TECHNICS AND CIVILIZATION

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The first draft of this book was written in 1930 and the second was completed in 1931. Up to 1932 my purpose was to deal with the machine, the city, the region, the group, and the personality within a single volume. In working out the section on technics it was necessary to increase the scale of the whole project: so the present book covers only a limited area of the first draft. While Technics and Civilization is a unit, certain aspects of the machine, such as its relation to architecture, and certain aspects of civilization that may ultimately bear upon the course of technics remain to be treated at another time. *L. M.*

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OBJECTIVES

During the last thousand years the material basis and the cultural forms of Western Civilization have been profoundly modified by the development of the machine. How did this come about? Where did it take place? What were the chief motives that encouraged this radical transformation of the environment and the routine of life: what were the ends in view: what were the means and methods: what unexpected values have arisen in the process? These are some of the questions that the present study seeks to answer.

While people often call our period the "Machine Age," very few have any perspective on modern technics or any clear notion as to its origins. Popular historians usually date the great transformation in modern industry from Watt's supposed invention of the steam engine; and in the conventional economics textbook the application of automatic machinery to spinning and weaving is often treated as an equally critical turning point. But the fact is that in Western Europe the machine had been developing steadily for at least seven centuries before the dramatic changes that accompanied the "industrial revolution" took place. Men had become mechanical before they perfected complicated machines to express their new bent and interest; and the will-to-order had appeared once more in the monastery and the army and the counting-house before it finally manifested itself in the factory. Behind all the great material inventions of the last century and a half was not merely a long internal development of technics: there was also a change of mind. Before the new industrial processes could take hold on a great scale, a reorientation of wishes, habits, ideas, goals was necessary.

To understand the dominating rôle played by technics in modern civilization, one must explore in detail the preliminary period of ideological and social preparation. Not merely must one explain the existence of the new mechanical instruments: one must explain the culture that was ready to use them and profit by them so extensively. For note this: mechanization and regimentation are not new phenomena in history: what is new is the fact that these functions have been projected and embodied in organized forms which dominate every aspect of our existence. Other civilizations reached a high degree of technical proficiency without, apparently, being profoundly influenced by the methods and aims of technics. All the critical instruments of modern technology—the clock, the printing press, the water-mill, the magnetic compass, the loom, the lathe, gunpowder, paper, to say nothing of mathematics and chemistry and mechanics—existed in other cultures. The Chinese, the Arabs, the Greeks, long before the Northern European, had taken most of the first steps toward the machine. And although the great engineering works of the Cretans, the Egyptians, and the Romans were carried out mainly on an empirical basis, these peoples plainly had an abundance of technical skill at their command. They had machines; but they did not develop "the machine." It remained for the peoples of Western Europe to carry the physical sciences and the exact arts to a point no other culture had reached, and to adapt the whole mode of life to the pace and the capacities of the machine. How did this happen? How in fact could the machine take possession of European society until that society had, by an inner accommodation, surrendered to the machine?

Plainly, what is usually called *the* industrial revolution, the series of industrial changes that began in the eighteenth century, was a transformation that took place in the course of a much longer march.

The machine has swept over our civilization in three successive waves. The first wave, which was set in motion around the tenth century, gathered strength and momentum as other institutions in civilization were weakening and dispersing: this early triumph of the machine was an effort to achieve order and power by purely external means, and its success was partly due to the fact that it

evaded many of the real issues of life and turned away from the momentous moral and social difficulties that it had neither confronted nor solved. The second wave heaved upward in the eighteenth century after a long steady roll through the Middle Ages, with its improvements in mining and iron-working: accepting all the ideological premises of the first effort to create the machine, the disciples of Watt and Arkwright sought to universalize them and take advantage of the practical consequences. In the course of this effort, various moral and social and political problems which had been set to one side by the exclusive development of the machine, now returned with doubled urgency: the very efficiency of the machine was drastically curtailed by the failure to achieve in society a set of harmonious and integrated purposes. External regimentation and internal resistance and disintegration went hand in hand: those fortunate members of society who were in complete harmony with the machine achieved that state only by closing up various important avenues of life. Finally, we begin in our own day to observe the swelling energies of a third wave: behind this wave, both in technics and in civilization, are forces which were suppressed or perverted by the earlier development of the machine, forces which now manifest themselves in every department of activity, and which tend toward a new synthesis in thought and a fresh synergy in action. As the result of this third movement, the machine ceases to be a substitute for God or for an orderly society; and instead of its success being measured by the mechanization of life, its worth becomes more and more measurable in terms of its own approach to the organic and the living. The receding waves of the first two phases of the machine diminish a little the force of the third wave: but the image remains accurate to the extent that it suggests that the wave with which we are now being carried forward is moving in a direction opposite to those of the past.

By now, it is plain, a new world has come into existence; but it exists only in fragments. New forms of living have for long been in process; but so far they have likewise been divided and unfocussed: indeed, our vast gains in energy and in the production of goods have manifested themselves in part in a loss of form and an impoverishment of life. What has limited the beneficence of the machine? Under

what conditions may the machine be directed toward a fuller use and accomplishment? To these questions, too, the present study seeks an answer. Technics and civilization as a whole are the result of human choices and aptitudes and strivings, deliberate as well as unconscious, often irrational when apparently they are most objective and scientific: but even when they are uncontrollable they are not external. Choice manifests itself in society in small increments and moment-to-moment decisions as well as in loud dramatic struggles; and he who does not see choice in the development of the machine merely betrays his incapacity to observe cumulative effects until they are bunched together so closely that they seem completely external and impersonal. No matter how completely technics relies upon the objective procedures of the sciences, it does not form an independent system, like the universe: it exists as an element in human culture and it promises well or ill as the social groups that exploit it promise well or ill. The machine itself makes no demands and holds out no promises: it is the human spirit that makes demands and keeps promises. In order to reconquer the machine and subdue it to human purposes, one must first understand it and assimilate it. So far, we have embraced the machine without fully understanding it, or, like the weaker romantics, we have rejected the machine without first seeing how much of it we could intelligently assimilate.

The machine itself, however, is a product of human ingenuity and effort: hence to understand the machine is not merely a first step toward re-orienting our civilization: it is also a means toward understanding society and toward knowing ourselves. The world of technics is not isolated and self-contained: it reacts to forces and impulses that come from apparently remote parts of the environment. That fact makes peculiarly hopeful the development that has been going on within the domain of technics itself since around 1870: for the organic has become visible again even within the mechanical complex: some of our most characteristic mechanical instruments—the telephone, the phonograph, the motion picture—have grown out of our interest in the human voice and the human eye and our knowledge of their physiology and anatomy. Can one detect, perhaps, the characteristic properties of this emergent order—its pattern, its

planes, its angle of polarization, its color? Can one, in the process of crystallization, remove the turbid residues left behind by our earlier forms of technology? Can one distinguish and define the specific properties of a technics directed toward the service of life: properties that distinguish it morally, socially, politically, esthetically from the cruder forms that preceded it? Let us make the attempt. The study of the rise and development of modern technics is a basis for understanding and strengthening this contemporary transvaluation: and the transvaluation of the machine is the next move, perhaps, toward its mastery.

CHAPTER I. CULTURAL PREPARATION

1: Machines, Utilities, and "The Machine"

During the last century the automatic or semi-automatic machine has come to occupy a large place in our daily routine; and we have tended to attribute to the physical instrument itself the whole complex of habits and methods that created it and accompanied it. Almost every discussion of technology from Marx onward has tended to overemphasize the part played by the more mobile and active parts of our industrial equipment, and has slighted other equally critical elements in our technical heritage.

What is a machine? Apart from the simple machines of classic mechanics, the inclined plane, the pulley, and so forth, the subject remains a confused one. Many of the writers who have discussed the machine age have treated the machine as if it were a very recent phenomenon, and as if the technology of handicraft had employed only tools to transform the environment. These preconceptions are baseless. For the last three thousand years, at least, machines have been an essential part of our older technical heritage. Reuleaux's definition of a machine has remained a classic: "A machine is a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinant motions"; but it does not take us very far. Its place is due to his importance as the first great morphologist of machines, for it leaves out the large class of machines operated by man-power.

Machines have developed out of a complex of non-organic agents for converting energy, for performing work, for enlarging the me-

chanical or sensory capacities of the human body, or for reducing to a mensurable order and regularity the processes of life. The automaton is the last step in a process that began with the use of one part or another of the human body as a tool. In back of the development of tools and machines lies the attempt to modify the environment in such a way as to fortify and sustain the human organism: the effort is either to extend the powers of the otherwise unarmed organism, or to manufacture outside of the body a set of conditions more favorable toward maintaining its equilibrium and ensuring its survival. Instead of a physiological adaptation to the cold, like the growth of hair or the habit of hibernation, there is an environmental adaptation, such as that made possible by the use of clothes and the erection of shelters.

The essential distinction between a machine and a tool lies in the degree of independence in the operation from the skill and motive power of the operator: the tool lends itself to manipulation, the machine to automatic action. The degree of complexity is unimportant: for, using the tool, the human hand and eye perform complicated actions which are the equivalent, in function, of a well developed machine; while, on the other hand, there are highly effective machines, like the drop hammer, which do very simple tasks, with the aid of a relatively simple mechanism. The difference between tools and machines lies primarily in the degree of automatism they have reached: the skilled tool-user becomes more accurate and more automatic, in short, more mechanical, as his originally voluntary motions settle down into reflexes, and on the other hand, even in the most completely automatic machine, there must intervene somewhere, at the beginning and the end of the process, first in the original design, and finally in the ability to overcome defects and to make repairs, the conscious participation of a human agent.

Moreover, between the tool and the machine there stands another class of objects, the machine-tool: here, in the lathe or the drill, one has the accuracy of the finest machine coupled with the skilled attendance of the workman. When one adds to this mechanical complex an external source of power, the line of division becomes even more difficult to establish. In general, the machine emphasizes specializa-

tion of function, whereas the tool indicates flexibility: a planing machine performs only one operation, whereas a knife can be used to smooth wood, to carve it, to split it, or to pry open a lock, or to drive in a screw. The automatic machine, then, is a very specialized kind of adaptation; it involves the notion of an external source of power, a more or less complicated inter-relation of parts, and a limited kind of activity. From the beginning the machine was a sort of minor organism, designed to perform a single set of functions.

Along with these dynamic elements in technology there is another set, more static in character, but equally important in function. While the growth of machines is the most patent technical fact of the last thousand years, the machine, in the form of the fire-drill or the potter's wheel, has been in existence since at least neolithic times. During the earlier period, some of the most effective adaptations of the environment came, not from the invention of machines, but from the equally admirable invention of utensils, apparatus, and utilities. The basket and the pot stand for the first, the dye vat and the brick-kiln stand for the second, and reservoirs and aqueducts and roads and buildings belong to the third class. The modern period has finally given us the power utility, like the railroad track or the electric transmission line, which functions only through the operation of power machinery. While tools and machines transform the environment by changing the shape and location of objects, utensils and apparatus have been used to effect equally necessary chemical transformations. Tanning, brewing, distilling, dyeing have been as important in man's technical development as smithing or weaving. But most of these processes remained in their traditional state till the middle of the nineteenth century, and it is only since then that they have been influenced in any large degree by the same set of scientific forces and human interests that were developing the modern power-machine.

In the series of objects from utensils to utilities there is the same relation between the workman and the process that one notes in the series between tools and automatic machines: differences in the degree of specialization, the degree of impersonality. But since people's attention is directed most easily to the noisier and more