# Automation for Productivity

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# Automation for Productivity

# Preface

Although automation has long been employed to provide a multitude of reasonably priced products for the American consumer, more and more it becomes evident that its real character as a manufacturing systems approach needs to be examined carefully and broadly as an economic phenomenon. In this book the purpose is to examine automation technology in its broadest sense and develop not only an appreciation for it as such but also present the organizational "how-to" by which business management can more effectively utilize automation to improve productivity and combat rising costs in the years ahead.

Fundamentally, this book is addressed to industrial managers so as to provide top management approach for attaining success in automating. In addition, it highlights the manufacturing research and long-range planning that will be required for creating the new manufacturing technology so necessary for assuring success in future automation efforts.

One of the important facts emphasized in this text is that automation is *not* merely another kind or type of machinery. To effect true productivity improvement requires a fresh look at the *entire* production process or facility – as a completely integrated system. With the developments of the past few years, rapid advances in the technology and the "tools of automation" have brought this imperative goal within the reasonable grasp of manufacturing management in almost every segment of industry. However, to utilize this progress, it is necessary to cope with some of the new problems which have arisen as a result. These must be met and solved before the full value of automated operations can be realized.

The key to management success with automation in the past has often been found to be elusive. Present revelations indicate this is still true. In this book, based on extensive experience, the most important facets of the industrial automation policy needed are placed in proper perspective. With a fundamental understanding, the chief executive can examine corporate goals, objectives and philosophy in terms of the present and the future. He alone can set the course for the future for he must answer the critical question, "On the day we open, is our new plant *already obsolete?*"

This text emphasizes a practical approach to the job of tying down workable solutions to the problems which must be solved. Drawing on the broad experience and practical know-how our company has gained from working with many industries, it can help increase understanding of the principles of automation, the engineering challenges it presents – and the sizeable rewards which automation can bring.

Most significant, this book should make it possible for business and industry to focus a keener insight on the social and economic responsibilities implicit in management today. Since automation will help provide more quality goods with fewer industrial workmen to provide the needs of society, more persons will be transferring into the services and a higher standard of living. As this takes place, it is imperative in the author's mind that businessmen consciously seek to promote the well-being of the people associated with the enterprise they represent and also accept a more intimate responsibility to the broad public it serves.

Automation technology helps support many personal interests and ambitions in a challenging context when its dynamic character is fully realized. This book attempts to offer this practical understanding in easily understood terms for a wide range of utility. Top managers and chief executives in business and industry will find it an important addition to their library of basic texts.

Hugh D. Luke

# Automation Economics and Technology

# Contents

# 1

# The Economics of Automation

Over the past three hundred years a widely diverse array of developments and inventions have laid the groundwork for modern-day automation. In manufacturing, processing, handling, and information systems today, the basic ideas of automatic operation conceived by such men as Evans, Watt, Arkwright, Jacquard, Perkins, Francis, and many others have merged to create the basis for the technology of automation. It is a natural and satisfactory answer to many of the problems which have arisen in the past several decades with the increasing American ambition for a higher standard of living.

Automation in business and industry has developed largely in a climate of free competition and a growing demand. An additional factor has been the difficulty encountered in processing and manufacturing by hand methods within acceptable quantity, quality, and cost levels. Wherever suitable cost and output were impractical of attainment, automation has gradually developed.

## WHAT IS IT?

The word "automation" is a contraction of the words automatic-operation. It implies the process of doing things automatically. It is not synonymous with any other word. It does not merely mean mass production; mass production is volume manufacture of interchangeable products. In the 1840s, Robbins, Kendall, and Lawrence of Windsor, Vermont, mass produced rifles on a truly interchangeable basis completely by hand methods.[1]

Automation is based upon but goes a long step beyond mere mechanization. Mechanization simply means doing things with or by machines, not *necessarily* automatically. True automation implies continuous or cyclic arrangement for manufacturing, processing, or performing services as automatically as is *economically practical* or necessary.[2] Hence, the premise of this book.

The primary feature of mass production is standardization of component characteristics so as to permit complete interchangeability. This means that any product or element in a manufactured lot can be substituted for any other at random. The technique of mass production permits production of piece-parts at diverse locations to specified tolerances so that all are sufficiently identical to permit random use or random assembly with other products. Its basic feature is the elimination of separate individual fitting up in manufacture and assembly. Mass production techniques constituted a major step in creating the possibility of providing large quantities of complex products with superior quality and uniformity at lower cost in time and money. But today, hand methods often fail to fulfill the requirements because of economics, market demand, speed, safety, and other factors. The solution is the succeeding step in the manufacturing picture – automation.

From the standpoint of the workman, automation eliminates the undesirable characteristics of mechanization in which the operator functions as an integral mechanical part of the production cycle. Instead it makes the operator a skilled director of an integrated production sequence; it requires greater knowledge of the product; it calls for increased responsibility; and returns in large measure pride in knowledge and workmanship.

Automation largely aims to take single separate processing operations and link them into an automatic continuous-line. It can involve a few separate operations or all operations from raw materials to finished product. For example, instead of making pipe by a series of separate steps, steel billets enter the rolling mill, are rolled into sheet; the sheet is formed, butt welded, cut to length and threaded, to emerge as finished pipe used for plumbing. By eliminating separate handling operations the pipe is produced at speeds of more than 17 miles an hour.

There are many examples of automation on hand today. As we run through only those everyday necessities such as toothpicks, matches, paper, flour, breakfast cereals, beverages, food products, chemicals, hardware, and on down the list, the story is impressive. But, today the accomplishments in these areas are being transplanted into other production fields. Automation *to some degree* can be found almost everywhere, from producing shovel handles to warehousing products. And the results are always similar – better products and distribution at lower unit costs.

## AUTOMATION IS AVAILABLE NOW

Automation is not a thing of the future. It is available now for solving many of our manufacturing and distribution cost problems. A brief listing of some of today's automation accomplishments provides a glimpse into the many present areas of use throughout industry.

There are consumer product plants such as one turning out appliances at the rate of one every 30 seconds with 2500 automatic and semiautomatic machines tied together with over 25 miles of conveyors.

Single paper mills, for instance, produce as much as 500 miles of facial tissue daily, six feet wide, on continuous automatic equipment.

By continuous automatic production in several steps from raw materials to finished parts, the lamp bulb industry produces an estimated 4 billion lamps per year.

Automated systems successfully recover high-purity iron from low-grade ores in our relatively depleted reserves. Almost totally automatic operation – with a per ton expenditure of electric power several thousand times greater than in open-pit mining – makes these processes economically competitive with foreign high-grade ores and improves the automation feasibility of subsequent steel production operations.

Telephone drop wire is produced on a round-the-clock basis at more than 2 billion feet a year. Copper is electroformed around steel base wire continuously, the wire is cleaned, lead and brass plated, inspected, and wound on reels at rates in excess of 3000 fpm. Extruded insulating cover is applied in a continuous automatically controlled operation.

Through the use of computers, paperwork in widespread groups of plants is closely coordinated. Sales data, office data, and shop orders come from the same master program, eliminating error and lost time. Orders can be placed and delivery dates set within several hours compared to the weeks or months previously commonplace.

Numerically coded tapes as well as computers are widely used to control various kinds of equipment. At present, machine tools, singly or in groups, follow instructions punched into a tape or provided by direct computer control. Machines use the digitized or computerized data to drill holes; machine surfaces;

select rivets from automatic feeders; place and drive the rivets under precisely controlled conditions; pick, bend, and connect electronic wiring; control punching operations; direct transfer machine functions; operate complex assembly machines; carry out performance and/or quality testing sequences; and control processing operations.

In warehousing, packages are carried into storage, delivered into specific areas, passed between floors, drawn out, and fed to delivery stations all under computer control of switches, relays, electric eyes, and other control devices. Work is progressing in computerized sorting and picking operations, normally a tedious and costly process which today sets a drastic limit on speed and cost in distribution of products.

In more than one plant today, production is an automatic computerized operation from raw materials to warehousing and shipping.

## TYPES OF AUTOMATION SYSTEMS

In the achievement of automation, groups or sequences of processing operations, automatic mechanisms, or machines and control devices are brought into a single system to produce continuous or cyclic operation. Wherever two or more automatic machines are tied together with overriding automatic controls to create self-feeding, a self-initiating and self-checking progressive production process, an automated system is created. Material, data or pieces can be introduced into such a system manually or automatically and the processing steps carried out without manual intervention to completion. Generally, almost any process can be automated to some degree. Actually, it is possible to automate a single operation, a sequence of operations, a whole department or a plant.

Automation can be segregated into several types. It is possible to create an automatic batch system or an automatic continuous system. One chemical process, for instance, may be more economically carried out in batches while another is most economical when produced continuously. Process characteristics as well as production economics dictate the best method. Thus, job-lot type operations may require batching arrangement with amenity to continuous change while mass production operations may be more economically carried out on a continuous basis.

Secondly, automation systems may be set up with end-control or in-process control. With end-control, processing is completed before testing, checking, or gaging is done. This is suitable with many processes and feasible with others. However, where precision output is necessary, in-process control is desirable for economic reasons. Material being processed is under continuous control – metal parts, for instance, are gaged in the machine, and correction or size control is accomplished during the operation, thus production of scrap is prevented.

Chemical and similar processing operations are held under continuous sensing and measuring instrument control, and necessary corrections are fed back to the equipment continuously.

## WHAT STIMULATES AUTOMATION?

It is fundamental that management keep in sharp focus the main reasons that can create the need to automate regardless of the scale of operations or their general character. By and large, it is a result of either the basic need to meet a mass market demand or to make possible a product that can be merchandized at an acceptable price, regardless of quantity.

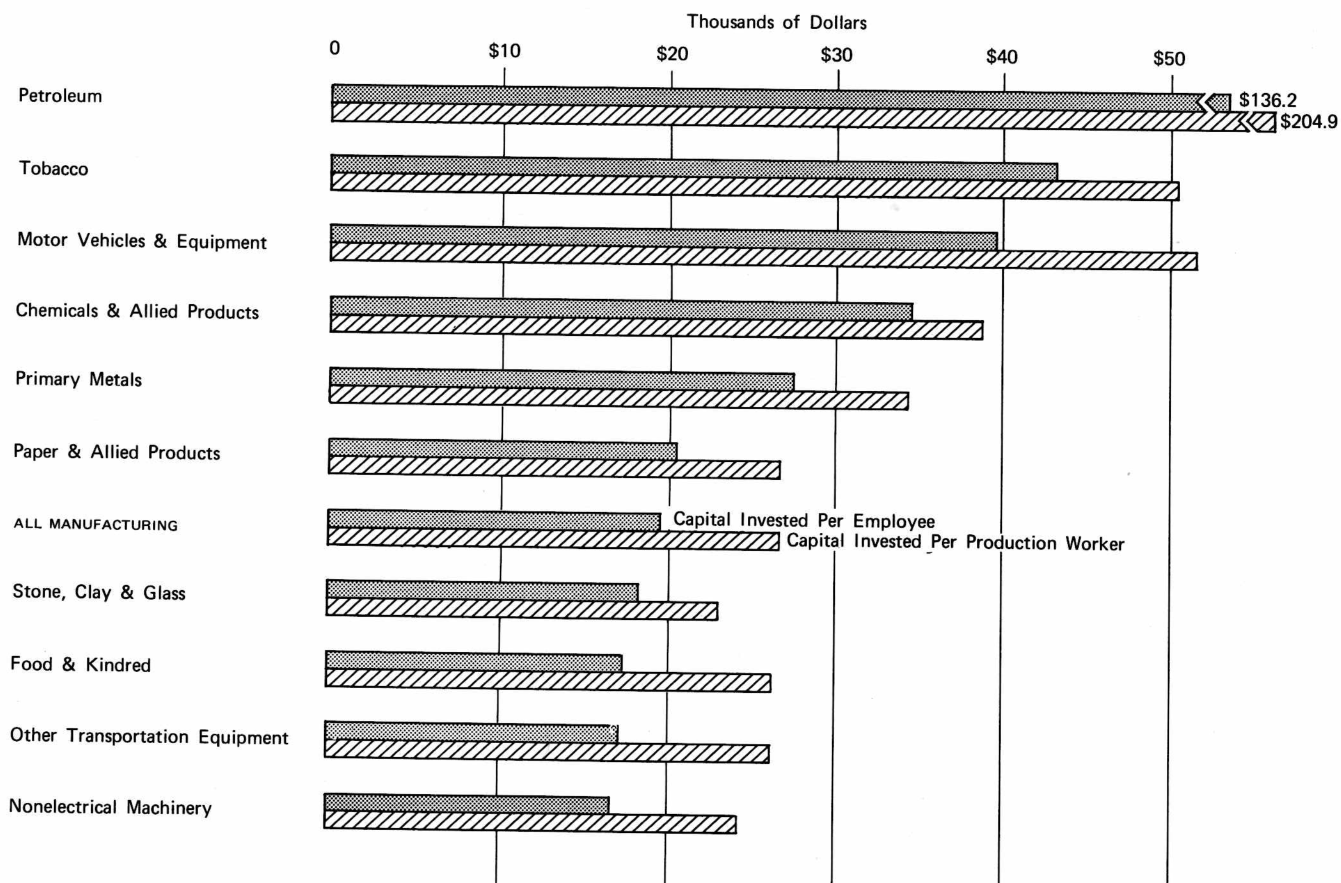
Today, the only reason that certain candy makers are able to deliver 5-cent candy bars made with real chocolate is automation. Fully automatic production lines permit economic operation in spite of the inflated cost of ingredients.

As cost of raw materials rises along with wages, only one end result can create an increased living standard. Commodity prices must hold the line or rise at a lesser rate than wages to create the desired differential between real income and cost of living. To make this possible, production and distribution costs must be cut. All production operations which do not help in creating product value must be eliminated or minimized as to time/cost – such operations include handling, inspecting, packaging, and warehousing.

In seeking to create higher quality products for lowest possible unit costs, innovative automation offers rather dramatic returns. The important achievement lies in the increased production gained from lower scrap losses and lost time, better and more uniform products, improved machine use, more economic use of materials, and simplified steps in reaching the customer.

While it is impossible to do everything automatically, there are quite a few areas where it is not only possible but desirable. Machines met the need when slave labor was eliminated and today automatic machines can eliminate monotonous and useless labor. As living standards rise and population grows, the mass market demand creates a growing pressure for quality goods. Outmoded hand methods cannot afford the necessary quantities, prices, or availability. Under a free competitive system, this trend eventually leads to automation.

Modern bakeries provide an interesting example. Conventional mass bread baking involves considerable wastage in stale loaves. Up-to-date installations make bread production completely automatic to the point where the bread reaches the customer absolutely fresh. Loaves are produced, baked in ovens, packaged, quick-frozen, and passed into storage continuously. Additional cost savings are achieved through the possibility of making longer production runs before changing to another type of loaf.


Thousands of Dollars
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$10
$20
$30
$40
$50
Petroleum
$136.2
$204.9
Tobacco
Motor Vehicles & Equipment
Chemicals & Allied Products
Primary Metals
Paper & Allied Products
ALL MANUFACTURING
Capital Invested Per Employee
Capital Invested Per Production Worker
Stone, Clay & Glass
Food & Kindred
Other Transportation Equipment
Nonelectrical Machinery

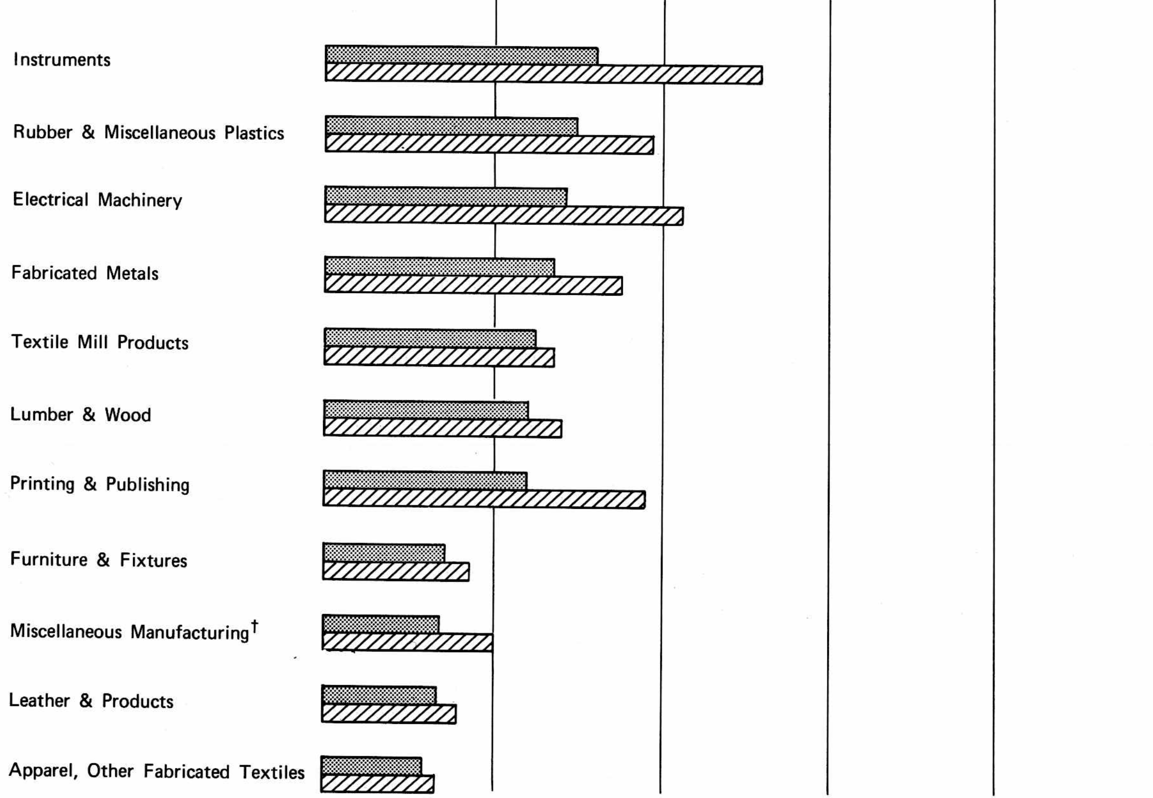


FIGURE 1. Capital Invested Per Employee in Manufacturing. *Petroleum refining extraction and pipeline transportation. †Includes ordnance and accessories. Data are for 1967.

Capital invested per employee in the manufacturing sector rose 3 percent in 1967 to $19,811. The petroleum industry, as in the past, had the highest capital invested per employee, $136,178; this was an increase of 13 percent over 1966. Investment per employee showed the largest annual increase in the "other transportation equipment" group, up 20 percent, reflecting a 30 percent increase in capital but only a 7 percent rise in employment. The largest decline in 1967 occurred in the tobacco industry, down 22 percent, resulting from reductions in capital accompanied by increases in employment.

## AUTOMATION INVESTMENT

In order to achieve this productivity advance with automation, a great change has taken place in cost of the tools of production. In the oil industry, for instance, a typical plant invests over $200,000 in tools for each worker – over 900 percent more than at the turn of the century, see Figure 1. And instead of a 60-hour week there is the less than 40-hour week with hourly pay greater than former daily pay.

Along with such investment in tooling has come radically increased electric power to aid men's efforts. In average manufacturing operations, a typical 1944 plant used about 4½ h.p. of driven machinery per man. By 1953 this had risen to 9½ h.p., now to 25 h.p. But, power for automated operation has sparked a much faster rise. Today, automated plants using over 100 h.p. per worker are commonplace and individual cases are on hand where one man controls 20,000 h.p. or more of integrated machinery. Pumps using electric motors up to 9000 h.p. are no longer unusual; sizes ranging up to 17,000 h.p. for centrifugal compressors are in everyday use.

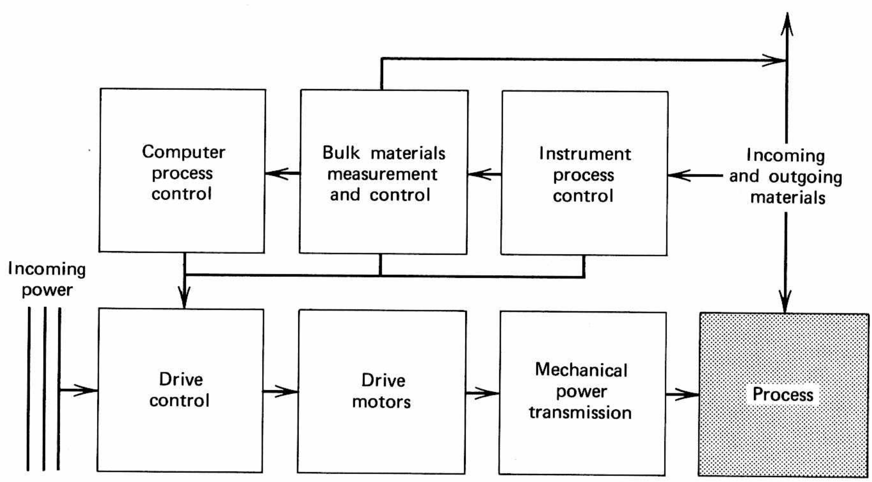


FIGURE 2. The Automation Process.

Successful applications of this complexity require study of the manufacturing process in its entirety as a multi-stage development – a series of fundamental manufacturing operations carried on as an integrated system. This new attack on the problem, as shown in Figure 2, contrasts sharply with the departmental or piecemeal approach common in the past.

In developing and implementing this approach it is imperative to recognize that the total system consists of three major subsystems that may be inextricably interwoven into the final whole. The three subsystems are: processing or making, handling, and controlling, as shown in Figure 3. Any one or all of these functions may be critical to success, Figure 4.

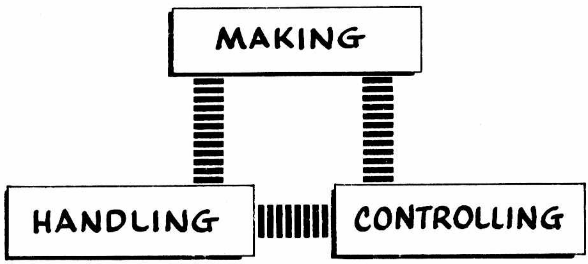


FIGURE 3. Integrated Manufacturing.

For the study and development of the most profitable areas to automate it is desirable to recognize the possible need for reorganization in order to breach traditional internal departmental barriers. A manufacturing group, properly organized and backed by authority from the top, will be needed to carry out the necessary internal activities.

Productivity and/or profit improvement via automation may never be realized unless there is a central philosophy to keep all efforts on target and in proper balanced relationship. A great part of the general accomplishment in controlling manufacturing quality and costs is influenced directly by the equipment policy that prevails. Although it often appears remote, a major objective is to maintain an acceptable profit margin in face of quality demands rising along with material and labor. To ascertain the most economic approach, all detailed cost elements must be evaluated. Accounting methods may require some study. Machine-hours rather than man-hours may be the most critical new factor. In-process inventory may be a key element. Total manufacturing costs, door to door, must be analyzed. The clue is "It *pays* to know your true costs." Most don't until it is too late!

The major question today then is: Do you *really* know where the automation payoff will be? The answer is you don't know and can't know unless a thorough feasibility study is made covering all phases of the manufacturing system to pinpoint the steps to take, where, and in what sequence – conceivably a master plan. Management planning must pinpoint the necessary steps to be taken and provide the means by which it can be carried out.

This includes recognition of the return on investment made possible by the contributions of new technology from manufacturing research and/or outside engineering expertise. Finally, it is in this area that the company must enforce a reasonable policy on acquisition of new capital equipment. There is often little