

perce66

Man in the Age of Technology

Arnold Gehlen

Translated by Patricia Lipscomb

With a Foreword by Peter L. Berger

Columbia University Press · New York · 1980

1 Man and Technique

The Organic and its Substitutes

SINCE THE TIMES of Nietzsche and Spengler a literature concerned with criticizing contemporary society and culture has flourished in Germany; and among its persistent motifs has been a polemic against technique.* This is a symptom that our own society has not yet finished its internal debate over the radical changes in its nature which are associated with the advance of industrialization. In Germany, public discussion often brings to the fore anxieties over the future state's probable similarity to an anthill; the manipulation of regimented brains; the individual's bewilderment, and the culture's decay. In this context, technique often appears in the role of the defendant, whereas it seems to enjoy remarkable popularity in the United States and in Soviet Russia. The Americans possess a widely diffused science fiction literature which enthusiastically projects technological Utopias, and takes pleasure in contemplating such extravagant conceptions as, for instance, a mastery over time which would allow one to wander, touristlike, into the societies of times long past.

It is not at all clear why in Germany we remain reluctant to concede the same rights of citizenship to technique as to other realms of culture, in spite of our achievements in technological innovation. The explanation may partly

* "Technique" is much less commonly used in English in this sense than is "technology"; but the meaning associated with the latter term is too narrow for the German *Technik*.

2 MAN AND TECHNIQUE

lie in the persistence of traditional views concerning the superiority of theory over practice, of pure over applied science. Or perhaps the old idea lives on, that the intellectual resources of idealistic philosophy can come to terms with all human problems; whereas, in reality, they are at a loss when confronted with technique. Indeed, on the whole, our philosophical concepts are in no way adequate to the circumstances of our own time. Our task here, however, is not the very large one of remedying this state of affairs, but a more modest one, to be pursued within the framework of philosophical anthropology. We shall look for objective viewpoints from which we may bring this astonishing domain of the human mind—technique—to bear upon our understanding of ourselves.

Technique is as old as man himself, for when we deal with fossil remains it is only when we come upon traces of the use of fabricated tools that we feel sure we are dealing with men. Indeed, the roughest wedge hewn of flint embodies the same ambiguity which today attaches to nuclear energy: it was a useful tool, and at the same time a deadly weapon. The modification to his own ends of things originally found in nature is an activity of man connected from the beginning with his struggle against his fellow man; and only quite recently have we sought to undo this fateful connection. If this endeavor is to succeed and produce perpetual peace, it must presuppose a very high level of technical attainment, without which no effective mutual control of armaments can be achieved.

Further reflection throws light upon this involvement of man with technique. Building upon Max Scheler's work,¹ modern anthropology indicates that man, lacking specialized organs and instincts, is not naturally adapted to a specific environment of his own, and is thereby

3 MAN AND TECHNIQUE

thrown upon his ability to transform intelligently any pre-constituted natural conditions. Poorly equipped as he is with sensory apparatus, naturally defenseless, naked, constitutionally embryonic through and through,* possessing only inadequate instincts, man is a being whose existence necessarily depends upon *action*.² On the strength of such considerations, such authors as W. Sombart, P. Alsberg, J. Ortega y Gasset, and others, have derived the necessity of technique from the limits of man's physical potential.³

Thus, among the oldest artifacts we find weapons, which are not given to man in the form of organs; fire should also be thought of in this connection, having come into use both for security and for warmth. From the beginning this principle of organ substitution operated along with that of organ strengthening: The stone grabbed to hit with is much more effective than the bare fist. Thus, next to *replacement techniques* that allow us to perform beyond the potentials of our organs, we find *strengthening techniques* that extend the performance of our bodily equipment—the hammer, the microscope, the telephone reinforce natural abilities. Finally, there are *facilitation techniques*,[†] operating to relieve the burden upon organs, to disengage them, and finally to save effort—as when use of a wheeled vehicle replaces the dragging of weights by

* In *Der Mensch* Gehlen argues, on evidence from comparative embryology, that the human gestation period is too short (by several months) to bring the human fetus to the same level of maturity at birth as for the fetus of closely related species.

† We translate the German *Entlastung* as "facilitation." *Entlastung* is a key term in Gehlen's philosophical anthropology. It characterizes the human being, as compared to other animals, as "burdened" (*belasten*) with the necessity of making arrangements for its own survival, due to the insufficiently tight fit between human physical equipment and the environment. It is thus the task of those arrangements to relieve or facilitate (*entlasten*) man's existence.

hand. If one flies in an airplane, all three principles operate—the plane supplies us with the wings we do not possess, outperforms all animal flights, and relieves us of making any contribution whatever to our own motion over vast distances.

Ultimately, all attainments of the human mind remain enigmatic; but the enigma would be all the more impenetrable if not seen in connection with man's organic and instinctual deficiencies; for his intellect relieves him from the necessity to undergo organic adaptations to which animals are subject, and conversely allows him to alter his original circumstances to suit himself. If by technique we understand the capacities and means whereby man puts nature to his own service, by identifying nature's properties and laws in order to exploit them and to control their interaction, clearly technique, in this highly general sense, is part and parcel of man's very essence. It truly mirrors man—like man himself it is clever, it represents something intrinsically improbable, it bears a complex, twisted relationship to nature.

These features are illustrated by the fact that the earliest and most fundamental technical attainments were achieved without reference to models given in nature. This is true of the starting of fires by friction of wood upon wood, of the invention of the bow and arrow, and above all of the use of the wheel, the rotating movement around an axis. This invention is so abstract that it was not attained even in high cultures, such as those of pre-Columbian South America, which possessed elaborate literatures, complex state apparatuses, and highly developed religions, and yet had to make do without the cart or the potter's wheel. Equally unprecedented in nature is propulsion by means of an explosion, as is one of the very oldest in-

ventions—that of the flint knife, which goes back to the Günz-Mindel interglaciation, half a million years ago. G. Kraft has pointed out that nowhere in nature do we find anything like a sharp blade which, propelled in a given direction, produces a straight or a curved cut.⁴

The world of technique, then, embodies the features we associate with our images of a "great man." Like that man, it is inventive, resourceful, life-fostering and at the same time life-destroying, involved with primeval nature in a complex relationship. Technique constitutes, as does man himself, *nature artificielle*.

Over the ages, the tendency to replace missing organs has reached beyond the sphere of the body, and penetrated into deeper and deeper organic strata. The replacement of the organic by the inorganic constitutes one of the most significant outcomes of the development of culture. There are two aspects to this tendency: artificial materials replacing those organically produced; and nonorganic energy replacing organic energy. As to the former, the development of metallurgy constitutes a cultural threshold of the first magnitude; we speak of the Bronze Age, Iron Age, etc. Metals replace and outperform materials immediately available in the environment, particularly stone and wood. As late as the Middle Ages ships, bridges, vehicles, and tools were largely made of wood, and no other fuel was known. Today, concrete, metals, coke, coal, and numerous synthetic materials have largely supplanted wood, and car bodies made of plastic may soon replace those made of steel. Leather and hemp have been replaced by steel cables, wax candles by gas or electricity, indigo and purple by aniline dyes, nearly all natural drugs and medicinal herbs by synthetic products. As Freyer has argued, the ultimate goal seems to be to produce materials with certain

selected properties.⁵ Thus the chemist says, "I want to produce a substance which can be molded at first, but then hardens spontaneously; another which would remain plastic at no matter what temperature; a third which might be carved at will, and a fourth one which can be spun into very fine thread."

As to the other aspect of this tendency, that is, inorganic supplanting organic energy, with the steam engine and the internal-combustion engine civilization has become dependent upon underground supplies of coal and oil. Ultimately these too are legacies of past organic life, yet they entail a key transition: as far as energy sources are concerned, mankind has made itself independent of those that are renewed from year to year. As long as wood remained the most significant fuel material, and the work of domestic animals the most important source of energy, the advance of material culture, and thus ultimately population growth, met a *limit* of a nontechnical kind that rested upon the slow tempo of organic growth and reproduction. By building hydroelectric power stations and by gaining control over nuclear energy, man has freed his energy supplies from the limitations of the renewal of organic substances.

The tendency, which characterizes the progress of technique, from the substitution for organs to the replacement of the organic as a whole, is ultimately rooted in a mysterious law pertaining to the realm of the mind. Briefly put, this law is: Nonorganic nature is more knowable than organic nature. Bergson has duly emphasized this.⁶ Our capacity for rational thinking, and the abstract models and mathematical concepts which it produces, approximate the givens of inorganic nature with astonishing exactitude; whereas, in spite of all progress in organic chemistry, we

are not much better informed than were the earliest philosophers of classical Greece as to the real nature of life. According to Bergson, intellect can only be judged in relation to action, and its primary aim is the production of artifacts: "Therefore . . . we may expect to find that whatever is fluid in the real will escape [the intellect] in part. Our intelligence, as it leaves the hands of nature, has for its chief object the unorganized solid."⁷

The basic knowability of inorganic nature and the stubborn irrationality of the organic are remarkable facts in themselves; but it is even more remarkable that only very recently has man learned to represent the course of natural events as a dead, wholly material, yet uniform process. One can conceive of nature as "an external world of facts," as a realm of things, of properties, and of regular transformations affecting them, a realm legitimized exclusively by virtue of being there and occurring in a certain fashion.⁸ This world saturated with facts, accounted for on equally factual grounds, constitutes *one single* complex, sufficient unto itself and legitimized by its sheer existence and its factual properties. Such a conception was occasionally put forward by early Greek philosophers, and made its reappearance in the seventeenth century with the rise of exact, experimental, natural science. This outlook need not be construed as an express philosophical theory (which as such would stand near positivism or materialism); rather, it generalizes an attitude inherent in scientific research and in technical practice from the time they began to be engaged in as distinctive activities. (There is a distinction between those unarticulated presuppositions which underlie the actual conduct of people, and the properly theoretical views those people may consciously expound.)

These last considerations are basic to the following

argument: the supplanting of organic by inorganic materials and energy through the development of technique is grounded on the fact that the realm of inorganic nature most easily offers itself to methodical, rational analysis, and to the associated practice of experimentation. The biological realm and that of the psyche are incomparably more irrational. Technicians and natural scientists tend to shape their own world views in accordance with the positivism-of-facts described above. The more successful sciences and techniques exercise a kind of radiation effect upon our image of the world.

In spite of this, this view of the world has been current only over the last three centuries, although mankind began to produce by means of technique some half million years ago.

The Modern Age: Its Superstructure

We all sense that since the times of stone tools or of the bow and arrow a *qualitative* transformation has occurred in what we call technique. But this change should not, as is often the case, be thought to consist in the transition from the simple tool to the machine. If we call "machine" any material arrangement which transmits energy and performs work, we can apply this term to the hunter's trap with its triggering mechanism, which has existed since the Stone Age. Even a rotating movement backward and forward can already be found in the Stone Age fiddle drill, and the continuous rotating movement of a working machine (water wheel) goes back to Roman times. Thus the difference between tool and machine is not the key qualitative difference involved in the transition from premodern to modern technique.

We get closer to the truth if we cease to visualize single machines, utensils, or discoveries, and consider instead structural changes in whole areas of culture. In the seventeenth and eighteenth centuries the natural sciences attained the modern configuration, that is, they become analytical-experimental. Briefly, an experiment consists in isolating natural processes in such a way as to make them open to observation and measurement. In two senses this makes the natural sciences, which previously relied basically on occasional observation and on speculation, similar to technical practice. In the first place the tools of physical experimentation are comparable to machines, although they are intended not to produce useful effects but to bring about pure, isolated natural phenomena. Even the inclined plane, used by Galileo to study the fall of bodies, is a "simple machine" of this nature. In the second place, by means of the logic of experimentation one isolates a natural process (which one observes under varying conditions), and to that extent the experiment constitutes a first step toward the technical use of that process. In this way, two spheres of culture, which formerly came together only in a few fields (in particular, in the construction of navigational devices, optical instruments, and precision weapons), and for the rest had remained essentially separate from one another, are now brought into the closest methodological connection. Technique derived the breathtaking tempo of its advance from the new natural science, and the science acquired from technique its practical, constructive, un-speculative bent.

Nonetheless, the astonishing accomplishments of the modern era would not have been achieved without the intervention of a third factor, the contemporary emergence of the capitalist mode of production, whose spirit, as Max

Weber showed, is a further product of the seventeenth century.⁹ The invention, or rather the radical improvement, of the steam engine by James Watt was financed by a capitalist interested in its industrial exploitation. Either entrepreneurs or states interested in techniques of warfare (note, for instance, the early employment of the wireless telegraph by war fleets) made possible experimental discoveries and their practical applications.

Today it is vital to understand the functional connection between natural science, technique, and the industrial system. Scientific research employs ever-new technical devices; nature is forced open through technique. The scientist must reach an understanding with the technician, for each problem is defined by the not-yet-available equipment required to solve it. Advances in theoretical physics, for instance, depend no less upon electronic computers than upon the brains of physicists. Measurements carried out with the cyclotron, using energies of several million electron volts, enter the values under calculation and thus the related theories. On the other hand, the larger industrial complexes possess their own research establishments. Natural science is no longer the monopoly of universities—indeed sometimes only grants from industry allow otherwise underfinanced laboratories in technological universities to keep going. The notion that technique constitutes “applied science” is obsolete and old-fashioned; today the three establishments—industry, technique, and natural science—presuppose one another. What is the ultimate basis of pharmaceutical chemistry—biochemical research, the industrial firms that commission it, or the production and marketing organizations of those firms? It no longer even makes sense to pose the question in this fashion.

Supernatural Technique: Magic

The rapid advance of modern technique has thus taken place in close alliance with natural science and the capitalist mode of production, which extend their hold with equal rapidity. All these factors feed upon one another. One cannot expect such historically unique and radical processes to remain without influence upon the consciousness of the men involved in them. The pragmatic-positivistic attitude which characterizes this “industrial system” has decisively extended its reach beyond the confines of the system within which it originally developed. It has affected, for instance, the political realm and, even more so, the realm of interpersonal relations. We shall have to deal with these phenomena later on, since they constitute the social-psychological problems of industrial society. For the time being, however, we must develop another idea, which should help to illuminate the human condition. This concerns the human impulses operating in the technical realm.

During by far the greatest part of its history, as we have seen, mankind has made do with fairly modest technical resources, however ingenious those early discoveries might have been. Such basically simple instruments and artifacts as the war chariot, firearms, or the plow, could have extraordinarily significant historical and social consequences. Even so, technique did not come to occupy the very center of man’s vision of the world, and thus also of his conception of himself. This is what is happening today, when for instance we look at cybernetics, to the theory of techniques of regulation, for clues to the workings of our own brains and nervous systems.¹⁰

If we ask, “Why did this not happen before?” we get a surprising answer. For millennia, in all primitive cultures

as well as in the higher ones (the Egyptian, the classical, etc.), man believed in the possibility of a "supernatural technique"—of what today we call magic. Since prehistoric times magic has held a central place in man's conception of the world and of himself. Even in monotheistic cultures which denied the possibility of magic, magic maintained a foothold on the margins of society—as shown by the trials of witches and magicians in the Middle Ages—and only modern, technical-scientific culture has dealt it a mortal blow.

Maurice Pradines calls magic "an attempt to bring about changes to the advantage of men, by diverting things from their own path and toward our own service."¹¹ It is easy to see that this definition can encompass both magic and technique proper, thus both supernatural and natural technique.

We cannot undertake, here, a closer analysis of magic,¹² but we must emphasize its tremendous diffusion in time and space. If we consider the remarkable similarities found in the magical practices of all races and civilizations, we see that magic must involve something anthropologically fundamental. "Rainmaking," for instance, was practiced in classical antiquity; according to Diogenes Laertius, Empedocles possessed this skill. The *Hammer of Witches* (1487) gives explicit directions for counter-magic to be used against magically induced bad weather. New Guinea natives practice rainmaking, just as do Omaha Indians, the Bantus of Delagoa, and the Chinese.

If we consider more closely the numerous accounts and documents available, a central concern of the magical "arts" becomes evident: the need to ensure the "regularity of the process of nature," and to "stabilize" the world's rhythm by smoothing out irregularities and exceptional oc-

currences. Thus, when defective births, moon or sun eclipses, or other strange events appear as unfavorable "signs" against which magic must intervene, what is being sought is the reinstatement of the usual uniformities of nature, just as when magic is employed to call forth the usual rains or winds which have failed to appear. The same holds true for the innumerable examples of "fertility magic," used to ensure the cycles of vegetable life or to increase the number of plants or animals. In fertility magic it is important to respect precisely given dates, seasons, or hours, or perhaps recurring phases such as the beginning of cultivation, of sowing, or of harvesting.

This primary human interest in the regularity of the processes of nature deserves emphasis: It betrays a semi-instinctual *need for stability in the environment*. Since reality is unavoidably subject to time and to change, the most stability one can hope for consists in the same effects repeating themselves automatically and periodically, as indeed they tend to do in nature. The primeval, "a priori" conception of the world, not yet influenced by science, views the world, and the men who are part of it, as caught in a rhythmic, self-sustaining, circular process of motion, thus constituting an animated *automatism*. Also, the magical forces with which the world is filled are neither arbitrary nor spontaneous; one can set them into motion by means of the appropriate, precisely repeated formulas, after which they operate under their own impulse, necessarily and automatically.

A considerable residue of this primeval, innate view is still present in astrology, in spite of all the "rationalizing" effects of the new, scientific world image. Most of us would be astonished at the number of businessmen and politicians who believe in an inescapable connection be-

tween the immense, rotating mechanism of the stars and the destinies of individuals—a connection which the metaphysics of primitive peoples views, without any sense of contradiction, as both willed by spirit and necessary. Something that has resisted all the thrusts of offended reason must obviously be deeply rooted in the mind of mankind.

The fascination with automatism is a prerational, transpractical impulse, which previously, for millennia, found expression in magic—the technique of things and processes beyond our senses—and has more recently found its full realization in clocks, engines, and all manner of rotating mechanisms. Whoever considers from a psychological viewpoint the magic which cars exercise upon today's young, cannot doubt that the interests appealed to lie deeper than those of a rational and practical nature. If this seems improbable, one should consider the fact that a machine's automatism exercises a fascination entirely independent of its practical uses, a fascination that might well be best embodied in a perpetual-motion machine whose only goal and activity would consist in forever reproducing the same circular motion. None of the innumerable individuals who over the centuries have grappled with the insoluble problem of perpetual motion, did so in view of any practical effect. Instead, they were all fascinated by the singular appeal of a machine that runs itself, a clock that winds itself. Such an appeal is not merely intellectual in nature, but has deeper sources.

That appeal involves what we may call a resonance phenomenon. Beset by the enigma of his own existence and his own nature, man must define himself by referring to what is other than himself, other than human. His awareness of himself is indirect, and his search for a self-

definition always must consist in comparing himself to something nonhuman, and then differentiating himself from that.¹³ It is not difficult to establish this point with reference to the concepts of divinity of the higher monotheistic or polytheistic religions, or alternatively with reference to the much more ancient and more widely diffused myths concerning man's descent from animal demons. Also, in interpreting his own psyche, man has largely referred to phenomena of the external world; availed himself of shadows, of blood, of mirror images and other visual phenomena in order to penetrate his own inner nature. Primitive religions have found throughout nature silent answers to the question of man's own essence.

Within this orientation, however, what necessarily makes the greatest impression is the fact that natural processes advance rhythmically and periodically, with an imperturbability that bespeaks a "logic," whether the attention be fastened upon the puzzling exactitude of the recurrent motions of the stars, or upon the stubborn, stereotyped, immutable habits of animals. And in fact, in a number of quite central aspects of his own nature man himself is an automatism; he is heartbeat and breath, he lives in and by a number of meaningful, functioning, rhythmical automatisms—think of the motions of walking, think above all of the ways in which the hand operates. Think of the "circle of action" which goes through object, eye, and hand, and which in returning to the object concludes itself and begins anew. The fascination exercised by the analogous processes of the external world bespeaks a "resonance," which conveys to man an intimate feeling for his very nature, by focusing on what echoes his nature in the external world. And if we today still speak of the "course" of the stars and of the "running" of machines, the

similarities thus evoked are not in the least superficial; they convey to men certain distinctive conceptions of their own essential traits based on "resonance." Through these similarities man interprets the world after his own image and, vice-versa, himself after his image of the world.

Objectification and Facilitation

We come thus to a point of great significance for determining the relationship between man and technique. For if there is a deep-seated bond between man and those processes of the external world that advance rhythmically, periodically, under their own momentum, this makes more comprehensible the *drive components* (*Triebkomponente*) implicit in technique. There is a widespread prejudice, largely of academic origin, to the effect that technical behavior is "merely rational" and "exclusively goal-oriented." Yet, as Hermann Schmidt has emphasized, the *objectification of labor* involved in technical phenomena is the result of a process specific to mankind, but of which we as individuals are not conscious, and whose motivation flows from the "sensual side of our nature." "Any group of men placed under identical conditions would always undertake to objectify labor as in response to a drive." In this connection, Schmidt quotes a remarkable statement of Walter Rathenau's: "Mechanization is not the result of free, conscious deliberation, expressing mankind's ethical will; rather, it grew without being intended, or indeed even noticed. In spite of its rational and casuistic structure, it is a dumb process of nature, not one originating from choice."¹⁴

The process in question can be variously construed.

Man—as I have shown at length elsewhere—is a being constituted for *action*, for the modification of the facts of the external world.¹⁵ One of his essential characteristics is the *circle of action* (*Handlungskreis*)—a modifiable, directed motion capable of correction on the basis of its outcome, and which in the end may become automatized and wholly habitual.¹⁶ "Each of our meaningful operations," writes H. Schmidt, "necessarily takes this form of a self-contained circle of action, where feedback connects the subject with himself on the basis of the previous results of his action." *Each* is appropriately said, for even the speaking-hearing circle constitutes such a circle of action—and language is the vehicle of all mental activity. "The circle of action is the universal form of man's meaningful expression."¹⁷ In keeping with this, Norbert Wiener calls feedback a very general feature of forms of behavior: "In its simplest form the feedback principle means that behavior is scanned for its results, and that the success or failure of this result modifies future behavior."¹⁸

It is not easy to understand the irrational impulses at work within technique. The need of man to read himself into nature and then to interpret himself in terms of nature (a need evidenced all over the world, and preserved at the very core of religion) is fundamental. All periodical, cyclical processes evoke a near-instinctual resonance in man; from the beginning he has seen himself as caught in a cycle of rebirth. Having thus brought himself close to the world, he relates to it mainly through his own power to act. Magic as supernatural technique brings into the circle of action the totality of the external world, makes it possible to summon the wind, to call forth the seasons, to transfer one's illnesses to animals. The basic need behind

the practice of magic—the need to stabilize the course of the world and free it from disturbances—is the need of an acting being.

It is an equally primeval fact, however, that man also objectifies his own material action, and through it makes an impact upon the world; he sees his action as part of the world, allows the latter to extend and reinforce his own action; he “objectifies” his own labor. Hence the tool. The stone is a “representation” of the fist, stands in its stead, and indeed magnifies its effect. Thus the narrow sphere of one’s actual control merges into the wider sphere of what one can control through imagination. In fact the expenditure of one’s physical energy diminishes in relation to the masses set in motion. Working with tools is demanding, but magical formulas suffice to stabilize the weather or to guarantee the spring’s return.

Here one can see in operation a further, fundamental human law: the tendency toward facilitation. As we have made clear elsewhere, the principle involved is one of general anthropological significance.¹⁹ Here only its implications for technique are relevant: the “larger circle of action” of magic relieves the burden of the weakness and helplessness one feels when confronted with the powers of nature, by facilitating the reduction of the world to human dimensions. The smaller circle, that involving work, facilitates in the literal, physical sense. The “objectification of human labor” into the tool makes it evident that a lesser effort can achieve greater results; for this reason we have already discussed the use of tools as a matter of organ facilitation.

One should not forget a third process of facilitation; both techniques share the same, implicit purpose, or at any rate tendency, to build habits, to lay down routines, to

make many actions a matter of course. This third tendency toward facilitation is expressed by R. Wagner as follows: “In this fashion the supreme tribunal, the cerebral cortex, frees itself time and again of whatever task has become highly probable, everyday and trivial, and keeps itself available for unusual and more sensational performances.”²⁰

One may now understand why technique, from its beginnings, operates from motives that possess the force of unconscious, vital drives. The constitutional human features of the circle of action and of facilitation are the ultimate determinants of all technical development. This is not to say that one may predict the content of a given invention by reference to those determinants; clearly the operation of an engine is to be understood on the basis of physical and technical considerations, rather than by reference to the motives leading up to its construction. However, if we consider the development of technique in its totality, we come upon a law more fundamental than these physical considerations, a law obeyed unconsciously yet invariably, which can only be identified on the basis of the concepts of the progressive objectification of human labor and performance, and of increasing facilitation.

This process develops in three stages. In the first, that of the tool, the physical energy necessary for labor and the required intellectual input still depend on the subject. In the second, that of the machine, physical energy becomes objectified by means of technique. Finally, in the third stage, that of automata, technical means make dispensable also the intellectual input of the subject. With each of these steps, the objectification of goal attainment by technical means advances, until the goal we have set ourselves is accomplished, in the case of automata, without our physical or intellectual participation. In automation, technique

attains its methodical perfection, and this conclusion of a development in the technical objectification of labor which had started in pre-history, is a distinctive feature of our own time.²¹

In the course of this development, which accompanies and largely determines the history of mankind, it is only recently that technique has come to occupy the space held for hundreds of thousands of years—during the times when men knew only primitive tools—by magic, the “supernatural technique.” But magic was also intended to (in the words of Pradines) “divert things from their own paths and toward our own service”; it sought unconsciously to strengthen the effectiveness, to multiply the reach of human action; and it envisaged something like the “great automatism,” whose operations are regulated by the information feeding back from areas of possible disturbance.

Automation

H. Schmidt's law of the three stages suggests that, from man's standpoint, the objectification of actions and faculties into the external world develops as if from the outside toward the inside. At first it is the performance of organs which are strengthened, improved, facilitated. Then the same thing happens to physical energy inputs: the energy expenditure originally carried out organically (by animals or by man) is taken over by nonliving matter. In the third stage, where we find ourselves, what becomes objectified is the circle of action itself, including its control and direction. At the same time, that part of physiological life which operates through circular sensory-motor processes becomes objectified—as does that part in which regulation is performed in a wholly automatic fashion, for instance by means of chemically transmitted information. Finally,

computing automata can solve differential and integral equations faster and more effectively than man, and appear as “a new source of mathematical knowledge.”²²

These modern regulatory devices endowed with feedback all rest on the principle that, unlike the automobile, the system does not vary in its operations according to commands imparted from outside, but rather under the influence of the results of those operations themselves. To this end one must build into such automata sensory devices, such as a thermosensor in the hot water tank, which switches an electric current on or off according to the temperature. Here thermal quantities are being regulated, but a variety of mechanical and electrical ones can similarly be regulated. “The essential is that such a mechanism should continuously react upon itself via a closed circle. Or, as one might also say: These devices are so arranged that a very small portion of the energy stream traversing the system is put to use for the regulation of the energy stream itself.”²³

The circle of regulation* can be considered in the first place as a “copy” of the circle of action; and in fact it is technically possible to build a car where the burden of driving is taken off the driver and taken over by automatic controls. But, apart from the circle of action, the same structural principle is found to operate in many physiological regulatory processes. The regulation of blood pressure, for instance, takes place through a self-enclosed circle of operations endowed with feedback.²⁴ Within the walls of the larger blood vessels, the aorta for instance, there are sensitive nerves which report information about rising blood pressure to a vascular nerve center in the medulla

* *Regelkreis*: the expression adopted in the text translates literally a German term whose meaning is not very different from “feedback.”

oblongata, and there activate a countereffect. The tension in the walls of the peripheral vessels is reduced; they become dilated and admit a larger flow from the aorta, where, as a consequence, the pressure diminishes. But this activates the opposite process, so that the blood pressure oscillates, pendulumlike, around a central value. Numerous biological states such as the regularity of breathing, the saline concentration and sugar content of blood, and bodily temperature, are regulated in this fashion, as is, for instance, the vestibular organ that controls equilibrium. Physiologists employ concepts also used in the realm of feedback automata, such as that of "reafference," in order to describe more effectively both voluntary and involuntary movements.²⁵

A philosophical evaluation of such matters would be premature, and it is best to avoid hasty mechanistic interpretations, such as that the insights into "life" afforded us by the technical circle of regulation have now made plain the mechanical nature of life itself. All one can say is that the circle of regulation, viewed as a complex of operations, appears to share the same *form* as the human circle of action and a number of physiological mechanisms of regulation; but this allows for fundamental differences in the components of that form. Thus what we have is an "isomorphism," a similarity of configuration,²⁶ not a similarity of nature; and we are today no closer than before to a "synthesis" of life. This leaves open the possibility of taking certain life processes, including some of the greatest significance, and treating them as objects in the external world, inanimate, and as it were "estranged." There are other, equally significant, processes for which this is not as yet possible; though cell division has already been analyzed with reference to regulation processes.

Thus the advance of technique allows man to transfer into inanimate nature a principle of organization which operates at various points within the organism. We have spoken of inanimate nature, meaning by this not unprocessed, raw, lifeless nature, but rather technical equipment produced by man himself. Prehistoric man attributed to raw nature a principle of organization, though in fantastic form, when he employed magical techniques to address the clouds or the winds as if they could hear him.

Modern technologists, however, have developed their regulatory devices without being aware of their isomorphism with biological processes, which became apparent only later; they have somehow, *unconsciously* and *semi-instinctively*, produced models applicable to certain life processes. As a predictable result of this, rich areas of experience such as technology, physiology, biology, and psychology, will enter into closer and more frequent contact, exchanging queries and theories with one another. It is still too early to consider cybernetics as a distinctive, self-standing, general science. For the time being it constitutes an endeavor to consider jointly and to cross-fertilize several sciences. Sociology will have to be added to those disciplines already mentioned, since the notion of "signaling back" raises the problem of communication, or rather of information transmission, not only in machines (such as computers) but also in living beings.