The Current Social Form of Automation and a Conceivable Alternative: French Experience

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A tool has always been the materialization of the intelligence of producers to attain more efficiently their goal. However, the end pursued, the social conditions to attain it, and the social modalities of the materialization of the intelligence have not remained unchanged throughout history, and neither are they the same in different societies [1].

Aims, conditions and modalities have varied and do vary depending upon the type of social relationship, that links those participating to the activities under consideration. This would explain, why the material form of the means of work, not only carries the stamp, but also symbolically represents and delimits practically 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, the social relationship is the wage relationship.

So we tried to identify and question the objectives, principles, presuppositions, social images, which oriented the technical choices characterizing some automated installations (especially in automotive industry: robotized welding lines, mechanical assembly lines, automatic testing equipment, and expert control and maintenance systems) reconstituting or following their design process and utilization. It appears these choices come under particular manufacturing philosophy and explain some social and productive problems.

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. One French carmaker agreed to an exploration of what a change of work organization 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.

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[1] This chapter is a modified and short version of an article published in *Sociologie du Travail* (4/1992: 469-496). Translator's notes marked with asterisks.

Freyssenet M., **The Current Social Form of Automation and a Conceivable Alternative: French Experience**, in Shimokawa K., Jurgens U., Fujimoto T., (eds), *Transforming Automobile Assembly. Experience in Automation and Work Organization*, Springer, Berlin, 1997, pp 305-317. Édition numérique, freyssenet.com, 2006, 120 Ko.

THE ECONOMIC AND SOCIAL PRESUPPOSITIONS BEHIND CURRENT PROCESS AND SOCIAL FORM OF AUTOMATION.

We identified three most important economical and social presuppositions: the profitability of investment depend on workforce reduction importance and rapidity, rapid repair would the key to the availability of automated lines, the greatest uncertainties about production are human and social.

First presupposition: the profitability of investment would depend on workforce reduction importance and rapidity

Decreasing the numbers of workers in manufacturing and maintenance is considered the favoured means to immediately increase financial performance. Other criteria to justify automation have appeared in reports on investment since the mid 1980s. But the 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 productive automated activities, surveillance by humans is quite often perceived as a highly unproductive time. It advantageously and easily can be replaced by automatic signals and stops in the event of faults or difficulties. So the operator can be assigned either to associated tasks of quality control, noting down information, preparing tools and doing preventive maintenance or to surveillance of several automated lines from a centralized control cabin.

But 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 must be possible when the machines are not working. Experience shows that these three conditions are fulfilled with difficulties. 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.

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. It is therefore being challenged today, and we are witnessing attempts, as yet unsuccessful, to substitute other modes of calculation.

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Second presupposition: rapid repair would the key 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. So the preoccupation is to act on all the time fragments, which make up an intervention.

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 by recourse 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, the time is reduced 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. Moreover, operations to increase reliability are only undertaken after analysis of automatic recordings of the amount and nature of downtime. 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.

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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. They are often reduced to having to draw up a summary or "blind" description, 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. The solutions envisaged, away from the real conditions of production, to eliminate the causes of breakdowns, turn out to be insufficiently adapted and 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.

Third presupposition: The greatest uncertainties about production are human and social

This presupposition is probably the most important. Technicist in formulation, it is connected to a fundamental preoccupation of the company. Companies need to reduce uncertainty in all areas and make the production process transparent in order to control it.

The efficiency of the technical system is said to be constantly threatened by the major elements of uncertainty, which are the productive worker himself, as human being, subject to faults, and as an employee motivated by his own interests, and 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. The concrete framework for work allows only for the operators to understand that part of the automated installation which the designers consider necessary and sufficient. It also constrains them to intervene according to the modalities considered *a priori* to be logical and coherent with the theoretical principles of the functioning of the system.

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 lasting.

This social process and form of automation stand in contradiction, in principle and in practice, with some present tentatives to implement work organizations which are really skilling.

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

The process and the social form of current form 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, real skilling forms of organization.

Organizations that "enrich"

These are the forms of organization, observed in particular in final assembly, 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 form 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, 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. 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 labour-

[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, ren-

ers, in the sense that, at the beginning, decomposition of tasks and specialization of machines were still far from what they would later become[1]. 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.[2] 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. We observed them specially in welding shops.

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 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.

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der 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.

[1] 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 interwar 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.

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

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[1]. Electronic and electro-mechanical screens at command and signalling 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[2]. 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 computer 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 and the implementation of several automated installations, specially the automatic laying of mechanical components under the body.

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[1] [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).]

[2] 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.

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

We have tried to see what the consequences would be of a skilling form of organization for the process of automation and for the technical characteristics of automated installations.

The application of the new design principles 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. The process and social form of automation described below are probably achievable in some places and temporarily. But the question is their durability in the current wage relationship.

Giving priority to increasing reliability without delay is a strategy for financial performance and for real skilling work, but it is achievable under certain social conditions

Now the performance in terms of output, quality, and timeliness depend on rate of utilization and stability of the settings of automated and integrated machines in lines. It is more efficient and more profitable to foresee or add a worker, if his 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.

An additional skilled employee is profitable if the rate of automated installation is gone up one or two percentage points during the year by his work.

The rapid analysis and elimination of the primary causes of faults, problems and breakdowns by an operating and maintenance team might be the method to continuously and permanently increase the rate of automated lines utilization.

The "short circuit" of increasing machine reliability that characterises 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.

The establishment of this "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.

This production and maintenance philosophy allows a progressive and non-excluding automation process

The reduction in the size of the workforce can be accomplished progressively as the team manages to increase the reliability of the line it is in charge of.

Moreover, the complete substitution of one type of workforce by another, which often takes place today, is not only unnecessary, but would be in this case 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. This knowledge 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 occurring events, 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 becomes an active and indispensable party in practice. Above all, 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. But for them to acquire the practical knowledge of the actual functioning of the production line and the faults that might occur, the technical design of the installation must allow for it, by being readable and intelligible, capable of being tested and analysed, adapted and modified.

Machines must be 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 must be visibility of their actual functioning during utilization. So they must be readable, understandable 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.

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 "extroverted" and "transparent" machines.

...testable and analysable...

It is impossible to predict *a priori* all the places, the mechanisms, the movements which should be recorded 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" the component parts and to "analyse" products flow.

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.

...adaptable and modifiable

Increasing reliability often comes about through adaptation to the particular conditions, in which a installation is utilized. So it 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. 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.

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.

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Giving priority to increasing reliability without delay, 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.

How far has it been possible to go in the projects, in which we have participated, towards application of the principles for design 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

Some implementation problems were sufficient in the experiment to prevent certain technical recommendations from being adopted. However, while very important, these difficulties are logically surmountable in time.

When the companies 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. The principles of technical design, spelt out before, 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 difficulty. Even when intellectually convinced, the engineers hesitate to proceed beyond improving the man-machine interface or increasing the social acceptability of automation.

The described social process and form of automation imply to be lasting two social conditions: to be able to guarantee employment and carrier; to accept the social dynamic of inversion of the division of knowledge from work.

First condition: Employees will not participate in increasing reliability, 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 companies far from their original activity.

Second condition: 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 becomes indispensable to the design of the next generation of machines, and may enter into either complementary or contradictory relationship with the more theoretical knowledge of the engineer. The workers are no longer just solicited by the design department to ask for their comments or suggestions, as happens today in the best cases. They are in a position to participate effectively. 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 co-operation without subordination. Are the companies in a position to accept this and to bear the weight of its social dynamic and consequences?

CONCLUSIONS

It has therefore become possible today to describe a process and social form of automation, which bring about a real and lasting inversion of the division of knowledge from work. But 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 not only sociologically, economically and culturally conditioned in their development and diffusion, but are also socially "constructed" and "constituted" by a set of objectives, principles, images, economic and social presuppositions, which are themselves rooted in the wage relationship and the division of knowledge from work, linked 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 work organizations in the factory, which only distributes what remains of knowledge. 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.

Technique is obviously "malleable", if it is considered in general. However, the techniques which are concretely implemented and in particular the production techniques discussed in social science research on work, 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 “constructed”. 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 social extra-territoriality. Productive techniques 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.

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