The Human Use of Human Beings

By Norbert Wiener

The "mechanical brain" and similar machines can destroy human values or enable us to realize them as never before. A leader of the new scientific revolution tells how and why.

THE *Human* Use OF Human Beings

CYBERNETICS AND SOCIETY

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stances which now renders possible the new automatic age.

The existing state of industrial techniques includes the whole of the results of the first industrial revolution, together with many inventions which we now see to be precursors of the second industrial revolution. What the precise boundary between these two revolutions may be, it is still too early to say. In its potential significance, the vacuum tube certainly belongs to an industrial revolution different from that of the age of power; and yet it is only at present that the true significance of the invention of the vacuum tube has been sufficiently realized to allow us to attribute the present age to a new and second industrial revolution.

Up to now we have been talking about the existing state of affairs. We have not covered more than a small part of the aspects of the previous industrial revolution. We have not mentioned the airplane, nor the bulldozer, together with the other mechanical tools of construction, nor the automobile, nor even one-tenth of those factors which have converted the form of modern life to something totally unlike the life of any other period. It is fair to say, however, that except for a considerable number of isolated examples, the industrial revolution up to the present has displaced man and the beast as a source of power, without making any great impression on other human functions. The best that a pick-and-shovel worker can do to make a living at the present time is to act as a sort of gleaner after the bulldozer. In all important respects, the man who has nothing but his physical power to sell has nothing to sell which it is worth anyone's money to buy.

Let us now go on to a picture of a more completely automatic age. Let us consider what for example the automobile factory of the future will be like; and in particular the assembly line, which is that one of the component parts of that sort of factory which employs the most labor. In the first place, the sequence of operations will be controlled by something like a modern high-speed computing machine. In this book and elsewhere, I have often said that the high-speed computing machine is primarily a logical machine, which confronts different propositions with one another and draws some of their consequences. It is possible to translate the whole of mathematics into the performance of a sequence of purely logical tasks. If this representation of mathematics is embodied in the machine, the machine will be a computing machine in the ordinary sense. Nevertheless, such a computing machine, besides ordinary mathematical tasks, will involve the logical task of channeling a series of orders concerning mathematical operations. Therefore, as present high-speed computing machines in fact do, it will contain at least one large assembly which is purely logical.

The instructions to such a machine, and here too I am speaking of present practice, are given by what we have called a taping. The orders given the machine may be fed into it by a taping which is completely predetermined. It is also possible that the actual contingencies met in the performance of the machine may be handed over as a basis of further regulation to a new control tape constructed by the machine itself, or to a modification of the old one. I have already explained how I think such processes are related to learning.

It may be thought that the present great expense of computing machines bars them from use in industrial processes; and furthermore that the delicacy of the work needed in their construction and the variability of their functions precludes the use of the methods of mass production in constructing them. Neither of these charges is correct. In the first place, the enormous computing machines now used for the highest level of mathematical work cost something of the order of hundreds of thousands of dollars. Even this price would not be forbidding for the control machine of a really large factory, but it is not the relevant price. The present computing machines are developing so rapidly that practically every one constructed is a new model. In other words, a large part of these apparently exorbitant prices goes into new work of design, and into new parts, which are produced by a very high quality of labor under the most expensive circumstances. If one of these computing machines were therefore established in price and model, and put to use in quantities of tens or twenties, it is very doubtful whether its price would be in a higher range than that of tens of thousands of dollars. A similar machine of less capacity, not suited for the most difficult computational problems, but nevertheless quite adequate for factory control, would probably cost no more than a few thousand dollars in any sort of moderate-scale production.

Now let us consider the problem of mass production. If the only opportunity for mass production were the mass production of completed machines, it is quite clear that for a considerable period the best we could hope for would be a moderate-scale production. However, in each machine the parts are largely repetitive in very considerable numbers. This is true, whether we consider the memory apparatus, the logical apparatus, or the arithmetical subassembly. Thus production of a few dozen machines only, represents a potential mass production of the parts, and is accompanied with the same economic advantages.

It may still seem that the delicacy of the machines must mean that each job demands a special new model. This is also false. Given even a rough similarity in the type of mathematical and logical operations demanded of the mathematical and logical units of the machine, the over-all performance is regulated by the taping, or at any rate by the *original* taping. The taping of such a machine is a highly skilled intellectual task for a professional man of a very specialized type; but it is largely or entirely a once-for-all job, and need only be partly repeated when the machine is modified for a new industrial setup. Thus the cost of such a skilled technician will be distributed over a tremendous output, and will not really be a significant factor in the use of the machine.

The computing machine represents the center of the automatic factory, but it will never be the whole factory. On the one hand, it receives its detailed instructions from elements of the nature of sense organs. I am thinking of sense organs such as photo-electric cells, condensers for the reading of the thickness of a web of paper, thermometers, hydrogen-ion-concentration meters, and the general run of apparatus now built by instrument companies for the manual control of industrial processes. These instruments are already built to report electrically at remote stations. All they need to enable them to introduce their information into an automatic high-speed computor is a reading apparatus which will translate position or scale into a pattern of consecutive digits. Such apparatus already exists, and offers no great difficulty, either of principle or of constructional detail. The sense-organ problem is not new, and it is already effectively solved.

Besides these sense organs, the control system must contain effectors, or components which act on the outer world. Some of these are of a type already familiar, such as valve-turning motors, electric clutches, and the like. Some of them will have to be invented, to duplicate more nearly the functions of the human hand as supplemented by the human eye. It is altogether possible in the machining of automobile frames to leave on certain metal lugs, machined into smooth surfaces as points of reference. The tool, whether it be drill or riveter or whatever else we want, may be led to the rough neighborhood of these surfaces by a photo-electric mechanism, actuated for example by spots of paint. The final positioning may bring the tool up against the reference surfaces, so as to establish a firm contact, but not a destructively firm one. This is only one way of doing the job. Any competent engineer can think of a dozen more.

Of course, we assume that the instruments which act as sense organs to the system record not only the original state of the work, but also the result of the functioning of all previous processes. Thus the machine may carry out feedback operations, either those of the simple type now so thoroughly understood, or those involving more complicated processes of discrimination, regulated by the central control as a logical or mathematical system. In other words, the all-over system will correspond to the complete animal with sense organs, effectors and proprioceptors, and not, as in the ultra-rapid computing machine, to an isolated brain, dependent for its experiences and for its effectiveness on our intervention.

The speed with which these new devices are likely to come into industrial use will vary greatly with the different industries. Automatic devices, which may not be precisely like those described here, but which perform roughly the same functions, have already come into extensive use in continuous-process industries like canneries, steel-rolling mills, and especially wire and tin-plate factories. They are also familiar in paper factories, which likewise produce a continuous output. Another place where they are indispensable is in that sort of factory which is too dangerous for any considerable number of workers to risk their lives in its control, and in which an emergency is likely to be so serious and costly that its possibilities should have been considered in advance, rather than left to the excited judgment of somebody on the spot. If a policy can be thought out in advance, it can be committed to a taping which will regulate the conduct to be followed in accordance with the readings of the instrument. In other words, such factories should be under a régime rather like that of the interlocking signals and switches of the railroad signal-tower. This régime is already followed in oil-cracking factories, in many other chemical works, and in the handling of the sort of dangerous materials found in the exploitation of atomic energy.

We have already mentioned the assembly line as a place for applying the same sorts of technique. In the assembly line, as in the chemical factory or the continuous-process paper mill, it is necessary to exert a certain statistical control on the quality of the product. This control depends on a sampling process. These sampling processes have now been developed by Wald and others into a technique called *sequential analysis,* in which the sampling is no longer taken in a lump, but is a continuous process going along with the production. That which can be done then by a technique so standardized that it can be put in the hands of a statistical computer who does not understand the logic behind it, may also be executed by a computing machine. In other words, except again at the highest levels, the machine takes care of the routine statistical controls, as well as of the production process.

In general, factories have an accounting procedure which is independent of the production. As far as the data which occur in cost-accounting are concerned, that part which comes from the machine or assembly line may be fed directly into the computing machine. Other data may be fed in from time to time by human operators, but the bulk of necessary clerical work will be cut to that not of a completely routine nature. For example, girls will be needed to take care of outside correspondence and the like. Even a large part of this may be received from the correspondents on punched cards, or transferred to punched cards by extremely low-grade labor. From this stage on, everything may go by machine. This mechanization also may apply to a not inappreciable part of the library and filing facilities of an industrial plant.

In other words, the machine plays no favorites as between overall labor and white collar labor. Thus the possible fields into which the new industrial revolution is likely to penetrate are very extensive; and include all labor performing judgments of a low level, in much the same way as the displaced labor of the earlier industrial revolution included every aspect of human power. There will, of course, be trades into which the new industrial revolution of judgment will not penetrate: either because the new control machines are not economical in industries on so small a scale as not to be able to carry the considerable capital costs involved, or because their work is so varied that a new taping will be necessary for almost every job. I cannot see automatic machinery of the judgment-replacing type coming into use in the corner grocery, or in the corner garage, although I can very well see it employed by the wholesale grocer and the automobile manufacturer. The farm laborer too, although he is beginning to be pressed by automatic machinery, is protected from the full pressure of it, because of the ground he has to cover, the variability of the crops he must till, and the special conditions of weather and the like that he must meet. Even here, the large-scale or plantation farmer is becoming increasingly dependent on cotton-picking and weed-burning machinery, as the wheat farmer has long been dependent on the McCormick reaper. Where such machines may be used, some use of machinery of judgment is not inconceivable.

The introduction of the new devices and the dates at which they are to be expected are, of course, largely economic matters, on which I am not an expert. Short of any violent political changes or another great war, I should give a rough estimate that it will take the new tools ten to twenty years to come into their own. A war would change all this overnight. If we should engage in a war with a major power like Russia, which would make serious demands on the infantry, and consequently on our man-power, we may be hard put to it to keep up our industrial production. Under these circumstances, the matter of replacing human production by other modes may well be a life-or-death matter to the nation. We are already as far along in the process of developing a unified system of automatic control machines as we were in the development of radar in 1939. Just as the emergency of the Battle of Britain made it necessary to attack the radar problem in a massive manner, and to hurry up the natural development of the field by what may have been decades, so too, the needs of labor replacement are likely to act on us in a similar way in the case of another war. The personnel of skilled radio amateurs, mathematicians, and physicists, who were so rapidly turned into competent electrical engineers for the purposes of radar design, is still available for the very similar task of automatic-machine design. There is a new and skilled generation coming up, which they have trained.

Under these circumstances, the period of about two years which it took for radar to get onto the battlefield with a high degree of effectiveness is scarcely likely to be exceeded by the period of evolution of the automatic factory. At the end of such a war, the "know-how" needed to construct such factories will be common. There will even be a considerable backlog of equipment manufactured for the government, which is likely to be on sale or available to the industrialists. Thus a new war will almost inevitably see the automatic age in full swing within less than five years.

I have spoken of the actuality and the imminence of this new possibility. What can we expect of its economic and social consequences? In the first place, we can expect an abrupt and final cessation of the demand for the type of factory labor performing purely repetitive tasks. In the long run, the deadly uninteresting nature of the repetitive task may make this a good thing, and the source of the leisure which is necessary for the full cultural development of man on all sides. It may also produce cultural results as trivial and wasteful as the greater part of those so far obtained from the radio and the movies.

Be that as it may, the intermediate period of the introduction of the new means, especially if it comes in the fulminating manner to be expected from a new war, will lead to an immediate transitional period of disastrous confusion. We have a good deal of experience as to how the industrialists regard a new industrial potential. Their whole propaganda is to the effect that it must not be considered as the business of the government but must be left open to whatever entrepreneurs wish to invest money in it. We also know that they have very few inhibitions when it comes to taking all the profit out of an industry that there is to be taken, and then letting the public pick up the pieces. This is the history of the lumber and mining industries, and is part of what we have called in another chapter the traditional American philosophy of progress.

Under these circumstances, industry will be flooded with the new tools to the extent that they appear to yield immediate profits, irrespective of what long-time damage they can do. We shall see a process parallel to the way in which the use of atomic energy for bombs has been allowed to compromise the very necessary potentialities of the long-time use of atomic power to replace our oil and coal supplies, which are within centuries, if not decades, of utter exhaustion. Note well that atomic bombs do not compete with power companies.

Let us remember that the automatic machine, whatever we think of any feelings it may have or may not have, is the precise economic equivalent of slave labor. Any labor which competes with slave labor must accept the economic conditions of slave labor. It is perfectly clear that this will produce an unemployment situation, in comparison with which the present recession and even the depression of the thirties will seem a pleasant joke. This depression will ruin many industries — possibly even the industries which have taken advantage of the new potentialities. However, there is nothing in the industrial tradition which forbids an industrialist to make a sure and quick profit, and to get out before the crash touches him personally.

Thus the new industrial revolution is a two-edged sword. It may be used for the benefit of humanity, assuming that humanity survives long enough to enter a period in which such a benefit is possible. If, however, we proceed along the clear and obvious lines of our traditional behavior, and follow our traditional worship of progress and the fifth freedom — the freedom to exploit — it is practically certain that we shall have to face a decade or more of ruin and despair.