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HUMAN THOUGHT: NEW ORIENTATION DUE TO AUTOMATISM

FOREWORD

The modern engineer, because of his tendency to express himself in language which, even in reference to very simple things, systematically retreats into mathematical symbolism—strictly incomprehensible to the average man—enrols himself, unconsciously or deliberately, in a jealously closed caste in which those we call "technocrats" shut themselves up. This is the caste which seeks to be the sole elite and necessary heir of the former nobility in the new social "pattern."

Because I believe the engineer's "craft" to be one of the most beautiful in the world, I regret this hermetic attitude which tends to turn the engineer into a modern equivalent of the alchemist, thereby widening immeasurably the gulf which, in all eras, has separated scientific thought from the understanding of contemporaries, creating an almost impassible obstacle to the diffusion of knowledge. I also believe that the

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diffusion of knowledge is imperative for the survival of our civilization in tomorrow's terribly technical world.

My remarks are intended for cultivated readers, but for readers who are not technicians. I propose to discuss, in simple terms, things which are not always easy, because they are related to a new way of thinking which is itself complex. My subject will lead me to talk of machines which think, which judge, and which decide. I will be satisfied if I am able to persuade the reader that such terms are not hazy expressions which it is surprising to find in the writings of men who are in other respects apparently serious, but that the thought, judgment, and decision of the machine are things totally different from the thought, judgment, and decision of man, just as the way in which electronic calculators operate has very little in common with the methods used by man when he performs calculations.

ON RESEARCH

The scholar dear to the caricaturists of the early 1900's—dusty, absent-minded, and a bit ridiculous—has, during the last couple of decades, been transformed into a man who, when fitted into a team, makes child's play of manipulating forces on a universal scale and of manipulating ideas of a daring and a complexity which have no common measure with our forefathers' placid cogitations.

Yesterday's scholar deduced his discoveries from brilliant intuitions, using an experimental equipment which was generally derisory. Now the production of men of genius is, by the fact of the quantic mutations which determine the evolution of the human race, obviously an exceptional enough incident for the progress of scientific thought to have been, for a long time, an extremely slow process.

We have changed all that. We began by raising to a marked degree the intellectual potential of the masses, which allowed us to use a large number of specialists carefully trained in the various branches of knowledge. We then organized, systematized, and rationalized research within the limits of a concept of productivity copied on the model of industrial productivity, and we put into research the necessary men equipped with enormous facilities in tools and in machines.

We have not gone so far, as Carrel would suggest, as to impose a future career upon the child, at birth, by acting upon his organism through appropriate means so that he may become a perfect element.

It will probably be useless to go that far, since in the light of present knowledge we can surmise that in a non-utopian future research will be the function of machines, man intervening only to guide their action toward the end which he determines.

Atrocious? Not necessarily. The norms of our education postulate a fetishism of thought, a sort of deification of intelligence—that still totally mysterious faculty "which makes us doubt suddenly that which, up to that moment, we had accepted with our eyes closed,"[1] which permits that "man, turning inward, knows that he knows, thinks that he thinks, and deliberates about thinking,"[2] and which, "transcending ourselves, allows us to perceive ourselves in the act of perception."

It is human to deify what we do not understand, and there is no denying the fact that we do not understand the mechanism of thought or the mystery of our own existence. The difficulty arises, to cite Niels Bohr, from the fact that "we are at the same time the actors and the spectators in the great drama of existence."

Tell someone that he cannot be compared physically with the popular athlete of the day; it is likely that he will readily agree, and he may even make a speech on biceps-cerebrum incompatibility. But tell him that he is not very intelligent, and you will probably have made a lifelong enemy.

If we commit this sacrilege of separating the concept of intelligence from its vein of divinity, and if, along with the cyberneticians, we admit that intelligence is as mechanizable as our other activities, there is no reason, until the time comes when we can produce machines which really think, for our not organizing man's intellectual activity according to "mass-production" methods.

There are two aspects to scientific evolution. The individual of genius will be able, occasionally, to discover entirely new things, generally in contradiction with admitted truth. These discoveries often cause knowledge to leap forward because they are not a development of something which was already known. Here, the isolated scholar is irreplaceable, and it is worthy of notice that such discoveries are generally made by men who proceed by pure reasoning, using little or no experimental equipment. They are generally of a basic character.

1. McCulloch.

2. A. Valensin.

The other aspect is that of organized research, or "research centers." Here specialists in various branches of knowledge are gathered together; problems are outlined, aims are indicated, and, working in series, by a slow progression of minute developments, the researchers solve the problems within the framework of the aims. When these aims correspond to a necessity, an immediate need, the process is called "industrial research." When they do not correspond to anything which is immediately usable, it is called "basic research."

In conformity with the general tendency of this century to leave out the individual, the researcher remains, as a general rule, anonymous within the staff of the organization to which he belongs, and his name is only rarely mentioned upon the occasion of a discovery. We must realize, in truth, that the contributions of various researchers to the solution of a single problem are so dovetailed that it would be difficult to separate them.

Thus the research center comes to resemble more and more the factory, with its organization of the work, its production figures, and the anonymity of its personnel. These organisms have been said to be "invention mills," or even "engineer barracks," according to a friend of mine, a rather cynical industrialist.

Because the personnel of a research center have but a faint hope of seeing their personalities expand, there has been considerable talk of the "prostitution of values." But at that point I rebel; all we need do is to see on what tasks university people are sometimes used in industry to appreciate the meaning of such an expression.

In the spirit of our old ideas in which a certain nobility was attached to research, all this may seem disappointing; but, whatever nostalgia we may feel over it, we must bow to the evidence. It pays off. We must realize that the researcher or the isolated inventor is no longer easily conceivable, because modern scientific thought as well as modern technology are such complex things and require the utilization of important means that are not accessible to the individual.

If all that was required was an Einstein to establish the historic equation

$$E = mc^2,$$

it has, on the other hand, taken years of painstaking work by hordes of researchers and considerable outlays of capital before the Alamagordo bomb and the final atomic reactors were possible.

It pays off, because, without the unbelievable accumulation of researchers in innumerable units created under the pressure of industrial needs, favored principally by hostilities, it is clear that our science and our technology would not have reached its present level.

That explains the exponential speed of our evolution. It also highlights the tragedy of our era: the divorce of science and culture, of the researcher and the practitioner.

ON INDUSTRIAL PROCESSES

If we have been forced to submit scientific and technical research to the imperatives of production, it is fairly conceivable that this arises principally from our need to push to the maximum the efficiency of industrial processes so as to produce constantly greater amounts of consumer goods of better quality at a lower price. An extremely important aspect of technology has come from this: industrial automatism seen from the angle of cybernetics. The application is designated by a term of possibly debatable phonetic value but which, because of the passionate disputes it has evoked, has imposed itself universally, since it telescopes into four syllables a complex definition, a technique, and a mysticism: "automation."

It is not within the scope of this article to repeat the often-expounded history of the evolution with which we are concerned or to explain technicalities. Whether automation represents the second, third, or fourth industrial revolution matters little in itself, inasmuch as we realize that we are concerned in a very real way with a revolution. In fact, automation, which is, technically, a process of organizing industrial automatisms into an indissoluble whole, represents above all a way of thinking about these structures which is new and often difficult.

It is hardly necessary to say that, if our business enterprises owe it to themselves to reconsider their efficiency standards constantly, this is due, principally, to the social evolution and to the continual transformation of our conditions of life. A quick backward glance will measure how far we have come.

When marchionesses indulged in the innocent pleasures of the swing, they could, without immodesty, exhibit a fine leg sheathed in silk. But at least you had to be a marchioness, for that silk stocking implied immense resources. Today, the most humble of the working women we encounter in our factories would feel irreparably dishonored if she were not flashing a pair of delicate nylons.

When, like veritable human cattle, men, women, and scarcely weaned babies were swallowed up at five o'clock in the morning in the textile mills, to emerge late in the evening, imagine the fate of the utopist, the dangerous, irresponsible dreamer, the madman who might have predicted the concern that industry shows for the worker today! Specialists are employed to beautify working sites and watch over the comfort of the worker, the work day has been reduced by half, time devoted to leisure may be estimated as more important than time devoted to work. After leaving the factory, the worker may go home in his small car to a house which he owns and may belong to powerful union organizations possessing their own banks, their own insurance companies, and their own industrial complexes.

When, about 1775, James Watt, who was then building his first industrial steam engines, could bore his cylinders on Wilkinson's new machine, the story goes that he went into raptures over the fact that nowhere did the boring error exceed 3 millimeters. Today, a set of automobile pistons is delivered, with its sleeves, with a tolerance of 2 microns on the running clearances. This has made the automobile possible for all.

A recent inquiry conducted in France for the *Express*[3] by the French Institute of Public Opinion gives the following results concerning the needs felt most keenly by eighteen- to thirty-year-old French citizens. To the question, "On the material level, are there things of which you feel yourself deprived?" the following replies were received:

	Per Cent		Per Cent
Vacation	42	Furniture	22
Automobile	39	Clothing	18
Amusements	35	Food	2
Household appliances	33	Others things	10
Housing	27	Nothing	10

And there we have it—the transformation in the conditions of life. It is a fact that the child born today already has, in fact or potentially, a sum of needs so great that to the eyes of the wealthy bourgeois living before the "first industrial revolution" it would have represented the

3. Maurice Lachin, "L'Automation au service de l'homme."

acme of an almost inconceivable luxury. It is because these needs must be met—and are met in advance—that the industrial problem arises.

This comfort and this sweetness of life, however exasperating existence may sometimes be, have been brought to us by the use of machines, and it is difficult to deny that, on the whole, humanity, industrialized peoples at the very least, is the happier for it. However, the evolution goes on, because, on the one hand, man is fundamentally always unsatisfied and because, on the other, there are still millions of men who go unclothed and hungry.

It seems at this point that the vein of the use of machines has been worked out: our machines have reached a stage of perfection such that they cannot very likley be further improved in any meaningful way. However, we must produce—always more, always faster, always better, always more cheaply—and it comes about that man, working with hands, muscles, and brain, can no longer keep up the pace. Consequently, it is necessary to free the machine from man.

But we must also give man more freedom from the factory. The cyberneticians have calculated that a man at work, whether he is a mechanic, a laborer, a calculating-machine operator, a chemist, a draftsman, or an accountant, utilizes only a minute fraction of his intellectual potential. Under such conditions work is a dull, insipid thing to which we are forced in exchange for our means of livelihood, and it is not true that this kind of work ennobles man. Equally untrue is the fatality of the curse on Adam, "Thou shalt earn thy bread by the sweat of thy brow."

Man is more valuable than that. Norbert Wiener, the father of cybernetics, has said:

> It is a degradation to a human being to chain him to an oar and use him as a source of power; but it is an almost equal degradation to assign him a purely repetitive task in a factory, which demands less than a millionth of his brain capacity. It is simpler to organize a factory or galley which uses individual human beings for a trivial fraction of their worth than it is to provide a world in which they can grow to their full stature.[4]

AUTOMATION

The balance sheet of an industrial cost price includes both direct and indirect labor as a considerable factor. "General expenses" contain a large

4. Norbert Weiner, *The Human Use of Human Beings* (Boston: Houghton Mifflin Co., 1950), p. 16.

share of it—salaries to maintenance personnel, wages for office personnel, salaries of staff and managerial personnel. Now, whereas the cost of labor tends to increase systematically, directly at first, then indirectly, from the fact of the constant reduction of working time, it develops that, in a parallel manner, the sale value of the manufactured item tends to be reduced in an equally systematic way.

On the other hand, the *raison d'être* of free enterprise is profit, and it is unrealistic to say that this is not the case in nationalized or community-owned enterprises. These are notoriously inefficient, and the profit is absorbed by payments to a generally plethoric personnel and by administrative gigantism.

Upon first analysis, the most obvious way of getting out of the dilemma is to begin by reducing the salary incidence according to the cost price (which leads to a reduction of the amount of labor absorbed by the manufactured item) and, finally, to eliminate the labor. In other words, it is a question of tending toward a state of affairs in which the factory can function quite alone; it is important, consequently, to replace man by calling upon automatic mechanisms which are to do his work, not only in what concerns his physical motions, but above all in the area of his noble functions: measuring, controlling, correcting, coordinating, calculating, judging, and deciding.

We thus come quite naturally to the point of imagining entities which resemble man, having man's gestures, his reflexes, and his thought—entities which we would place before our machines to guide them as man guides them today.

"We are, at present," says Culbertson, "in a position to construct automatons which, in all possible cases, would have the reactions which, in the same cases, Mr. Jones or Mr. Smith would have."[5] But he hastens to add: "We could build them *if* we had enough separate parts available, *if* we had enough time ahead of us, *if* our space were not at a premium." If we used separate parts whose size would average a cubic millimeter, the synthetic Mr. Smith would probably have the proportions of Notre-Dame of Paris, and it would take an army of installers several generations to assemble him. And Culbertson concludes, as the pure mathematician he is: "I shall not be concerned for the moment with these technical details. We shall always be able to study them later; I propose, for now, to establish a method for building robots."

5. J. T. Culbertson, "Some Uneconomical Robots."

The installation of robots—less perfect ones, certainly, than those of Culbertson—in front of each of our machines would be possible, probably spectacular, and certainly very "science fiction," but totally absurd. Notoriously, man does not constitute the best possible machine; there is, consequently, no sense in trying to copy him. What is more, why try to produce synthetic men when the production of the original model, assured by an infinite number of artisans of doubtful competence, is so abundant as to threaten to engulf the earth?

Now our machines have been conceived as a function of the human operator; they have been designed to adapt as well as possible to man's form, to his normal gestures and reflexes. The screw-cutting lathe, for example, assumes its familiar form quite simply, in view of bringing the work level within reach of the man's hands. In the automatized complex it is possible that this lathe may be reduced to a revolving tool, hidden somewhere in the bowels of the complex machine.

If we want to take a few steps in the direction of the "manless factory"—which is technically possible right now, but whose probability, for evident economic, social, and material reasons, lies in a still-distant future—it is important, within the framework of cybernetic thought which proposes to "make action efficacious," to rethink basically the *whole* business enterprise, the present structure of which is obviously based on man.

And, moreover, the expression "rethink the enterprise" is inexact; it is necessary to rethink each one of the actions which come together in the activity of the enterprise, from the direct action which acts physically upon the product and modifies it, to such indirect actions as those which, to give concrete examples, assure the planning of stocks in such a way as to produce the circulation of materials and products which feed the direct action, making it possible and efficacious.

Let no one be deceived by this: automation is only in a very accessory way a matter of machines, however automatic these may be individually. It is self-evident that to instal one, two, or ten automatic machines in the shops of a factory has in itself only a minor and secondary influence on the over-all balance sheet.

This point will never be sufficiently emphasized: automation does not consist in signing a few order forms which will produce the installation of a few new machines here and there in the factory, somewhat according to the whims of inspiration. In the same way, for example, the

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electrification of a railroad system is not effected by ordering a few electric locomotives which will be dispatched, for better or for worse, over the line. Everyone knows that the electrification process implies a basic reorganization, a complete revision of the norms, means, and conditions of exploiting the system.

And we must also stress this aspect: the necessarily fragmentary automatization of a complex is an operation which pays off only relatively well and which is very costly, but it constitutes the easy way, easily carried out and easily understood. Automation, on the other hand, implies a study, preliminary to any execution of plans, of a basic character, and which is long and difficult—if you want to derive from the operation all the benefit it promises. I think that it is necessary to emphasize this, at the risk of becoming boring, for, as we all know, an emergency exists. Now it is generally agreed that the preliminary study for the construction of a new plant takes, in average cases, from two to five years and that the figure varies little according to whether the study is made in the conventional frame of reference or according to the norms of automation. But the study preliminary to the conversion of an existing enterprise also requires a minimum of from two to three years. The table of technical specifications relative to automation easily runs, for an average installation, from one to two thousand pages, not including diagrams.

For the moment, most industrialists seem to be retreating into a prudent expectancy, a policy of wait and see the dangerous attitude: "We don't want to move in too soon; let the others go ahead." However, when one of them decides to "go ahead," it is understandable that he will not be so charitable as to inform his competitors of his intentions. As a result, when he puts his "automated" factory into operation, he will have assured for himself, along with means of exploitation of an unprecedented efficiency, an advance of two to three years during which he will be permitted to sweep the markets for his own benefit. Moreover, since automation implies a highly increased production, it is imaginable that he will hardly be inclined to grant licenses which would permit his competitors to copy his achievement.

At the 1955 Margate convention a delegate summed up the situation in a clean-cut manner: "There is no point in asking ourselves whether automation will bring in more or less lush profits; it is important to decide now whether, by adopting automation, we will be able to fight with some chance of success to keep our place in the sun, or whether, by not adopting it, we shall close our factories. It's as simple as that."

That is simple, neat, and clear, but it places a formidable problem before active industry; it implies that we must either go out of business or rethink to a fundamental degree,

> not only the whole of our manufacturing processes, but also all the organization of the business enterprise, from services of supply all the way to sales, and including production and maintenance services and the new services of technical correlation. We must shake up profoundly what we have, and this must of necessity be done by stages, so as to permit the factory, during the conversion period, to continue to produce with the old means, and also so as not to have to proceed in rapid succession to mass discharges of personnel. And it is not enough to reach the point at which the machines turn all by themselves. Generally, we see in automation only a means for reducing the labor force, and we forget that the savings thus effected, if they remain appreciable, will be largely offset by the new maintenance service. The forces of this new service will be on a level of technical education which has no common measurement with the personnel we now employ.[6]

Nothing would be more false than to imagine that automation constitutes a method for effecting economies—the kinds of economies which we begin to make systematically during a depression period and which are of the same class as those which have resulted in the proletarization of so many middle-class families. As a man of experience has proclaimed: "savings on equipment cost a business nothing—nothing except its future and its chances of survival."[7]

It would be impracticable to discuss here the complex plan of a factory, or even of an automated production line, because it is of too technical a nature. However, so as to make felt the manner of thinking which presides over these installations, I want to show, for example, how an operation which has been rethought from the angle of automation is transformed. The operation is here isolated from the rest of the complex to make the demonstration clear.

In the synthetic textile industry, at the end of the manufacturing circuit of the fiber, there is a manually controlled hydraulic press in which the product is compressed and baled; the bales are then manually weighed, numbered, classified, and warehoused. The question is asked about automatizing this press, which, because of the very large relative volume of the non-compressed fiber as it leaves the final dryers, must form the bale in several steps.

6. The writer's "Le démarrage de l'automation."

7. F. K. Shallenberger, "Economics of Plant Automation."

Automatizing is, quite obviously, within the competence of mechanics who, tackling the problem, instal a few "micro-switches," some relays, and some pneumatic effectors. The press is now termed "automatic" because, controlled by a single man-team, whereas formerly it required at least four, or twelve, man-days, it carries out the various pressing operations all by itself. As a sign of the times we even go so far as to utilize electronics in the form of a photoelectric cell which detects when the bin is full.

However, the automatician proceeds in another manner. He begins by condemning this installation, which is uninteresting, elementary, and not very rational. Having said this, he begins to disturb everyone by asking questions. Little by little the questions bring out a state of affairs which is not without interest.

Textile fiber is an extremely hygrostatic material. For this reason, by agreement within the trade, the bales are sold at "standard humidity," which means that the real weight has no relationship to the invoiced weight. The fiber is brought from the final dryer on a continuous-conveyor belt. Its humidity content is, at this time, not fixed, and every five minutes a sample is taken and analyzed by the production control laboratory. The figures obtained are entered on a form opposite the date and the hour of the sampling.

In shipping, it is necessary to indicate on all accounting forms, customs declarations, waybills, etc., each individual bale with its identification number and real weight. Laboratory forms provide the humidity ratings which were noted at the moment the bale was formed and make possible calculations, individually for each bale, of the theoretical weight at standard humidity which will be invoiced and will form the basis of the transaction.

After digesting these bits of information, our automatician, who had rather mysteriously disappeared from circulation, reappears one fine day, stating that he is not bringing in the best possible solution because, anxious to limit the expenses involved, he has sought to re-use to the maximum the existing equipment. Then, after a moment of silence, intended to give his listeners an appreciation of how reasonable he is, he proceeds to the outlining of his project.

Immediately above the press he instals electronic equipment which constantly measures the humidity percentage of the fiber. On the press bed he instals a weighing device, also electronic, which reacts upon the controls of the press in such a way that it will turn out bales whose real weight is linked to an electric size which determines the adjustment of the machine. At the same time a signal coming from the humidity-index measuring unit constantly revises this electric size, so that the press produces bales at a variable real weight but at a theoretical weight which is at constant standard humidity.

It follows—but those are details, he says—that the press is adjusted in such a way that, without any intervention, it manufactures bales without interruption as long as fiber arrives in sufficient quantity over the conveyor. It also follows that an elementary mechanism (have I mentioned that our automatician lumps indistinctly all that can be added entirely on the outside of the system under one and the same term: "elementary mechanisms"?) assures the automatic baling and banding and that there is scarcely any problem in going ahead in such a way that the traveling bridge crane which runs into the warehouse will return and pick up the bales as they are finished and will take them to the warehouse.

Taking advantage of the fact that his listeners are strangely silent, he continues on the momentum of his first blast and observes that there is no longer any reason to number the bales and that the tiresome filling-in of innumerable forms becomes useless; that the control laboratory is freed from its equally tiresome analyses and that consequently it can use its personnel on more serious tasks; that the system as a whole is more accurate than manual operation and that there is no reason for not stepping up the cadence considerably; that, since in any case the traveling bridge crane is equipped with automatic controls for putting the bales into the warehouse, we can easily add to it magnetic-tape equipment which will have it bring out of the warehouse the bales required for filling an order and set them down, in routing order, on the waiting trucks.

No doubt he will want to add that the coding of the magnetic tape can be done by automatic accounting machines which fill in the forms and that, at the same time, the data—the information—can be fed into the ordinator which establishes the stock planning, the production planning, the state of the factory report, etc. But he will probably say nothing about this, for he is somewhat wary of the reactions of those around him who have a curious propensity for becoming flabbergasted when he explains such simple and obvious things to them.

Although this is not immediately visible, the installation presents certain important technical problems. However, in the mind of our automatician, none of this is very serious; such things are "installation incidents." What is important is the process of logical organization of interdependent automatic sequences which leads to a coherent, highly overlapping whole, with a functioning which is accurate, rapid, and entirely automatic. And that, even on the elementary scale of this example, is automation.

It is indeed worthy of notice that the whole installation presents one of the characteristics of partial automations: from the beginning, extensions toward future automatisms have been anticipated. When the time comes, it will be only a matter of linking them up. Right now the traveling bridge crane and its coded-tape control, the ordinator, etc., can be tied in. But, if you look carefully, you will find somewhere on the junction panel a group of unmarked terminals which arouse the curiosity of the installers. On the master plan these terminals are identified by the legend: "To Future Units."

You have already raised the objection that this is all very complex; and so it is. No one of us has ever stated that the new techniques were simple and easy, and the difficulty which many men feel in thinking in abstractions and in complexities is perhaps the greatest one encountered by automation in its effort to take hold. We must, however, resign ourselves to making a decision. Without reopening here the argument over the intelligence of machines, we must admit that automation utilizes automatic devices which are substituted for man as he exercises his intellect. However insignificant this may be at the present stage, we are applying processes which parallel intelligent activity. I believe that there is no hope of being able to achieve this by simple, rudimentary means, like those with which we have been able to get by up to now. We are headed for a world with an extremely complex technology; that is a fact, and we must bow to it. Better still, since "'bowing" contains a suggestion of passivity, it would be more realistic to say that, in response to this fact, we must prepare ourselves for life in the complex mode. Such a statement assumes its full value if we remember that it is becoming increasingly difficult to "get by" with the reasonings of conventional physics; each day it becomes more necessary to call upon the theories of relativity in the area of our current preoccupations.

Again I should like to call attention to certain aspects which it is important to keep in mind. As we go forward in establishing the plan for the automated business enterprise, we are forced to observe that gradually the analogy with the living organism is accentuated. And this is no mere figure of speech. Now, to admit that analogy as being a basis for valid reasoning is, quite simply, to espouse the cybernetic mode of thought.

ON CYBERNETIC THOUGHT

Everyone knows that cybernetics—the "crossroads science," to use G. Boulanger's vivid expression—was, in its early days, defined by Norbert Wiener as the science of "the entire field of control and of communication theory, whether in the machine or in the animal."[8] But upon examination it was rapidly shown that the implications of cybernetics are so infinitely vast that we can form an image of the cybernetician "which shows him preoccupied with a new form of thought still seeking its expression, but anxious also to produce, for the future, a synthesis of the living and the inert, based upon the deepest resources of culture and the most modern data of technique."[9]

It was therefore necessary from the beginning, in the interest of making realistic activity possible, to limit the areas in which, for the present, cybernetic thought could get a foothold in concrete things. Thus we have come—by analogy with the theory of relativity—to differentiate *limited cybernetics* and *general cybernetics,* limited cybernetics obviously including the area of industrial and technical applications.

From one of the general definitions: "The new way of thinking which, rejecting a priori any notion of a boundary line between living matter and inert matter, admits that, since the curve which describes the evolution of the machine is of more rapid increase than the one which describes man's evolution, the former, in time, will finally catch up with and pass the latter," we can deduce that cybernetics is "the methodology of action," the "science of finalized behaviors," or even "the art of making action efficacious."[10]

8. Norbert Wiener, *Cybernetics, or Control and Communication in the Animal and the Machine* (New York: John Wiley & Sons, 1948), p. 19.

9. Professor G. R. Boulanger, president of the International Cybernetics Association, "Opening Address," Second International Cybernetics Conference, Namur.

10. Various contributors, First International Cybernetics Conference, Namur, 1956.

In the area of general cybernetics applied to human societies such concepts require, to give a concrete example, that we say what there is in common between a sewing machine and a union defending fishermen;[11] and a common term does exist between them. If we keep in mind the fact that an action is never initiated except to attain a goal and that incontestably the fishermen's union has as clearly defined a goal as that of the sewing machine, the common term between the two examples is the action, which, to attain the goal, must be efficacious.

Returning to limited cybernetics, and consequently, to the plan of the automated factory, we are forced to note that the various composites of actions which we make automatic are finalized; that is, they are undertaken only to reach goals which, in their turn, are to be integrated into the *raison d'être* of the enterprise. And it is important here to be aware of certain phenomena. To quote Stafford Beer:

> A complete organism is a machine capable of maintaining itself in a disturbed environment only because it is coördinated. In each case, the objective is vital, despite a varied series of goals which are useful and sometimes contradictory. A business enterprise wants to earn the maximum profit; a man may want to get maximum enjoyment out of life; but neither of the two systems can adopt a strategy based on these motives alone.[12]

The system, under such conditions, can be brought to behave in a manner disastrous to its long-term survival. "The man," continues Beer, "may drink a quantity of whisky to seek pleasure, and may die of cirrhosis; the business can make a great deal of money by sacrificing its customers, and fail for lack of orders."

The goal of an automatic production line is obviously production. But, if "the action is efficacious," the production will soon go beyond all imaginable limits, and the line will have made short work of absorbing all the capital of the business in order to transform it into huge stocks of manufactured goods.

That immediately introduces the concept of "partial goals" which are to be integrated in their turn into a complex automated system which, within the limits of the "final goal," is to co-ordinate them. Here again it is important to proceed with caution, for one can easily imagine the exaggeration in which we may flounder if the co-ordinating complex is to control in detail all the individual actions. Returning to the analogy

11. L. Couffignal, "Science, technique, cybernétique."

12. Stafford Beer, "The Irrelevance of Automation."

with a living organism, again, according to Beer, this would imply that "a man would be fully conscious of each beat of his heart. He would rapidly become neurotic."

Thus it is important to subdivide the business enterprise into a certain number of organs, individually autostable within the framework of goals which, by their construction, they are obliged to attain with maximum efficacy—goals which are variable, imposed by a central automatic complex that itself remains stable despite the perturbing effect of the environment, and that tends with maximum efficacy toward its own goal.

Here again it would be straying far from my proposed limits for this article if I attempted to draw the reader beyond the rudimentary considerations which I have just indicated into the complex forest of cybernetic thought, which still has virgin timber in many of its reaches. I simply hope that the few notions which I have expressed justify to the reader's satisfaction the fact that, fundamentally, we are authorized to designate cybernetics and the branches of knowledge which derive from it as being "a new way of thinking."

ON THE SOCIAL IMPLICATIONS

We must admit, however overwhelmed we may be by our daily technical concerns, that we cannot help thinking sometimes about what will happen to the living matter around us—a living matter which, at least in principle, our activity tends to eliminate from our factories to a maximum degree.

It does occur to me to worry about what will become of Smith or Jones, whose usefulness will disappear as soon as, in a short while, a given automatic circuit is put into operation. For the moment, of course, the Smith problem and the Jones problem have nothing tragic about them. The persons involved will be put to work in other services which are still manual—but that does not alter the fact that this is a transitional solution, for, when conversions to automation are increased in those enterprises which today are reluctant to be in the vanguard, the Smiths and the Joneses, during a period of transition at the very least, will be legion.

Without doubt, the problem is formidable; and it is being watched, for in every circle it creates a deep uneasiness—even at times a kind of panic.

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We find ourselves in the truly tragic situation of having to solve, quickly, problems which we know are imminent, which we sense to be serious, but which are unfamiliar to us, because we find ourselves faced with an evolution which nothing will stop, about which we can formulate hypotheses, but whose reactions we are incapable of predicting.

It seems possible to sum up the situation in the fact that we are going to be submerged by a crowd of Smiths and Joneses whose culture and training are too elementary to allow them to be of any use in the new factory. Moreover, it has become a commonplace to say that we are suffering from a lack of engineers (although, at the moment, that is not obvious when one considers the tasks to which the university-trained man is generally assigned in industry), and this lack is quite a likely possibility in the case of the future factory.

However, conditions have never been better or more imperious than they are today for allowing every individual, however little he may have to do with industrial activity, to increase his knowledge and to acquire knowledge of the new techniques. It is painful enough to have to remind people that this requires, on the part of the interested parties, a certain amount of energy and a great deal of interest, for many engineers must find themselves in the situation of one of their number who told me that, having left the university twenty years before, he had never since had either the leisure or the inclination to do more studying.

In sum, we find ourselves faced with a double problem. On the one hand, automation will work in such a way that we shall have to get rid of a certain number of men who do not have the requisite technical training; on the other hand, we shall have to hire technicians who will be experts in a field which is not that of the business enterprise's product.

Suppose we do "vertical integration"—a method which is now tending to spread and which consists in acting so that, in all areas, the business enterprise is self-sufficient. We have the raw material in the form of our present personnel to whom after all we do owe certain considerations, since in general they have served us for quite a few years and have accumulated an experience capital which, even if it cannot be used in its present form in the automatic factory, is nonetheless still valuable. Therefore, we are going to train this personnel in the new techniques.

It is important first of all to operate a selection which we are totally incapable of insuring in the present state of affairs, whatever the degree of efficiency of the psychotechnical services attached to the business enterprise. Consequently, we shall have to organize so that this selection may work spontaneously.

To make this clear, we can begin by systematically organizing information sessions to which the entire personnel of all types and without distinction is invited, and without—and this is important—any kind of attendance requirement. These sessions are graded so as to present increasingly difficult ideas, and the interested persons are explicitly told that dropping out during the course will never give rise to any pejorative personnel rating and that, on the contrary, they will be doing the business a favor if they feel they should not persevere in a direction which is difficult for them and which might prove to be poorly suited to their skills and particularly to their tastes.

By the end of the course a *de facto* selection will have been effected, and we shall have before us those elements for whom the strong possibility exists that they may be capable of receiving the most advanced technical training.

We will give them this training either through the factory engineers or through specialists hired on the outside and in the form of regular courses which will give those interested not only the rudiments of specific specialization but also the recall—or the teaching, if need be—of mathematics, physics, electronics, electricity, etc.

That will require from the business a certain organizational effort and an outlay of money, principally in the form of hours of work "lost," from the point of view of the manufactured product. This time, although not negligible, certainly does not represent a major item on the balance sheet, especially if it is likely that a tax exemption will be obtained on the amount of the worker's educational bill. That is likely, since it involves a service which can be considered as rendered to the community, the worker being assured that he retains his individual freedom even if on the very day of the conclusion of his studies he decides to take his newly acquired learning elsewhere.

In addition, nothing prevents us from considering that what has been spent in this way constitutes one of the most profitable investments which the enterprise may have had the opportunity to make for a long time.

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I am under no illusion that these few general indications are the solution to the social problem which rightly concerns us. At best, they are merely suggestions within a limited area.

CONCLUSION

Because the large-scale application of modern techniques and of modern science, within the scope of a new way of thinking which is generally unfamiliar, is imminent and inevitable, it is important to diffuse this knowledge widely and without delay and to prepare ourselves intensively to face the situation. The thought that countries with as poorly developed but as excessive a population as China's, for example, are pushing automation intensively gives sufficient indication of what unforeseeable events threaten us—and these need not necessarily be armed hostilities. We must not delude ourselves, either, concerning the fact that, as soon as the protagonists of the two opposing ideological systems have had sufficient time, our present-day adversaries will become our most formidable competitors. And, if ever we shall have failed to insure that our industrial technology is maintained on the level of that of the "big powers," they will reduce us in our turn to the rank of underdeveloped countries.

We must be aware of all the aspects of the evolution we are living through, for, as we use the means which science puts at our disposal, we shall either proceed toward a world in which, as Norbert Wiener sees it, man will be able to grow to his full stature or toward one in which it will not be pleasant to live.

Because stagnation is a step in the direction of entropy, and because we have at our disposition the human intelligence which will gradually be freed from those sordid tasks that the thinking machines will perform, I believe that it is necessary to continue working with fervor at noble tasks. For however intelligent the machines may become, and however small, weak, inconsequential, and often stupid man can be, he still merits our faith in him and in his creative genius.