AUTOMATION IN INDUSTRY

8 February 1955

1665

CONTENTS

Publication No. L55-98

INDUSTRIAL COLLEGE OF THE ARMED FORCES

Washington, D. C.

Mr. Arthur T. Vinson, Vice President-Manufacturing, Manufacturing Services Division, General Electric Company, was born in Plainfield, Illinois. He was graduated from Michigan State College in 1929 with a degree in electrical engineering. He completed the Advanced Management Program of Harvard University's Graduate School of Business Administration in 1951. He joined the General Electric Company as a student engineer at the Fort Wayne Works and in 1945 became assistant production manager. He was transferred to Schenectady, Apparatus Department in 1945 and in 1948 became manager of the Welding Equipment Division with headquarters in Fitchburg, Massachusetts. In 1951 Mr. Vinson served as manager of Employee and Community Relations of the Small Apparatus Division at Lynn, Massachusetts, and later returned to Schenectady as assistant manager of Manufacturing in the Manufacturing Services Division and manager of the Wage Administration of the Employee and Plant Community Relations Services Division. He assumed his present position in 1953. This is his first lecture at the Industrial College.

AUTOMATION IN INDUSTRY

8 February 1955

GENERAL NIBLO: The industrial revolution began about a century and a half ago. It was brought about through the use of power, energy, and the advent of the steam engine. Today we stand on the brink of what some historians may call a second industrial revolution. This time the basic concept is the automatic factory, commonly referred to as automation.

Our speaker this morning is Mr. Arthur F. Vinson, Vice President of General Electric, in charge of their Manufacturing Services Division. He will discuss automation and stress the factors that management must evaluate when considering the use of automation in industry. He will also discuss the significance of automation during any future economic mobilization.

Mr. Vinson, it is a pleasure to welcome you to the Industrial College faculty of guest speakers and present you to this year's class.

MR. VINSON: Thank you, General Niblo and Captain McCaffree. Gentlemen, it is with mixed feelings that I appear before you this morning. It is a real pleasure to be here. I have been well acquainted with some of the members who have been in this college before you, and know what fine work has been done here. I say "mixed feelings" because when Captain McCaffree invited me to come down here, unfortunately he told me that I was to replace a speaker who couldn't make it, and that was Dr. Weiner.

I thought over that a long time, I can assure you, before accepting, because I knew two things for certain: First, that if there were any of you in the audience who would have understood Dr. Weiner's talk this morning, I am sure you will have no trouble at all understanding mine. Second, if there are any of you who could fully understand Dr. Weiner's talk, I am sure that I will be talking at a level for which you will not have much respect.

I regret that I can't keep this completely informal. However, I hope the question and answer period will be. But I want to bring you a message this morning that needs to be illustrated and, therefore, I will have to stick fairly closely to the script.

I can't resist telling you a story. I heard Dr. Weiner in New York talk to an MIT audience. There were 500 of us in that audience. I believe there were about two--and I was not among them--who understood Dr. Weiner's talk. He was away out in the future.

This story concerns the time Dr. Weiner came out of one of the MIT buildings and was walking across the campus. On the way he met Dr. Conant. The two of them stood talking for some moments. As they were leaving, Dr. Weiner turned to Dr. Conant and said: "I wonder if you can help me. What building did I come out of before I talked to you?" Dr. Conant pointed: "You came from that building." "Thank you very much," replied Dr. Weiner, "that means I have had lunch."

I want to warn you that I will know whether I have had lunch today, being just a manufacturing man for General Electric.

The newest thing that we are up against is the matter of automation. I think our biggest obstacle is not in creating or in defining it, on which I will spend a little time here, but in its application. It is really getting the automation concept in the form in which people will accept it and do something about it. In other words it has to be tailor-made for the customer who is going to use it.

The backbone of this Nation's expanding economy and its enviable standard of living has been the ability to produce more goods for more people at less cost. Our productive future correspondingly is the logical extension of our past technological progress, with one important difference: The production demands will be greater than any we have ever known.

Using my own electrical manufacturing industry as an example, we know that we must be able to double our present output by 1964. This is typical of the task facing the fastest growing industries. And yet it is estimated that the predicted available work force will increase less than 13 percent by 1964.

The solution to this vital problem of increased industrial productivity--one of the great challenges and opportunities of today--has come to be characterized by a word, perhaps the most misunderstood in our modern vocabulary. That word is "automation."

There are just about as many definitions of automation as there are people trying to define it. It has come to mean as many different things as there are points of reference from which it is viewed. It is a great deal like the old Aesop fable of "The Elephant and the Six Blind Men"--each of whom defined the whole elephant in terms of the particular part which he was able to touch and explore (chart 1, page 4).

To some people, automation means mechanization; to others, the pushbutton factory and materials handling; and to still others, automatic controls, automaticity, and cybernetics--words that conjure up visions of robots running machines and factories without men. Actually, these words have little or no bearing on the industrial concept of automation today.

The word itself is a relative newcomer to the industrial vocabulary, but the ideas and thinking to which it applies are not new. They have been known for a long time, but have been applied only during the past decade to industry as we know it.

Today's industrial interpretation of automation is continuous automatic production. (Chart 2, page 5.) It is a way of manufacturing, based on the concept of production in a continuous flow, rather than processing by intermittent batches of work. As such, it embraces the automatic making, inspecting, assembling, testing, and packaging of parts and products in one continuous flow.

Yes, the word is new, and even though an inventor named Oliver Evans built a completely automatic flour mill near Philadelphia back in 1784 (chart 3, page 6)--and by "completely automatic" I mean that there were no workers in the mill--in spite of this and other later apparent contradictions, automation is still just barely started.

The important thing to know is that it is not a second industrial revolution. Its nature is evolutionary, not revolutionary. Automation is built upon the solid foundation of progressive, step-by-step upgrading of both our manufacturing operations and people, and is of itself a progressive process.

As you might suspect, when we start talking about automatic factories and automation, we hear much weeping and wailing. Many people fear the principle involved; in fact, according to one survey, nearly three-fourths of the working population believe automation will result in layoffs and unemployment; they believe that its evils considerably outweigh its benefits.

CHART 1

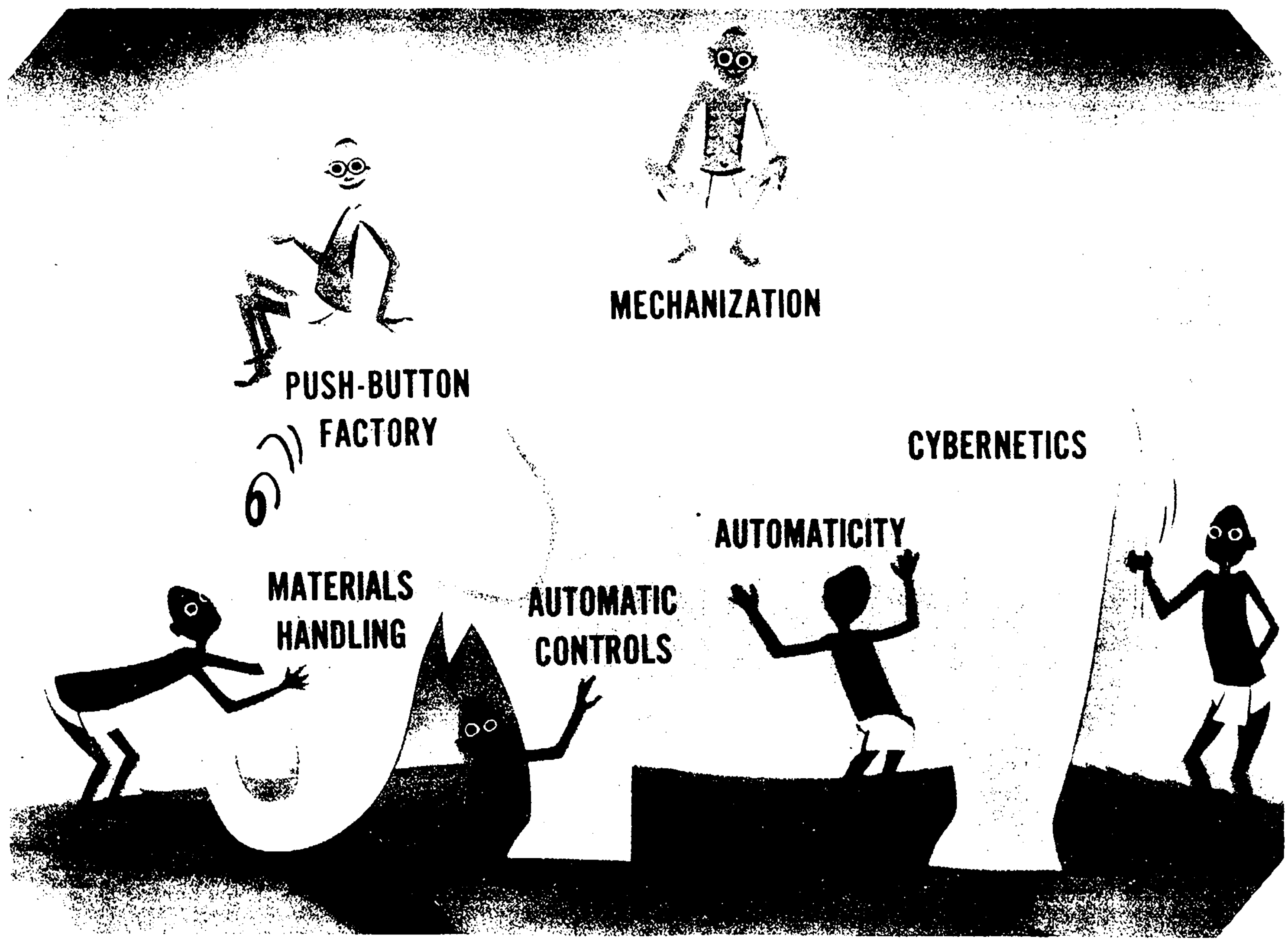
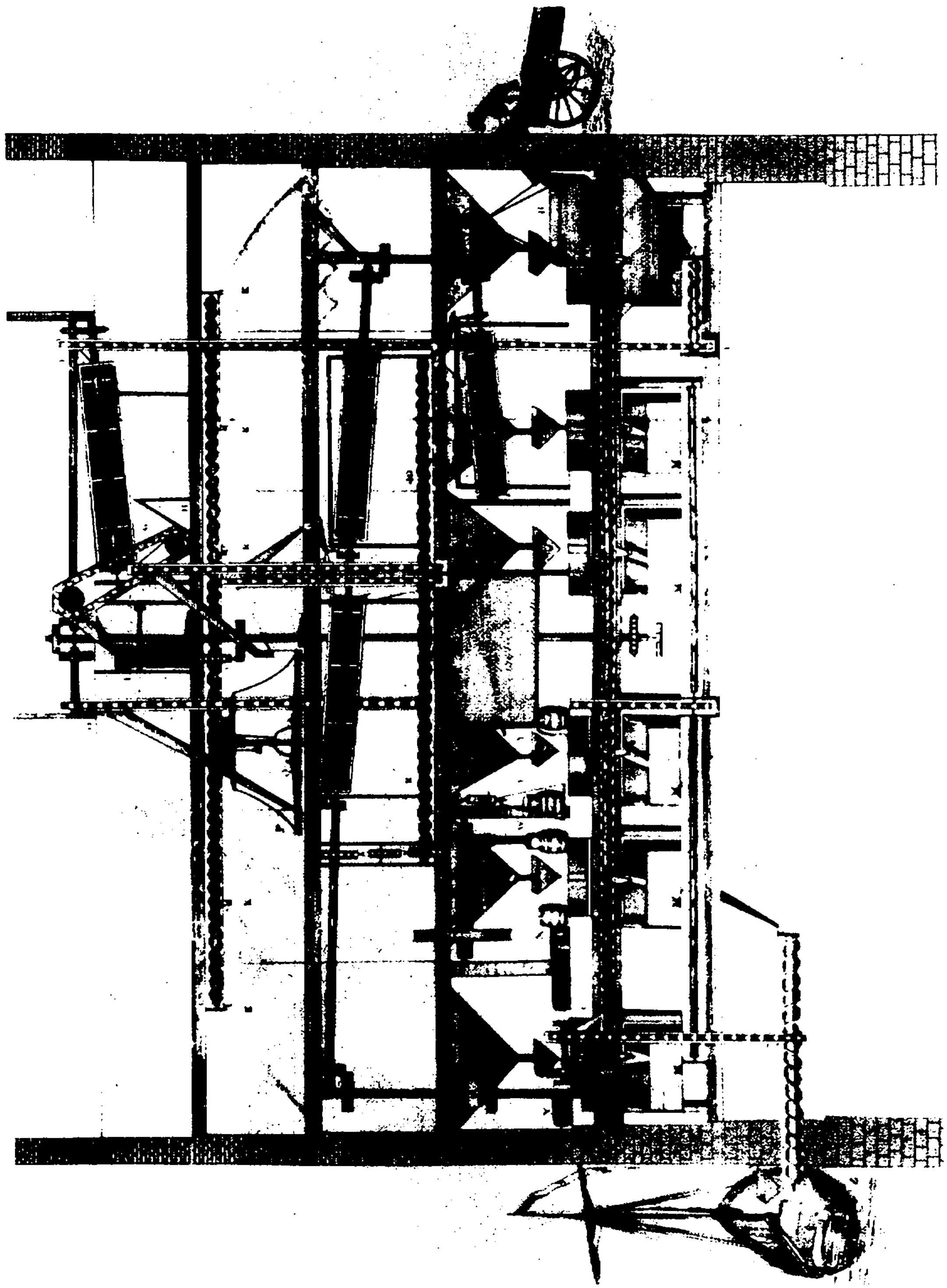

MECHANIZATION
PUSH-BUTTON FACTORY
CYBERNETICS
AUTOMATICITY
MATERIALS HANDLING
AUTOMATIC CONTROLS

CHART 2

CHART 3



This viewpoint is not surprising, nor is it new. Back in the year 1661, when a loom was set up in Danzig to weave as many as four to six webs at once, the authorities suppressed it because they thought it was hard on the poor people, who, taking courage from the authorities' example, seized the inventor and drowned him in a nearby creek! So you can see that the misunderstanding about automation cannot be dismissed lightly. Basically, automation does take over jobs performed by men; but automation need not bring unemployment, as some people fear, for three very positive reasons:

First, in terms of the numbers of men required to produce a product, the reduction is a temporary displacement which can be offset by the demands of a broadening market, as well as the creation of new industries. And don't forget, it still takes many men to build, service, and operate any automatic machine.

Second, automation does not happen overnight; it is an evolutionary process. Manual, direct-labor work will be progressively transformed into work which will be cleaner, easier, safer, and more rewarding to the worker, who, through the process of automation itself, will be trained for the more skillful accomplishments required in the better jobs of the future.

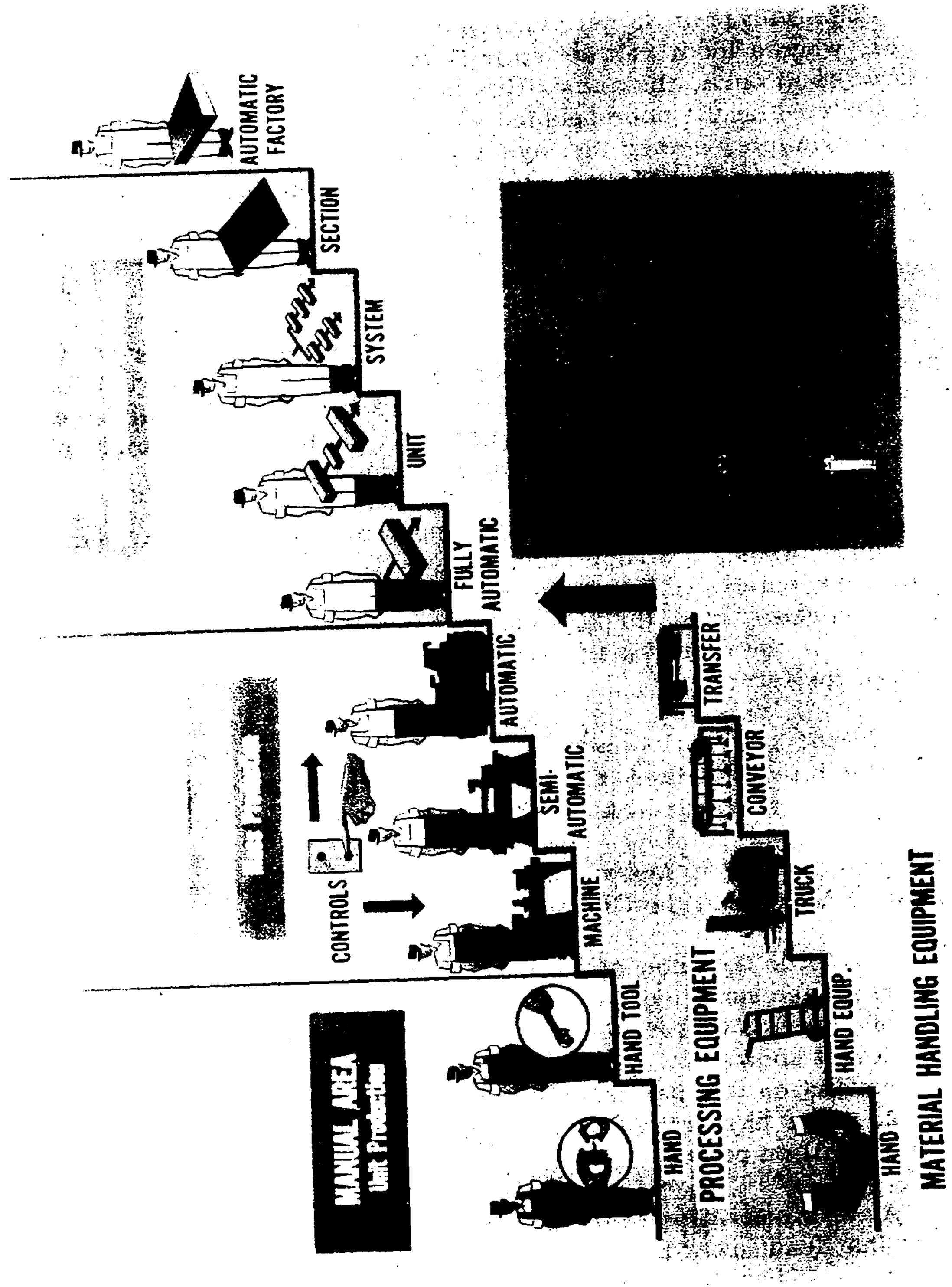
Third, and most important, automation is the necessary solution to a predicted shortage of labor. It is designed to do the work of men who are not there; it is a solution to a problem, not a cause.

The late Philip Murray apparently shared these same thoughts when he addressed the CIO as its president in 1951:

> "I do not know of a single, solitary instance where a great technological gain has taken place in the United States of America that it has actually thrown people out of work. I do not know of it, I am not aware of it, because the industrial revolution that has taken place in the United States in the past 25 years has brought into the employment field an additional 20 million people."

As an illustration of the progressive steps of industrial development that lead toward automation, let's look at the metalworking industry. (Chart 4, page 8.) First is the manual area of manufacturing--many people combining to produce one unit at a time, first only by hand and then with the aid of handtools and simple, manual materials-handling equipment.

CHART 4


MANUAL AREA
Unit Production
HAND
HAND TOOL
CONTROLS
MACHINE
SEMI-
AUTOMATIC
AUTOMATIC
FULLY
AUTOMATIC
UNIT
SYSTEM
SECTION
AUTOMATIC
FACTORY
PROCESSING EQUIPMENT
HAND
HAND EQUIP.
TRUCK
CONVEYOR
TRANSFER
MATERIAL HANDLING EQUIPMENT

Next, we progress to the mechanization area, where mass production is the result of the introduction of the driven machine and simple conveyor. The addition of increasingly complex controls and materials-handling equipment leads up to the automatic stage, in which many operations can be performed. The job of the production worker has been limited to no more than loading and unloading the automatic machine, whereas the amount of supporting, or indirect, labor required for maintenance has been materially increased. And thus we are ready for the beginning of the automation area.

Here is where continuous automation production starts in a small way, with fully automatic machines integrated with transfer devices to perform a series of operations. The production worker, as we now know him, has been trained and upgraded to become the skilled machine specialist or maintenance expert. By logical steps these machines are grouped into automatic units. The units are then grouped into automatic systems, the systems into an automatic section, and finally, some day we may come to expect the automatic factory.

It would seem obvious from this long and challenging development problem that the era of the so-called automatic pushbutton factory is still ahead of us. It certainly will not come by just the sudden, uneconomic application of money or effort. Except in process industries, such as chemical, petroleum refining, and some foods--industries where the products are fluid--automatic factories are rare, if they exist at all. For an average manufacturer to think of the "automatic factory" turning out assemblies or products today is purely wishful thinking.

Today the opportunities lie in doing the job at hand with the tools available; that is, progressively upgrading our operations and people in the mechanization and into the automation areas. Automation, as such, will have to pay its way in a step-by-step program, as industry takes a practical approach to the constant use of each year's technical advances in manufacture.

It is also true that automation is not limited to high-volume production items, such as refrigerators, lamps, or automobiles. In most of the industries today, operations can be found in all the levels of mechanization. There is ample opportunity to move these operations at least one more step up the ladder. And that means investing in more highly mechanized equipment rather than more buildings, filled with the same old kinds of equipment, using the same old methods. Of course new plants will be necessary also.

The average industrial investment ratio of equipment versus land and buildings should rise in the next nine years from about two to one up to as high as four to one, a further reminder that bricks and mortar are increasingly secondary to the production facilities that they house. As a result of all this, annual factory output is expected to rise from 50 to 75 dollars per square foot by 1964, (chart 5, page 11) as industry increasingly utilizes the unique advantages of electrical automation in its manufacturing operations.

Already there has been a marked increase in the industrial use of power. Between 1946 and 1952 the power used by each production worker rose from 10,750 to 16,350 kilowatt-hours annually--a 52 percent increase. (Chart 6, page 12.) In fact the industrial use of power between 1946 and 1952 went up faster than industrial production itself, so that the electrical content of the average product increased by a significant 24 percent. This pattern of industrial electrification is continuing upward, so that in 1964 we believe well over 90 percent of our Nation's manufacturing horsepower will be electric. There is no doubt in my mind that the trend to automation is and will be a key factor in this growth.

But what of automation today? Can it be applied everywhere, or are there some qualifications for its use?

As we see it, there are two main factors that determine the extent to which automation may be applied economically: volume, and nature of the product. For the purposes of this discussion, the "nature" of the product is considered to include the elements of design, standardization, and materials and processes. (Chart 7, page 13.) Here we see their relationship to the three areas of manufacturing--manual, mechanization, and automation. First, let us look at product design and see how it influences automation.

Here are three chairs. They are fundamentally the same--something to sit on--but the design of each is different. In each case, the chair was designed to suit a particular area of manufacturing. In the manual area, the chair was designed so that it could be made by hand, or with handtools. It required many manual operations. In the mechanization area the metal parts of the chair were designed to be formed on machines and hand-assembled. It required fewer manual operations. In the automation area a fresh approach to chair design has been taken. The "blast away" technique was used. The manual operations were designed out of the product, by using a different manufacturing process and different materials.

CHART 5

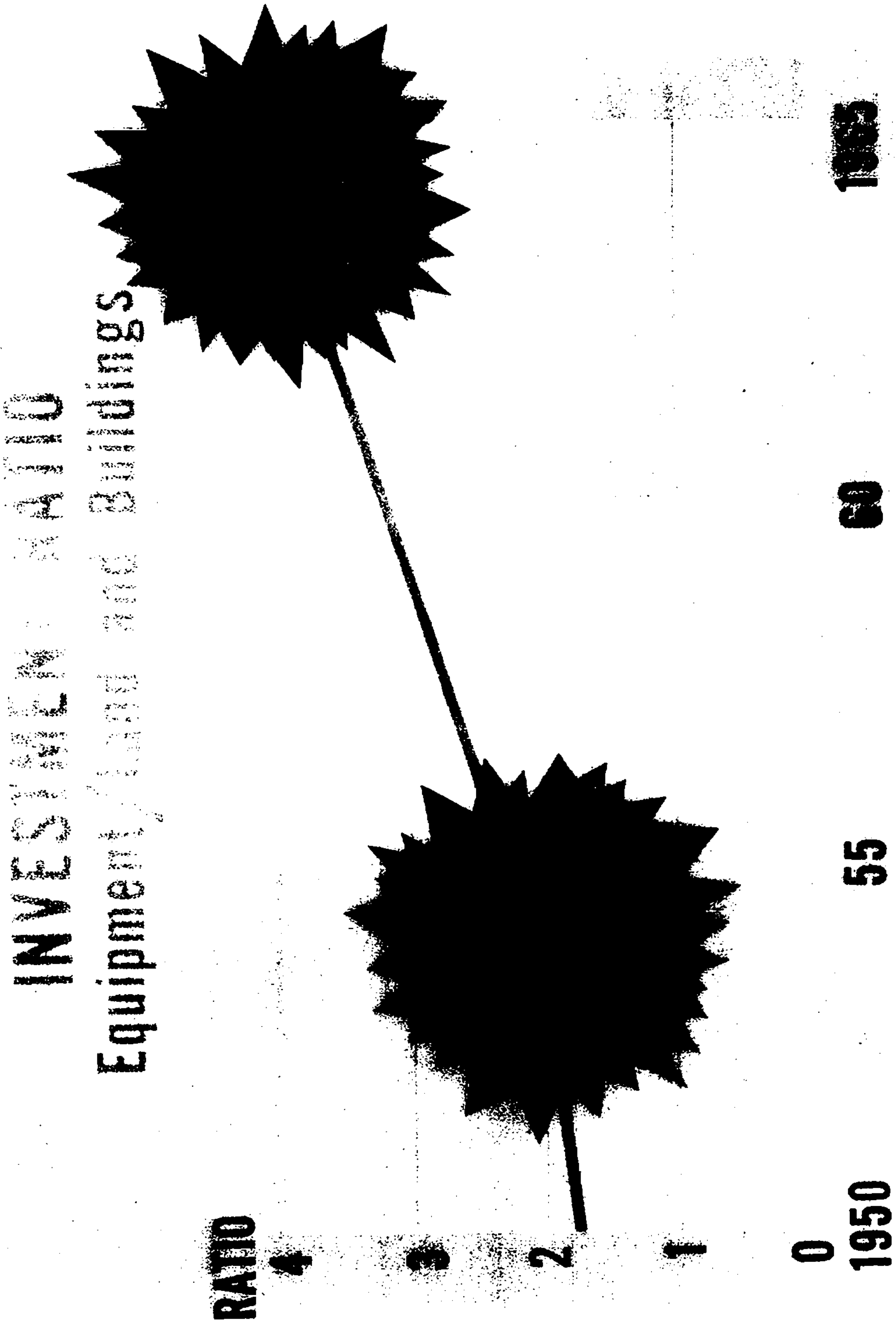


CHART 6

ANNUAL ELECTRIC ENERGY CONSUMPTION PER WORKER

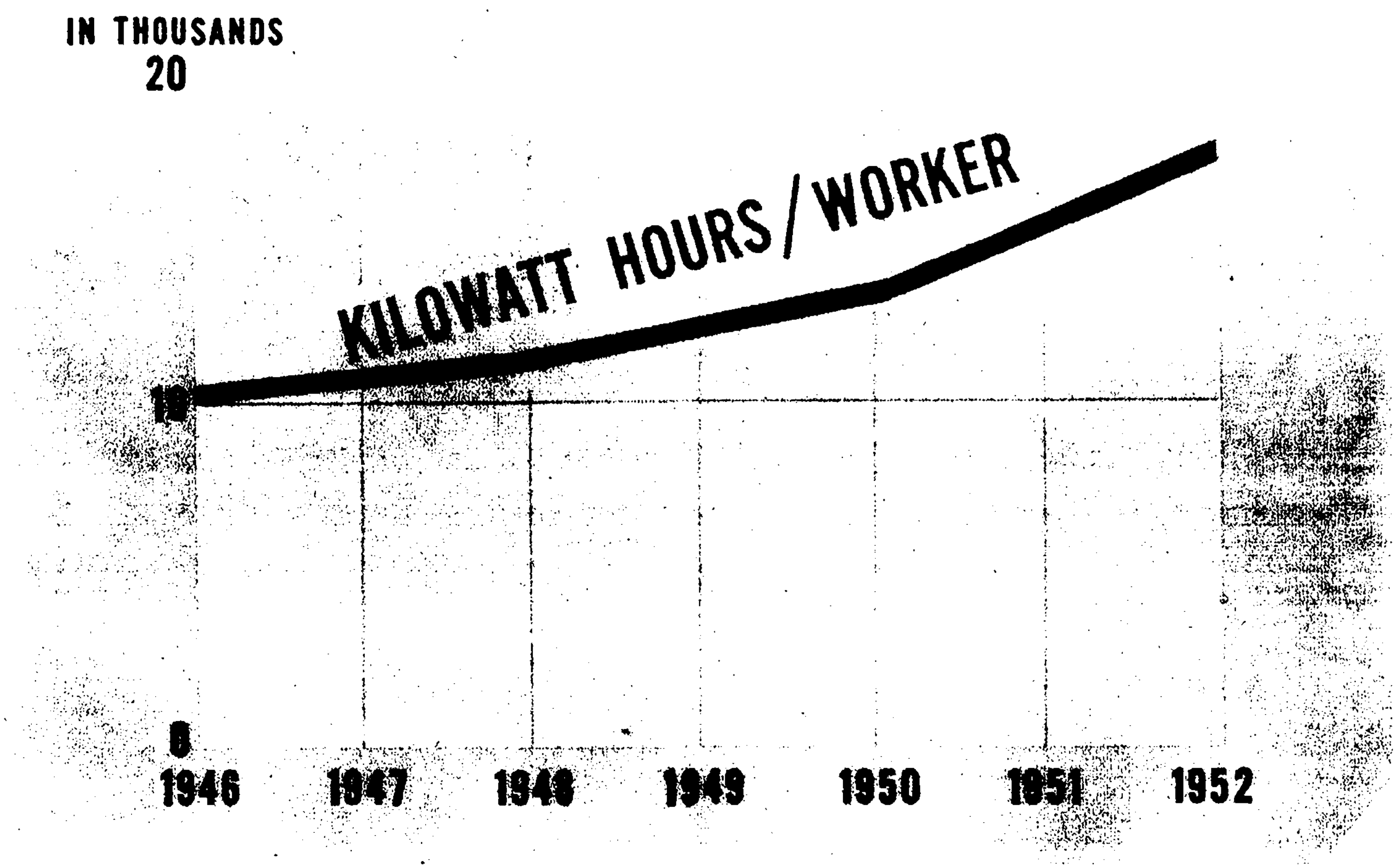
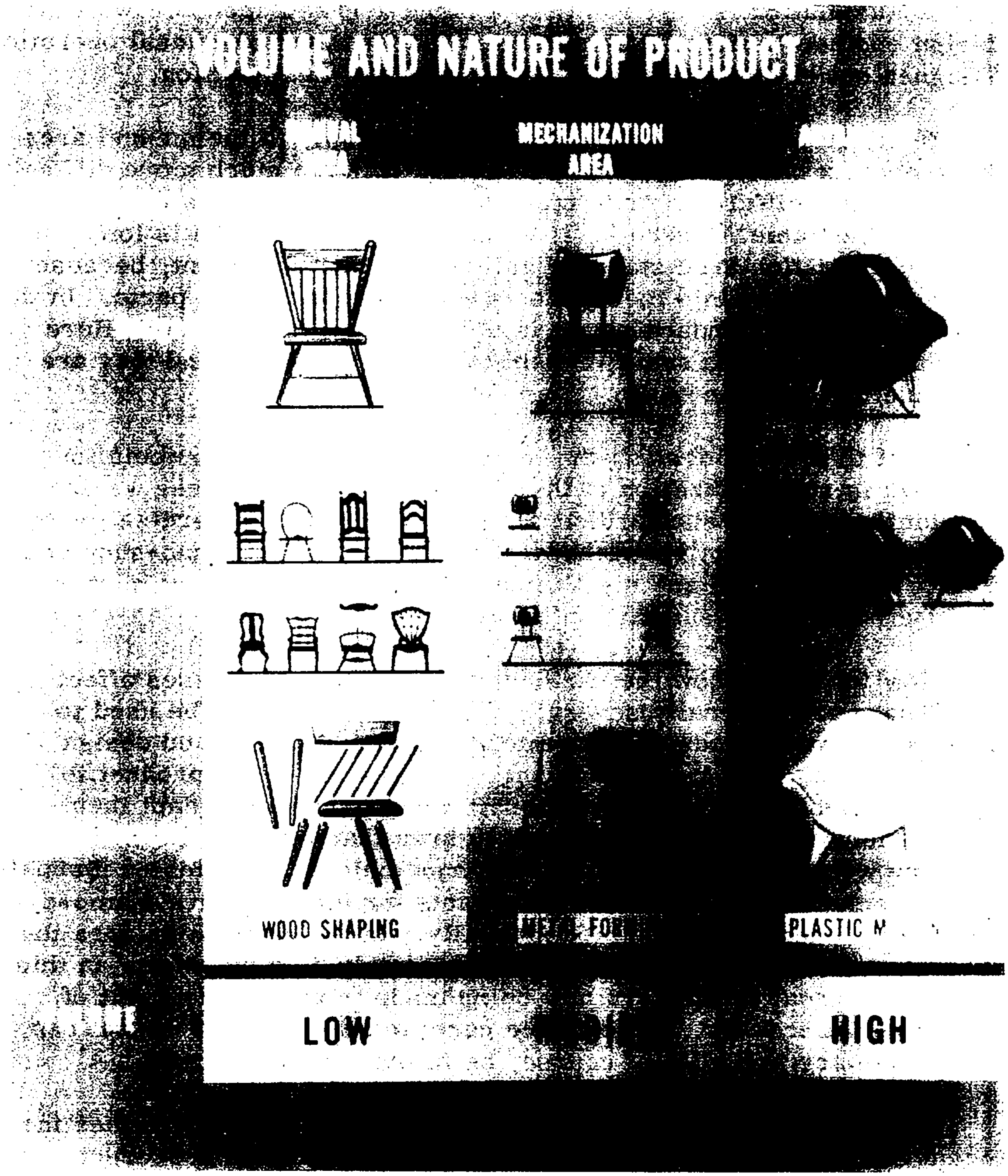


CHART 7

1679


VOLUME AND NATURE OF PRODUCT
MECHANIZATION AREA
WOOD SHAPING
PLASTIC
LOW
HIGH

This last example not only points up the challenge to designing for the automation area, but also points up the fact that the eventual extent of automation is dependent, to a large degree, upon how well the design engineers meet this challenge. The number of manual operations designed out of the product is a key to economic automation.

Next, let us look at product standardization. In the manual area there are six chairs, each one different. It is not much more difficult to make them different, or to make a "special," than it is to make them all the same. There is little tooling and production is low. In the mechanization area standardization becomes important, because we are now getting into tooling costs and interchangeable parts. In the automation area standardization is of the utmost importance. Here the chairs are all the same, except for color and trim; and they are all made on the same tools.

Next to product design, the important factor of any automation program is standardization of the product or parts. Unless we are constantly trying to standardize our products--the standardization that builds volume--we will find that we are operating under job-shop conditions in the manual and mechanization areas, while the competitors are operating in the automation area.

Now let us see how the various materials and processes affect us. There are generally several different ones that can be used to make a part or a product. The manufacturing engineer and design engineer must work together during the designing of the product to select the best material and process. Certain of these adapt themselves more readily to the automation area than others. In the manual area the wood chairs are shaped with handtools and assembled manually. In the mechanization area the metal parts for the chair are stamped out on machines and assembled manually. In the automation area the chair is made of plastic and molded completely in a machine. In this connection great strides are now being made in the development of "chipless" processes, that produce parts to size in fewer operations. Their primary use will, of course, be in the automation area.

This brings us now to the second main factor that determines the extent of economic automation--the volume of the part or product. The low-volume chair falls in the manual area, the medium-volume chair falls in the mechanization area, and the high-volume chair falls in the automation area. This classification is determined, to a large extent, by such factors as manufacturing costs, styling, and customer demand. To obtain economical, continuous automatic production--automation, in other words--the total volume of the parts must be high. Total volume, however, need not consist of identical parts; it may consist of similar standardized parts that, as far as the equipment is concerned and with the appropriate controls, can be treated as identical parts.

As you have seen, the extent to which automation can be applied economically is determined, not by the size of the business, but, rather, by the volume and nature of the products manufactured. In job-shop functions there are often some high-volume operations (with many manual operations) that lend themselves to automatic manufacturing methods. While we have been looking at automation at the product level, it generally takes place several steps below that level. In other words automation is generally applied to components and subassemblies of a complete product.

For instance, the four legs of the chair in the mechanization area could possibly be automated. Even with low production items, such as large motors, the production of laminations, which is high, may be automated. (Chart 8, page 16.) Another example would be the turbine blades in a jet engine. Here the production of jet engines may be comparatively low, but the number of turbine blades required per engine is high. (Chart 9, page 17.) An entire department or section need not be automated; it may be only a few machines at first; then, progressively, as experience is gained, automation may be applied to other operations.

We will now see how all of this affects people and manufacturing facilities. Here we see their relationship to the three areas of manufacturing (chart 10, page 18).

First, let us look at people and see how the skills, starting in the manual area, are being progressively upgraded until we require the mental skills in the automation area. Also we see how the manual direct-labor work will be progressively transformed into work which will be cleaner, easier, safer, and more rewarding for the worker who, through the process of automation itself, will be trained for the more skillful accomplishments and assisted toward the better jobs of the future.

CHART 8

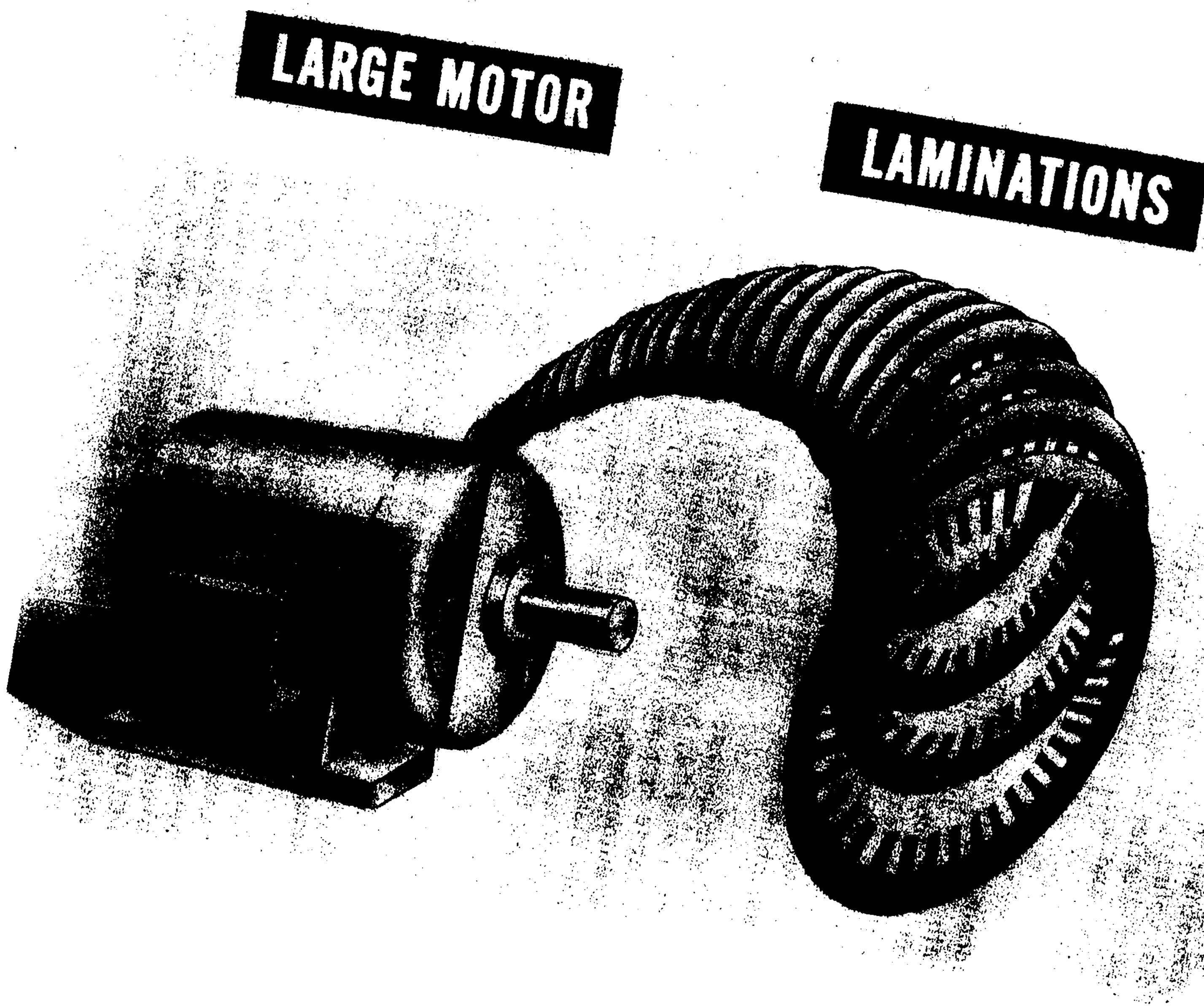


CHART 9

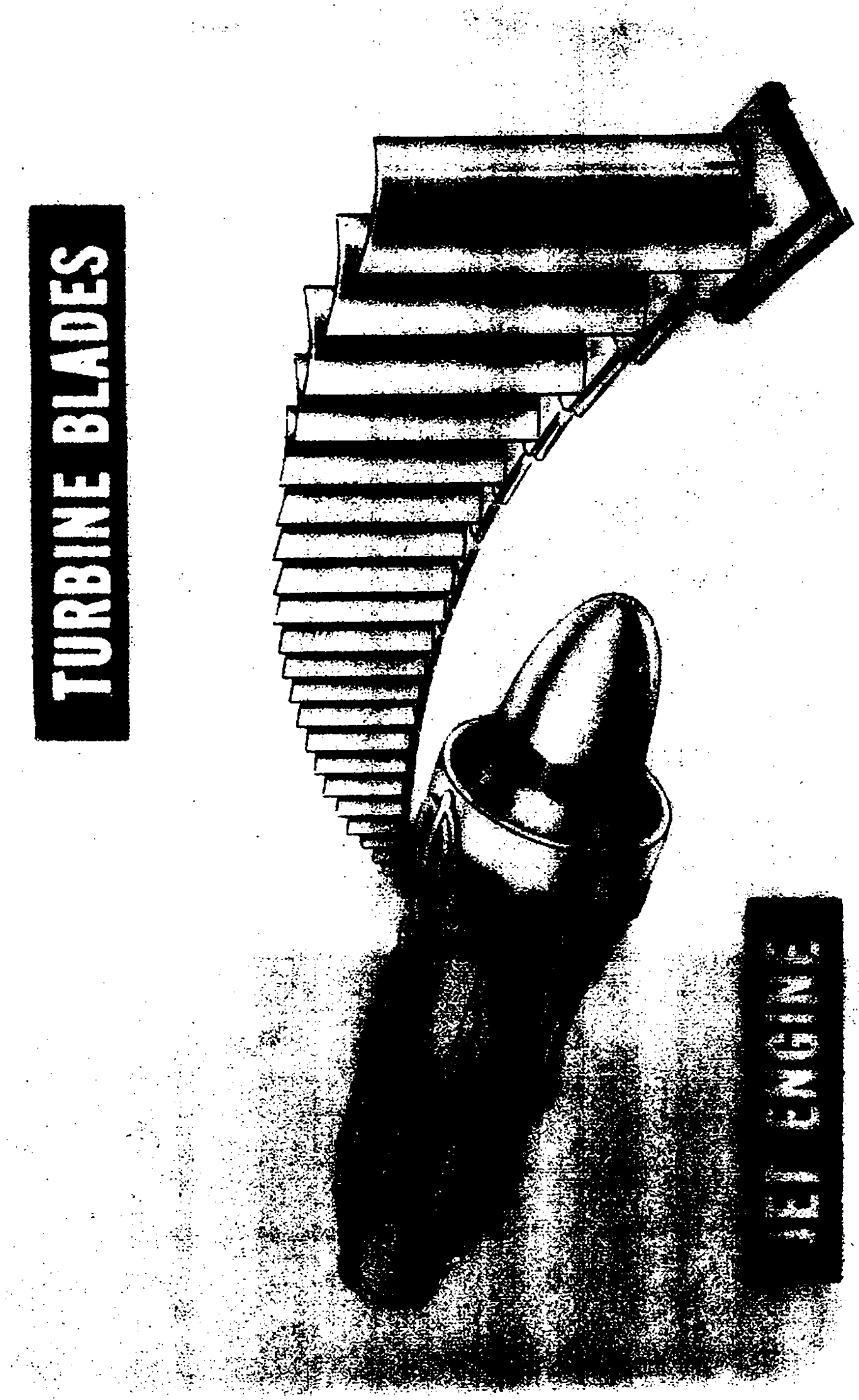
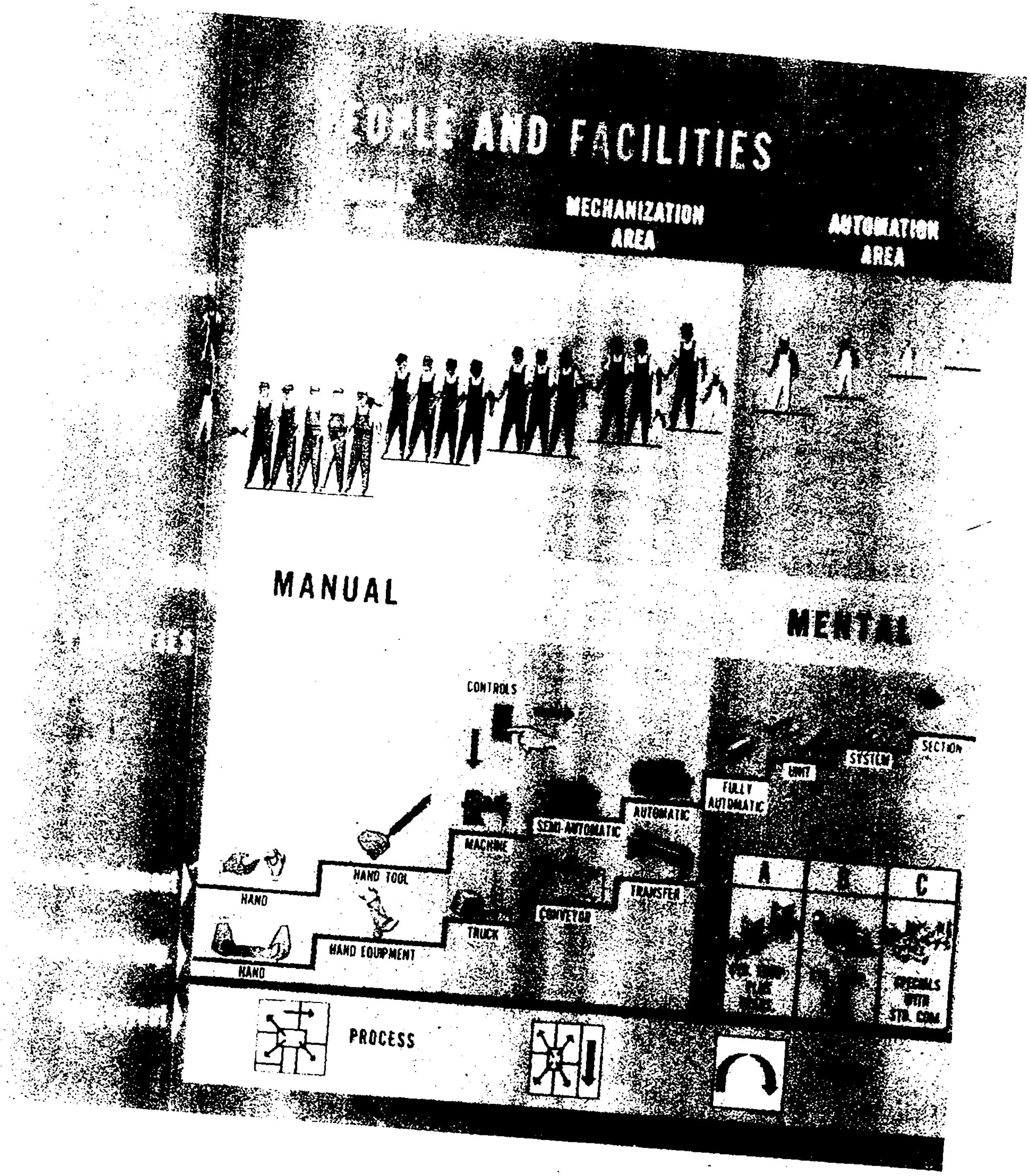


CHART 10


AND FACILITIES
MECHANIZATION AREA
AUTOMATION AREA
MANUAL
MENTAL
CONTROLS
SECTION
SYSTEM
UNIT
FULLY AUTOMATIC
AUTOMATIC
SEMI-AUTOMATIC
MACHINE
HAND TOOL
HAND
HAND EQUIPMENT
HAND
TRUCK
CONVEYOR
TRANSFER
A
B
C
SPECIALS WITH STD. COMP.
PROCESS

The trend toward automation has already played a big part in upgrading the labor force. For one thing, it takes a specialist with a high degree of skill to run many of the new machines. For another, the problems of maintenance multiply as the machines become more complex. Thus both the operator and the maintenance man have been upgraded and generally have gained their new skills on the job.

Let us look at the manufacturing facilities again, and see how the material-handling equipment is integrated with the process equipment when we reach the automation area. To simplify the discussion of equipment in the automation area, we have divided it into three broad classes. We will look at these classes a little closer (chart 11, page 20).

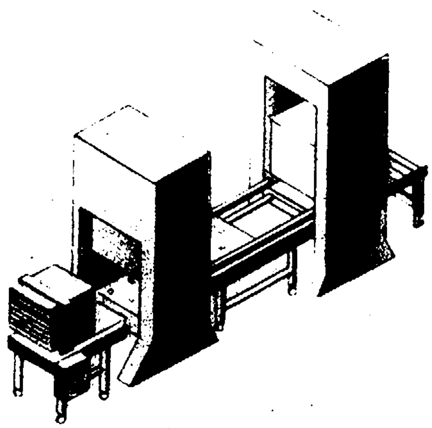
Class A--standard machines with transfer equipment added. A large number of existing machines may be automated today by the addition of transfer equipment. Class B--standard machines equipped with transfer mechanisms. Many machines may be purchased today equipped with transfer mechanisms or are designed for the addition of such equipment. Class C--special machines using standard components with transfer equipment. This class of equipment usually is intended for special applications combining several operations.

Some of today's equipment may be upgraded economically into the automation area by the addition of transfer mechanisms. This makes it possible to automate certain operations with a minimum investment in equipment, as well as gain a great deal of experience. However, when new production machines are being purchased, or old ones replaced, they should be equipped with transfer mechanisms whenever possible. Most machine-tool builders today will furnish standard machines with transfer equipment, or special machines made with standard components.

One of the best ways to determine the manufacturing status of a plant's operations is to look at the plant layout. Such as the three symbolic examples at the bottom of this chart, for this is the summation of all manufacturing planning in visual form. (Chart 12, page 21.) In this chart you can see the material-handling equipment, process equipment, and product design and standardization to a certain extent. A plant layout also indicates the amount of direct and indirect labor; that is, the gradations of labor skills from the purely manual to the purely mental.

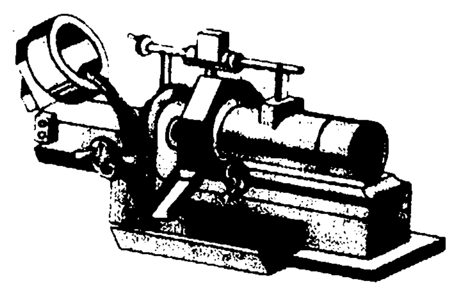
CHART 11

CLASSIFICATION OF EQUIPMENT IN AUTOMATION AREA



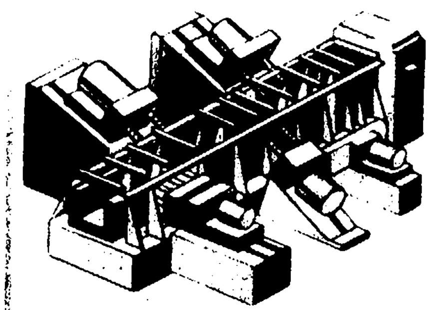
CLASS A

Standard Machines with Transfer Equip. Added



CLASS B

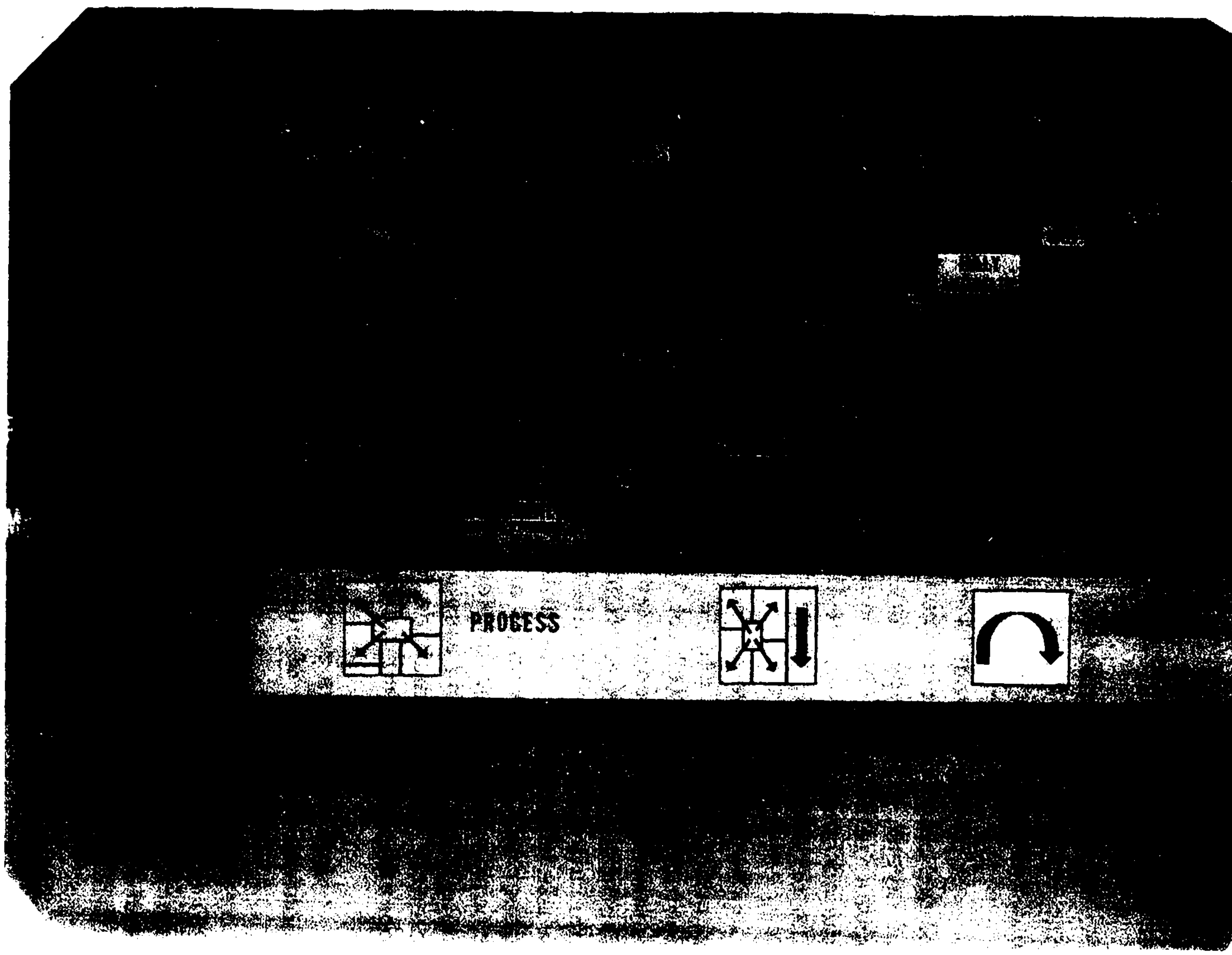
Standard Machines Equipped with Transfer Mechanism



CLASS C

Special Machines Using Standard Components

CHART 12



In the manual area of manufacturing, we have what is known as process layout, where the punch presses are in one section, assembly in another section, and painting and finishing in still another. Here the parts are moved in lots from one section to another, with each section performing its own operations.

In the mechanization area we see a combination of a process layout and a product layout. Here the high-volume parts have been taken out and set up in a product layout.

A product layout is where the equipment is arranged in the order of the operations required by the product. It is the straight-line type of layout, where you may have a punch press, an assembly operation, and a finishing operation all in the same area. As we progress into the automation area, we find that the whole section is laid out around the product layout, where the material flows between operations.

So far we have discussed briefly the relationships of nature of the product, volume, people, and facilities to the three progressive manufacturing areas. (Chart 13, page 23.) On this basis you might be interested in our educated guess of the average level of industrial manufacturing operations. (Chart 14, page 24.) In general the "making" operations fall in the middle or upper portion of the mechanization area; while inspection, assembling, testing, and packaging might fall into the upper end of the manual area. The average of all manufacturing operations is probably in the low side of the mechanization area. You will note that this rating also applies generally to labor, and points out clearly the opportunities for progressively upgrading manufacturing operations and labor force one or two steps toward the automation area.

And now let us review several developments in the field of automation which may be of interest.

The first is the construction, by General Electric (chart 15, page 25) of a system that has as its objective the automatic assembly of electronic components to a printed circuit board. The assembled board will then constitute a subassembly in a piece of electronic equipment, such as a radar or communication equipment.

The Automatic Component Assembly System differs greatly from other pieces of automatic factory equipment in that it is designed to be controlled in its sequence of operation by information which it reads and interprets from punched business machine cards. By using this

CHART 13

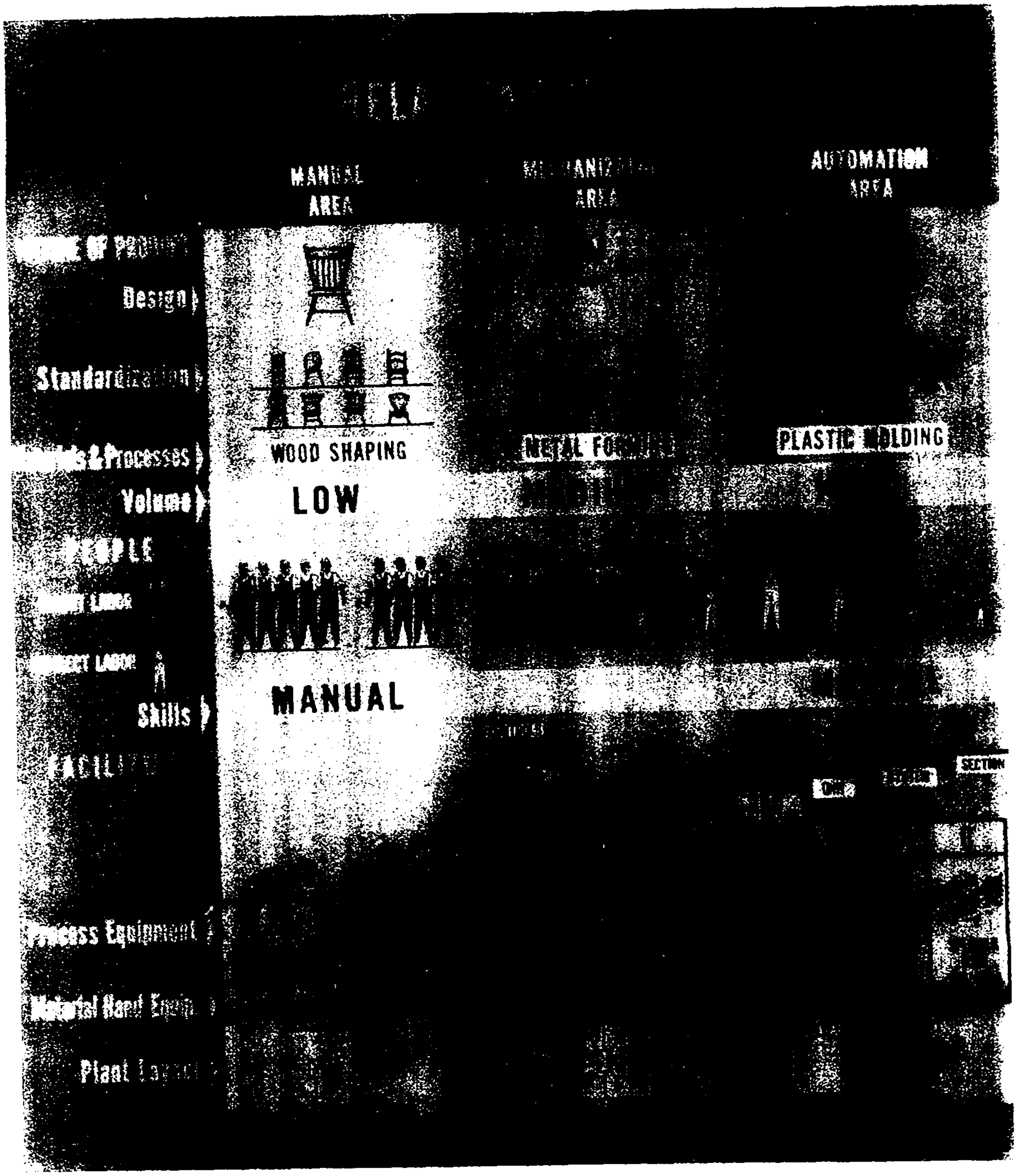
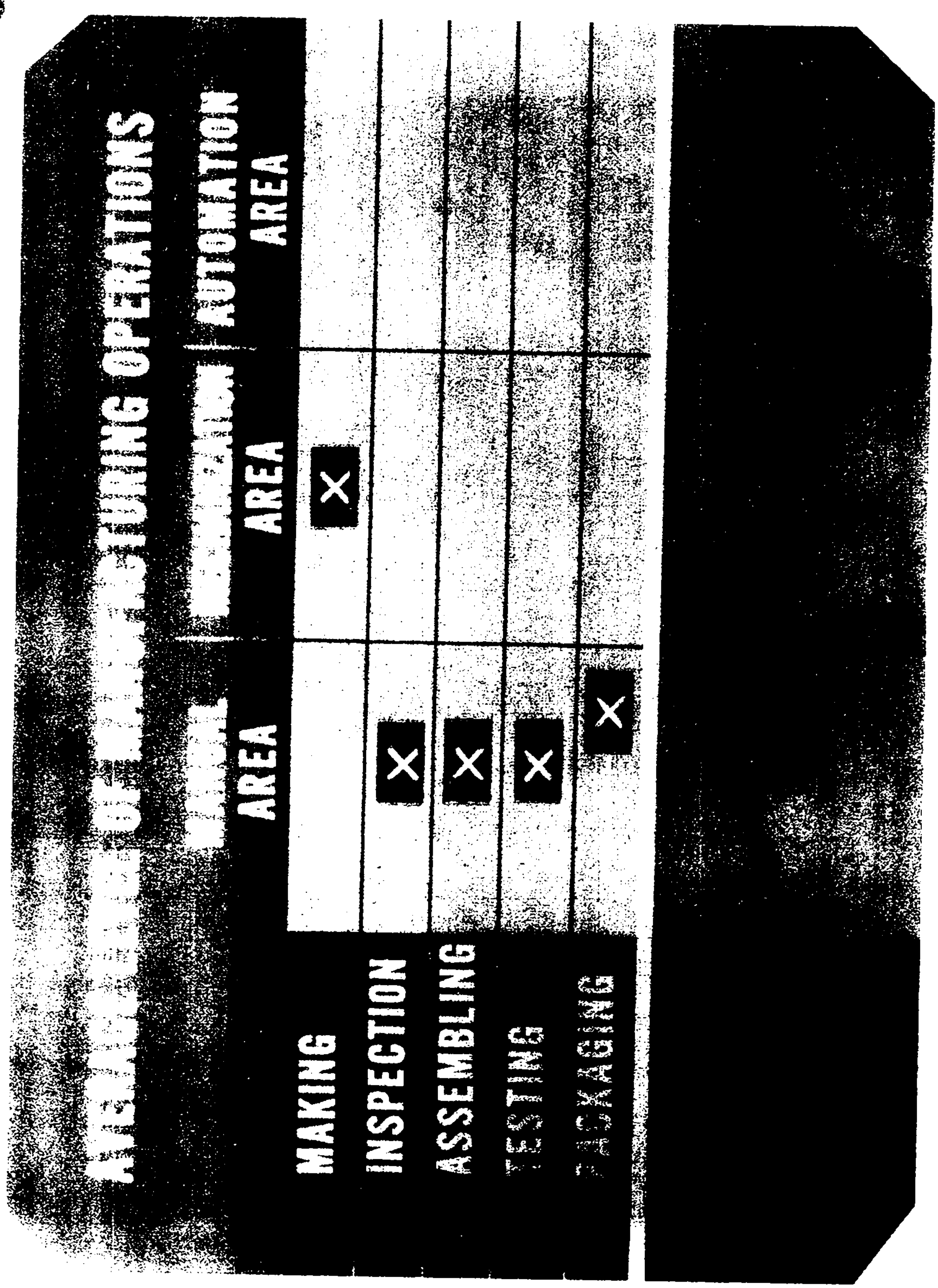

MANUAL AREA
AUTOMATION AREA
Design
WOOD SHAPING
Volume
LOW
MANUAL
Skills

CHART 14


OPERATIONS
AREA
AREA
AUTOMATION AREA
MAKING
INSPECTION
ASSEMBLING
X
X
X
X
X

1691

CHART 15

method, a technique is employed which is far more versatile and flexible in control than present-day automatic manufacturing techniques, since the changeover of control from the manufacture of one piece of equipment to an entirely different type of an assembly requires only the removal of one "deck" of punched cards and the substitution of another "deck" containing the new instructions. This feature of flexibility is of great value in the production of job-lot quantities of a large number of different types of electronic circuit assemblies, such as are used by the armed services.

General Electric is carrying on this development as part of an industrial preparedness program to provide techniques and facilities for increasing the supply of equipment for military purposes.

As a matter of fact, prior to this contract, engineers of the General Electric Company investigated techniques for a flexible positioner capable of being automatically controlled from punched-card program equipment.

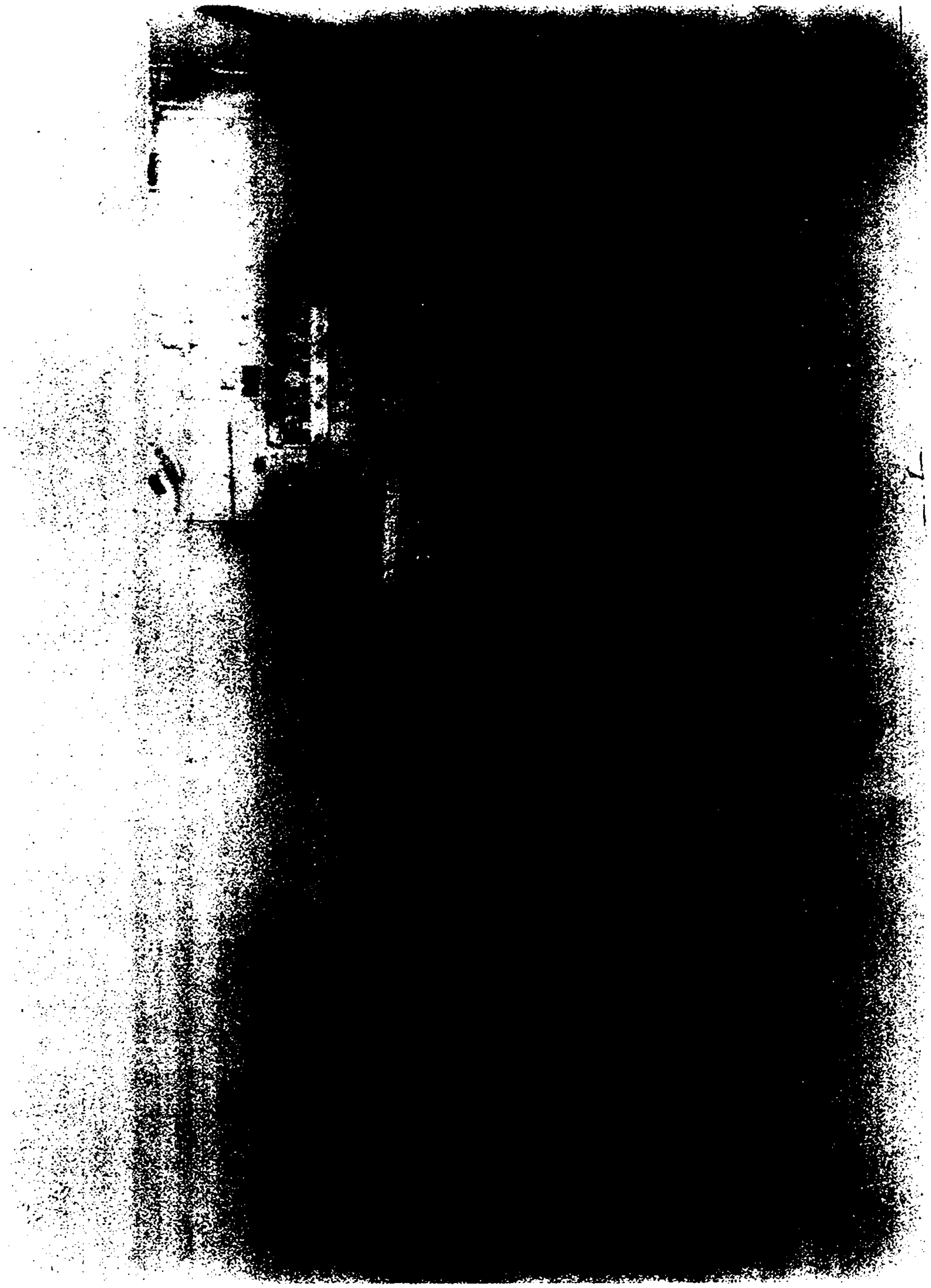
The Wiedemann Punch Press was an ideal machine on which to carry out this development as "One More Step" toward automatic factory operation.

(At this point a sound-motion picture was shown, entitled "One More Step.")

What you have just seen in this motion picture is of course one particular type of development model. The General Electric Company also has another similar equipment--the Numerical Positioning Control--which is now a working production model, manufactured and sold by our Schenectady Specialty Control Department. Here is the first unit which was installed on a Wiedemann punch press in our Low Voltage Switchgear Department in Philadelphia. (Chart 16, page 27.) Also known as the Punched Card Control, this device is used to automatically position the work piece, index the turret, thus bringing the correct punch into position, and initiate the punching operation--a cycle requiring roughly from two to six seconds, depending on the machine travel (chart 17, page 28).

Before concluding, I would like to emphasize the sometimes overlooked significance of the attitude and role of management in the practical realization of industrial automation.

CHART 16



1694

CHART 17

Management must recognize that an automation program embraces all the functions of a business and not just the techniques of manufacturing. Management must recognize that an automation program is a step-by-step analysis of a company's products from a financial, marketing, and engineering viewpoint which results in simplification and standardization--the two keys to the successful application of automation in the factory.

It is up to management--management with vision, enthusiasm, imagination, and courage--to apply this way of manufacturing to its business. Management must determine the degree of automation that its business requires and then develop an overall, progressive program, and see that it is properly carried out. Those who fail to do so will slowly lose ground, just as surely as those who attempt the program on too sweeping a front will lose their shirts. The game is going to be immensely rewarding for the successful, but very punishing on the reckless.

The effect of all this technological growth in the years ahead should be evident in many directions. From the vantage point of the next decade we should see that:

1. Workers have been upgraded from dull, repetitive jobs to tasks that are worthy of human judgment and skills.

2. Industrial productivity has increased beyond the proportion of the increase in capital investment.

3. The quality of many products is finer than ever before.

4. Inventory investment has been released for more productive use because of the high rate of inventory turnover.

5. Multiple-shift operation has taken over to offset the heavy investment in automatic equipment.

In short there will be more and better goods at lower unit cost.

There is no longer any question as to whether American industry will automate. To not only be competitive in the years ahead, but also to acquire the productive potential for the supply of the materials of war--both in capacity and techniques--that will help secure our national future, industry must plan and is planning its progressive steps to automation today.

MR. BAUM: Ladies and gentlemen, Mr. Vinson is ready for your questions.

QUESTION: In discussing automation you referred to the large investment that is required. What dollar investment do you consider reasonable to replace one worker?

MR. VINSON: It is very difficult to answer that, because I don't know any one answer for it. A great deal depends upon the circumstances. I don't know how to generalize on it. Our investment per worker is, if I recall correctly--and I am quoting purely from memory--around 10,000 or 15,000 dollars, somewhere in that neighborhood, in most of our plants.

The reason I can't answer it with any one figure is that, as we progressively mechanize or automate, the economics change rapidly. It is very easy to figure the returns on the first one, whether or not you should automate a particular operation. But if you are working on a line, and you have already mechanized, let us say, 80 percent of it, we find that in order to get the automatic flow from the rest of it, you can always afford to spend perhaps 10 times as much to automate the last 10 operations or whatever it may be.

So what we actually do in our company is this: We have what we call an Appropriation Council, and we look at all investments of 100,000 dollars or over--that happens to be the limit--on a company-wide basis, and measure them on really two basic things. One, we measure the return on the investment, which is not a very complete measurement. Two, we look at the cash flow, in other words how quickly the money that we are investing will come back; that is, we look at the payoff period.

We look on the average at 20 to 30 projects in that category per month. We have no rule of thumb. We have okayed investments which took five years to return the money. I would say the average ordinarily is from a year and a half to two years. Some of them pay off in three-quarters of a year. That is one way we look at them. We have not found any completely satisfactory, or any one measuring stick for the thing you are asking about--in other words how you decide whether you put your money in or not.

There is another thing we have to evaluate that is even more important than that, that is, What are the prospects of making it work?

You can't hook a dollar sign on that. We are in the position of picking off the easy ones at the present time.

QUESTION: Mr. Vinson, there seems to be a lot of concern about the effect of automation on our conversion in time of war. Will you comment on that?

MR. VINSON: I will be glad to comment on it. I think there are several answers to that. If we are foolish enough to put any high investment in inflexible automation, I think the effects on conversion to war could be serious and adverse compared with what we experienced the last time, where we could convert, for example, fractional-horsepower motors for washing machines over to dynamotors and such things in a short time.

In our type of business--electric motors--for example, we can afford a high investment in flexible automation. And the kind of automation that we are putting in would, I believe, have a very good effect on conversion to war, because of necessity the type of automation we are using in those shops is highly flexible automation.

I don't believe most of our machines would know the difference if they were making a military motor or a civilian motor. You probably have noticed in your studies and your thoughts here at the college that when you start making things automatically, the quality goes up. So from that standpoint alone I don't think we would again have to go through the tremendous training period that we had to the last time.

I well remember the difficulty we had getting people accustomed to military quality versus civilian quality. For example: Washing machine motors have to run only a few days a week. When they won't work, the housewife may be very angry, but no airplane is falling down.

That doesn't answer your question, I am afraid.

QUESTION: What I had in mind, Mr. Vinson, was that these constant modifications in design keep the plants flexible, and they might lose some of that flexibility with automation.

MR. VINSON: There might be something in that. Our designers may become accustomed through automation to make fewer design changes, to save them up. However, in our civilian business we are faced with two kinds of design changes. We have rigid control of the standard design change which is not vital to the operation of the product. We save them up. We may make a model change once every six months. We used to make them every week. However, we do have instances where changes can't wait, where flexibility has to come right away.

I think the design flexibility will have to be greater in those shops that are civilian and have to be converted to war. We have many shops that are "at war" all the time, where you just augment their force or move those design engineers over into the civilian shop. I wouldn't think that at this time we would get far enough with automation for it to be a real military problem. I personally don't think so. I am rather pessimistic about the prospect of rapidly jumping into the automatic factory era although we will have some kinds of products, including lamps and vacuum tubes, that may well be moved into that area. However, the military requirements are going through that same process from day to day right now. Some of them are being made on completely automatic machines now.

QUESTION: There is some real technological unemployment in the coal mines. There is really serious unemployment of a local nature in other lines. Do you foresee any real opposition to automation from organized labor?

MR. VINSON: Yes, I do. I don't know how serious it will be. I think a lot depends on how much education the labor leaders really go after. If they continue to attend schools--I don't say schools such as this, I am sure you don't have any of them here, but they are attending, for instance, the Harvard Business School and others--the sincere labor leaders, some of whom I know, I am sure will see this picture; for example, the quote I gave you from Phil Murray earlier. I think there will be many labor leaders that will fight this thing bitterly--we are experiencing that already--not realizing that the lower costs of the goods will in the end create more employment, as we all know.

I am sure you all know of examples. Take the old buggy whip. Some people say the buggy whip is just another kind of accelerator. Now that we are making different kinds of accelerators, more people are being employed than ever were employed making buggy whips.

I think there is more to the coal industry, however, than meets the eye. That isn't automation. It is competition with a different kind of fuel, and the fact that they priced themselves out of the market.

There is another group of people out of employment--bricklayers--in most cities. There is another case where they priced themselves out of the market. Everyone is finding ways of designing buildings without bricks. They are finding ways to operate without coal. When atomic energy comes into common use, there may be more dislocations.

I think mobility of labor is probably one basic answer. Certainly we have a lot of reasons from the humanitarian standpoint for prompting it. We found that in our own factories we have had to do some real planning to try to avoid these dislocations.

QUESTION: Coming back to the economics of this business--Do you have any figures on this control of punch machines, as illustrated in your film? Just on a superficial recollection it would appear that production isn't increased in the automated versus the hand type of thing where you have to have that many dies besides a computer in the process. The cost of the punched card computer would be quite high, wouldn't it? Can you give us some idea of its cost?

MR. VINSON: Yes. I would be glad to do so. The selling price of this automation has still not been established. I think it will be about 20,000 or 25,000 dollars. It may come down even lower when we get into competitive production.

I think the production increase has been about 10 to 1 in our shop. The time saved is in keeping the machines running a greater percentage of the time. More than that, there is the flexibility. In other words the making of a change is a lot simpler than it was.

QUESTION: Mr. Vinson, your vivid description caused me to wonder whether the military departments might find it practical to use automation in their vast warehousing operations. Do you consider it to be feasible, economical, and efficient?

MR. VINSON: You have put your finger on the weakest area in the manufacturing-distribution picture.

We put tremendous effort on factory mechanization. We work on manufacturing costs. We put in all the latest ideas and plans, even in the marketing area. But when it comes to warehousing, we go on using hand trucks--now some electric trucks. We are still using horses quite a bit like we used to do in 1900. That is indeed an area where there is a great deal to do.

We have two young men, engineers, working right now on the idea of the automatic warehouse. It is nothing unique. There is one in New York State now. It uses punchcards. The punchcard has the order on it--for so many of each item. The card is put in a machine, and the parts are thrown into a hopper in the warehouse. The machine wraps them up and turns them out through the back door. It is all done completely automatically.

It is very difficult to make an automatic warehouse pay off. We have a partly mechanized-control warehouse. We can't mechanize it too far. We are hoping that when we can get an opportunity to start with the building itself, we can make an automatic warehouse pay off. We may design such a warehouse so it won't look like a building at all. It will be a warehouse and nothing but a warehouse.

We have one of our most mechanized warehouses in General Electric in our jet engine plant. We have it probably 30 percent mechanized.

I think there is a great future in that. I don't think we have scratched the surface.

QUESTION: Could that be applied to the inventory end also, in order to produce some economy in the number of clerks necessary in the warehouse?

MR. VINSON: Very definitely. As a matter of fact, we do use a great deal of automatic inventory control--automatic counting, automatic indicating of inventory levels, and simple methods of reordering at the correct time.

QUESTION: Mr. Vinson, have you any good figures on the ratio of the decrease in unskilled and semiskilled labor and the increase in highly skilled labor, like process engineers and electronic maintenance people, that have been brought about through the automatic operations?

MR. VINSON: I have some. I don't know how good they are, because they are taken from only two specific cases. But in a lamp plant, for example, as it becomes rather fully mechanized, the maintenance people go up on about a ratio of 10 to 1.

Now, in that particular case, while this 10-to-1 increase was going on in the skilled labor, the unskilled part came down at a slower rate. The unskilled started off from a different base so there was a net reduction in people.

I can only say that where we have had mechanization or automation plans fail--and we have had that happen here and there--it has been because we underestimated the maintenance. As a matter of fact, the manager of Ford's Cleveland engine plant told us that the biggest miss that his people made on that phase of the plant was underestimating the maintenance. They spend a great deal of time in planning maintenance, getting duplicate tools, and so on.

We are going to have to change our whole nature of apprentice training. We have been training a lot of mechanics, machinists, and so forth. Now we are going to have to train a lot of electronic maintenance or electrical maintenance or mechanical maintenance people as well.

We are going to have to start thinking entirely differently about costs. We are no longer talking about the ratio of indirect to direct labor when you have a highly mechanized plant. You are not going to worry about overtime, or overtime premiums, and those things. You are going to worry about your investment, worry about keeping the line working, about what percent of yield you get off the line. It is an entirely different game.

QUESTION: How do you compare your automatic assembling of standard electronic parts to the Navy's Tinkertoy project, where they also manufacture electronic parts?

MR. VINSON: The Navy's Tinkertoy goes far beyond in total anything we were talking about here. No industry could afford a development like that, in my humble opinion. It would be uneconomical. It is a developmental job. But if this hadn't been started by the Navy Department, I don't think we would ever have gotten the automatic factory type of thinking so far advanced. In my opinion no one is going to put into production the exact Tinkertoy development.

QUESTION: They are not?

MR. VINSON: No. I don't think so, as such. But I think we have adopted a lot of pieces of it. Let me illustrate with another example.

We set out to make a machine that way that would automatically make a complete motor rotor. It was a beautiful machine. It was wonderful. Believe me, I could sell tickets just to come in and look at it run. The only trouble with it was that it never worked. We sunk around 350,000 dollars into it--that is a lot of money in my way of thinking--and that particular machine never worked.

You could say, well, we didn't get our money back. But we did, because in that process we found out how to measure out the exact amount of motor punching; how to ladle the right amount of aluminum for the rotor, et cetera. We now have these pieces working on separate machines, and it has saved us that 350,000 dollars many times over.

When I said I don't think Tinkertoy will ever be put into production, it would be more exact to say that I think all of the good thinking in Tinkertoy is already being put into production.

MR. BAUM: Mr. Vinson, I thank you for a very informative and stimulating lecture and question period.

MR. VINSON: I would like to thank the group. It has been a great pleasure.

(25 Mar 1955--750)S/sgh