Quelle 3

Zum Inhalt:

Menschen waren schon immer auf die Nutzung von Technik angewiesen, aber seit dem 19. Jahrhundert leben wir in einer »verdichteten« technischen Kultur. Was dies für eine moderne Technikgeschichte bedeutet, erläutert Martina Heßler anhand der Bereiche Produktion, Haushalt, Mobilität und Kommunikation, Menschenbild sowie Unfälle und deren Folgen. Dabei schildert sie, wie sich Praktiken und Wahrnehmungen – vor allem in Bezug auf Raum und Zeit – und das menschliche Selbstverständnis im Kontext von Technologien wandelten. Sie liefert damit eine umfassende Einführung in Zugänge und Gegenstand der Technikgeschichte. Darüber hinaus begründet sie eine Kulturgeschichte der Technik, die auch zukünftige Entwicklungen in den Blick nimmt.

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Zu S. 60 im Buch

Die automatisierte Fabrik wurde in den 1950er Jahren in der westlichen Welt intensiv diskutiert. Unmittelbar nach dem Zweiten Weltkrieg begannen beispielsweise bei Ford oder General Motors Bemühungen zur Automatisierung der Produktion. Während vielfach kritische Stimmen laut wurden und beispielsweise Helmut Schelsky oder Friedrich Pollock, aber auch der Kybernetiker Norbert Wiener auf die Gefahren der Automatisierung für eine Arbeitsgesellschaft hinwiesen, äußerten sich zwei kanadische Autoren, Eric Leaver und John Brown, euphorisch über die Möglichkeit, Menschen durch Maschinen zu ersetzen. Sie betonten die Überlegenheit der Maschine, die besser, zuverlässiger, genauer arbeite als Menschen und zudem ununterbrochen und ohne Widerstände die Tätigkeiten ausführe. Sie nutzten damit Argumente, die im Kontext der Automatisierungsdiskussion immer wieder verwendet werden sollten und eine Überlegenheit der Maschine postulierten. Ihr Artikel aus dem Jahr 1946 ist offensichtlich inspiriert von der Kybernetik. Sie prophezeiten Maschinen, die sehen, hören und tasten können. Das Textdokument ist ein typisches Beispiel der in den 1950er Jahren zu findenden Automatisierungseuphorie.

Aus: Eric Leaver/John Brown, »Machines Without Men«, in: *Fortune Magazine* 5, 1946.

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Machines Without Men

BY E. W. LEAVER AND J. J. BROWN

ARGUMENT: *The modern factory could well be automatic, scientific, flexible, and functional. It is not, because it still depends too heavily on manpower, tradition, and rule of thumb. The elements required to build a fully automatic factory are now known; they have not been integrated into a coherent structure because such a simplification is opposed by the current philosophy of machine design. This philosophy leads to specialization of a machine in terms of its* product, *rather than in terms of its* function. *When man changes his basic ideas of machine design, the effects will constitute another industrial revolution.*

Imagine, if you will, a factory as clean, spacious, and continuously operating as a hydroelectric plant. The production floor is barren of men. Only a few engineers, technicians, and operators walk about on a balcony above, before a great wall of master control panels, inserting and checking records, watching and adjusting batteries of control instruments. All else is automatic. Raw materials flow in by conveyer, move through automatic inspection units, fabricating machines, subassembly and assembly lines, all controlled from the master panels, and arrive at the automatic packaging machines as finished product—radios, refrigerators, tractors, fountain pens, carburetors, helicopters, or what you will.

This factory of tomorrow will be as different from the present manufacturing establishment as a hydroelectric plant is different from an old steam-power installation fed by a line of boiler-tenders and men digging coal. Once a hydroelectric unit is installed, all that remains is to control and distribute the power. The same, in principle, will be true of the factory of the future. Our present machine tools belong to the former coal-and-iron technology. The new organization of machines will be electrical. This is made possible by the development of a great variety of circuits and devices for linking machine units together in a new way. It will entail a greater and greater regimentation of machines, rather than of men.

Nowhere is modern man more obsolete than on the factory production floor. Modern machines are far more accurate and untiring than men. Available and in use are hundreds of electronic gadgets that can do everything a workman can, and do it faster, better, and continuously. But such gadgets heretofore have been merely attached as accessories to the familiar types of production machines. And no matter how many automatic devices have been piled on individual machines, the practical industrialist has still found it necessary to have a man operate the last control device. This is true only because industry continues to operate under an inflexible theory of machine design developed long before any electronic controls were known.

Present production machinery is the logical outgrowth of the eighteenth century and a philosophy of design that keeps the *product* rather than the *operation* in view. The Benthams in designing machinery to mass-produce pillow blocks were primarily interested in the blocks, not in the operations that produced them. This highly practical Anglo-Saxon interest exclusively in results has led industry far from the rational line of development in production machinery. It has led to increasingly uneconomic specialization. One of the latest examples is a machine made during the war to turn out aircraft cylinder heads in quantity. It was ninety feet long, a marvel of precision and ingenuity, and cost in the neighborhood of $100,000. Rough castings went in one end, and finished cylinder heads dropped out the other at the rate of one a minute. The machine is now just scrap metal; that type of cylinder head is no longer made.

The authors propose an entirely different view of machine design that will concentrate on basic operations rather than on the product. In this view the machine is considered as the total production unit, combining both the machine itself and the functions of the workman who might operate it. The parts of this machine will be as specialized as any of the present production tools, and may be even more complicated, but they will be specialized and complicated in a different way. This question of specialization is the fundamental difference between the design theory of the eighteenth century and that suggested here.

The new machine is made up of many small units plugged together. Each unit is capable of performing one function, and several plugged together will be capable of doing all the operations required to build a given part. A great number of units linked electrically and by conveyers will produce and assemble a complete product. The complete machine will be highly adaptable, with easily detachable components designed to be shuffled and rearranged at any time to build an entirely different product.

Perhaps the most immediate implication of the new machine is the replacement of unskilled labor by higher-skilled technicians and operators. But there must be no over-all reduction in the size of the labor force, for such machines will be valuable only where there is a mass market. Therefore there must be continued maintenance of a large and reasonably solvent wage-earning population. The new machines will force the issue, force society to find a better use for men than to make them mechanical operators of machines. Perhaps the first and happiest use for a flexible new system of machines may be found, paradoxically enough, in those backward industries where working conditions, rates of pay, and production have fallen so far behind that manpower shortages are a continuing problem. These backward areas exist all over the building-materials industry, in some parts of the metal-fabricating industry, in mines, and elsewhere. The manpower problem could be solved here, at one fell swoop with the material shortages themselves, by developing a machine technology that combines flexibility with automatism.

The new machines will also lead to the decentralization of

See editors' note on authors, page 196.

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industry, lessening of financial control, decline in value of sheer manpower, revision of military-security concepts, and acceleration of technological change. But before speculating on the future, let us examine the new machine in its existing parts.

Three classes of machines

Specialization of machines in terms of end product requires that the machine be thrown away when the product is no longer needed. Yet the work the production machine does can be reduced to a set of basic functions—forming, holding, cutting, and so on—and these functions, if correctly analyzed, can be packaged and applied to operate on a part as needed.

The fully automatic factory requires three types of machine units, all now available in reasonably efficient form. These basic units fall into three classes: (1) to give and receive information, (2) to control through collation, and (3) to operate on materials. Each class must first be considered in its separate parts before attempting to put together a full-scale production unit.

The machine units dealing with information correspond in function to the human senses—sight, hearing, smell, taste, and touch—as well as the more involved processes of memory and cogitation. These exist in dozens of electric and electronic forms, and may be divided into four main types.

First, there are the detectors whose function is to *obtain* information. Examples are devices for detecting differences in pressure, such as microphones and vibration pickups; for detecting differences in temperature, such as thermocouples, thermometers, pyrometers; and for "seeing," such as photoelectric cells. Equipment of this kind is now widely used as supplementary-control and warning devices in industry. The second type of information unit *carries* information from one place to another. Example: the telephone circuit. The third type, corresponding to human memory, *records* information and stores it for repeated use. Common examples are the office Dictaphone, all manner of punch-card systems, perforated tape, and recordings on plastic, paper, wire, and film. The last type of information unit is one that *calculates*. Examples range from the adding machine and other business machines to the new electronic-tube counter known as ENIAC.

The second class of basic machine unit, the collation-and-control device, is a chassis of electronic tubes and circuits that accepts information fed into it by information units and in turn feeds controlled power to the operations units in accordance with this information. Basically this class of machine compares electrical impulses from different sources and, if they do not agree, applies the difference to other circuits that act to equalize the impulses. It also is capable of accurately controlling large amounts of power to drive production machines. Such equipment, using bridge circuits and thyratron tubes, is already widely used in industry in individual machine controls. In its new application it is the link between the informational class of machine units and the machines that actually make things.

The third class of machine unit is that which performs an actual manufacturing operation. These operations may be subdivided into three types.

The first is *transport*, i.e., all sorts of moving and carrying, whether by pushing, rotary, or reciprocating motion. The material moved may be solid, liquid, or gaseous. The second fundamental operation is *fabrication*. It includes all the operations on a mass of raw material from the time it enters the plant to the

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time it leaves—from such operations as rolling, cutting, punching, forming, assembling, polishing, and painting to the final operation of packaging. The third type of operation is *holding*. In some machines the work is held while the cutting tool moves (shaper, mill, drill, forge, saw); in some the tool is held firmly and the work is moved (lathe, router); while in others both work and tool move (surface grinder, thread-cutting lathe, tool-post grinder, thread grinder). In each instance the holding is as important as the cutting.

Automatic holding and guiding mechanisms are foreshadowed in many parts of modern production machinery. An automatic screw machine makes use of fingers to feed materials, an automatic collet to grasp and hold them, and moving arms to carry a cutoff tool from one point to another. The gain in automatism here, however, is at the expense of flexibility. To obtain both flexibility and automatic production requires a new approach to machine design. One result of this new concept we call a hand-arm machine, combining most of the present automatic holding devices and some new ones. Hand-arm machines may take many possible forms, some designed for work of extreme finesse, others for heavy duty. Basically they will consist of an articulated arm, mounted in a turntable device on a heavy base, with the free end equipped with a holding fixture—gripping fingers, vise, magnet, or collet, depending on the nature of the operation—in place of a hand. In the base are the mechanism and circuits to rotate the turntable, pivot and flex the arm, and move the holding fixture. This machine is capable of all the motions of a workman's arm, but in addition the position of the extremity can be very accurately controlled, and the hand itself rotated at the wrist. It already exists in prototype.

Putting an automatic tool together

With these three classes of machine units clearly laid out, we are now in a position to assemble the elements of a representative machine tool. A simple part might require only one or two units of each class; one requiring many operations would need perhaps a score of each. What we are about to describe is a production machine for making a single part, not a complete product. The part, we shall suppose, is a brass ring with internal thread to hold the microphone in a telephone handset.

Engineers first lay out the blueprint and operations for the part to be manufactured. The blueprint specifications and sequence of operations are then recorded, say, on a perforated paper roll, like an endless player-piano roll, with the perforations corresponding to the type and length of operations the machine tool must perform to make raw brass tubing into the brass ring. This record is loaded into a type of informational unit called a master record-control rack, where it moves under a pickup head at constant speed. The pickup translates the perforations into electrical impulses, which are transmitted to the production floor and fed to a collation-and-control unit. As the collation unit receives the starting signal, it sends controlled power to start the hand-arm and fabricating machines.

The central fabricating unit for this type of operation might be an automatic lathe with standard spindle to hold and rotate the material, a compound rest to hold the threading tool and direct it in making the cut, and two hand-arm machines to handle material, change tools, and perform the final milling operation and cutoff. Brass tubing feeds in automatically through the headstock. The power fed to the machines is determined by the control impulses sent down from the master record, and its duration is controlled by the length of perforations in the record

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roll. The timing of the machine operations is determined by the position of the perforations relative to one another. The record moving through the rack causes everything to take place in orderly procession. During fabrication, tools may change in the holding fixture, the position of the work in the holding unit may change, and speeds of rotation and feed will change.

As soon as any hand-arm or fabricating machine moves, detector devices go into action. These are an integral part of the unit, mounted to "watch" every critical operation. One such device might be a detector to pick up excessive vibration in the lathe spindle. It consists of a detector head clamped to the lathe and connected by a circuit to a basic information unit on the floor beside it—an electronic chassis composed of a standard power pack, amplifier, and distributor panel plugged into one another to form a single unit. The pressure head detects changes in pressure (vibration) at the spindle and converts them to electrical impulses. The amplifier increases their power and feeds them at standard impedances and power levels to the distribution panel, which sends them to the collation-and-control unit. At the slightest increase in vibration, the collation unit adjusts the power to the lathe spindle. One or more detector devices may be connected through the information unit to the collation unit, which constantly compares their impulses with the standard impulses coming from the master record and accurately regulates the whole operation.

At the end of the cycle the finished brass ring is dropped on an outgoing conveyer belt, where it passes an informational unit equipped with detectors to inspect its shape and dimensions. The detectors are connected with the collation unit, which compares with the master record and passes or rejects the part. Then the record roll, being an endless tape, starts the cycle of operations all over again.

Within each class, the basic machine units take many different forms. The informational unit, for instance, may be merely a remote indicating thermometer sending out electrical impulses as temperature rises, or it may be the complicated master record-control rack translating perforations into electrical impulses to control all the machines. Another simple information

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A NOTE ON THE AUTHORS: Eric W. Leaver, research physicist, and Dr. J. J. Brown, physicist and writer, were associated with Canada's wartime radar research in Toronto. Like so many other scientists engaged in war tasks, they caught the habit of direct application of pure science to practical problems. Leaver and Brown began thinking and tinkering with the application of electronics to industry, and the result is this thesis on automatic machines, which they regard as simply a preliminary statement of ideas. Any thoroughgoing development of these ideas, they feel, would require a rewriting of Reuleaux' *Kinematics of Machinery* in the light of modern electronics and electrochemistry.

Leaver is a thirty-one-year-old, English-born inventor, who came down from a Saskatchewan farm at eighteen with $10 in his pocket and a new type of avigation instrument, which he proceeded to sell to a Chicago manufacturer for a substantial sum. He supplies the basic inventive ideas for the team. Dr. Brown follows through with research and performs the writing chores. He was born thirty years ago in Alberta, was graduated from Yale, and taught for a time at Cornell University before returning to Canada to join the radar project. The team is now experimenting with various phases of the automatic system of industrial controls and building prototype equipment. The Editors

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device might be a photoelectric detector watching the cherry-red condition of a hot tungsten carbide cutting tool. If a record of operations is desired, detector impulses may be fed to a simple counter, to an indicator panel with plug-in meters or oscilloscope for visual indication, or to a standard recording unit for making a permanent record. The fabricating tool itself may be a modified lathe, pressure molder, punch press, or any of the basic production machines required for a given operation. Many new types of machines will appear as soon as a new philosophy of design is developed. These machines, and the products they make, will be unlike anything we have today. Products are always designed in terms of the production machine.

The automatic factory at work

A factory is an aggregation of production, assembly, and handling machinery, controlled from a central position. The automatic factory will be made up of many production-machine units like the one described above, each making a single part, one connected to another by a conveyer system, and all linked through a central master control panel. Its automatic operation will start from the point where automatic transport units unload raw materials from truck or freight car and pass them through the first inspection.

Inspection is accomplished without human aid by means of information devices, available in great variety, for scanning, counting, testing, and so on. Each piece of material passes through the units in turn. Metal stock is tested for correct size and hardness, semifinished products for size, color, shape, material, and weight. Substandard pieces are automatically pushed off onto another conveyer that takes them to either shipping or salvage. Materials that pass inspection are fed by conveyer to warehouse bins or directly to the production machines. The finished parts pass from the production machines, through another inspection, to subassembly and assembly machines.

The assembly machine, another kind of production tool, again employs the hand-arm type of unit, working over an assembly jig, controlled by a master record. The first part needed for an assembly is picked off the conveyer and placed in the jig. Having operated once, the hand-arm that supplied this part cannot work again until it is triggered. When the parts have been assembled in the jig, a riveting, welding, or induction heating device darts in to fasten them together and the finished product is ejected. For most products a moving line of assembly jigs would probably be used, with a radial system of conveyers feeding in completed parts and subassemblies.

The production floor may be visualized something like this. The final assembly machine is the hub of a great wheel of fabricating and subassembly operations. Conveyers converge on this hub, carrying finished small parts and complete subassemblies. A conveyer belt moves the assembly jigs from one end of the final assembly machine to the other. Batteries of hand-arm machines work in stages along the way, their sequence and motions controlled by the same type of perforated master record as directs the operations of the fabricating units. Suppose we carry on with the telephone handset, a single part of which was used to illustrate the processes of fabrication. The first hand-arm machine in the assembly line picks up a black Bakelite case and places it with both ends up in an open jig. This movement causes the jig to close firmly on the case and hold it for subsequent operations. As the jig moves along on the endless belt down the center of the assembly machine, other hand-arms insert or place

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the wire harness, cord, contacts, earphone subassemblies, and other parts, while smaller hand-arms fasten them in place with screws. When the completed handset reaches the end of the line, the jig releases it on a conveyer belt for final inspection.

Product inspection is also carried out by detector devices, each looking after one characteristic and rejecting any units that do not come up to specifications. Each unit may be tested for contour, size, weight, strength, and performance before it goes by conveyer to the packaging machinery. Packaging will employ much the same machines and methods in use today, but with a much extended range of application. In the new type of factory everything from electric toasters to automobiles will be packaged automatically.

In such a factory the human working force is confined to management, which makes the policy decisions as to how many of what items to produce, and an engineering and technical staff, which carries out the decisions. If a product is to be changed, new specifications for a new product in the form of punch cards or blueprint records are substituted for the old in the master record-control racks. Teams of technicians go down on the production floor to rearrange, set up, and reconnect the interchangeable units of production. Then the continuous production run is started again.

Leading to a new industrial order

An economy that makes full use of such production machinery will be so different from the present it will constitute a new industrial order. The advantages to management are, perhaps, obvious. Higher volume and cheaper goods are immediately discernible. The production rate will be higher, not being limited to human considerations anywhere in the chain. The production rate will also be constant and continuous, permitting a close figuring of costs. Both man-hour and machine-hour production rates will be incomparably higher, and consequently goods will be cheaper. They will also be better, because the machines will achieve much greater precision in manufacture, controlling tolerances of all kinds much more closely than now.

The great adaptability of the new machines will make for an industry that is quick on its feet. Interchangeability of basic units will allow a manufacturer to accommodate himself to sudden changes in the market, turning from hearing aids, say, to intercommunication sets practically overnight. A maker of vacuum cleaners, noting a bottleneck in the delivery of phonograph motors by regular suppliers, could in a matter of days slip in a short run of phonograph motors. Such versatility of production would make the market more responsive to supply and demand, therefore more competitive, and therefore would keep levels down. Also it would keep new products coming faster.

At present the increasing specialization of machines in terms of product retards the development of new goods. To make a new item a manufacturer must scrap most of his present machines. One reason why nobody makes phonographs that play complete symphonies without pause is that the industry has an investment of many millions of dollars in equipment to produce the old four-minute records. The technical resources for longer and better recordings are here, but the production machinery is inflexible. For another example, the writers give garage space to two automobiles built by the same company ten years apart. The later model has more chromium and gadgets, is less angular, and uses more gas. But in essentials—engine, chassis, spring suspension, type of drive, and so on—they are nearly the same automobile. The present inflexible automobile-

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production machines make changes slow in coming. During the war, when cost was no object, factories came out with more radically new products in three years than they had in the previous thirty. But the consumer is already beginning to wonder what has happened to all the marvelous new devices he has been reading about in the magazines. Until we get a flexible new system of machine production, we cannot readily get new cars, trains, refrigerators, and homes.

The old-fashioned machines not only cause a long delay between invention and application, but they kill off a large part of the potential market. Under the present system manufacturers cannot go into production on a new article until they are reasonably sure of volume. Banks will not risk the money to get a new product into mass production except in a stabilized and assured market. This dilemma usually extends for years. Meanwhile a small but potentially sizable market for the new product may be lost. Under the regime of the new machine, production may be started as soon as a small market is known to exist, and as the market grows, methods may be changed and new designs incorporated using the same basic machine-tool elements.

This is well illustrated in a potential new branch of the aircraft industry, the manufacture of helicopters. There is no doubt that a small but substantial demand exists and might grow larger if price could be brought under $5,000. But the only way to get price down to this level is to mass-produce, and mass production under the present system means an investment of millions in specialized machines, jigs, and fixtures. Since helicopter design is changing rapidly, the whole factory might be obsolete before the first unit was sold. Under these circumstances mass production is a very poor risk. If the aircraft industry were tooled up under the new system of flexible machine units, however, a small part of production could be turned over to meeting the present demand at lower cost, and expanded or changed over as rapidly as new designs grew. No matter how radical the changes were, they could be quickly applied to the product merely by making changes in the master record and resetting the machine units.

The ramifications of this idea are endless. Indeed, this reorganization of machines may lead to a greater decentralization of industry. For manufacture may be started in a small way, shifted rapidly to new products if the first do not pan out, and risks thereby shortened. Not being dependent on masses of unskilled labor, factories may be situated away from high-priced urban centers. Over-all capital investments may therefore be smaller, and the financial control of industry lessened. Such factors as flexibility, decentralization, and nondependence on manpower can have profound implications for national security. War in the atomic age—if anyone is so foolish as to allow it—will start and finish rapidly, and be decided primarily by the economic resources of the contestants and the speed with which they are mustered. Overspecialization of machines and overconcentration of industry, with one or two years required to convert to war, may make industrial giants as obsolete as dinosaurs.

The disadvantages of the new machines are greater initial complexity and greater initial investment—at least in their first development. The only major disadvantage, however, is one that is shared with everything useful ever invented. The new machine is new, and involves the scrapping of old ideas and most present factory equipment. But present equipment, being inflexible, is going to be scrapped in any case and replaced with machines equally inflexible. We propose to replace them with a new kind of machine.

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Replacement of machines means replacement of men, and here the advantages may be more hotly challenged. The automatic factory may well loose waves of temporary unemployment. But the long-range benefits are hardly to be contested. It is better to regiment machines than men. The whole trend of present automatic controls and devices applied to present production machines is to degrade the worker to an unskilled and tradeless nonentity. The development of completely automatic production lines would reverse this by demanding a highly skilled force of technicians and operators. The astonishingly rapid development of new skills and occupations under the pressures of war shows that men are up to it. By the use of training programs, a shorter work week, and other devices, the shocks of transition could be cushioned. Here for the first time we have a production system so potentially efficient that the two-or-three-day week is economically feasible. This system is designed to supply a mass market, and without the mass market it would be worse than useless. Its cheaper costs could be passed on in higher wages to the worker and greater value to the consumer. It must, therefore, balance out at a higher level of living than ever before.

Many of the ills of modern industrial society can be traced in large part to the regimentation of workers and other materials that do not take kindly to it; and the failure to regiment machines that are ideally suited to it. Our present industrial system tends to regiment the worker and destroy his skills and initiative, without a compensating measure of economic security. Regimentation of machines cannot hurt the machines, and can emancipate the worker forever from degrading or monotonous toil.

The human machine tender is at best a makeshift. We are beginning to develop fabrication, control, safety, and observing devices immensely superior to the human mechanism. This development is only in its infancy, yet already we have machines that see better than eyes, calculate more reliably than brains, communicate faster and farther than the voice, record more accurately than memory, and act faster and better than hands. These devices are not subject to any human limitations. They do not mind working around the clock. They never feel hunger or fatigue. They are always satisfied with working conditions, and never demand higher wages based on the company's ability to pay. They not only cause much less trouble than humans doing comparable work, but they can be built to ring an alarm bell in the central control room whenever they are not working properly. In every department of nonemotional thinking, planning, and doing, machines can be built that are superior to human workers on the same job.

Why not use them? A recent list of manufacturers in the U.S. making equipment and parts that can be integrated into the system discussed here runs to nearly 10,000 names. A recent survey, which does not include many devices we consider important, lists 16,821 distinct electronic devices now in industrial use. These fall for the most part into the informational and control classes, where the bulk of development has taken place. But operations units for transport, fabrication, and holding have undergone an almost equally heavy development in recent years, and all the basic materials for a radical reorganization of machines are here. All that is needed is a rethinking of machine design, a new way of thinking about the nature of machines.

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