connected to those forms depending upon the objectives chosen. However, the techniques which are concretely implemented in given situations and in particular the production techniques discussed in social science research on work and in which the current debate is interested, are materially constraining, prescriptive and substitutive, for so are their presuppositions today. They determine the content of work, not because techniques are determining in themselves, but because they are themselves socially determined. They only possess the "hardness" or the "malleability" of the social whose materialization they are. The opposed theses of "technological determinism" and of the "social neutrality of techniques" share in common here that they confer upon techniques a status of extra-territoriality with respect to the social, as if they belonged to another reality entirely. Productive techniques are socially determining because they are socially determined. They belong to the realm of sociological analysis, with nothing special to mark them out, like any other social product. It is of course necessary to think of the social not as a separate area of field of analysis alongside the economic, the technical, the political, but as marking out the limited number of social relationships (each with its own economics, techniques, symbolisms) in which we are historically called to act.

The research on which this article is based

Freyssenet M., *Évolution du contenu et de l'organisation du travail d'usinage,* CSU, Paris, 1984, 84 p.

Freyssenet M., "Les conducteurs confirmés d'unités automatisées", in *Travail et automatisation dans l'industrie automobile*. *Actes du Gerpisa,* n° 2, 1986, pp.75-92.

Freyssenet M., Imbert, F., *Genèse sociale de choix d'automatisation et d'organisation: le cas de l'aiguillage dans les chemins de fer,* CSU, Paris, 1986, 185 p.

Freyssenet M., Thénard J.C., "Choix d'automatisation, efficacité productive et contenu du travail", *Cahiers de recherche du GIP Mutations Industrielles,* Paris n° 22, 15 décembre 1988, 67 p.

Freyssenet M., *La conception de lignes automatisées d'embouteillage conduites par des ouvriers professionnels,* GIP Mutations Industrielles, Paris, 1988, 35 p.

Charron E., Freyssenet M., Imbert F., "Conception des équipments et travail de maintenance", in *Cahiers de recherche du GIP Mutations Industrielles,* Paris, n° 30, 30 mai 1989, 72 p.

Blanc M., Charron E., Freyssenet M., "Le ‘développment’ des systèmes experts en entreprise", in *Cahiers de recherche du GIP Mutations Industrielles,* Paris, n° 35, 30 novembre 1989, 85 p.

Freyssenet M., "Les formes sociales d'automatisation", in *Cahiers de recherche du GIP Mutations Industrielles,* Paris, n° 37, 30 janvier 1990, 47 p.

Freyssenet M., "Les techniques productives sont-elles prescriptives?" in *Cahiers de recherche du GIP Mutations Industrielles,* Paris, n° 45, 23 mai 1990, 39 p.