AUTOMATION

A Study of its Economic and Social Consequences

by

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FROM THE INTRODUCTION TO THE FIRST GERMAN EDITION

This book is one of a series of enquiries into the changes in the structure of society which are being undertaken by the *Institut für Sozialforschung* at the University of Frankfurt. Members of the Institute have shown a lively interest in this piece of research and the author has appreciated their stimulating suggestions.

Part I of this book was first published in 1955. It contains an historical survey and a discussion of the problems raised by the introduction of automation as they appeared in the closing months of 1954. Part II deals with the most important developments both in the theory and practice of automation that occurred in the year 1955. As far as possible we have tried to avoid repetition by cross references. Our index will also assist the reader to find topics discussed in both parts of the book.

This study is concerned mainly with the economic and social consequences of the advent of automation. It has, however, been necessary to describe also the technical methods and devices used in the automatic process of industrial production. This is desirable because an elementary knowledge of these matters is obviously essential to an understanding of the social and economic effects of automation.

We do not presume to offer to our readers a comprehensive sociological theory of automation. But we do attempt to give sufficient information and to discuss a certain number of problems which will enable the reader to form his own judgement on the validity of the hopes and fears raised by the coming of the 'second industrial revolution'.

The author desires to thank those who have helped him to gather the material needed in order to write the book. He also wishes to acknowledge the permission he has received to quote from various sources. While these acknowledgments have been made in the text he would like to thank once more the Joint Committee on the Economic Report (Congress of the United States) for permission to publish extracts from its *Hearings*. The voluminous material assembled by this Committee has by no means been exhausted by the present writer. The author thanks W. E. Vannah for permission to reprint certain diagrams from *Control Engineering* which is one of the leading scientific journals

concerned with all aspects of automation. The author is indebted to Mr T. F. Silvey (National Headquarters of the Congress of Industrial Organisations) for numerous bibliographical references. Without the unfailing help of Mrs A. H. Maier of New York it would hardly have been possible to assemble in a short time all the material—and some of it was relatively inaccessible—required before the book could be written.

FREDERICK POLLOCK

Zurich (Switzerland),
March 1956.

NOTE ON THE ENGLISH EDITION

With only minor changes the English edition of this book is a translation of the first German edition, published in September 1956. However, the bibliography has been brought up to date until November 1956. The great majority of the new publications on automation deal mainly with technological aspects and are therefore of no great significance for those who are studying the broader problems of automation. For this reason it has not been necessary to make any substantial changes in our text. The comparatively few recent books and articles which enter more deeply into the economic and social consequences of automation have—as far as we can see—neither contributed new empirical data nor developed theoretical aspects which have not substantially been covered in this book.

Our study of automation is mainly based on American experience. Comparatively little material bearing on developments in Britain and on the Continent was available when this book was being written. Moreover, the United States are far ahead of all other countries with regard to the extent of automatisation of plants and offices, as well as the discussion of its consequences. If allowance be made for the differences resulting from the enormous domestic market and the much larger supply of capital, American developments may be regarded as typical of the introduction of automation in any economy based on private enterprise. Just as the first industrial revolution in England in the eighteenth and nineteenth centuries was the forerunner of similar economic and social changes all over the world, so the advent of automation in the United States heralds the spread of automatic methods of production, distribution and data processing in all industrial countries.

F.P.

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November 1956.

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PART I

HISTORICAL, SOCIAL AND ECONOMIC PROBLEMS OF AUTOMATION TO THE END OF 1954

'An age of plenty for the living is now technologically possible and feasible. The only thing lacking to bring it about is wisdom. . . . If the language of contemplation is not altogether lost, the nation might find nothing so profitable as a period set aside for sustained thought directed to the completion of the miracles—which is to say, how to keep the servant from becoming the master. The uniqueness of man is thought. The time to demonstrate that uniqueness is now.'[1]

[1]N. Cousins in the leading article of the Special Number of the *Saturday Review*, New York, January 22, 1955, entitled 'Atoms and Automation'. The Special Number contained seven articles on the 'second industrial revolution'.

CHAPTER I

WHAT IS AUTOMATION?

'AUTOMATION' is a new word in the English language. It originated in the United States and has recently been widely used but it has not as yet found its way into the current books of reference. Indeed it has a number of different meanings, ranging from conveyor-belt production to highly complicated forms of automatic machinery. The word has various synonyms such as 'cybernetics', 'automatic control', 'control engineering', 'automisation' and many more.[1] It appears, however, that 'automation' is now ousting the other words as an expression denoting a technical development which is replacing human labour by machinery in factories and workshops in a way that would have been thought impossible only ten years ago.

At one time 'automation' was a matter which was discussed only in those scientific circles intimately concerned with the problem and it was also of interest to engineers, works managers and readers of science fiction. But now a very much wider section of the public is taking an ever-increasing interest in automation. At its annual meeting in 1954, one of the largest trade unions in the United States, instead of inviting as its guest speaker the usual prominent politician, asked the head of the department of electrical engineering of the Massachusetts Institute of Technology, the most important technical college in the United States, to address it.[2] During the autumn of 1954, sixteen stations of a big television network included in their programme a documentary film on 'Automatic Control', in which the leading scientists and practical experts in the field of automation were the 'stars'.[3] According to a statement of the president of the Congress of Industrial Organisations, the rapid development of automation has made it

[1] 'Cybernetics' is also a new word. See below, p. 12.
[2] *C.E.*, Nov., 1954, p. 17 *et seq.*
[3] *C.E.*, Jan., 1955, p. 12 *et seq.*

impossible to postpone any longer the struggle for 'a guaranteed annual wage'.[1] More and more people are convinced that 'a second industrial revolution' is on the way. A characteristic pronouncement of this kind has appeared in the *New York Times*. The writer of a leading article declared that we are now on the threshold of a second industrial revolution which is making sensational progress. Its consequences promise to be as far reaching as those of the first industrial revolution. The characteristic which differentiates the present revolution from the first is that machines are able to guide and control other machines. This is the essence of automation.[2]

The year 1954 saw the appearance in the United States of the first issues of four new monthly periodicals concerned mainly with problems of automation.[3] There are also many scientific, business and technical journals which regularly include learned papers on the progress of automation.[4] The appearance of an ever-increasing number of articles on automation in popular journals—not intended for experts—provides further evidence of an increase in public interest. In addition to the many technical works dealing with automation (and allied problems) there are already available several good books on the subject intended primarily for the layman.[5]

[1]Walter P. Reuther, *Report* of the C.I.O. 16th Constitutional Convention, Washington, 1954.

[2]*New York Times*, Dec. 1, 1954.

[3]*Automation* (Cleveland); *Automatic Control* (New York); *Control Engineering* (New York); and *Instruments and Automation* (Pittsburgh). Unfortunately the files of only two of these periodicals—and they were incomplete—were available to the author when he was writing this book. A German periodical devoted to the technical problems of automation—*Regelungstechnik* (Munich)—has been published since 1953.

[4]*Harvard Business Review* (Boston); *Business Week* (New York); *Factory Management and Maintenance* (New York); *The I.S.A. Journal* (published by the Instrument Society of America (Pittsburg); *The Management Review* (New York); and many others.

[5]The fullest account is John Diebold, *Automation. The Advent of the Automatic Factory* (New York), 1952). The dangers of automation—and a thorough examination of the theory of 'cybernetics'—will be found in Norbert Wiener, *The Human Use of Human Beings; Cybernetics and Society* (Boston and London, 1950). A valuable brief scientific exposition is given in *Automatic Control* (Special Number of the *Scientific American*, November 1952); reprinted under the title: The Editors of Scientific American, *Automatic Control*, New York 1955. A 4-page bibliography of books and journals devoted to automation (including many non-technical items) is to be found in the *Bulletin of the Business Information Bureau* of the Cleveland Public Library (Cleveland), Vol. 24, No. 4 (July-Dec. 1953). It is stated that supplementary bibliographies will be issued. Professor Thomas J. Higgins (of the University of Wisconsin) publishes regularly in the periodical *Control Engineering* lists of books and articles on the theoretical and technical problems of automation. See the issue for November 1954 and later issues. These bibliographies include comments and criticisms on the books and articles which have been listed.

(I) MEANING OF AUTOMATION

There is no universally accepted definition of the term 'automation'.[1] We propose therefore to indicate the general characteristics of 'automation' as the term is commonly used. At the same time we hope to eliminate the contradictions inherent in certain conceptions of 'automation' and to provide a definition which will be acceptable to those who study this phenomenon of modern industrial society. By 'automation' we understand the use of certain methods of automatically producing and preparing goods; of producing information; and of making calculations (e.g. book-keeping)—methods which are characteristic of our present stage of technical development. We speak of the 'era of automation' in the same way as we speak of the nineteenth century as the 'age of the industrial revolution' or the period between the two World Wars as the 'phase of rationalisation'. We sometimes use the term 'automatic production' instead of 'automation'.

The aims and methods of automation may be provisionally defined as a technique of production the object of which is to replace men by machines in operating and directing machines as well as in controlling the output of the products that are being manufactured. If this aspect of automation is complete the product is not touched by human hands from the beginning to the end of its manufacture. Automation may be applied to part of the process of manufacture or to the entire process of turning raw materials into finished products. The first is called 'partial automation', the second 'complete automatic production'.[2] When automation is fully applied to office work all calculations, accounts and book-keeping are done by machines instead of by men. Machines produce all the statistics and other information that may be required and also do the necessary typing. We propose to discuss later the many other functions that special electronic machines are capable of performing in offices.

The most important and fundamental principle of automation

[1]The use of the term 'automation' to mean different things has caused confusion. A group of organisations interested in this matter is endeavouring to reach agreement on a unified terminology.

[2]Virtually completely automatic processes have been introduced into some armaments factories (particularly atomic plants) and also certain factories producing goods for civilian consumption (such as oil-refineries and plants making motor-car engines). See below pp. 23-25.

is the *integration* of formerly separate and unconnected processes of production into a single unified process, or, to use a technical expression, into 'flow production'. This is achieved by using exceedingly complicated and specialised machines which are guided by electrical controls. It might be said that the technique of the conveyor-belt, which has hitherto been used mainly to facilitate the *assembling* of a product, is now being used in the actual *working* of the material from which the product is made. At the same time the men formerly working on the conveyor-belt are themselves being replaced by new machines. All this has been made possible by new machines and techniques—called 'feed-back', 'computer', 'servo-mechanism' and so forth[1]—which have been evolved in the last fifteen years largely by the practical application of the mathematical 'theory of communication'. It will be appreciated that 'automation' has a wider significance than the mere introduction of automatic machinery. Economic and social consequences of a revolutionary character may well follow from the increasing use of new machines which operate with amazing efficiency and have an almost fantastic output.

In the circumstances it is easy to see why a new word ('automation') had to be invented to describe the new machines and the new techniques. To have used the older word 'automaton' would have led to some confusion. It is necessary to differentiate clearly between production with the aid of 'automatons'—i.e. automatic machines such as automatic looms which are constructed on mechanical principles—and the entirely new methods of production that we have just described. It might be said that the age of 'automatons' precedes the age of 'automation'. The age of 'automatons' has been described as follows:

> 'The increased use of *automatons* of all kinds is an essential aspect of technical progress. The factory itself develops into an automaton when all the work necessary to turn out a finished product is performed by automatic machines which continually repeat the same action in exactly the same way. The *worker* no longer helps the machine but simply controls its automatic functions. . . . We are on the eve of an age in which automatons will be used to an ever increasing extent to solve more and more technical problems . . . [the function of] automatons is to repeat the same action with the same mechanical

[1]A discussion concerning the meaning of these terms follows, see below p. 12 *et seq.*

uniformity with which a gramophone record continually repeats the same piece of music in exactly the same way. It
of machine that characterises modern technology. It
matons that differentiate modern technical processes from those of earlier times'.[1]

The unique feature of the *new* technical development is the introduction of electronic devices to take over from the worker even those limited functions which he still exercised in a plant in which 'automatons' had been installed. These functions included (i) moving materials to the machines, (ii) starting and stopping machinery, (iii) controlling both the volume and the quality of the output, (iv) the general supervision of the whole process, and (v) handling of non-automatic machines and tools.

If modern automation is pushed to its logical conclusion the whole physical labour of making a product in a factory is done by machinery and not by human operatives. This is already possible in theory though—for reasons to be discussed later—it can in practice be achieved only in certain special circumstances. When automation is complete a plant 'produces the product of the required quality without any human intervention'.[2] Four distinguishing features of a fully automatic plant may be noted:

(i) Complete co-ordination of the various stages of the process of turning the raw material into the finished product—including packing. The process starts with the arrival at the plant of the raw (or semi-raw) material and finishes only when the finished product is packed and ready for despatch.

(ii) Each separate stage in the manufacture of the product is linked with the preceding and following stages in such a way that the entire process proceeds smoothly and without the slightest interruption.

(iii) After every stage in the process of manufacture the product is automatically moved from one machines to the next.

(iv) The product is automatically checked after each step in the process of manufacture—and also at the end—so as to ensure that the prescribed standards of workmanship have been maintained throughout. If the product does not reach this standard

[1]F. G. Jünger, *Die Perfektion der Technik* (second edn., Frankfort (*M.*), 1949), p. 31 *et seq.* Italics supplied.
[2]R. Oetker, 'Vollautomatisierung' in *Regelungstechnik*, 1954, Number iii.

the necessary adjustment of the machine—or process—takes place automatically or, alternatively, the machine itself gives a warning so that it can at once be examined. Moreover, there are indicators on certain machine tools and special machines which warn the operator—before a breakdown occurs—that some part of the apparatus is wearing out.[1]

A plant in which automation has been fully introduced may be compared with the conveyor-belt system since production is divided into a number of separate operations which are eventually co-ordinated systematically into a continuous process. There is, however, a fundamental difference between the traditional conveyor-belt system of production and the process employed in the automatic factory. When automation is complete most of the tasks formerly undertaken by men working on the conveyor belt are performed by machines. The only men required in an automatic plant are the engineers responsible for starting, supervising and repairing the machines.[2] It has been seen that the position is somewhat similar with regard to the handling of automatic machines which are independent units and not linked in a continuous process. It is often possible for an electronic device to perform the functions of a highly-skilled worker in operating non-automatic machines and machine tools.

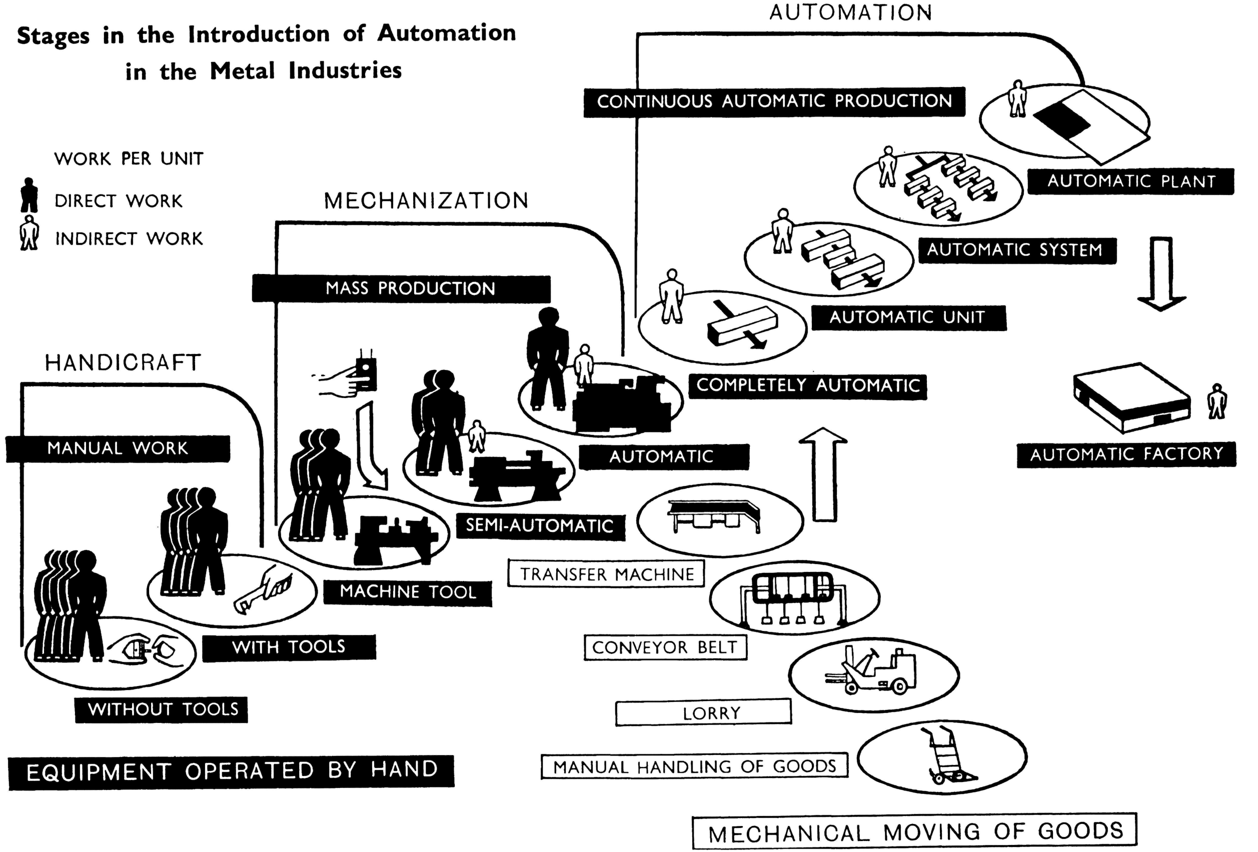
On the other hand there is no analogy between the conveyor-belt system of production in a factory and the introduction of automation into office work. Here the duties formerly undertaken by senior and junior office staff holding various qualifications—assisted by a large number of mechanical aids—can now be performed by electronic computers[3] and also by other specialised pieces of apparatus such as mechanical shorthand writers, punched cards, sorting machines and so forth. These new machines assemble information concerning stocks and finance (book-

[1]C. F. Hautau, 'How to Automate' in *F.M.M.*, August 1954, p. 118, and *Fortune*, Oct. 1953, p. 169 *et seq.*

[2]Automation has also been applied to the preliminary tasks which have to be completed before the automatic plant can be set in motion—e.g. estimating transport requirements for raw (and semi-raw) materials; production of transport time-tables to ensure that all these materials reach the plant on time; calculation of detailed work-programmes in the automatic plant; and estimating transport requirements when the product is complete.

[3]We use the word 'computer' here to differentiate this type of machine from the simpler adding and calculating machines.

DIAGRAM I



[Please see over

Notes on Diagram I

STAGES IN THE INTRODUCTION OF AUTOMATION IN THE METAL INDUSTRIES[1]

This diagram attempts to represent the stages in which the manufacture of metal goods has developed from manual craft-work to the completely automatic factory. The diagram naturally greatly oversimplifies the process of change. The figures are symbols and have no statistical significance. Most of the expressions used in the diagram need no explanation, but the following notes may be useful.

Automatic means automatic machines, i.e. separate machines which are used at this stage. The machines are controlled by human beings.

Completely automatic means that the supervision of the machine and the control of the quality of the product is done by the machine.

Automatic Unit. Here several machine tools are linked by transfer devices into a single unit. The same method can be used in machine construction (e.g. plants making cylinder blocks for motor vechicles) or in making the AUTOFAB (see p. 130).

Automatic Plant. All machines and processes in a plant or workshop are automatic and are linked by automatic devices. In other plants or workshops in the factory conventional methods may still—as in the American steel and motor car industries—be used.

Automatic Factory. This is the logical completion of the process of automation. It has been achieved only in a few factories so far—e.g. the most modern oil refineries and the grenade factory at Rockford (Illinois) (p. 24 *et seq.*).

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1. S. A. June, *The Automatic Factory. A Critical Examination.* (Pittsburg, Pennsylvania, 1955) p. 16. Reproduced by kind permission of the Instruments Publishing Company of Pittsburg.

keeping), produce statistics of output and sales, make mathematical calculations and perform a great variety of clerical functions which have to be regularly repeated in an office.

In an office in which automation has been introduced only a small staff is needed. Engineers supervise and maintain the electronic devices. Clerical workers feed the computer with the information it requires (the 'input') and handle the results produced by the computer (the 'output'). Office staff also have to perform certain tasks which are not regularly repeated—such as the writing and filing of letters which cannot be standardised; the interviewing of customers and of colleagues from other departments in the plant; and, in general, the carrying out of those functions which require initiative and responsibility.

The most important functions in an automatic plant are performed by engineers. They plan and organise the entire process of production. They co-ordinate the work of the automatic machines. They construct new automatic machines and tools as well as the intricate devices which link them all into a single process. They are responsible for the smooth functioning of the entire system of automatic production. In co-operation with the 'managers', the engineers have to secure the integration of the activities of the automatic plant with the work of the other departments of the firm.[1] In doing all this the engineers are obviously continually facing exceedingly difficult problems, many of which will be solved only in years to come. But this much is already clear. Since the days when the movement towards rationalisation first began to make headway the importance of the part played by the skilled craftsman in the process of industrial production has been steadily declining. As the age of automation draws nearer this decline will undoubtedly continue. New groups will assume more and more control over our economic life. They are the engineers (and their assistants) and the managers who are responsible for guiding the destinies of great industrial undertakings.[2]

[1]In an article entitled 'Must Management change to prepare for Automation?' N. C. Hurni, the leading expert in the department of the General Electric Company (U.S.A.) responsible for 'operation research', argues that if an automatic plant is to be successfully established it is essential that the functions of the plant should be properly co-ordinated with departments responsible for (i) market analysis, (ii) planning the type of product to be made, (iii) planning the purchase of raw materials, (iv) planning output, (v) planning distribution of the finished product.

[2]See below, p. 213 *et seq.*

(II) FEEDBACK AND COMPUTERS[1]

Reduced to its simplest terms, automation may be defined as the combination of electronic devices such as computers and self-regulators (or feedbacks) with the most efficient machinery at present available. The principles behind the computer and the feedback have been known for some time but it was the invention of electronic devices which made possible their practical application to modern industry. Neither the computer nor the feedback could have been constructed had it not been for the pure mathematicians who successfully developed the 'theory of control of communication'[2] during the second World War when it was imperative that certain important technical problems should be solved with as little delay as possible. Norbert Wiener, Professor of Mathematics at the Massachusetts Institute of Technology, was responsible for much pioneer work in this field. The fundamental principles of his theory are to be found in his book on *Cybernetics, or Control and Communication in the Animal and the Machine.*[3] The second part of the title shows that the author believed that it was possible for machines as well as living creatures to 'communicate' with each other. Comparative research into the control of machines on the one hand, and the control of the temperature, the blood, etc., in a living organism on the other, has led to some astonishing results. It has been shown that so many analogies can be drawn between the two sorts of 'control' that it is possible to use technological terms (normally applied only to machines) to describe the biological functions of a living organism. It is actually possible to gain a better understanding of certain human ailments of a psychological character by means of the comparative research into the control of living organisms and the control of

[1]In this section we propose (i) to give an exposition in brief outline of the 'theory of communication', and (ii) to explain those technical matters which must be understood in order to appreciate the special characteristics of automation. In the books and articles on automation written for the layman there are detailed descriptions of the technical aspects of the subjects (see bibliography below, particularly the special number of the *Scientific American* (November 1952)).

[2]'Communication' includes the giving and the receiving of information, instructions etc. of any means (speech, writing, the telephone, the telegraph, films, signals) and by various symbols (words, figures etc.).

[3]Published in New York in 1948. Wiener (*op. cit.*, p. 19) explains how the word 'cybernetics' (from the Greek word for 'pilot') came to be applied to the theory of control and communication. For a review of the theory of communication written for mathematicians see C. E. Shannon and W. Weaver, *The Mathematical Theory of Communication* (University of Illinois Press, 1949).

machinery.[1] The theory to which we have referred lays down the mathematical laws governing methods of automatic control provided that the control is based upon communications with the outside world. Norbert Wiener wrote:

> '. . . The many automata of the present age are coupled to the outside world both for the reception of impressions and for the performance of actions. They contain sense-organs, effectors, and the equivalent of a nervous system to integrate the transfer of information from the one to the other. They lend themselves very well to description in physiological terms. It is scarcely a miracle that they can be subsumed under one theory with the mechanisms of physiology'.[2]

This is, of course, a quite inadequate account of the communication theory, which falls within a new field of research and which can be understood properly only if one is prepared to master the necessary mathematical technique. The theory is a statistical theory and does not fall within the scope of Newton's mechanics.

The principle of 'feedback' was used in its simplest form in the governor on Watt's steam engine. It was used also in the machinery controlling a ship's rudder. These are early examples of purely mechanical 'feedbacks'. A thermostatically controlled heating apparatus is a good illustration of the principle on which the modern feedback works.[3] The heater is constructed in such a way as to maintain the temperature of the air within certain narrow fixed limits. As soon as the maximum prescribed temperature is reached, the 'sensory organ' of the heater—i.e. the thermostat—sends a 'message' by electricity to give this information to the controlling organ of the heater. Thereupon the controlling organ automatically switches off the heat. When the temperature of the air has fallen below the prescribed minimum temperature another 'message' is sent to the control mechanism and this time the heat is automatically turned on again.

What has taken place may be stated in the following general terms. A product has certain qualities or characteristics which are given to it as the result of work done by hand or by a machine. In

[1]Wiener, *op. cit.*, p. 168 *et seq.* See also the report in the periodical *Regelungstechnik* (1954, Part 5) of the proceedings of a conference at the Darmstadt Technical High School (*Technische Hochschule*) on 'Biological Control'. An interesting paper ('Regelung in der Biologie') by Professor H. Mittelstaedt of the Max-Planck Institute deals with a development of Wiener's theory. This paper appeared in the periodical *Regelungstechnik* (1954, Part 8).

[2]Wiener, *op. cit.*, p. 55.

[3]*C.E.*, Oct. 1954, p. 21.

our illustration the 'product' is the heat and the quality of the product is the continual maintenance of the temperature of the air within prescribed limits. When automation is applied to the heater 'information' is passed from one device to another so that the product (i.e. the heat) is automatically controlled. The heat is regulated in such a way that the temperature of the air always remains within certain fixed limits. The principle upon which the 'output' of the automatic heater is regulated can be applied to every stage in the process of which a product is made in a factory. If there are a large number of maximum and minimum limits within which certain operations must fall, highly complex devices will naturally be required. The practical application of the feedback principle depends upon the ability of the engineer to invent (i) a 'sensory organ', (ii) a device which reaches a 'decision' in the light of the 'information' provided by the 'sensory organ', and (iii) a method for putting this 'decision' into effect. Not long ago the possibility of constructing machines worked in this way was hardly thought possible. Yet since 1945 large numbers of such devices—generally electronic—have been invented and put into operation. Owing to the rapidity with which the electronic industry is expanding the number of such devices used in industry will inevitably increase month by month.

For our purpose it is necessary to appreciate both the reason why and the extent to which labour is saved by the introduction of the feedback technique. In the absence of automation the operator has to control the working of the machinery. He uses his senses of sight, hearing, taste or smell to regulate the performance of the machine, to judge the quality of the product that is being made, and to decide what corrections may be necessary in the working of the machine. In some branches of industry which have reached an advanced level of technical efficiency, there are devices which warn the operator that the machine requires attention. This is a system by which the errors of the machine and of the whole process of production can be put right only by the action of the operator. This is technically known as an 'open circuit'. On the other hand, when automation is introduced the personal intervention of the operator is, to a great extent, no longer necessary. The machine now regulates itself. This method is based upon the feedback principle and is called the 'closed circuit'.

In the days when the 'feedback system' or 'closed circuit' was not more than an engineer's dream the decisive link in the technical control of output was the work of the human operator. When studying such methods of production—represented, for example, by the conveyor-belt system—the engineer tended to regard the human operator as a sort of nigger in the woodpile. His very presence represented a challenge to the engineer who devoted his energies to rendering the intervention of the human operator superfluous. Today the engineer's dream is becoming a reality.

It may not be without interest to speculate on the future development of the feedback system by considering its possibilities in the chemical industry. Before a 'closed circuit' can be secured in this industry it will be necessary for the product to be tested automatically at each stage in the process of manufacture and for the results of those tests to be automatically recorded and acted upon.[1] Today the tests are made by chemists and their assistants in laboratories at each successive stage in production. The necessary information is passed on to the operator in charge of the control room. By adjusting the appropriate dials this operator makes the necessary corrections in the process. The next phase will see the introduction of a series of automatic devices at each stage of production to test the quality of the product and to report the results of these tests to the main control centre. On receipt of the result of each test the men in charge of the control centre will turn a few dials and in this way he will correct the working of the machines. Two advantages will be secured by this partial introduction of automation. First, some labour will be saved. Secondly, time will be saved and it will be possible to adjust quickly the sort of errors that can occur in the working of even costly machines which were thoroughly checked when they were installed. The introduction of the 'closed circuit' will be achieved when functions formerly performed by the man in the control centre are taken over by a device which will automatically correct the working of the machines in the light of information derived from the tests of the quality of the product made automatically at each stage of the process. As progress is made towards automation on

[1] P. A. Wilks (junior), 'Analysis Moves from Lab to Line' in *C.E.*, October 1954, p. 42.

these lines the duties and the status of the men controlling the machinery will inevitably change. Today the testing in the laboratory is done by busy chemists and their assistants in overalls who seldom have time on their hands. When the testing is done automatically the man in charge of the dials in the control room will be one of the more responsible employees who will not find life so hectic as it used to be in the laboratory. And when automation is fully introduced the man in charge of the control room will be smartly dressed and will have leisure to read his newspaper. He will know that his services will be required only in exceptional circumstances. Only if something goes wrong that the new electronic devices have not been designed to control will the human operator have to intervene.[1]

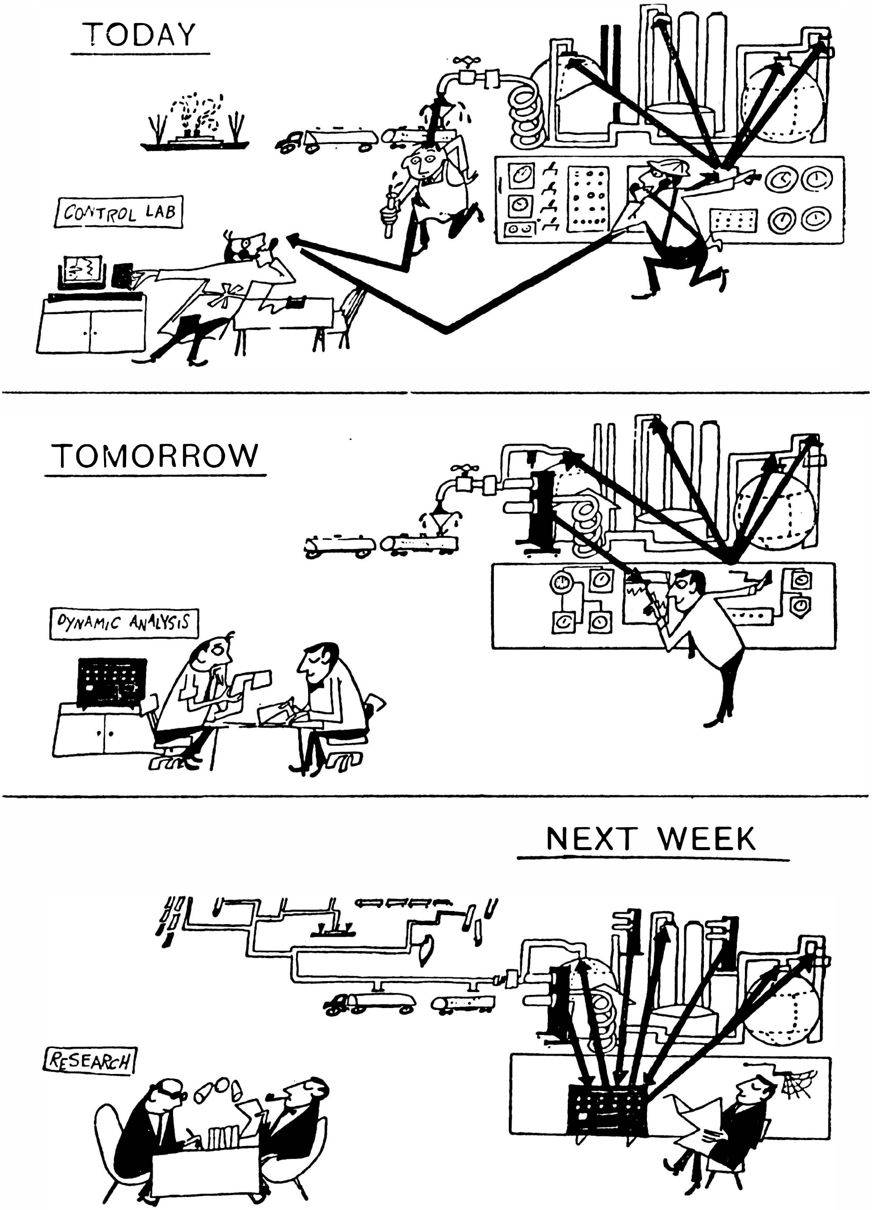
'Giant brains' are the most striking representations of that group of relatively small electronic devices which complete the 'closed circuit' in the way that we have forecast in our discussion on the chemical industry. Various 'brains' have been made, such as the Universal Automatic Computer (UNIVAC) and the Electronic Numerical Integrator and Calculator. The use of the word 'computer' as a generic name for these machines has often been criticised. It has been pointed out that the ability to 'compute' is by no means the only function of these electronic brains. Computers can perform logical operations with the information fed into them and they are capable of doing intricate calculations. They carry out their functions far more quickly than the most highly-skilled human being and far more accurately than lies within the capacity of many men and women.[2]

[1]The argument that the coming of automation will profoundly affect the position of the worker has often been illustrated from the changes that may be expected to occur in the clothes that the worker will wear in the future. Thus Professor G. S. Brown's lecture to the steelworkers' trade union (to which reference has already been made) begins with the words: 'Dinner clothes in a steel mill? Steel has become an industry wherein I would not think it facetious if the workmen wore tuxedos on the job.' (*C.E.*, November, 1954, p. 17). According to an authority on the oil industry it would be technically possible to complete the 'closed circuit' in certain refineries which are already nearly completely automatic. But it is not proposed to introduce full automation because it is considered desirable to have available a certain number of workers whose services can be used for routine duties and emergencies. (*Hearings*, p. 475). Regarding the use of a completely closed circuit in the production of electric power see p. 133.

[2]The term 'electronic combination-machine' is perhaps one which most accurately indicates the capabilities of a 'giant brain'. For full accounts of these machines (written for the laymen) see E. C. Berkeley, *Giant Brains* (4th edn., New York and London, 1955) and Louis Couffignal, *Les Machines à penser* (Paris, 1952).

DIAGRAM II

The Road to Complete Automatic Control



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A brief survey of the history of the development of electronic computers may help the reader to appreciate how numerous are the possibilities with regard to the various uses to which these giant brains can be put. During the second World War American scientists were asked to invent a device for an anti-aircraft gun which would give the gunner the information he required in order to take aim accurately. Owing to the speed of modern aircraft the gunner could not himself make this calculation quickly enough. It was necessary to ascertain the point at which the course of the enemy aircraft and the course of the shell fired from the anti-aircraft gun would intersect—bearing in mind the speed of the aircraft and the speed of the shell. The data needed for this calculation included (i) the movement of the picture of the aircraft on the radar screen, (ii) the weather conditions, and (ii) the range of the anti-aircraft gun and the speed of its shells. It was necessary that the electronic device should not merely make this calculation but that it should pass the 'information' on to the anti-aircraft gun and then actually move the barrel of the gun into the position in which a hit on the target was most likely to be secured. In spite of the obvious difficulty of solving the problem in a short time the device was constructed.[1] Preliminary researches by Vannevar Bush and by Norbert Wiener (originally undertaken in another connection) paved the way for this successful invention.[2]

Another very important early electronic device was the calculating machine. This apparatus could do very complicated calculations very quickly. Such calculations—although they involved only the four basic arithmetical operations of adding, subtracting, dividing and multiplying—would have taken even a trained mathematician a long time to perform. In the early days of the second World War experiments in the development of calculating machines was pressed forward. The lack of sufficient qualified mathematicians coupled with the enormous demand for large-scale calculations in connection with the manufacture and use of modern weapons made the problem one of great urgency. The fantastic speeds at which the calculations had to be made and the absence of sufficient experts to do the calculations by hand made

[1]The device is a 'closed circuit' or 'closed loop'. The radar screen is the 'sensory organ' and the arrangement for training the gun on to the target takes a 'decision' in the light of the 'information' fed into it.

[2]Wiener, *op. cit.*, p. 9 *et seq.*

it essential to introduce human labour only

> '. . . where it is absolutely unavoidable, at the very beginning and the very end. . . . This means that not only must the numerical data be inserted at the beginning, but also all the rules for combining them, in the form of instructions covering every situation which may arise in the course of the computation. Thus the computing machine *must be a logical machine* as well as an arithmetic machine.'[1]

The computer shares with the calculating machine the ability to carry out the same process time and time again with the greatest consistency and accuracy. The electronic computer can not only perform all the mathematical operations that the mechanical calculating machine can do but it can give the answer very much more quickly. In addition the computer has the capacity of making comparisons. The 'collator' device in the machine is able to judge whether a piece of information fed into it is compatible with an earlier item of information which it has stored in its 'memory'. If the two items are not compatible the computer can indicate the extent of the divergence. The computer can therefore not only add, subtract, divide and multiply but it can also make comparisons. In accordance with the instructions that it receives the computer can solve a problem which involves all five operations. The ability to forecast the future course of an aircraft—from no more data than that provided by the radar screen—is a relatively simple problem for a computer.[2]

The larger computers at present in use have three main parts:

(a) the calculating section which performs the five basic operations of adding, subtracting, dividing, multiplying and comparing.

(b) the control section which checks every operation as soon as it has been made. If it can do so it corrects errors immediately—but mistakes occur very rarely indeed—and if it cannot do the ocrrection it stops the machine so that the human operator can put the error right.

[1]Wiener, *op. cit.*, p. 139 (italics supplied).

[2]There are two different types of computers: (i) Digital computers. These machines work directly with numbers or digits. (ii) Analogue computers (differential analyzers) are able to compare a new measurement with an old measurement which has been fed into the machine at some previous time. See Wiener, *op. cit.*, p. 69. When we refer to a computer in this book we usually mean a 'digital computer'. It has been observed that it is much more economical to use an analogue computer than to machine new parts for a numerical computer. It also facilitates certain types of research, since 'the differential analyzer performs the mathematical operations needed to solve the differential equations of motion of the system under study' (*Battelle Technical Review*, Columbus, Ohio, Sept. 1954, p. 93).

(c) The 'storehouse' of the computer is its 'brain'. It is fed with all the necessary instructions and data that may be required for the solution of problems in the future. This information is 'stored' in the 'brain' of the machine—to be 'remembered' for future use.[1]

Moreover, the computer also has a device which transmits all items of 'information' and all 'instructions' concerning the problem to be solved (i.e. the 'programme') to the appropriate sections of the machine. The computer also has a device for delivering the problem it has solved in whatever form is desired—for example in decimals,[2] in words, as a graph, or in the form of impulses which operate some other machine linked with the computer.

The following figures will give the reader an idea of the speed with which a large electronic computer can work.[3] In one minute a computer can transcribe on to a magnetic band the information recorded on 240 normal punched cards, each card having 80 or 90 columns. Once the information is recorded on the magnetic band the computer can pass on to its 'storehouse' (or 'memory section') 10,000 figures or letters in one minute. This information can be 'remembered' for an indefinite period by the machine. The calculating section can perform the following operations in one second with figures ranging from one to ten million—1,905 additions or subtractions, 465 multiplications, 257 divisions and 2,740 comparisons. The results of these operations are available very quickly. A device, working at great speed, transcribes the results from the magnetic band on to paper. In one minute 72,000 letters or figures are transcribed in this way. When the computer is used to perform a number of operations simultaneously it can handle up to 14,000 operations in a second. A single example may be given to illustrate the great speed at which computers work:

> 'A jet engine used to be designed by trial and error. You had to build it first, or a costly model, to find out how it would work. Now, an electronic computer helps solve long and complex jet development

[1] The time that it takes for the 'storehouse' section to deliver information is reckoned in thousandths of a second.

[2] The computers work on the binary system and not on the decimal system. But computers are capable of automatically transcribing their results from the binary to the decimal system.

[3] These figures have been taken from reports made by the manufacturers of computers. For progress made in 1955 see below, p. 119 *et seq*.

problems in advance. In 15 minutes it goes through 8 million mathematical calculations and comes up with an answer that would take a mathematician 7 years.'

It is not possible to give details concerning all the various tasks that can be performed by a computer.[2] All that we can do is to summarise briefly some of the tasks actually performed at present by these machines. This will enable us to consider some of the interesting possibilities of saving labour in the future by the extended use of computers:

1. *Mathematical and Statistical Calculations*, including advanced mathematical calculations for scientists and engineers to help them solve both theoretical problems and also practical engineering problems.[3]

2. *Book-keeping Operations* of all kinds including wage sheets, balance sheets, calculations, etc., and also the necessary statistical information based upon these figures. When calculating wages the computer records additions for overtime and bonuses as well as deductions for taxes and insurance. In preparing a balance sheet the machine records turnover tax, luxury tax, discounts, freight charges, etc. The computer can prepare a statement of costs including materials, wages, overheads, and also the costs incurred by separate sections of the plant. And all this is done 'to the nearest farthing'.

3. *Preparation and Control of Programmes of Production and Despatch.* This includes planning: (a) delivery dates, (b) the quantities of raw materials and semi-manufactured goods required, (c) the number of workers required; (d) the punctual delivery of the product by the conveyor-belt. The computer can also solve specific problems by co-ordinating information provided by engineers, foremen and workers in the different sections of the plant.

4. *Preparation of Reports* of all kinds for the directors and management of a firm. These include (a) routine reports which give the management without delay all the information it requires, including details of the working of the firm; (b) special reports which—

[1]Fom an advertisement of General Electric (1954).

[2]See R. F. Osborn, 'G.E. and UNIVAC: Harnessing the high-speed Computer' in *H.B.R.*, July-August, 1954, p. 99 *et seq.* for an excellent account of the various uses to which a giant American computer has been put.

[3]We do not propose to discuss here the immense significance of electronic calculators for the future advance of knowledge in the natural sciences and perhaps also in the social sciences.

if there were no computer—could be prepared only at a prohibitive cost and even then might not be available in time.[1]

5. *Takes 'decisions' concerning the functioning of a 'Closed Circuit'* or a complete system of 'closed circuits' (i.e. an entire plant). The computer 'decides' which machines are to be used on a particular job and regulates the supply of raw materials and semi-manufactured goods to these machines. The computer sees to it that, at every stage in the process, there is no departure from the prescribed variations in output.[2]

When considering the efficiency of computers it must be remembered that much complicated preparatory work has to be done before a computer can handle a new 'programme'.[3] On the other hand it would be easy to exaggerate the difficulties inherent in preparing a 'programme' for a computer. Firms which manufacture computers arrange courses at which workers are instructed in the preparation of 'programmes' and the operation of computers. These firms state that only three months are required to give this instruction. An 'expert programmer' can be trained in six months.

In concluding this introductory section on the technical basis

[1]'The great value of the new mechanisms lies in the fact that they make it possible for management to make decisions that are timely and accurate, with the assurance of knowledge rather than by guesswork or intuition.' (Leslie R. Groves, quoted by *A.C.*, August 1954, p. 43.) It is not without significance that General Groves—who, since 1948, has been in charge of the department of scientific research of a firm that has produced one of the most efficient computers on the market—was, until 1947, the leading Army officer concerned with the 'Manhattan Project' (the government agency for the manufacture of atomic bombs).

[2]Machines which are linked with computers have a device which enables them to function by means of impulses transmitted to them on an electro-magnetic band. An example is the piece of milling machinery built by the Massachusetts Institute of Technology on the 'closed circuit' principle. It is capable of making 150 different products. See *Fortune*, September 1952, p. 170 and *Management Review*, February 1954. For further progress in the development of machines worked by impulses from electronic computers see below, p. 120 *et seq.*

[3]The head of the computer department of a large American aircraft firm stated that if a programme of work was being prepared for a computer capable of performing 16,000 operations per second it would take some time to translate into a binary code the problems which the machine was required to solve. In addition it takes time to work out the programme in all its details. It is necessary to prepare the instructions to feed into the machine. A computer can only solve problems prepared for it by an expert mathematician (*B.W.*, June 5, 1954, p. 158 *et seq.*). This is true only of the preparation of an entirely *new* programme. The continued use of a programme which has already been prepared involves merely feeding the machine with additional information. Since 1955 methods have been devised whereby the principles of automation can be applied to working out a programme for a computer.

of automation we may summarise the working of the 'closed circuit' as follows:[1]

> 'First of all there is the "sensor" that reports by feedback to the computer what is going on in terms of speed, pressure, size, weight or anything measurable. Then there is a "memory", which remembers and knows what should be going on and what to do. A "collator" compares information from the "sensor" with informations from the "memory". If there is a disagreement the collator asks the "memory" what to do. The "memory" answers, whereupon the computer-director carries out the instructions of the "memory".'[2]

It is indeed no exaggeration to say that in the automatic system of production the machine takes over 'functions that bear an uncanny resemblance to sensory perception and intelligence, so that judgment is added to skill.'[3]

(III) HOW AUTOMATION SAVES LABOUR

The following examples of how automation saves labour have been taken from the American daily press and from scientific journals which deal specifically with automation. These examples are not necessarily typical illustrations but are given simply in order to give some indication of the amount of labour which has already been saved by installing automatic machinery or which is likely to be saved when automation is introduced. Consequently we have not summarised reports on the result of introducing automatic machinery into those branches of industry in which no great saving of labour may be expected because for a long time the labour has played only a subordinate part in the final processes of manufacture. Examples of this type of production are oil refineries, atomic energy plants and certain types of chemical works.

Manufacturing Plants

Hitherto automation has been applied only to particular sections or departments of manufacturing plants. There are, however, a few cases in which automation has been applied to the whole process from the arrival of the raw material to the despatch of the finished article.

[1] This summary is based upon W. Kaempffert's description ('Science in Review' in *N.Y.T.*, Dec. 12, 1954), an excellent account of the 'closed circuit' written for the layman.

[2] W. Kaempffert in *N.Y.T.*, Dec. 12, 1954.

[3] *Ibid.*

There is a tyre factory in the United States in which the process of manufacture from raw material to finished product is entirely automatic. Here 300 tyres are made in an hour.[1] Similar complete automatic processes have been introduced into the production of glassware, the making of paper (continuous process from the cellulose pulp to finished article ready for delivery) and the manufacture of steel pipes for use in the oil-fields.[2]

The armaments industry has made striking progress towards complete automation. It is reported that in the manufacture of rifle-grenades by automatic machinery only two workers are needed to produce 900 grenades per hour whereas on the old conveyor-belt system 23 men were required to do the work. In this factory the automatic machinery cost only one third of what would have been paid for installing the conveyor-belt system and it also had the great advantage of occupying much less space —560 square feet as compared with 10,550 square feet.

The best-known example of a completely automatic plant in the American armaments industry is the grenade factory at Rockford in Illinois. Only 140 men work on a shop floor 1,000,000 square feet in extent—including engineers and men responsible for handling and servicing the machinery. No human hand touches the product from the time when blocks of steel enter the manufacturing process to the time when the finished weapons have been packed. This plant, constructed towards the end of the second World War, is already partially obsolete since it would be possible to reduce still further the number of men on the shop floor if the newest devices and methods are used.[3]

An example from civil industry of the automatic production of parts of a product is the manufacture of motor chassis in Ford's Cleveland plant. Here 26 machines carry out 532 operations to turn a six-cylinder steel block into an engine block. Only 41 men are required in such a plant. They include the job-setters who get the machines ready at the start of the process, the men who supervise the process, and the men who replace worn-out parts of machinery when a control-device known as a 'tool meter' gives the

[1]Advertisement in *Fortune*, Dec. 1954.
[2]Advertisement in *Fortune*, Dec. 1954.
[3]John Diebold, *Automation: the advent of the automatic factory* (1952), pp. 74-80. Detailed reports concerning this plant will be found in *Hearings*, p. 253 *et seq.* and p. 569 *et seq.* See also *F.M.M.*, July 1954, p. 88.

necessary signal. If the conveyor-delt system were used it would take 117 men four and a half hours to do the job. In the automatic plant 41 men can do this in three hours.[1]

At one time 250 employees 'in grimy work clothes' turned out gramophone records amid the stench of burned rubber and the ear-splitting noise of hydraulic presses. In eight hours they turned out only one-fifth of the records now produced by sixteen 'softly purring' linked machines supervised by four 'neatly dressed' operatives.[2]

Finally reference may be made to an automatic foundry in which the introduction of automation led to a saving of 70 per cent in the wages bill. Among the advantages claimed for the new system in this foundry particular reference may be made to the improved quality of the product, the reduction in floor-space required, and the fact that preparations for a new 'programme of production' take only forty-five minutes.[3]

To what a pitch of efficiency automation can reach may be seen from recent plans for the erection of an automatic plant for making pistons. If a breakdown occurs in the process of manufacture the work to be done will be automatically transferred to reserve machines, the balance of production will be automatically preserved so that maximum output may be achieved while repairs are being made.[4]

Wholesale Trade

An example may be given of the use of an electronic computer in warehouse-control and in the despatch of goods in the wholesale trade. In a warehouse handling 12,000 different articles it is possible at any time for ten employees—holding key-posts in the control-system—to secure from the computer precise information concerning stocks and orders. Moreover with the help of the same machine these ten employees can fulfil about 80,000 separate orders in one day. Before the introduction of a system controlled

[1]*Fortune*, October 1953, p. 171 and *Soziale Beziehungen in der Industrie*, March 1954. For information concerning other motor vehicle works in which the manufacture of parts of the finished product is virtually automatic see, for example, *B.W.*, November 6, 1954.

[2]*Management Review*, February 1954, article on 'The Automatic Factory: Progress to date'.

[3]*F.M.M.*, October 1954, p. 45.

[4]*N.Y.T.*, December 12, 1954.

by an electronic computer 150 employees were required to perform the work now done by ten employees.[1]

Book-keeping

The working of Lyons' Electronic Office (LEO) has been described by the *Economist* in an article entitled 'Electronic Abacus'.[2] In 1953 Lyons, who own a large number of cafés, installed an electronic computer which was built in England. This machine calculates and records the wages paid to 33,000 employees. In calculating the net wage it takes account of twenty different deductions and extra payments. At the same time it provides information concerning the number and kind of notes and coins required to pay the wages and also the number of insurance stamps that will be needed. A clerk using normal office equipment would, on the average, take eight minutes to caculate the weekly wages of a single employee. The electronic computer does the same work in about a second. The report gives no figures concerning the labour saved by introducing the computer, but it was stated that the new method saved a great deal of time, labour and space. In addition the computer calculates the stocks, orders and balance sheets of a large number of Lyons' cafés.

Detailed information is available concerning the achievements of one of the largest American computers which has been installed in a plant belonging to the General Electric Company. In two hours this machine calculates the wages of 12,000 workers. It provides information concerning net payments and the distribution of wage-costs over various accounts. All results are transcribed on to a magnetic band. In another four hours the computer prints the wages cheques for those employees who are not paid in cash; and wage sheets both for the pay-clerks and the accountant. This computer can perform in six seconds a task which formerly kept a large number of clerks occupied for a whole week.[3] The machine has other functions as well.[4] It supplies continuous information concerning stocks in hand and new materials required.

[1] *H.B.R.*, 1954, No. 3, p. 4.
[2] *Economist*, March 13, 1954, p. 789 *et seq.*
[3] *H.B.R.*, 1954, No. 4, p. 102 *et seq.*
[4] The author of the report summarised above shows how, step by step, the computer can be set to solve even more complicated problems.

It automatically co-ordinates requirements for all kinds of materials into a single production programme. The information is classified according to daily and weekly requirements. The machine shows what orders have to be completed every day. Moreover the computer is used to make the preparations necessary to send out orders. It draws up the despatch plan. It plans the completion of a waggon-load of goods of different types made in different departments of the plant. It prepares invoices and accounts for customers. It keeps the records and accounts of the sales department. All the figures produced by these operations are automatically reproduced by the machine in statistical form for the accounts department and for those responsible for writing reports for the directors.

Transport: Allocation of Freight Space and Passengers' Reserved Seats

A substantial saving of labour has already been made by installing computers in offices dealing with transport by rail and air. As an example we may refer to a method that is employed by a large air-line in making its flight reservations. The magnetic 'memory' of the computer is supplied with time-table data of up to 2,000 flights (departure times, destinations, routes, etc.). It is supplied also with information concerning the seats already booked, the cancellations, the space available for freight, and the position concerning fuel supplies. With this information at its disposal the machine can in less than half a second either reserve a seat or say that no seat is available.[1]

Public Administration

Apart from offices dealing with military administration there are a number of civilian offices in the United States in which computers are used. One of these offices is concerned with producing as quickly as possible actuarial tables which can be used in connection with pensions for widows and orphans. By using the old methods (calculating machines, dictaphones, typewriters, etc.) about 40,000 working hours would have been needed to do this work. On the other hand the new method took only 1,443

[1]Advertisement of the maker of the computer in *H.B.R.*, 1953, No. 6, p. 4.

working hours—including the preparatory work—and the computer itself was in operation for only 104 hours. An investigation showed that the cost of the work was only 7½ per cent of what it would have been if the traditional methods had been used. This calculation included a depreciation allowance for the computer, the cost of materials, overheads and wages.[1]

Insurance Offices

The president of an American insurance company has stated that '. . . we are anxious to get the "electronic revolution" under way, in our offices, for we are certain our future would be restricted without it'.[2] He discussed the experience of his firm in using a computer which performs the following operations: Calculation of rates on individual policies; regular assessment of premiums; production of demand notes for premiums (addressed and ready to be inserted into a 'window envelope'); keeping records of premium payments received; calculation of reserve liability (as prescribed by law); calculation and recording of commissions paid to agents etc. At one time 150 clerks using conventional modern mechanical aids were employed to do this work. Now the services of 130 of these clerks are no longer required. Other large insurance companies have also installed computers.[3]

Other Aspects of Clerical Work[4]

Office machines which are guided and controlled by electronic devices are so much more efficient than the traditional methods of doing repetitive clerical work that even medium-sized concerns will find that it pays to install them. Already smaller computers are being built. Their makers claim that their capital cost will be saved in a few years even in a plant which employs no more than 500 workers. In large American undertakings a considerable number of repetitive clerical tasks are already being performed by the new methods. These tasks include the typing of circular letters (and carbon copies) and certain records which have to be kept regularly. Those who install these machines unanimously

[1] H. A. Hancock, 'They met a Deadline' in *Systems Magazine*, May-June, 1954.
[2] C. E. Becker, 'Life Insurance gets the UNIVAC' in *Systems Magazine*, March, 1954.
[3] See, for example, *D.Z.*, November 24, 1954.
[4] *F.M.M.*, July 1954, p. 69.

declare that they have great advantages over conventional methods since they save both time and money. Moreover the control devices ensure that virtually no mistakes are made. Some 300 shorthand-typists would be needed to type 1,800 notices but an electronic typewriter can do the work in a second.

(IV) LIMITATIONS OF AUTOMATION

It has been argued that the spread of automation will drive the workers out of the factories and the clerks from the offices. Others, however, claim that it is absurd to suppose that automation will have social consequences of so drastic a nature. They assert that the idea of a 'factory without workers' is a false generalisation from a number of exceptional cases. They believe that workers will always be needed. If this statement is put in a sufficiently general form it is no doubt correct. Automatic machines are designed, constructed, installed, operated and serviced by human beings. It is human beings who decide what goods are to be made and in what quantities they are to be produced. Human beings decide how the products are to be distributed. Automatic machines can do repetitive work. They can also take 'decisions', though only in the light of circumstances previously foreseen by human beings. We propose to discuss the limitations of automatic machines within their own field of performing repetitive tasks and of taking certain sorts of 'decisions'. The development of automation is limited by the technical knowledge of engineers, the cost of constructing automatic machines, the demand for automatic machinery, and the availability of trained specialists capable of designing, constructing and operating such machines.

From a purely technical point of view there is no doubt that automatic machines can be devised to perform any repetitive task more rapidly, more accurately and with greater care than human workers.[1] Quite recently automatic methods have begun to be used in setting machines to work and an extension of this aspect of automation may confidently be anticipated. Moreover in the checking the quantity and quality of the product made in a factory automation could replace an army of inspectors and analysts. Output per square foot of floor-space is continually being

[1] *F.M.M.*, July 1954, p. 88.

increased by installing automatic machinery.[1] In practice the progressive introduction of more automatic machinery is limited by the existing type of production methods in use. Frequently very difficult problems of construction have to be overcome before it is possible to graft the new electronic devices onto existing machines. Indeed it is not uncommon to adapt the product itself to the new method of production. When the existing conveyor-belt system is already subdivided into numerous processes the introduction of automatic devices may involve a radical reconstruction of the whole system of production.

It has been stated that in the use of computers 'there is only one limiting factor: man's ability to review a given problem analytically and then to translate that problem into language which the machine can understand.'[2]

The economic efficiency of automatic machines is not unlimited and this factor restricts the extension of the use of these devices more effectively than purely technical considerations. Many cases have been reported in which an automatic process has been interrupted and human labour has been used to do something which could be done by an electronic device.[3]

> 'In the present early application of automation to factories, manpower is substantially reduced, not completely eliminated. Currently, it is too costly for most factories to go the limit. The necessary instruments and mechanisms could be made, but at a cost so great it is not profitable to displace all production workers *right away*.'[4]

[1]*F.M.M.*, July 1954, p. 87 *et seq.* See also the statement made by a member of the U.S. Atomic Energy Commission concerning the new methods of testing materials automatically.

> 'Good inspectors are hard to find, expensive to train. Worse yet, even the best are inconsistent. If a man inspects the same part twice, he may pass it the first time, reject it the next . . . [Eddy-current sensing devices] can test many types of metal parts for flaws and other imperfections. . . . And they can fit into systems that automatically reject substandard pieces.'

(R. Hochschild, 'A new Tool makes Inspection automatic' in *C.E.*, Oct. 1954, p. 35 *et seq.*).

[2]J. H. Higgins and J. S. Glickauf, 'Electronics down to Earth' in *H.B.R.*, March-April, 1954, p. 99.

[3]See, for example, the excellent article entitled 'Pontiac does it with Machines and does it better' in *B.W.*, November 6, 1954, p. 121 *et seq.* This article states that a plant belonging to General Motors increased its output by 25 per cent by introducing the newest automatic methods. There was no change in the cost of labour and machinery. But in this plant some isolated jobs, which could be performed automatically, continued to be done by the traditional conveyor-belt method because the existing demand for the product did not appear to warrant the outlay that would be necessary to introduce an electronic device.

[4]T. F. Silvey, 'Automation—New Impact and Challenge' in *Looking Ahead* (National Planning Association), Oct. 1954, p. 5 (italics supplied).

The problem of the demand for the product of a plant has an important bearing on a decision to introduce automatic machinery. It may be that total sales are too small to justify the cost of making the plant fully automatic. This limitation of the expansion of automatic machines will, however, be quickly reduced in the future by developments in the construction of machines which have automatic controls. The problem here is the *flexibility* of devices and machines. This is a factor of cardinal importance in considering whether it will pay to introduce automatic devices. We shall return to this problem later. There is now a tendency to build more 'flexible' automatic machines which are capable of various uses and also to construct very efficient but quite small computers which will be much cheaper than the large computers. It is likely that in future even medium-sized firms will be able to afford to introduce automatic
volume of sales of a product depends, to some extent, upon production costs. The hope of increased sales might justify the purchase of costly automatic machines to replace methods of production which themselves called for a highly efficient organisation of labour. When the new automatic methods are introduced it is nearly always possible to reduce the price of the product. Goods can now be mass-produced on a large scale and so the market for their sale is extended. The use of automatic machinery does not prevent a manufacturer from making such alterations in the appearance of his product as may be necessary to promote increased sales since changes of this kind are usually of a superficial character.

A factor which limits the introduction of automation is the shortage of highly qualified engineers capable of constructing the new electronic devices and automatic machines and of solving the exceptionally difficult problems associated with planning a completely automatic 'closed circuit' production process. But much is being done to overcome the difficulties caused by the shortage of trained men. Many engineering firms as well as the makers of electronic devices themselves are prepared to install automatic machines for their clients. Large concerns

[1]'Single-purpose machines have their place in our economy—but it is the remarkable flexibility made possible by automatic control that holds the most important meaning of our new industrial revolution'. (John Diebold, 'Control for the Job Shop' in *A.C.*, Sept. 1954, p. 36). See below, pp. 120 *et seq.*

and the manufacturers of automatic machines have extensive schemes for training employees to handle the new types of machinery. Steps are also being taken to train a new generation of 'control engineers'. In the autumn of 1954 many American technical colleges offered courses on 'Control System Dynamics' which were attended by 25,000 students.[1]

The factors favourable to a very substantial expansion of automation are far more powerful than the adverse factors which might be expected to retard automation. When automation can be introduced as part of the process of rationalisation this new technique has overwhelming advantages over traditional methods of production. With no increase in cost automatic machines can produce more and better goods than conventional machinery. To produce the same quantity of articles of better quality automatic machines require *less* expenditure on all the factors of production. Savings are made not only on wages and salaries but also on circulating and fixed capital.[2] A German writer lists the following decisive advantages of automation:

(i) Costs are reduced by saving wages. It is no longer necessary to pay high wages to the type of skilled worker who was once an invaluable asset to a firm because, from long experience, he had some particular process 'at his finger-tips'.

(ii) Uniform and better production by the most economic use of raw materials and machinery.

(iii) Expansion in the volume of production without any increase in costs.

(iv) Reduction in the capital invested in the concern because the physical assets of the firm are being more efficiently used.

(v) Savings made by a reduction in the number of accidents.[3]

When attempting to anticipate the future of automation it must

[1]'Our Profession Grows', a leading article in *Control Engineering*, Oct. 1954. The University of Harvard offers the degree of Master of Science in Data Processing. The course leading to this degree is run jointly by the Division of Applied Science, the Economics Department and the Graduate School of Business Administration. See, however, pp. 214, 239 and below for the results of this shortage of technicians.

[2]Savings in circulating capital are (for example) effected because smaller quantities of raw materials are warehoused and are available in the plant. Moreover the amount of raw material wasted in the manufacturing process is reduced. Savings in fixed capital are made because the shop floor-space is reduced and the investment in machinery—per unit of the product manufactured—is less than it was before automation was introduced.

[3]G. Neumann, 'Regelungstechnik und Wirtschaftlichkeit' in *Regelungstechnik* (Munich, 1954), Part 3.

be remembered that it is still only in its infancy in many industries. As an illustration of the future possibilities of automation it may be suggested that in the chemical industry devices will be introduced which will enable firms to transfer to the production line itself the tests of the quality of a product which are now made in a laboratory. Automatic testing will be on the 'closed circuit' principle. Another example of what the future may hold occurs in a report on electronic calculators. The report examines the steps by which a 'programme' of work for one of these giant machines can be drawn up so as to increase the range of functions of the computers. Osborn's survey of plans to extend the sphere of operations of computers is of interest:

> 'Production control including the co-ordination of materials, machine loading, and labour loading.... Long range sales forecasting job which will correlate such existing but inadequately used data as the birth rate and new family formations; disposable income and the level of employment; our models and prices compared with competitors' models and prices and the availability of electricity in new areas. . . . Our integrated system, when completed, will provide a dynamic distrib ution analysis. . . . This should give management the opportunity to adjust selling effort and factory effort to make maximum use of the production facilities at its disposal . . . to make the right appliance and deliver it to the right place at the right time . . .'[1]

Professor Wiener explained that when the computer receives 'instructions' something happens which is not dissimilar from the learning process of the human mind.[2] Since he wrote a machine has been constructed which can be 'taught' by human beings to use certain tools in order to get a particular job done. It is a lathe on which

> 'the skilled lathe operator goes through his usual steps in both set-up and control of turning a single piece. His every action is recorded on magnetic tape. For subsequent pieces the tape is played back and identical operations are performed without the operator. . . . Carrying the concept to its logical extreme, factories equipped with such automatic devices could "create" new factories.'[3]

If automatic machines of this kind came into general use many highly-skilled workers would be freed for new tasks. Still more important is the possibility of using such machinery in under-developed countries to overcome quickly the shortage of

[1] R. F. Osborn, *op. cit.*, p. 103.
[2] Norbert Wiener, *The Human Use of Human Beings. Cybernetics and Society* (Boston and London 1950), pp. 59-84.
[3] *C.E.*, September, 1954, p. 76.

skilled workers which is at present a major factor holding up the process of industrialisation.[1] To illustrate this use of automation it may be mentioned that in a country district in Mexico an automatic factory for making pipes was erected by Italian engineers. After only a short period of training, Mexican workers were able to operate the plant.[2]

Electronic devices are of fundamental significance when considering the future of industrial production by automatic machines. Mr Baker, the Vice-President of the General Electric Company, is positively lyrical when he writes about electronic devices:

> 'Electronics is man's most versatile and useful slave, it is a jinni [genie] who can move mountains, a magic carpet that can guide itself through a fog or storm or darkness; a magic mirror that can show you the other side of the world. Electronics controls rivers of molten steel, measures the thickness and strength of materials without touching them, discards the one bad bean from tons of beans, finds hidden treasure buried in the ground. Electronics measures the height of clouds, turns on street lights as dusk falls, "smells" dangerous gas leaks, warns of the approach of intruders in total darkness and brings Hopalong Cassidy, Fred Waring and the United Nations into our living room. These and many more are the peacetime applications of Electronics. But if Electronics is a jinni [genie], it is not a helpless one. It is capable of protecting what it has created. . . . Electronics senses the approach of enemy ships or planes or subs. . . . Electronics controls the guns that fire at them, guides the missiles that speed to destroy them. . . .'[3]

Two irresistible forces combine to foster the extension of electronic devices—the competition between firms to secure for themselves the technique which pays best and the international race for the possession of the deadliest weapons. It is therefore not surprising that automation is rapidly gaining ground in all the great industrial states. In England Sir Ben Lockspeiser, the secretary of the Department of Scientific and Industrial Research, told the Institute of Directors at its annual conference in 1954 that automatic machines would one day revolutionise both factories and offices.[4]

[1]See Wassily Leontief in a special number of the *Scientific American*, September 1953, p. 157 *et seq.*

[2]*C.E.*, Oct. 1954, p. 17.

[3]Statement by W. R. G. Baker (Vice-President of the General Electric Company and head of its Electronic Department), quoted in a prospectus of the Televisions-Electronics-Fund, Inc., 1954. For the electronics industry, see below, pp. 163-4.

[4]Sir Ben Lockspeiser, 'When Industry and Science get together' in *The Director*, Nov. 1954, p. 260.

A. E. Prokopovich, a Stalin prize winner, gave a lecture in East Berlin which has been printed under the title *Eine automatische Fabrik* (1954). The author gave a detailed description of an automatic factory which has been set up in Russia to make piston-heads for lorry engines. This plant was turning out pistons as early as 1954. Prokopovich claimed that it was 'the first fully automatic plant in the world'. The whole process was completely automatic 'from the casting of the small metal pigs from which the pistons are to be made to the packing of the finished articles'. A remarkable feature of the plant is that the assembly lines are so arranged that eleven different kinds of pistons can, if necessary, be produced.[1] The manufacture of the pistons is so efficiently controlled that the rivets are accurate to within 0.01mm. and the cylindrical form of the pistons is accurate to within 0.003mm.[2]

Prokopovich's summary of the stages in the manufacture of piston heads illustrates the wide range of functions of automatic machinery. In his lecture Prokopovich stated that the automatic plant carried out the following operations:

'1. Uninterrupted preparation of the raw material for the casting process, including maintenance of a constant temperature and maintenance of the desired physical and chemical properties of the metal.

'2. Faultless casting of uniform metal units of the correct volume and density.

'3. Emptying of the moulds which are returned for the next casting operation.

'4. Heat treatment of the casting whereby the necessary strength is secured with the minimum of internal stress.

'5. Control of strength of metal.

'6. Automatic manufacture of pistons which conform rigidly to the prescribed shape.

'7. Testing of pistons according to their weight.

'8. Tin-plating the piston rods.

'9. Control of output and sorting of pistons into various categories according to their measurements. (The groups differ from each other by only 0.0025mm.).

[1] A. E. Prokopovich, *Eine automatische Fabrik* (1954), p. 7. See also *Automation* (Department of Scientific and Industrial Research, London), 1956, pp. 5-10.
[2] *Ibid.*, p. 35.

'10. Greasing (to prevent rusting), wrapping (in vellum paper), packing and sealing.'

For each shift and for each assembly line ten workers only are needed. Seven are qualified skilled fitters and three are semi-skilled machinists. Very considerable savings in man-power have been made in comparison with modern Russian car plants run on conventional lines. Prokopovich declared:

> The total labour force declined by 76 per cent. The number of fitters and machinists (taken together) was reduced by 81 per cent. The number of fitters alone was reduced by 94 per cent. Labour costs were reduced by 81 per cent.[1]

Prokopovich stated in his lecture that another advantage of automation was that the piston-heads could be made twice as quickly as by conventional methods.

Moreover in Soviet Russia there exist numerous publications which demonstrate the independence of development, originality of approach, and rapidity of advance in theory which characterises modern Russian work on feedback control theory.[2]

It has been stated that a German work[3] is the most important on the technique of automatic controls; that there are three English learned journals devoted to automation;[4] and that a recently-formed society of Japanese control-engineers has already secured a membership of over 1,000. Similar reports from other industrial countries can leave no doubt in one's mind concerning the significance of automation as a world phenomenon.

[1]*Ibid.*, p. 39. From other sources we know how important a part automation is already playing in two other Russian industries—armaments and the manufacture of agricultural machinery (*C.E.*, Sept. 1954, p. 11). See also H. Schwartz, 'Are the Russians ahead of us in Automatic Control?' in *Automatic Control*, July 1954, p. 23 *et seq.* Schwartz argues that the Russian leaders have accepted automation as the industrial technique of the future and that the United States has therefore no choice but to bend all her energies to extend the use of automatic machines. See also below, pp. 101 and 110.

[2]Professor Higgins's bibliography in *C.E.*, Dec. 1954, p. 49.

[3]W. Oppelt, *Kleines Handbuch technischer Regelvorgänge* (Weinheim, 1954).

[4]We have already mentioned the use of giant electronic computers in England. The Ministry of Supply has ordered a Three-Dimensional Analogue Computer (TRIDAC.). It is claimed that this machine will be able to do in twenty seconds the work formerly done in eight hours by a hundred persons using mechanical adding machines (See *Die Tat*, Oct. 9, 1954). A report concerning a British calculator installed by a New York bank has rather less of a fantastic air about it. With the aid of this machine three people can complete in one day accounts that were formerly done by twelve persons in three days—a reduction in working hours from 288 to 24 (i.e. one twelfth). See *N.Y.T.*, Dec. 30, 1954.

(V) THE SECOND INDUSTRIAL REVOLUTION

Lewis Mumford in his penetrating study of *Technics and Civilisation*[1] has discussed the fundamental distinction between a machine and a tool. While the tool is useful only in the hands of a skilled worker the peculiar property of the machine lies in its ability to perform automatically the same operation with great precision without the assistance of a skilled operator. Machine tools—as their name implies—are a 'synthesis' of tool and machine which can be worked only by trained operatives. But technological development from the days of the earliest mechanical devices has always tended to replace labour by machinery. Until quite recently the fully automatic machine represented the climax of this development. In relation to the machine the worker

> '. . . is, so to say, a machine-herd, attending to the welfare of a flock of machines which do the actual work: at best, he feeds them, oils them, mends them when they break down, while the work itself is as remote from his province as is the digestion which fattens the sheep looked after by the shepherd.'[2]

The movement towards rationalisation—culminating in the conveyor-belt system of production—was another step towards automation. In plants in which this system was introduced the worker 'stepped into the breach' to perform the few remaining tasks which (for technical or economic reasons) were still not mechanised. In a book written before the second World War Georges Friedmann described the progress that had been made in this movement towards 'integral automation'. He showed that the surviving manual workers in the most technically efficient plants were now no more than the ' "bouche-trou" de la mécanisation'.[3] In a way they fill the little gaps which are bridged not by the machine, but by the sensory organs of human beings. Although he wrote his book nearly twenty years ago the author was confident that it was only a matter of time before these functions, too, would be performed with the aid of machinery.

It is astonishing that as early as 1938 Couffignal should have

[1]Lewis Mumford, *Technics and Civilisation* (New York, 1934), p. 10 *et seq.*
[2]Lewis Mumford, *op. cit.*, pp. 410-11.
[3]Georges Friedmann, *Machine et Humanisme: Problèmes humains du machinisme industriel* (18th edn., Paris, 1954), p. 179. Although Friedmann wrote before the fully automatic plant in the modern sense existed, his fourth chapter on 'L'automatisme: dialectique de la division du travail' reads as if it aimed at giving a dialectical description of the way in which automation developed.

written a book[1] in which he discussed the various spheres of activity

> '. . . où l'homme a été *ou pourra* être remplacé par la machine, et de rechercher les lois de cette substitution. A la limite, on rendrait ainsi possible une détermination logique préalable des opérations industrielles susceptibles d'être automatisées.'[2]

Since the mechanisation of the process of production has developed logically step by step it might appear to be doubtful whether the coming of modern automation should properly be described as 'a second industrial revolution'. It may be remarked that the 'first industrial revolution' did not come suddenly. There was a long period of preparation which lasted from the days of the automatons, water-wheels and atmospheric engines of the seventeenth and eighteenth centuries to Watt's steam engine and the first power loom. It is reasonable to talk about an 'industrial revolution' in the early nineteenth century because of the vast changes both in the process of production and the structure of society which occurred at that time owing to advances in technical knowledge. These changes included (a) the displacement of human and animal muscular effort by the steam engine; (b) the decline of production by skilled craftsmen owing to the large-scale introduction of machines operated by relatively unskilled men; (c) the social and cultural changes brought about by the fall of the old middle classes, the rise of a new class of factory worker and the transformation of an ever-growing section of the population into wage-earners and salaried employees. The first industrial revolution is the history of the last 150 years—a process of uninterrupted change marked by the appearance of an imposing series of scientific discoveries and technical inventions which have continually improved the efficiency of labour. But the changes brought about by such inventions as the internal combustion engine and the dynamo have been quantitative rather than qualitative.[3]

Today the idea of the coming of a 'second industrial revolution'

[1]L. Couffignal, *Sur l'analyse mécanique. Application aux machines à calculer et aux calculs de la calculs de la mécanique céleste* (Paris, 1938).

[2]Georges Friedmann, *Machine et Humanisme: Problèmes Humains du Machinisme Industriel* (1954), p. 177, note 1.

[3]G. Friedmann distinguishes between three industrial revolutions—the first characterised by the steam engine, the second by electricity and the third by atomic energy. See G. Friedmann, *Où va le travail humain?* (Paris, 1950), p. 207. See below, pp. 203 *et seq.*

—originating in the middle of the twentieth century—is gaining ground. For the first time since the dawn of the industrial age machines are being invented which displace not only man's muscular effort but also the functions performed by his sensory organs and by his brain. 'The first revolution, still continuing, mechanized manufacturing processes. The second will automatize them; i.e., it will remove man from the manufacturing operation itself and relegate him to maintenance and supervisory roles.'[1]

Norbert Wiener takes the view that 'the first industrial revolution, the revolution of the "dark satanic mills", was the devaluation of the human arm by the competition of machinery. . . . The modern industrial revolution is similarly bound to devalue the human brain at least in its simpler and more routine decisions'.[2]

Just as the steam engine became the symbol of the first industrial revolution—although it was obviously only one of the decisive factors making for technical change at that time—so today the electronic computer is the symbol of a new industrial era. This particular type of machine is obviously one aspect of recent developments.[3] The similarity between the first and second industrial revolutions lies in the fact that in both cases a large number of scientific discoveries and technical inventions culminated in the development of a new type of industrial production and also led to fundamental changes in the social structure. These technical and social changes represent something more than a step by step development from the old to the new. They have produced something 'new' in a qualitative as well as in a 'quantitative' sense. It is this aspect of modern change in industry and society which justifies the use of the term 'second industrial revolution'.

[1] *Fortune*, Oct. 1953, p. 168.

[2] Norbert Wiener, *Cybernetics or Control and Communication in the Animal and the Machine* (1948), p. 37.

[3] It is surprising that atomic energy—the great new source of power—is so seldom mentioned in discussions concerning the second industrial revolution. The series of articles in the *Saturday Review* special number (to which reference has already been made) did, however, give proper weight to atomic power. Recently E. Salin in an article in *Kyklos*, Vol. VIII, p. 1 *et seq.*, entitled 'Vor einer neuen Etappe der industriellen Revolution' has argued that synthetic materials, atomic energy and automation are the salient factors in a new phase of industrialisation. He considers that the risks and dangers to the world of the new industrial revolution are more serious than were those of the original industrial revolution. See also articles in *Die Zeit*, Feb. 9, 16, and 23, 1956, entitled 'Drei Schritte, die die Welt verändern'.

CHAPTER II

SOCIAL CONSEQUENCES OF AUTOMATION

WHAT are the economic and social consequences of the second industrial revolution? How is this revolution likely to affect wage-earners and salaried officials? No serious attempt has yet been made to answer these questions. But they raise problems which will decisively influence the future welfare of the great industrial countries. Indeed their influence will be world-wide. So far most comments on automation are either alarmist statements or assurances that the fears expressed by the pessimists have been greatly exaggerated. We propose to discuss briefly some of the factors which influence the social aspects of automation.[1] It is clear that no new problems of economy theory are involved. If modern automation were a movement which had something of the explosive character of the first industrial revolution there would indeed be a danger of widespread unemployment. Even if the social consequences of automation were to resemble those of rationalisation in the inter-war period of 1919-39 rather than those of the first industrial revolution it would still have serious economic and social consequences for the majority of the workers. We shall show that the disturbance in the labour market and in the lives of the wage-earners brought about by rationalisation were more serious than is generally imagined. It has been argued that the effects of automation will be of a more fundamental nature because machines are now performing functions which have hitherto been man's sole prerogative.

Automation may threaten to deprive wage-earners and salaried employees not only of a particular job but it may perhaps

[1]H. Christian Sonne, chairman of the National Planning Association (Washington, D.C.), announced in *Technological Advance and National Policy* (National Planning Association, Special Report No. 34, Dec. 1954, p. 7) that the Association had begun to make an enquiry into possible future economic and social consequences of automation.

even render certain professional skills redundant and undermine the social status of many people employed in industry. Only a privileged minority—responsible administrators, engineers, supervisors and maintenance men—can feel that their jobs are safe.

It is frequently argued that the social consequences of automation are likely to be only of a short-term nature and that in this respect they will be similar to the consequences of all previous technical advances. Today an ever-growing proportion of the population is enjoying a far better standard of living than was possible in earlier ages. It is argued that this in itself proves that temporary misfortunes are not too high a price to pay for the steady improvement of living standards. This argument emphasises the purely 'temporary' nature of the sacrifices that have in the past been the price of technical progress. This so-called 'compensation theory' uses the argument that the men who lose their jobs because of technical changes quickly find new employment elsewhere because the reduction in production costs—the inevitable result of industrial progress—soon stimulates an increased demand which in turn leads to an expansion in output. This 'compensation theory' is simply an application to a special case of the general theory of the successful self-regulation of the economy of a free market.[1] Quite apart from the question of the validity of this theory the experience of the inter-war years (1919-39) has shown that in an industrial state (and to an ever-increasing extent in other countries as well) there are economic and sociological circumstances which make it impossible to leave the fate of society to the fluctuations of the free market. Consequently it is no longer possible to accept the view that the economic and social consequences of automation can be airily dismissed by invoking the self-regulating mechanism of the free market. In the long run it is possible that the holders of the compensation theory may be right but we have to consider the short-term, as well as the more remote, effects of automation.

In order to see what the effects of automation are likely to be

[1]For the 'compensation theory' see Alfred Kähler, *Theorie der Arbeiterfreisetzung durch die Maschine* (Leipzig, 1933); Wladimir Woytinsky, *Drei Ursachen der Arbeitslosigkeit* (Geneva, 1938); Hans-Joachim Rüstow, *Theorie der Vollbeschäftigung in der freien Marktwirtschaft* (Tübingen, 1951); Adolph Löwe, 'Technological Unemployment Re-examined', in Gottfried Eisermann (ed.), *Wirtschaft und Kultursystem*, Erlenbach-Zurich 1955.

we must consider those factors which will in all probability influence the redundancy of workers both from a long-term and a short term point of view. These include the actual anticipated extent of redundancy, the speed with which men are replaced by machines, and the extent to which new opportunities of employment will arise. Other factors to be considered are the size of the existing pool of unemployed, the extent to which workers are on short-time and the mobility of the labour force. Finally we must consider the state of the whole economy—the effect of tendencies towards expansion or contraction of output which are likely to occur in the light of technical improvements or of other circumstances or of a combination of the two. In short we must bear in mind all the factors which might disturb the equilibrium of the economy as well as the ability of the economy to settle down to a new economy. We have not included 'effective demand for goods' as one of the factors influencing the extent and duration of unemployment. An effective demand sufficient to secure 'full employment'[1] is in itself—among other things—one aspect of the 'compensation theory' concerning technological progress to which we have referred. It merely describes—without explaining—one aspect of an economy.

The same causes which make it impossible to accept the validity in our day of the law of the self-regulating mechanism of the free market also make it impossible any longer to draw a valid distinction between the short-term and the long-term consequences of a technical revolution. It has been argued that in the long run the working of the free market would itself produce an adequate compensation for technological unemployment and that Keynes was wrong when he argued that equilibrium in an economy could be reached in a period of high unemployment as well as in a period of full employment. Even if this could be proved from a theoretical point of view it would not be a matter of much practical importance in the world today owing to the way in which power is distributed in modern societies. Only a mere handful of liberal doctrinaires seriously doubt that the

[1]We use the term 'full employment' in the sense in which it was defined by United Nations experts—'a situation in which unemployment does not exceed the minimum allowances that must be made for the effects of frictional and seasonal factors' (*National and International Measures for Full Employment*, New York, 1949). See also *Employment Policy*, Cmd. 6527 of 1944.

mass unemployment which occurred in the United States in the early 1930s was the last occasion in which the unemployed and those workers whose jobs were in jeopardy were prepared to suffer patiently—without vigorous resistance—until long-term market adjustments eventually relieved their misery. In any modern industrial state the government must at once take steps to remedy the situation as soon as unemployment figures rise above what the workers are likely to stand. Any government which failed to do this would place in jeopardy the very existence of society itself.

Modern economic theory can give us only very limited help when we are considering the future economic consequences of automation. An examination of what has actually happened in industry in the last 50 years may throw more light on to the problem. We cannot always accept past experience at its face value but we must be prepared to analyse this experience with the aids of the tools of economic theory.

(I) CHANGES IN THE ECONOMY OF THE U.S.A.[1]

At this point it will be useful to indicate in outline the salient changes that have occurred in the economy of the United States of America between 1900 and 1950. Next we shall discuss the economic and social consequences of the movement for rationalisation in the United States in the inter-war period (1919-39).

[1]This examination of changes in the American economy is based upon the following sources which in future are cited by the Roman numerals (I, II, etc.) with which they are numbered. We have compiled these statistical tables and have calculated the indices. Sometimes we have made an estimate in place of a missing figure. All these statistics give only rough approximations. It cannot be claimed that many of them are absolutely accurate because it is not uncommon to find surprising discrepancies in official statistics.

I. *Historical Statistics of the United States* (Washington, 1945).
II. *Statistical Abstract*, 1954 (Washington, 1954).
III. *Economic Report transmitted to the Congress*, January 20, 1955 (Washington, 1955).
IV. A. M. Edwards, *Population. Comparative Occupation Statistics for the United States*, 1870-1940 (Washington, 1943).
V. G. L. Palmer and A. Ratner, *Industrial and Occupational Trends in National Employment*, 1910-40, 1910-48 (Wharton School of Finance and Commerce, University of Pennsylvania, 1949).
VI. J. H. Durand, *The Labour Force in the United States*, 1890-1960 (New York, 1948).
VII. *Federal Reserve Bulletin* (Washington, 1954).
VIII. *Monthly Labour Review* (Washington, 1954).
IX. *Survey of Current Business* (Washington, 1945).

Finally we shall examine the state of the American labour market on the eve of the 'second industrial revolution'.

INCREASE IN POPULATION AND LABOUR FORCE OF THE (CONTINENTAL) U.S.A., 1900-1950[1]

	1900	1930	1950	Growth 1900-50
Total Population (millions)	76·1	123·2	181·7	75·6
1900=100	100	162%	100%	100%
Number of foreign-born Population (millions)	10·3	14	10·2	—
Population of Working Age[2]	58	89·4	112·2	54·2
1900=100	100	153%	193%	93%
Working Population (millions)	29	50·1	64·8	35·8
1900=100	100	172%	223%	123%
Unemployed (millions)	1·6	4·3	3·1	—
Unemployed as percentage of Population of working age	50·2%	56·1%	57·7%	15%

It will be seen from this table that in the period 1900-50 the population of the U.S.A. has doubled and the labour force has increased by 123 per cent. The number of jobs—including those in the armed services and public administration—has grown by some 36 millions, i.e. by about 700,000 a year. These rates of growth are about 10 per cent greater than the increase in population due to excess of births over deaths and to immigration. The number of persons in employment—taken as a proportion of the labour force—has grown by 15 per cent despite the raising of the school age and the tendency for people to retire sooner. The main reason for this has been the enormous increase in the number of women in employment. In 1950 twice as many women were working as in 1910. The proportion of the female population at work has increased from 25 per cent to 29 per cent.

[1]Sources: I, p. 32 and p. 65; II, p. 13 and p. 43; III, p. 153. The estimated population in 1955 was 164 millions.

[2]1910 and 1930—over the age of 10.
1950—over the age of 14.

GROWTH OF GROSS NATIONAL PRODUCT AND OF PRODUCTIVITY OF LABOUR IN THE UNITED STATES, 1900-1950[1]

	1899[2]	1929	1947	1953	1955
Gross National Product (in milliard $ of 1954 value)	—	182	283	374	387
1929=100	—	100	155	205	213
Agricultural Output					
1929=100	—	100	107	124	134
Non-Agricultural Output					
1929=100	—	100	160	212	220
Industrial Output (unphysical quantities)[3]					
1899=100	100	364	649	—	—
1929=100	27	100	173	234	241
Output per head (of all employed persons)					
1899=100	100	162	193	—	—
Output per head (in industry)					
1929=100	—	100	—	145	—
Working week in Industry (hours)	59	44	—	40.5	—

It will be seen from this table that

(a) gross national product of the United States has doubled in the last 25 years (taking the depreciation of the dollar into account) while the population has grown only by about a third.

(b) industrial output has increased nearly sevenfold in the fifty years 1900-1950 and has more than doubled since 1929.

(c) the productivity of labour (i.e. of all persons gainfully employed) has increased about 100 per cent between 1900 and 1950. This is an average annual increase of 2 per cent. Important differences are masked by averages of this kind. In the 1930s the rate of growth of the productivity of labour was generally not much more than 1 per cent a year. In the last 10 hectic years,

[1]Sources: I, p. 66 *et seq.* and p. 179; II, p. 228 and p. 810; III, p. 138 and p. 166; VII, p. 1297; corrected and expanded from *Economic Report of the President transmitted to Congress*, 1956, p. 169 and p. 194. The gaps in the table are due to the fact that no statistics are available for these items.

[2]Adequate estimates of the gross national product of the United States are available only for the last 25 years.

[3]These figures of industrial output come from different sources and caution should be used in comparing them.

however, the growth of the productivity of labour has increased by as much as 4 per cent (in the last quarter of 1954).[1] There are also very big differences in the increase in output per hour in various industries. These range from 10 per cent in the smelting of non-ferrous ores to 900 per cent in the industries manufacturing rayon and synthetic fibres.[2] In considering the increase in productivity it must be remembered that in the period 1900-50 the working week has on the average been shortened from 59 hours to 40 hours.

DISTRIBUTION OF GAINFULLY-OCCUPIED PERSONS IN VARIOUS CIVILIAN EMPLOYMENTS IN THE U.S.A., 1900-1950 (PERCENTAGES)[3]

	1900	1910	1940	1950
Agriculture and Forestry	35·3%	30·9%	18·8%	12·5%
Industry and Mining	24·5%	23·3%	25·9%	27·8%
Building	5·8%	61%	4·6%	61%
Transport and other Public Utilities	5·8%	8·7%	2%	7·9%
Commerce } Banking, Insurance, Brokers, etc.	11·7%	11·7%	17%	18·9%
Banking, Insurance, Brokers, etc.		1·6%	3·3%	3·4%
Services[4]	13·9%	10·6%	11%	8·8%
Self-employed and Senior Administrative Posts[5] } Public Administration		47%	7·5%	8·4%
Public Administration	2·5%	1·9%	4%	4·5%
Miscellaneous		·5%	·9%	1·7%
	100%	100%	100%	100%

[1]*Fortune*, January, 1955, p. 66.
[2]Source: II, p. 224.
[3]Sources: I, p. 63; II, p. 221 *et seq.*; V, p. 10.
[4]Not strictly comparable.
[5]Including some public officials: hence the low figures under this heading 'Public Administration'.

It will be seen from this table that the proportion of the labour force engaged in farming and forestry declined by one third between 1900 and 1950. In the same period the total labour force increase two-fold. In 1900 out of 27.4 million jobs 10 million were occupied by workers engaged in farming and forestry. The equivalent figures for the year 1950 were 56.2 millions and only just over seven millions.

In the period 1900-50 the share of industry and mining in the total labour force increased by 10 per cent. The number of workers in industry and mining increased from 7 millions to 16 millions. The share of the building industry in the total labour force remained more or less constant. The numbers of persons engaged in building increased from 1½ millions to over 3 millions between 1900 and 1912.

The statistics for the 40 years 1910-50 show that there has been a slight decline in the share of transport and public utilities in the total labour force. The increased demand for labour on the part of public utilities did not quite counterbalance the decline in the number of men employed on the railways. The share of commerce in the total labour force increased by more than 5 per cent. Other increases were: nearly 18 per cent for the professions and persons holding senior administrative posts (including some members of the civil service and other forms of public employment); a twofold increase in banking, insurance, stock-exchange staff, etc.; a more than twofold increase in (civilian) public administration (though some public servants fell into other categories).

From this table (*page 48*) it will be seen that in the non-agrarian sector of the American economy the labour force as a whole increased by a third between 1900 and 1950 but the number of skilled and semi-skilled jobs remained about the same. The skilled workers have become an ever-increasing proportion of the total labour force: they increased from 4 millions to 6 millions between 1910 and 1930 (i.e. about 50 per cent) and from 6 millions to 8 millions between 1930 and 1950 (i.e. another 33 per cent). The situation with regard to non-agricultural unskilled workers has been different. Between 1910 and 1930 their numbers increased (though only at half the rate of growth of the total labour force) while in the next 20 years they declined by 40 per cent (as a proportion of

CHANGES IN DISTRIBUTION OF THE LABOUR FORCE OF THE UNITED STATES, 1900-1950[1]

	1900	1910	1930	1950
Total labour force	**76**	**100**	**131**	**170**
Skilled workers (millions) **1910 = 100**	4·3 **98**	4·4 **100**	6·3 **143**	8·2 **186**
Semi-skilled workers (millions) **1910 = 100**	— —	·55 **100**	·8 **145**	1·17 **213**
Unskilled workers (excluding farm labourers) (millions) **1910 = 100**	5·4 **98**	5·5 **100**	6·3 **115**	3·8 **69**
Craftsmen (excluding farm labourers) (millions) **1910 = 100**	9·7 **63**	15·4 **100**	20·6 **134**	23·7 **154**
Farm workers (millions) **1910 = 100**	— —	5·4 **100**	4·2 **78**	2·5 **46**
Office workers (millions) **1910 = 100**	— —	2 **100**	— —	7·1 **355**
Sales Personnel (millions) **1910 = 100**	— —	1·8 **100**	— —	4 **222**
Service (including domestic service) (millions) **1910 = 100**	— —	3·5 **100**	— —	6 **171**
Manufactures[2] Productive workers (millions) **1909 = 100**	4·5 **71**	6·3 **100**	8·4 **133**	11·8 **187**
Other workers (millions) **1909 = 100**	0·4 **57**	0·7 **100**	1·3 **185**	3 **425**
Total industrial Labour Force (millions) **1909 = 100**	4·9 **70**	7 **100**	9·7 **139**	14·8 **211**

[1]Sources: I, p. 65; II, p. 205, p. 208 *et seq.*, and p. 810; III, p. 153; V, p. 21; VIII p. 1377.
[2]Figures for manufactures are for 1899, 1909, 1929, and 1950.

the labour force). Most of these unskilled workers have become semi-skilled workers. The number of semi-skilled workers more than doubled between 1910 and 1950. The significance of this upgrading of unskilled workers to semi-skilled workers should not, however, be exaggerated. In work on a conveyor belt performed by semi-skilled labour '60 pour cent environ des opérateurs employés dans les ateliers peuvent être "mis au courant" en trois jours, et assurer une production aussi rapide que les plus entrainés de leurs camarades, au bout de quelques semaines'.[1]

Although there has been a considerable increase in the total number of skilled and semi-skilled workers in the years between 1910 and 1950 the number of craftsmen (in the non-agrarian sector of the economy) has grown at a slower rate than the labour force as a whole—namely 15.4 millions to 23.7 millions (rather over 50 per cent) whereas in the same 40 years the total labour force has expanded 70 per cent.

The decline of the labour force employed in agriculture is clearly shown by the statistics. Between 1910 and 1950 the number of farm workers declined from 5.4 millions to 2.5 millions (i.e. to less than 50 per cent).

It is characteristic of the changes in the distribution of the labour force in the period under review that the number of office workers (in administration and commerce) should have grown more quickly than that of any other gainfully occupied group. In industry (excluding mining) the number of workers engaged in production in the narrower sense increased two and a half times between 1900 and 1950 the increase in the number of 'other workers'—i.e. many office workers—increased more than sevenfold. In the economy as a whole the number of office workers more than trebled between 1910 and 1950 and the number of office workers in wholesale and retail trade more than doubled.

Since our comparison has been limited to the period 1900-1930 on the one hand and 1950 on the other, the unanimous conclusion of all who have studied these statistics appears to be justified. The American economy has shown itself to be a remarkably dynamic economy. Looking back today we can see that, despite occasional

[1] G. Friedmann, *Où va le travail humain?* (1950), p. 228. In another book (*Problèmes humains du machinisme industriel*, 18th edn., Paris, 1954) he cites figures from the Ford works which show that as early as the 1920s 43 per cent of men learnt their jobs in one day while another 36 per cent took up to a week to become proficient (p. 197).

reverses, this economy has succeeded in re-establishing its equilibrium on a higher plane than ever. The American economy has succeeded in giving to an ever-increasing proportion of its rapidly-growing population a much higher standard of living, a substantially shorter working week, and a degree of security against unemployment or inability to work owing to illness or disablement.

In these fifty years increased mechanisation has doubled the output of every hour's work done in both the agrarian and the industrial sectors of the economy. Many jobs once done by men are now performed by machines. Nevertheless in 1953 there were no signs of widespread technological unemployment because of this. In some way these workers had been absorbed in the industrial economy and, in addition, 36 million additional workers were gainfully employed in 1950 as compared with 1900. But, as we shall explain later, these achievements have not been possible without painful economic readjustments which have been achieved only at the cost of certain sacrifices. We shall show also that the immense development of the American economy—the expansion of output and the changes in the distribution of the national income—is in itself no guarantee that the advantages of automation will in the future necessarily triumph over the drawbacks of automation without the deliberate intervention of the State.

(II) EFFECTS OF RATIONALISATION IN THE U.S.A. (AFTER 1919)

There are significant similarities between the effects of the two world wars upon economic and technical developments. Today atomic power, electronic devices and automation are already being used on a considerable scale. This is possible only because of the technical progress made during the second World War. In the same way the inter-war years saw the sidespread application of the internal combustion engine to transport and agriculture, great advances in aircraft construction and wireless communication, the rationalisation of industry and the widespread introduction of the conveyor-belt system. And these changes were due largely to technical advances that had been made during the first World War. It is perhaps an exaggeration to suggest—as some people have done—that the technical progress of the years 1919-39 amounted to 'a new industrial revolution'. Nevertheless these twenty years saw a rapid expansion in the use of new technical devices and methods of production in industry which led to widespread 'technological unemployment'. It is significant that during the 1930s there was much discussion concerning the way in which workers were losing jobs owing to introduction of improved machines. There were demands that the state should adopt a policy desired to secure 'full employment' either by undertaking public works on a large scale or by government 'planning' to replace the laissez-faire free market economy of earlier times. Even today no agreement has been reached among economists in the controversial question concerning the extent to which rationalisation was responsible for the widespread unemployment of the early 1930s. The International Labour Office investigated the problem in 1931 but was very cautious in coming to any definite conclusion. The report stated that:

> '. . . it must be recognised that the various measures taken in its [rationalisation's] name during the last few years in the organisation of industry have resulted in a serious degree of unemployment. It may be admitted that this unemployment is temporary. The dismissed workers have many chances of fairly speedy re-engagement, either in their old occupations or in another, in consequence of the growth in business produced by technical progress. But the effect of constant new progress being made is also that new workers are constantly being dismissed, even before the others have been able to find a new job. This appears to be what has happened during the past few years in several countries where rationalisation measures have been adopted at a very rapid pace.
>
> It is possible that this tendency will continue in the future, and will become more and more general and distinct. The consequent unemployment should then be considered to an increasing extent as a sort of physiological unemployment. By this we mean a sort of unemployment that must be accepted as normal, since its causes cannot be abolished without injuring general progress'.[1]

In a work published in 1933 Kähler discussed the question of unemployment caused by the introduction of labour-saving machinery. He came to the conclusion that when technical advance reaches a certain level it brings with it problems of such a magnitude that they cannot be solved by the self-regulating mechanism of the free market.[2] Woytinsky, in a study sponsored

[1] *The Social Aspects of Rationalisation*, Geneva, 1931, pp. 265-6 (I.L.O., Studies and Reports, Series B (Economic Conditions), No. 18). In the second sentence of this extract the 'compensation theory' appears to be accepted. The events of later years did not justify the view expressed.

[2] A. Kähler, *op. cit.*, p. 138 *et seq.*

by the International Labour Office, pointed out that in the summer of 1929, when employment figures reached their maximum after the first World War, there were nevertheless more people out of work and on short time than there had been—even in years of depression—before 1914. He thought that the world economic depression of the early 1930s would not have reached such serious dimensions 'if the world social system had not already been shattered by unemployment which had actually risen in a period of trade-boom'.[1]

Woytinsky argued that unemployment was due to a combination of three factors—technical progress, movements of population, and general economic developments. In his most recent book Woytinsky expresses the view that technological factors generally play only a relatively minor role—compared with other factors dislocating the smooth working of the economy—in causing large-scale unemployment. He believes that *steady* technical advance is perfectly compatible with an appropriately high level of employment.[2]

It has frequently been asserted that the great depression of the early 1930s in the United States was at any rate partly due to the movement towards rationalisation in the previous decade. It has also been argued that this crisis was overcome with the help of the 'New Deal'[3] and that the whole structure of the economy was changed so as to find work for the unemployed in jobs (nearly all of a purely civilian character) which were of benefit to the community as a whole. But an examination of official American statistics shows that this is an erroneous point of view.[4]

If we take the 'gross national product' as a rough measure of 'total output' we find that—in dollars of equal purchasing power—output had by 1938 again attained the level reached in 1929. But in this period (1929-38) the labour force had risen by 10 per cent (from 49.4 million to 55 million) and the number of unemployed had actually increased nearly sevenfold (from 1.6 million

[1] W. S. Woytinsky, *op cit.*, p. 167.

[2] W. S. Woytinsky and associates, *Employment and Wages in the United States* (New York, 1953) p. 80 (italics supplied).

[3] Some people would say 'in spite of the New Deal'.

[4] Statistics of unemployment in the United States (prior to the census of 1940) are mainly based upon estimates which differs considerably from each other. We have used official data as far as possible. For American statistics of unemployment see W. S. Woytinsky and associates, *op. cit.*, chapters 32 and 33 and p. 716.

to 10.4 million). In other words in these eight years the proportion of the labour force out of work had risen from 3.2 per cent to 19 per cent. Despite the rearmament programme of the first two years of the second World War the percentage of the labour force unemployed only declined slowly and in 1940 amounted to no less than 14.6 per cent. Even in 1941 it was still 10 per cent. In the first year that the United States was a belligerent it was about 5 per cent. Not until later war years did it fall below 2 per cent—the minimum practicable level.[1]

It must be remembered that American statistics of unemployment in the 1930s do not reflect accurately the full extent of unemployment. They recorded only persons who were *wholly* unemployed and ignored 'disguised unemployment' in its various forms. They ignored people working short time. They ignored people who had lost their jobs and were trying to earn a living as door-to-door canvassers. They ignored people who, though out of work, did not sign on at labour exchanges or apply for unemployment benefit. Three figures for the year 1939 may be given to illustrate the way in which short-time working disguised the true extent of unemployment. In that year official statistics of short time were collected for the first time. Only 52 per cent of the labour force had been fully employed throughout the year and 19 per cent had worked for no more than six months. The unemployment statistics for 1939 state that 17 per cent of the labour force was unemployed.[2]

In view of the inadequacy of the statistics that are available it is obviously very difficult to make any precise estimate concerning how many out of the total number of unemployed in the United States in the 1930s were out of work because they had been replaced by machines.[3] This much, however, is quite clear. Until

[1] *Statistical Abstract of the United States*, 1954, p. 195.

[2] See also Theodore Caplow, *Sociology of Work* (Minneapolis, 1954), p. 256 *et seq.*

[3] It has been pointed out—quite correctly—that it is very difficult to prove by statistics that unemployment is due to technological causes. It can be done when a whole occupational group becomes superfluous—e.g. stokers on steam locomotives when diesel engines are introduced or stokers on ships when mechanical stoking devices are installed. Technological unemployment cannot be proved statistically when rationalisation (e.g. introduction of conveyor-belt process) is introduced slowly into a plant or is introduced when the plant is closed or is working short-time. When there is a trade boom technological unemployment is masked if an increase in output takes place with the same (or with a reduced) number of workers. Increased productivity of labour is not always secured at the cost of technological unemployment—but it may very well be obtained in that way. See W. S. Woytinsky and associates, *op. cit.*, p. 395 *et seq.*

the United States became a belligerent in the second World War the American economy had not succeeded in achieving 'full employment'—even in the limited sense given to the term by the Employment Act of 1946. It was only because some jobs were available outside the so-called 'productive' sector of the industrial economy that at any rate a proportion of those persons who were displaced by machines (or their successors who would have had work but for the machines) did not join the ranks of the unemployed. Only the greatly increased production that was necessary when the United States became a belligerent—only the inclusion of 25 per cent of the labour force in the armed forces and the public administration—at last brought unemployment down to its irreducible minimum.[1]

(III) THE AMERICAN LABOUR MARKET (AFTER 1945)

Since the second World War only a small part of the American civilian labour force—never over 5 per cent (1946-54)—has been out of work. It has often been argued that this freedom from unemployment—in an economy which has changed fundamentally since 1929—proves conclusively that technological unemployment has ceased to be a serious problem. The Americans are justly proud of the immense increase in their volume of output and standard of living whether measured by total income or by the great reduction in the average hours of work.[2] In order to save labour much new machinery has been installed in American factories since 1946 and many improved methods of work have been introduced. In addition, as we have already seen, there has been a marked trend towards the introduction of fully automatic factories. Yet these developments are not regarded with any alarm.

[1]For a variety of reasons any comparison between employed and unemployed in the United States in 1929 and 1939 requires certain adjustments in the statistics—e.g. the change in the number of public officials. In 1929 there were about 3.1 million officials (Federal Service, civil service of the States, municipal and other local officials). In 1938 there were about 4 million such officials. But for this expansion (by about 33 per cent) in the number of public officials the figure for total unemployment—making allowances for a small increase in the armed forces—would have increased (*caeteris paribus*) by about 1,000,000 (*Stat. Abstr.*, 1954, p. 399 and p. 419).

[2]In American industry the length of the average working week decreased from 59 to 40 hours between 1900 and 1950. See *St. Abstr.* 1954, p. 228 and *Historical Statistics of the United States*, p. 67.

Those who fear that they may lead to technological unemployment are told that, after all, the United States has enjoyed 'full employment' since 1946 and that the recession of 1954 did not develop into an economic crisis. Those who try to reassure the pessimists also fall back on the familiar 'compensation theory' to which we have referred.

Even if one left out of account the probable large-scale changes in the economy that one would expect to follow the widespread adoption of automation it would still be true to say that a careful examination of the available statistical material suggests that the 'full employment' recently enjoyed in the United States does not rest upon foundations which are as firm as optimistic interpreters of economic trends since 1946 would lead us to believe. We propose to draw attention to a few figures which may serve to correct over-optimistic statements that have been made concerning the fundamental stability of the American economy since 1946. No official statistics—least of all those prepared in the United States—are issued in such a form as to enable a student immediately to draw from them valid conclusions concerning complicated data of an economic and social nature. It is necessary both to fill in the gaps in statistical tables drawn up in a somewhat arbitrary fashion and to interpret correctly the available figures.

An examination of the unemployment statistics for the year 1954 (when there was a 'recession' in the American economy) shows that the climax of unemployment came in February and March. In those months 5 per cent of the civilian labour force was out of work. In the whole of 1954, however, on an average only about 4.6 per cent of the civilian labour force was unemployed. If these figures could be taken as an index representing the ability of the labour market to absorb workers in a 'normal' economy—i.e. one geared to producing the goods required in time of peace—an optimistic interpretation of the statistics would be entirely justified. But the American economy of 1954 was to be great extent a 're-armament' economy.[1] In spite of the declared policy of the Republican administration there was little decline in

[1] The author uses the word *Wehrwirtschaft* which he defines as follows—'An economy in which an exceptionally high proportion of the gross national product is devoted to the production of armaments compared with the proportion which was usual in non-totalitarian industrial states in the inter-war years (1919-39)'.

the size of the Federal bureaucracy.[1] Above all the 're-armament' aspect of the economy was clearly shown in the great size of the armed forces and in the large number of persons in civilian employment who were working to satisfy the needs of the armed forces. The size of the Federal civil service and the size of the armed forces—the latter figure was 3,600,000 at the end of 1954—are both known. But the size of that part of the labour force which worked to satisfy the needs of the armed forces is not known. It is indeed very difficult even to estimate this figure. We estimate that in the calendar year 1954 the United States spent 50 milliard dollars on the armed forces (including pensions for ex-servicemen). This represents about 15 per cent of the gross national product.[2] Even if we assume that—owing to the relatively high productivity of the armaments industries—this 15 per cent of the gross national product could be produced only by 5 per cent of the civilians (excluding government officials) in employment we should still arrive at the high figure of 3,000,000 persons who were working for the armed forces in the United States in 1954.[3]

How many unemployed would there have been in the United States in 1954 had there been no 're-armament economy'? On this supposition it might be reasonable to suggest that there would have been a very substantial reduction in the number of Federal civil servants, in the size of the armed forces and in the proportion of the labour force engaged in satisfying military needs. Let us assume, too, that these reductions had no significant indirect effects upon the size and structure of the gross national product. Accepting these assumptions—and both are of a highly hypothetical character—we estimate as follows the number of unem-

[1]In 1952 there were 2,400,000 persons employed in the Federal Civil Service in the United States. In 1954 the figure was 2,200,000. The total number of persons engaged in public administration (Federal Civil Service; State civil services; municipal, county and other local authorities) was 6,600,000 in both 1952 and 1954. See *M.L.R.* Dec., 1954, p. 1381.

[2]In the United States the financial year runs from July 1. Government expenditure in a calendar year is therefore not covered by a single budget. A more exact calculation than the one we have attempted would involve adding together (a) Sums approved in the budget of 1954 and spent in that calendar year, and (b) Sums approved in earlier budgets but only spent in the calendar year 1954.

[3]This is only a very rough estimate. If other factors had been considered a higher total would have been reached. These factors include e.g. the output of the capital-goods industries (insofar as their products were purchased by the armaments industry); and the output of those producers whose income depended *indirectly* upon government expenditure on the armed forces.

ployed in the United States (in a normal peace-time economy and in the absence of effective government intervention to check unemployment):[1]

Federal Civil Service. If this were reduced from 2,200,000 to 900,000 (the highest figure under the New Deal) the number thrown out of work would be	1,300,000
Armed Forces. If they were reduced from 3,600,000 to twice the highest figure reached in the inter-war years (300,000) the number thrown out of work would be	3,000,000
Civilians in industry working for the armed forces. If these workers (estimated at 3,000,000) were reduced by four-fifths the number thrown out of work would be	2,400,000
Unemployed in 1954, even under the re-armament economy, (ignoring workers on short time) ...	3,000,000
Total	10,000,000[2]

We have made this estimate simply to draw attention to the magnitude of the problem that would arise if it were possible to change from a 're-armament' to a normal peacetime economy in the United States.[3] If our estimate were correct—and the figure we have suggested is in fact obviously far too low—it

[1]Generally speaking such indirect consequences would presumably tend to increase the number of unemployed. We must assume that in 1954 there was in no branch of industry an unsatisfied demand for goods from people able to pay for them. We assume too, that there were opportunities for producing new types of goods to satisfy 'new' demands. On the other hand it could be shown that in a peace economy the 'gap' between savings and investments would lead to a critical situation. The decline in purchasing power of the unemployed would reduce the demand for certain goods and so cause additional unemployment. With large numbers of people out of work the government would have had to start public works on the largest possible scale. It would have embarked upon a programme of building new schools, hospitals, roads and so forth.

[2]Assuming that no measures were taken to combat unemployment by working short time and assuming that the government did not intervene by checking capital exports and by starting public works.

[3]We have ignored the difficulties which would, in practice, arise if the American economy had to adjust itself to peacetime conditions—difficulties which would be aggravated by the absence of any substantial additional civilian demand to replace military orders.

would mean that, given a peace-time economy, the high standard of living which the Americans enjoyed in 1954 could be maintained with a labour force 15 per cent smaller than the existing one. It may be suggested that the figure which we have given is not an unreasonable one to give some indication of the magnitude of the problem because in 1939—the last year of peace and also a year of 'recession'—there were about 10,000,000 unemployed in the United States (or about 19 per cent of the total labour force).[1]

However rough and ready our calculations may be we consider that they show clearly that full employment of the American labour force depends upon the continuance or even the extension of public expenditure. It would of course be very difficult to try to estimate the precise extent of this dependence, and this is true of a time when the effects of the 'second industrial revolution' have as yet hardly had any appreciable effect upon the labour market—and when the electronic industry (the driving force behind this industrial revolution) is still expanding rapidly and is itself giving employment to an increasing number of workers.

We shall now consider to what extent it will be possible to avert the danger of unemployment—due to a decline in the amount of capital investment, a decline in the present high level of activity in the building industry, and a decline in jobs owing to the introduction of automatic machinery.[2]

[1] *St. Abstr.* 1954, p. 195. Further evidence of the important influence which rearmament has had upon the level of employment in the United States may be seen from the statistics of unemployment in the years immediately following the second World War. At that time there was a heavy demand for goods for civilian use to make up for the shortages of wartime. Nevertheless unemployment in the United States rose from 2,100,000 to 3,400,000 between 1948 and 1949 (an increase of 60 per cent) and remained at over 3,000,000 in 1950 despite the war in Korea. It was *after* 1950—when rearmament began in earnest—that the figures of unemployment fell rapidly.

[2] A report of the Los Angeles Chamber of Commerce states that in the district which it serves nearly 61,000 workers have found employment since 1946 in the new electronics industry. These workers earn (in wages and salaries) nearly quarter of a milliard dollars. In the period under review there were in Los Angeles 374 firms which were concerned with research and development plans in electronics; 19 engineering and construction offices; 22 research undertakings which specialised in the maintenance of electronic devices. In addition various firms—e.g. aircraft companies—maintained their own laboratories for research in electronics. It may be observed that so far the armaments industries have been the main customers of the firms supplying automatic machinery and electronic devices. See Georg M. Attura, 'Leaner markets than you think' in *C.E.*, Oct. 1954, p. 29 *et seq.* The latest report on the growth of the electronics industry in the Los Angeles area gives the following figures for 1955: 436 firms employing over 72,000 persons, with orders for the armed forces absorbing almost 75 per cent of output.

(IV) ECONOMIC AND SOCIAL DANGERS OF AUTOMATION[1]

Today we are on the threshold of the age of automation. The effects of automation on the economy and on society still lie in the future. Nevertheless we propose to try and forecast what these effects may be on the assumption that future decisions concerning the development of automation are left to private enterprise. We shall make this attempt because in all the great industrial states society is in a state of flux and the introduction of a new method of production might easily have consequences of an exceedingly far-reaching nature. In the circumstances these problems cannot be discussed too soon. In the first Industrial Revolution the exploitation of the new technical processes was left in the hands of men whose sole interest in them was to make more profits. This led to a human suffering on a scale that the politically conscious worker of today would not accept for a moment.

People who continually sing hymns of praise about the rise in average living standards made possible by technical progress usually forget to mention that those whose 'sweat, blood and tears' have brought about these changes have themselves seldom enjoyed the rewards of their efforts. It is often said that it is useless to try and hold up technical progress because advance in industrial methods is inevitable.[2] But nowadays this argument will carry now weight with those who fear that they will be the first 'victims' of such changes. A study of recent history can leave no doubt in anyone's mind that prolonged mass employment is the surest harbinger of totalitarian revolution.

In recent years there has been some discussion on the consequences of automation. Two points of view have been expressed. The majority of those who have taken part in this controversy have argued that automation will not bring evil consequences in its train. They said that it is foolish to conjure up imaginary disasters. They admit that automation will bring disturbances to the labour market but they argue that every technical advance

[1]See below, pp. 148 *et seq.* and 203 *et seq.*

[2]To be sure, such major industrial transitions are not accomplished without disruptions and dislocations. Some men will have to change jobs and some companies will fall by the wayside. But from a broad viewpoint, this is a modest price to pay for our vast industrial growth and the constantly rising standards of living we all enjoy' (*United Business Service*, Boston, Oct. 11, 1954).

has had effects of this sort. They believe that any upset to the economy will be overcome. Hitherto the minority which does not accept this optimistic view of the future of automation has been in the awkward position of warning people of a danger which is not immediately obvious. But since the autumn of 1954 the American trade unions affiliated to the Congress of Industrial Organisations have given their support to those who decline to take an optimistic view of the situation. The destructive possibilities of nuclear energy are obvious to everyone. Automation may threaten the future of free society as much as nuclear energy. But this possibility can be explained only by advancing theoretical considerations. No one can demonstrate the possible evils of automation in the striking fashion that the destructive powers of nuclear energy can be made evident to the meanest intelligence by the simple process of dropping an atomic bomb.

We propose to summarise and then to criticise the arguments of the 'optimists'.

Arguments of the 'Optimists'

The arguments advanced to support the view that the general adoption of automation in industry will probably not seriously disturb the equilibrium of the economy may be summarised as follows:

It is true that every technical advance carries with it the danger of temporary 'technological unemployment'. It is true also that the widespread adoption of automatic devices will mean the replacement of skilled workers and black-coated workers by machines. Nevertheless the social consequences of automation will depend entirely upon the way in which automation is introduced. In the first place it is necessary to consider *the size of the industrial regions* suitable for the introduction of partial or complete automation. In the hope of reassuring the alarmist it is pointed out that in the United States—which is by far the most advanced manufacturing country—only about a quarter of the entire labour force is engaged in industry. Here only 8 per cent of the labour force works in those branches of manufacture which are ready for complete automation[1] (but this estimate refers to the year

[1] J. Diebold, *Automation. The Advent of the Automatic Factory* (1952), pp. 149-50, citing R. L. Meier, *Automation in the American Society* (unpublished).

1952). According to the author of this estimate only a half of these 8,000,000 workers are likely to be replaced by automatic machines in the next 20 years. But he admits that other branches of industry will be indirectly affected by automation.[1] Many other writers admit that one of the most important fields for the future use of automatic devices will be in the offices of business houses and the public administration. We shall deal later with the special significance of this development.

The thesis that the expansion of automation will affect only a limited part of the labour force and will therefore be free from serious social disturbances has frequently been supported by other arguments, most of which we have already mentioned. Thus it is said that even automatic factories need the services of many skilled men who work the control-dials, set the machines in readiness for a new programme of production, and do the necessary repairs or changing of machine-parts when there is a breakdown. Moreover, some automatic controls which could in theory be introduced will in fact not be installed as they are too expensive.

There are also other reasons why the introduction of automation will be a slow process in many branches of industry. These include the immense labour of preparing a plant for the introduction of automatic machinery, the 're-designing' of the product when automation is introduced; and the lack of skilled 'automation engineers'. Moreover, many technical problems concerning the installing of automatic machines have still to be solved. It is more difficult to mount automatic machines capable of making 'individual products' than to install machines to process a fluid product. Again, the extent to which 'non-flexible' automatic machines can be used profitably may well depend upon the possibility of exploiting a really large market. The very high cost of constructing a completely automatic factory has also to be considered.

When all these factors are considered it is clear that in general

[1]Diebold's list of industries which are ready for immediate automation (based on the U.S. census classification) is as follows: 'bakery products, beverages, confectionery, rayon knit goods, paperboard containers, printing, chemicals, petroleum refining, glass products, cement, agricultural machinery, miscellaneous machinery, communications, limited-price retailing and some miscellaneous items' (Diebold, *op. cit.*, p. 149).

the introduction of automation is bound to be a very slow process. In these circumstances no difficulty should be experienced in finding new jobs—in an expanding economy—for those who become unemployed owing to the introduction of automatic machines and services.[1]

The argument that the automatic functioning of a free economy will absorb the workers displaced by the new machinery is frequently supported by reference to the experience of the past. It is said that an examination of the evolution of the economy of the United States shows that there is no need for anyone to be unduly alarmed about the future social effects of automation.[2] The following statement—impossible to imagine in the years of depression of the 1930s—typifies the newly-won confidence of American leaders of big business:

> 'Many have said that automation would displace labour and cause widespread unemployment. Certainly the same things must have been said about all of the other significant advances in manufacturing during the last 50 years. In my opinion, automation will do just the opposite. It will create more jobs—create more products at less cost—and increase the ability of people to consume.'[3]

Another and less convincing argument of the supporters of the 'compensation' theory is that when a firm introduces automation it commonly finds that the labour rendered redundant by the new machines can be usefully employed in performing other tasks created by the expansion of demand. Those who put forward this argument consider that there is no reason to foresee any decline in the aiblity of industry to absorb men rendered redundant by automation.[4]

[1]'There is no great danger that automation will create sudden upheavals in our way of life. The automatization of American industry must necessarily be a slow and gradual process. Since the growth of automation will be evolutionary and not revolutionary, it would have no abrupt, harsh impact upon our working population—no more than the gradual shifting of employment from dying industries into new industries to which we are thoroughly accustomed. And let's all remember that the willingness to make such shifts is essential to the dynamic American economy' (R. H. Sullivan, Vice-President of the Ford concern, quoted in *B.W.*, Nov. 27, 1954, p. 155).

[2]'The introduction of new and more efficient industrial machinery and processes obviously cannot be accomplished without creating some disturbance for some individuals and some companies. But consistently the longer range effect of such local and temporary disturbance has been more jobs and better jobs for Americans' (*A Message to American Industry*, prepared by the Dept. of Economics of the McGraw-Hill Publishing Company, Oct. 1954).

[3]D. S. Horder, Vice-President of the Ford Motor Company, quoted in *B.W.*, Nov. 27, 1954, p. 155.

[4]J. Diebold, in an address to the Congress of American Industry (reported in

Finally it is said that the management of a firm, which accepts its responsibilities towards its employees, will take adequate measures in time to prevent hardship when labour-saving devices are introduced. In the period of preparation the vacancies caused when employees reach the age of retirement are either not filled at all or the old workers are replaced by skilled men who can be kept on when automation is introduced. For many years this policy has been followed by the leading American telephone companies with the result that when an automatic exchange has been opened it has not been necessary to dismiss any workers.[1]

Criticism of the Optimists

It may be granted that the 'optimists' are justified in arguing that the extent and duration of 'technological unemployment' depends upon the circumstances prevailing at the time when the change-over to automation occurs. Should these circumstances be exceptionally favourable it would perhaps be 'more accurate . . . to say that we are the beneficiaries of a new intellectual revolution in the application of science to industry' rather than in the throes of a 'new industrial revolution'.[2] Given a suitable environment one could easily imagine that great technical changes could be introduced smoothly without upsetting the normal working of the economy. But is automation really likely to be introduced in such favourable circumstances that the whole operation could be regarded as an unmixed blessing? Is it really true that automation can be given a warm and uncritical welcome as a boon which will enable 'machinery to relieve men of hard, monotonous, soul-destroying labour'? Can automation be accepted simply as a means by which productivity and living-standards can be raised?

Let us recall what we have already said concerning the ability of the American labour market to absorb men who may lose their jobs owing to automation.

It will be remembered that we suggested that in recent years the labour market of the United States has by no means been in

N.Y.T., Dec. 1, 1954). It may be added that representatives of this 'optimistic' school of thought concerning the future effects of automation rely upon generalisations based upon individual experiences in the past. Yet they are the first to criticise the 'pessimists' for making use of this very technique.

[1] J. H. Collins, 'Will "Cybernetics" do away with People?' in *Management Review*, July 1954.

[2] *C.E.*, Oct. 1954, p. 20.

so strong a position as is sometimes supposed from the point of view of absorbing the victims of technological unemployment. We showed that it is doubtful whether the American economy could find employment every year for hundreds of thousands of additional workers unless the government embarked upon either a further expansion of the armaments programme or a substantial programme of public works. This situation has become more critical on account of the ever-increasing speed with which labour-saving machinery is being installed. Between 1946 and 1954 some 300 milliard dollars were invested in new plant and machinery in the United States. According to estimates (made from reliable sources) it is probable that a further 200 milliard dollars will be invested for the same purpose in the next five years. This high rate of investment must lead to a rapid increase in the efficiency of the American labour force. Output per worker will go up. This means that the same gross national product could be produced by an ever-declining labour force. Recent research on the growth of the productivity of labour has shown that the rate of expansion in output per worker increased from 2 per cent (the average for 1930-45) to about 4 per cent at the end of 1954. Output per worker has therefore doubled between 1930-45 and 1954.[1] If no other factors influenced the situation it would be true to say that such an improvement in the efficiency of human labour would inevitably lead to the attainment of a much higher standard of living. But in a society dominated by private enterprise there is a very real danger that a great increase in output per worker will lead to unemployment. A simple calculation shows that a continual improvement in labour efficiency of 2½ per cent annually —this assumes that the high rate of growth of 4 per cent achieved at the end of 1954 cannot be maintained[2]—would result in 1955

[1]See estimate in *Fortune*, Oct. 1954, p. 100 *et seq*. These statistics include only expenditure on 'plant and equipment'. They do not include either government expenditure on armaments, highways and other public works, or personal expenditure of the public (not even motor cars or other 'durable' consumer goods). Recent developments in the productivity of the American labour force are discussed in an article by G. Burck in *Fortune* entitled 'The Engine: Rising Productivity' (Jan. 1955, p. 66 *et seq*.). See also below, p. 186 *et seq*.

[2]Recent new investment in the United States has been on a fantastic scale. Plans for future investment are also remarkably high. A 4 per cent rate of growth in the productivity of labour is therefore by no means outside the bounds of possibility. We have however based our discussion on the generally-accepted 2½ per cent rate of increase. See G. Colm, *The American Economy in 1960* (Washington, 1952), p. 19.

in achieving the gross national product of 1954 by a labour force of 1,500,000 fewer men. This increased efficiency of the labour force is taking place at a time when there are 500,000 unemployed. There are also 500,000 (possibly 800,000) young workers waiting to enter the labour market. In addition a proposed reduction in the armed forces means that some further hundreds of thousands of men will be looking for jobs. It may well be asked how the labour market can stand the strain when the gross national product of the United States continues to expand and the rate of growth of the efficiency of the labour force continues to increase. The strain on the equilibrium of the economy would become more serious if the government reduced its expenditure on armaments. It would be a serious matter even if the government failed to increase its expenditure on armaments.

These factors in the situation must surely form part of the 'circumstances' in which automation will be introduced. Yet little weight is attached to them by those who cheerfully argue that the transition to full automation will not seriously upset the smooth working of the economic system.

Let us examine some of the arguments of the 'optimists' a little more closely. It has been suggested that only a limited number of industries are ready for full automation. But a glance at the trade journals shows that Diebold's list of such industries is already out of date. His list omits motor vehicles, aircraft components, foundries for non-ferrous metals, preserves, munitions, paper, iron and steel, cigarettes and—above all—the vast number of repetitive tasks in business and public offices which are capable of being performed by automatic devices. And this additional list of industries in which full automation could be introduced is growing. These industries have already spent or allocated hundreds of millions of dollars to build plants which have automatic machines and devices. We have already given some examples. And we have also drawn attention to the fact that in theory there is no manufacturing process which is incapable of being automatically controlled. The President of the motor workers' trade union (U.A.W.-C.I.O.) declared at the annual meeting of his union in the autumn of 1954 that the Massachusetts Institute of Technology had stated that it had now become possible to make a complete motor car by purely automatic processes.[1] At the end of 1954 it was made known that the Massachusetts Institute of Technology had constructed a machine which could turn out aircraft components which had not been touched by human hands during the entire process of manufacture.[2]

So much for the number of industries ready for full automation. Let us turn now to the question of the speed with which it will be possible to introduce automation.

It has been pointed out that a study of industrial history shows that there has been a progressive reduction in the time-lag between the date of an invention and the date when it is put to practical use. Whereas at the end of the nineteenth century this time-lag was about twenty years it is now only a few years.[3] Today it is a matter of extreme urgency that new weapons of war —which are based upon scientific and technical research—should be turned out with the least possible delay. And in industry working for the civilian market the completion of a completely automatic plant may give a company an excellent opportunity 'to blast their competitors clean out of industry'.[4] In these circumstances it seems reasonable to suppose that new inventions and processes will be put to practical use at positively breakneck speed. An examination of the daily press and the trade journals suggests that this is what is actually happening.

The continual expansion of the electronics industry (which produces most modern automatic machines and devices) may be taken as a measuring rod of the speed with which new inventions are coming off the production line. While the American motor vehicle industry took sixteen years to achieve a turnover of a milliard dollars the electronics industry took only six years after the second World War to reach a turnover of no less than five milliard dollars. It has been estimated that by 1960 the American electronics industry will have a turnover of 20 milliard dollars and few people think that this is an overestimate.[5]

The point of view that we have expressed is confirmed by numerous statements from people with special knowledge of

[1] *B.W.*, Nov. 20, 1954, p. 166.
[2] A survey of those branches of industry into which automation had been introduced by the end of 1955 will be found below, pp. 150-1.
[3] W. Leontief, *op. cit.*, p. 150.
[4] *F.M.M.*, July 1954, p. 83.
[5] *Christian Science Monitor*, July 9, 1954. See below p. 163 *et seq.*

automation. Two may be mentioned. Professor G. S. Brown, in a speech at the annual meeting of the United Steel Workers (Congress of Industrial Organisations), to which we have already referred, declared that 'automatic control will mushroom, that we want it to mushroom, and that we couldn't stop it even if we wanted to'.[1]

One of the *Weekly Letters*—which give reliable information of economic and political affairs in the United States—confidently asserts that automation is making very rapid progress in that country. A detailed investigation by the agency which issues this *Weekly Letter* states that business leaders themselves were hardly aware of the speed with which automatic machines and devices were being introduced. The trend towards automation had begun earlier but the much more 'rapid tempo' of automation in 1953 and 1954 was something new. The agencies considered not only that the introduction of more and more automatic machines as self-evident but that this expansion would continue 'at the zooming rate of the present'. And the end of the process would not be in sight when ten years had passed.[2]

These statements—and many more could be given—should be a warning to the facile optimists who argue that the gradual nature of the trend towards automation is a guarantee against technological unemployment on a large scale.

Moreover certain other arguments advanced by optimists to reassure those who fear widespread technological unemployment owing to automation will not bear close inspection. One of these arguments is that there are various practical difficulties which will put an effective brake on the speed with which automatic machinery is introduced. Of course there are difficulties which have stood in the way of the quick introduction of automation. Some of these difficulties have not yet been fully overcome. But just as we have shown that the range of industries capable of changing over to automatic machines is much larger than some people imagine, so too it may be said that the 'optimists' have grossly underestimated the extent to which the difficulties to which we have referred can be overcome. Problems which a few years ago—even a few months ago—appeared to be unlikely to be

[1]Quoted in *C.E.*, Nov. 1954, p. 19.
[2]*The Kiplinger Washington Letter*, Sept. 25, 1954.

solved for a long time have in fact been solved in a surprisingly short time. It seems as if even experts in these matters are finding it difficult to realise the speed with which practical problems which have hindered the full adoption of automation are in fact being overcome.[1]

The ignorance even of experts of the progress that is being made in the invention of new automatic devices may be illustrated by the following—in itself unimportant—story. The journal *Fortune*—as we already mentioned—called a conference of scientists and practical men interested in automation. At this conference the director of a firm building automatic machines stated that the absence of certain technical devices still rendered it impossible to introduce complete automation. He said that no device existed which could do what a human operator could in the event of a machine breaking down. A human being could look and listen and feel, but no machine was capable of doing this. Thereupon the general manager of the Specialty Control Department of General Electric, one of the largest American electrical engineering firms, got up and said that his firm was able to supply an electronic device which could locate faults in an automatic machine.[2]

We turn now to the question of the cost of automation. It seems to us that this has generally been exaggerated. The capital cost of installing automatic machines and devices differs considerably in various branches of industry. Estimates—which may however be out of date by this time since they were made in 1952—suggest that the cost of installing automatic machinery may vary between 1 per cent and 19 per cent of the capital value of the machines. Six per cent has been given as the average cost.[3] In some industries—such as oil refineries and many branches of the chemical and textile industries—the automatic machines turn out a 'continuous product', e.g. petrol, rayon filament, etc. In other industries the factories turn out separate articles. In

[1]The growing need to secure promptly information concerning the adoption of new automatic devices may explain why the fourth of the American technical journals devoted mainly to questions of automation had over 18,000 subscribers within three months of the appearance of the first issue. This exceeded by 3,000 the sales estimated by the publishers for the first three years of the life of the journal. See *C.E.*, Dec. 1954, p. 63. By September 1955 the number of subscribers had risen to 25,000 (*C.E.*, Sept. 1955, p. 4).

[2]*Fortune*, Oct. 1953, pp. 168 *et seq.*, esp. pp. 185, 187. [3]*S.A.*, Sept. 1952, p. 158.

such factories the cost of automation now and in the future will probably be more than 6 per cent. But what matters is not how many dollars have to be spent to install automatic machines but how long it will take the machines to save the money laid out upon them. The most expensive automatic machines—the giant calculators which perform repetitive tasks in offices—actually repay their initial cost in a few years by saving in salaries. And this is true of a calculator installed by a firm which was by no means amongst the biggest in the country.[1] The really big American firms have ample funds available to introduce automatic machinery if they are satisfied that these machines will pay. Even medium-sized firms will soon be able to dispense with the services of a considerable portion of their clerical staff by using electronic calculators which are both simpler and cheaper than the giant computers. And such calculators are already on the market.

We have seen that another argument advanced by those who see no reason for alarm at the economic consequences of automation is that those thrown out of work by automatic machines are bound to find new and often better-paid jobs not only in looking after and repairing the automatic machines but also in the expanding industry which makes such machines. This idea is based upon the 'compensation theory'. It is, however, difficult to accept the force of this argument. One of the main reasons for introducing automatic devices is to secure higher productivity. And higher productivity implies achieving a *net* saving in wages and salaries. If automatic machines are installed in a plant and all employees who have been redundant are found other work in the same factory or find jobs with a firm making automatic machines then—assuming output to remain constant[2]—it would not be

[1]It has been estimated that a firm with a staff of 12,000 workers and salaried employees could pay over a million dollars for a UNIVAC computer and recover the outlay in two years on net savings in salaries to office staff—even if the machine were used only for relatively simple and well-known bookkeeping and stock-taking calculations and for the work of the dispatch department and was not used for the highly-complicated tasks which such machines are quite capable of performing. See *H.B.R.*, 1954, No. iii, p. 105. It should also be borne in mind that the savings effected in factory and office space are often considerable (D. G. Osborn, S. A. June and others, *The Automatic Factory* (Pittsburgh), 1955).

[2]An exceptional case deserves mention. This is when—by a deliberate act of social policy—the purchasing power of consumers is increased *pari passu* with the fall in production costs. If that happens effective demand increases despite redundancy due to automation. We shall discuss this special case in the following section.

possible to secure a *net* saving in wages and salaries. The 'redundant' workers would merely be doing different jobs. All that would have happened would have been a change in the methods of production—not increased productivity (in the sense of a *net* saving of wages and salaries). Increased productivity in this sense is the same as reducing the amount of labour required for each unit that is produced in the plant. And it is immaterial if this labour is employed in actually turning out the product or in constructing or servicing the automatic machines which ultimately make the product.

Nevertheless it is possible that workers rendered redundant by automation may find *temporary* employment in plants making the new automatic machines and electronic devices. But the significance of this possibility of 'compensation' for redundancy can be appreciated only if it is known to what extent and for how long this new employment is available. Obviously opportunities of finding this new employment will decline as soon as there is some slowing down in the present vast expansion of the industry responsible for making automatic machines and electronic devices. When the immediate demand for these machines is satisfied the output of the plants making them will settle down at a lower and more 'normal' level. Moreover it should be appreciated that it is in these very plants which construct automatic machines and electronic devices that the productivity of human labour is increasing rapidly. Therefore as time goes on these plants will be able to absorb only a declining proportion of those workers in other factories rendered redundant by the coming of automation:

> 'The electronics industry . . . which produces the controls and computers that, more than any other factors, are the key to the new technology, turned out 275 per cent more output in 1952 than in 1947 with only 40 per cent more workers.'[1]

The experience of many years shows us that the 'productivity' of machines is continually increasing—i.e. the same 'productive capacity' can be secured by an ever-declining volume of capital investment. This means that 'fewer workers are required to produce machines that are capable of displacing more machine operators'.[2]

[1]*Report of Resolutions Committee*, 16th Constitutional Convention of the Congress of Industrial Organisations, Los Angeles, Dec. 6-10, 1954, p. 14.

[2]*Report of Resolutions Committee*, p. 14.

We are therefore bound to come to the conclusion that the arguments of the 'optimists' are supported neither by theoretical considerations nor by practical experience. We shall now consider what can be done to meet the very real danger of technological unemployment owing to the introduction of automatic machinery. In the next section we propose to make several suggestions concerning the solution of this problem.

(v) REMEDIES FOR TECHNOLOGICAL UNEMPLOYMENT[1]

The suggestions which we shall discuss are plans to ward off 'technological mass unemployment'. Only occasionally—as when the Congress of Industrial Organisations demands a guaranteed year's wage—have these proposals been linked specifically with the problem of automation. The object of the proposals that we shall discuss all aim at stabilising and, if possible, extending the 'effective demand' for labour, for consumer-goods, and for production-goods. This can be done in various ways—(i) by adjusting the demand for labour to the changed conditions brought about by technical progress; (ii) by increasing the purchasing power of consumers by a wage policy or by government intervention; and (iii) by a deliberate (though indirect) attempt to control the rate at which automation is introduced into the economy. In examining these various proposals we shall consider their effects upon automation in a society which—even without automation—is more and more threatened with technological unemployment. We shall discuss these plans on their own merits without considering whether those who first made them had the 'second industrial revolution' of the age of automation in mind or not.

We shall first examine the measures which can be taken to influence the supply and demand of *labour* directly. The simplest solution of the problem of technological unemployment appears to be the attempt to train workers made redundant by automation so as to enable them to undertake more responsible work (if possible in the same plant) by watching over and servicing the new machines or performing some other task for which training is necessary. The latter would seem to be a more hopeful approach to the problem than the former. We have already seen that only

[1]The problem of technological unemployment is also discussed below, p. 164 *et seq.*

some of the workers rendered redundant by automation can be found new jobs in looking after automatic machines. The question arises, however, as to whether it is really possible to train redundant workers for entirely new jobs demanding a higher degree of skill than those which they have hitherto performed. In particular this doubt must arise when considering the fate of the semi-skilled workers—a very large group. A leading expert has expressed the view that 'too few people worry about how the displaced worker will move into his new and more expert assignment'.[1] If it proves to be impossible to absorb redundant workers in the plant in which they have hitherto been employed it may be possible to find them new jobs—either in the same town or elsewhere—of a type to which they are accustomed and for which additional training would be not necessary.

It has been suggested that either the firm in which redundancy occurs owing to automation or some public authority should be financially responsible for assisting unemployed workers to find new jobs (in the place in which they are living or in some other town). Another proposal is that the older workers who are not able to learn a new trade and for whom no work at their own trades is available should qualify for a pension before they reach the normal retirement age. This is sometimes coupled with a proposal to increase retirement pensions.

More drastic proposals to ease the pressure in the labour market are those which advocate a *further reduction of the legal working week*, without reducing wages. For some time there have been discussions in the United States concerning the possibility of introducing the four-day week in the not-too-distant future in all the more advanced industries. And these, of course, are to a great extent the branches of manufacture in which automatic machinery is being introduced. It has been said that only by introducing a four-day week will it be possible to keep an ever-expanding labour force in full employment in view of the relatively rapid decline in the demand for labour in time of peace.[2]

[1]G. S. Brown, *op. cit.*, p. 18.

[2]An official estimate of the potential economic growth of the United States in the next ten years assumes that in the non-agrarian branches of the economy it will be possible to introduce a 36-hour week and that in future every American worker will be able to work 200 hours less in a year than at present. See *Potential Economic Growth of the United States during the next Decade* (Washington, 1954), p. 6 *et seq.*, and 'The Four-Day Week—How Soon?' in *Fortune*, July 1954. Elsewhere it has been stated:

The introduction of a four-day week—which would mean raising hourly rates of wages by no less than 25 per cent—would not be confined to the economic aspects of society. It is necessary to consider the effects of the four-day week on the smaller and technically less advanced plants. And then there is the question of what the workers would do with their newly-found additional leisure. A sharp reduction in the length of the working week would no doubt appreciably ease the pressure on the labour market—especially if such a measure was accompanied by a raising of the proportion of the gross national income secured by wage earners and salary earners. The introduction of a four-day week, if accompanied by increased productivity of labour, might well lead to an increased demand for mass-luxuries and for 'services' of all kinds and this in turn would increase employment in the luxury and 'services' industries. On the other hand an increase in the national wages bill (if this were more than a temporary phenomenon) might cause a rise in prices and so start an inflationary spiral.

Despite the protests of businessmen, economists and other experts, the Eisenhower Administration has adopted the policy of preparing for the initiation of public works on a grandiose scale so as to be ready to get them started as soon as unemployment figures rise to a level likely to alarm the public:

> 'Government must use its full power to protect its citizens from depression, unemployment and economic distress.'
>
> * * *
>
> 'Today, it is no longer a matter of serious controversy whether the government should play a positive role in helping to maintain a high level of economic activity. . . . What we debate . . . is . . . the nature of governmental action, its timing and its extent.'[1]

Statements of this kind represent a return to the policy of full

'Industry must take care to pass on the gains of automation in shorter hours and higher wages. If and when automation makes it possible, labor may be entitled to press for such advances as the four-day week' (*Life*, Jan. 17, 1955, p. 35). See also Oscar Schnabel, 'More Inflation or More Leisure' in the *New Leader* (New York), Dec. 20, 1954.

[1]The first quotation is from a speech by President Eisenhower and the second is from a lecture by Professor Arthur F. Burns, Chairman of the President's Council of Economic Advisers. See *Report on the Business Outlook* (Washington, D.C., Oct. 28, 1954). The editor of this report remarked that such statements clearly represented a departure from formerly accepted economic principles according to which the duty of government was limited to fostering the expansion of the economy—and public works were simply the main means by which it was hoped to attain this end.

employment as advocated by Keynes and his followers. The closing sentences of an article to which we have already referred called 'Automation—Blessing or Curse?' are typical of this change in policy and show how it is hoped that the problems likely to be raised by automation will be solved by this policy.

> 'Government recently has largely confined its recession-antidote public works projects to blueprinting the possibilities. Now it ought to draw a line—perhaps the present line of 2.7 million—above which unemployment will not be allowed to go without putting more of these projects into concrete. Fortunately, nearly all such measures can be made in capital improvements—new highways, schools, better housing, etc.—which will eventually pay for themselves by what they add to the income and brainpower of the economy.'[1]

It is not necessary to summarise the discussions concerning the policy of full employment which have been going on among scientists for twenty years. It may be pointed out, however, that a policy of public works can act effectively against technological mass unemployment only if they are introduced on a sufficiently large scale and for a sufficiently long period of time to achieve their object. And if they were introduced on a large scale for a sufficient number of years they would represent an important step in the direction of State Socialism.[2]

One of the more drastic plans to combat mass unemployment due to technical progress is that for a 'guaranteed annual wage' or a 'guaranteed employment plan'[3] advocated for some years by the leading trade unions in the United States. The plan was the main topic discussed at the annual Congress of Industrial Organisations held in December 1954 and it was clearly linked with fears concerning technological unemployment owing to automa-

[1] *Life*, January 17, 1955, p. 35.

[2] See the reports of the expert committees of the United Nations (*National and International Measures for Full Employment*, Lake Success, New York, December 1949) and the subsequent discussion.

[3] The change of name from 'guaranteed annual wage' to 'guaranteed employment plan' is probably due to the fact that a guaranteed annual wage is asked only for those workers who have at least two years 'seniority' in a firm. Other workers would—if thrown out of work—be entitled to one week's wages in respect of every two weeks service. The cost of these payments is to be borne partly by industry and partly by the unemployment insurance scheme. Another aspect of the plan is that firms should pay a minimum wage on the basis of a 40-hour week—even although fewer hours are in fact worked. See *Steady Work, Steady Pay. Questions and Answers about the U.A.W.-C.I.O. Guaranteed Employment Plan* (Detroit, 1954). For the first reactions of the employers to the plan see *B.W.*, November 20, 1954. For a further discussion about the plan see below, p. 243.

tion. The comments of the motor workers trade union on the plan ended with the words:

> 'The rapid growth of automation means that no worker, regardless of his skill or length of service, can be certain that his job will not be entirely eliminated in the future. The Guaranteed Employment Plan offers security for every one. Every worker needs it.'[1]

The main reason why the American trade unionists supported this scheme in December 1954 was because they wanted the assurance of a guaranteed annual wage. The attempt to secure safeguards against working short time was a secondary consideration. The plan was not intended in any way to hinder the expansion of automation. The American trade unions support automation. They believe in technical progress and they are no Luddites. On the contrary the plan

> '. . . will compel management to exercise a degree of social responsibility in introducing automation by having to bear a large part of the social costs of irresponsibility'.[2]

It is clear that the American trade unionists hope that the Guaranteed Employment Plan will push up the cost of automation —if this takes place at a time when redundant workers cannot quickly find fresh jobs—to such an extent that industrialists will be forced either to postpone automation until trade improves, or at any rate to introduce automation more slowly than they would otherwise do. Moreover, American trade unionists hope that the Guaranteed Employment Plan will make it difficult for industrialists to establish new automatic plants in new localities which possess advantages of a technical or commercial nature. Such a policy might leave thousands of workers behind in 'ghost towns'. The leaders of the American trade unions declared that the Guaranteed Employment Plan was not being put forward in the hope that their members would be living permanently on the dole. On the contrary, in view of the dangers threatened by automation, it was hoped that the Plan would

> '. . . stimulate employers to provide steady, full-time employment. Costs arising under the Plan are essentially penalties for failing to provide steady work'.[3]

It is not at present possible to foresee the outcome of this

[1] *Steady Work*, Question 61.
[2] *Steady Work*, Question 57.
[3] *Steady Work*, Question 3. See also the *Report of Resolutions Committee*, Resolution No. 16; *Technical Progress and Full Employment*, p. 13 and W. P. Reuther, *op. cit.*, p. 15 *et seq.* and p. 98 *et seq.*

campaign in the United States for a guaranteed annual wage. Should the plan be adopted in the major American industries engaged in mass-production—and it is in these industries that automatic machinery is being introduced—the future expansion of automation (and indeed of other labour-saving devices) may be held in check. If the American trade unions gained a victory in their struggle for a guaranteed annual wage future historians might regard this as a social change of fundamental importance brought about by the universal adoption of automation.

A policy which succeeded in maintaining a high level of employment despite the introduction of automatic machinery would exercise a powerful influence upon the development of both consumer-goods and producer-goods industries. If employment is maintained and men continue to draw wages the total demand for consumer goods is unimpaired. In these circumstances there would be no danger of wages falling or of the producer-goods industries suffering in any way.

The magnitude and urgency of the problem of technological unemployment has, however, given rise to a number of new proposals designed to maintain—and even to expand—the demand for both consumer-goods and producer-goods. In this connection the demand for a guaranteed annual wage again deserves mention. Moreover the welfare legislation of the United States—which only a few years ago was criticised because it was alleged to be incompatible with a private enterprise economy—will also have the effect of maintaining consumer demand. A series of further proposals have been made which would all have the same effect upon consumer demand. These include the reduction of income tax for the lower income groups and various tariff measures designed to maintain home demand.

Recently it has been suggested that other measures should be taken to re-enforce—or even to replace—this policy of influencing wages and prices. It has been argued that, in the modern world, it is unwise to rely upon the functioning of the free market as this may take too long to adapt itself to changing conditions. It is said that we cannot wait for the lower costs of production—made possible by improved machinery—to be reflected in lower prices for the consumer. It may take too long for the increase in real income of the consumers to mop up a growing gross national output. On the contrary the consumers should—in their capacity of producers—get higher wages at once and goods should be reduced in price at once. If that happened there would be no time-lag in the disposal of the increased gross national output. This point of view has been expressed by the American trade unions and even by leaders of American big business. The following somewhat Utopian view has been expressed with particular clarity by one of the directors of the Ford concern when he was discussing the plan for a guaranteed annual wage:

> 'The higher the wages we earn the greater will be the demand for the things that American workers produce. The lower the prices we charge, the more we can afford to buy. With more leisure time, we will buy more radios and television sets, home workshops, sporting goods, and other recreational equipment which has not yet been invented. All these things that add up to a better life for you and me also add up to more and better jobs for the people who manufacture and service the goods we will buy. Thus the effects of automation should reach out through the whole fabric of our economic and social life, raising our living standards at a rate we haven't even imagined.'[1]

Statements of this sort might lead one to suppose that the modern manager of a firm is more interested in maintaining full employment than in maintaining maximum profits! In a recent book one of the leading authorities on the modern joint stock company has argued that the business corporation has a 'conscience' and that the corporation is capable of developing into one of the most important agencies for securing the smooth working of modern society.[2] Nevertheless in an economy based upon the private ownership of the means of production it is impossible to escape from two hard facts. First it is the level of wages and salaries which determines the purchasing power of most consumers and which—at least in those sectors of the economy as yet uninfluenced by automation—is itself a decisive factor in determining the cost of producing an article. Secondly, in order to survive every firm must make as large a profit as possible. High profits are necessary because it is essential to build up large reserves to finance the ever-growing need for new capital investment.

We cannot discuss here the problems raised by Berle's attempt

[1] R. H. Sullivan, quoted by *B.W.*, Nov. 27, 1954, p. 155 *et seq.*

[2] A. A. Berle, *The 20th Century Capitalist Revolution* (New York, 1954), p. 61 *et seq.*

to give a fresh interpretation of the theory of 'economic harmony'. But there is one comment—to which we have already referred in another connection—which may not be out of place. It may be possible in certain branches of industry to pass on to consumers—in lower prices—the reduction in production-costs secured by the introduction of automatic machinery. But that does not mean that there will be a general fall in prices in all sections of the economy. But in the meantime it is possible that mass unemployment might lead to a contraction of purchasing power which would lead to a slump.

From a purely technical point of view the expansion of the consumer-goods market would not raise any insuperable difficulties in the American economy, which enjoys such ample reserves of strength in all the factors of production. If there were a reduction in armaments the consequent reduction in the demand for goods could be maintained either by a programme of public works or—as actually happened in 1954—by appropriate adjustments in taxes or credits.[1]

The maintenance—even the expansion—of the market for consumer-goods can be the foundation stone of a stable demand for producer-goods so long as the American consumer-goods industries do not command adequate technical equipment to meet all the possible demands for their goods. There are at present insuperable difficulties in giving a definite answer to the question—Can the adoption of the measures we have mentioned (or of a combination of some of them) successfully ward off or mitigate the unemployment which it is feared automation and the general trend of events in the American economy will bring about? There are important factors in the situation which will one day determine the answer to this problem. These factors include (i) the nature and the extent of the defensive measures against unemployment and the vigour with which they are adopted; (ii) the particular combination of defensive measures adopted to meet unemployment; (iii) the general economic and political situation

[1]To illustrate this point it may be mentioned that one very effective means by which purchasing power was maintained was the reduction in rates of interest charged for loans on houses. This led to a boom in the building trade which proved to be an important factor in overcoming the 'recession' in the United States in 1954. Moreover tax concessions were made when business capital was written down in value. This, too, helped to overcome slack trade.

both in the United States and in the world when large-scale unemployment comes. We should need an electronic computer to weigh up the effects of all the possible combinations and permutations of circumstances that might affect the success or failure of the various measures that might be taken to try and ward off technological unemployment in the United States. This much can, however, be safely asserted—if the results of the 'second industrial revolution' are met merely by improvisations and palliatives and left virtually to the 'free play' of economic forces, then it is possible that destructive tendencies might develop of such force that no 'free' society would be strong enough to withstand them.

(VI) SOCIETY IN THE AGE OF AUTOMATION[1]

We now propose to discuss certain possible sociological consequences of automation which might be expected to occur in an unregulated private enterprise economy. To a greater extent than in previous chapters we shall have to rely upon general principles and upon the experience already gained when the movement for the 'rationalisation' of industry became an important factor in the situation.[2]

Complete automation represents the final triumph of the machine over the human worker. If no proper steps are taken to ward off the technological unemployment which may be expected to follow automation it is possible that there would be a repetition of the grave social evils that followed both the first industrial revolution and the movement towards rationalisation. Automation will relieve the human worker of a great part of exhausting and soul-destroying routine jobs just as the machines of the first industrial revolution relieved him of at any rate a part of the heavy manual labour to which he had formerly been accustomed.

Two changes in the attitude of workers to society and in the consciousness of the workers may be expected to follow the advance of automation on a large scale. The first change follows from the fact that automation is the culmination of a long process which began when the powerloom replaced the handloom and

[1] See also p. 213 *et seq.*

[2] The most profound studies concerning the social and human problems of 'rationalisation' are the two books by Georges Friedmann (cited above, pp. 37-38).

continued until the conveyor-belt system of production was perfected. Bit by bit machinery has taken over tasks formerly performed by human beings and in doing so it has destroyed the value of old-established industrial skills. The second change works in the opposite direction. Automatic machinery may be expected to create a greater demand for a new skills than any previous advance in technology. These machines will call into existence a new class of highly-qualified specialists to operate and service them.

The movement towards rationalisation was based upon the idea of the division of labour. Every effort was made to divide up a job into smaller parts and to speed up production by every means.

Everyone knows what happened to the workers. They became 'slaves' to the machine. They were condemned, at the behest of the all-powerful machine, to perform precisely the same operation hour after hour and day after day. Men protested by every means at their disposal—from the pulpit to the cinema—against the inhumanity of this sort of work. Now automatic machinery will to a great extent put an end to the type of labour which was characteristic of rationalisation. Automatic machines controlled by all the various electronic devices that the ingenuity of engineers can devise will free mankind from the slavery of 'chain-labour' (as the French call work on the conveyor belt).[1] No sensible person wants to lose the advantages—high productivity for less heavy manual labour—gained by technical advances such as rationalisation. But everyone should welcome the prospect of the ending of the truly inhuman work demanded by the conveyor-belt and similar systems. We now know that this sort of work—which turns men into nervous wrecks before it destroys their souls—can be done just as well, if not better, by automatic machinery. Then we have to face the problem—what is to be the future of the worker who is 'freed' from purely mechanical toil? What work, worthy of a human being, will be available for him?

We have already explained why, in our opinion, only a relatively small part of the workers made redundant by automation will be able to find satisfactory employment in supervising and servicing the new machines. Unless the rate at which automation is introduced and the extent to which automatic machines are installed is properly controlled and unless proper measures are

[1]*Travail à la chaine.*

taken to find suitable work for redundant employees, then the men and women who lose their jobs will form a great pool of unemployed. And their position will be an unenviable one because some will be unskilled, while those who are skilled will find that there is no longer any demand for the trade in which they were trained.

Our attempt to forecast the changes in the social structure which will follow the widespread adoption of automation may perhaps be criticised as useless since we are concerned with future events which cannot be anticipated. Moreover it might be said that, however widely automation may be introduced into large-scale manufacture and power industries and for the performance of routine clerical jobs in business offices and public administration, there will always be a large sector in the economy in which automatic machines cannot be introduced. Automation is never likely to make much progress in farming, mining, transport, small-scale industry, building, the service industries, small shops, and professional work. In reply to this criticism it may be pointed out, in the first place, that the experts are by no means agreed as to the extent to which automation may, in the future, spread to industries which at present do not seem to be suitable for it.[1] Moreover

[1] 'Thus the possible fields into which the new industrial revolution is likely to penetrate are very extensive, and include all labour performing judgments of a low level, in much the same way as the displaced labour of the earlier industrial revolution included every aspect of human power. There will, of course, be trade into which the new control machines are not economical in industries on so small a scale as not to be able to carry the considerable capital costs involved, or because their work is so varied that a new taping will be necessary for almost every job. I cannot see automatic machinery of the judgment-replacing type coming into use in the corner grocery, or in the corner garage, although I can very well see it employed by the wholesale grocer and the automobile manufacturer. The farm labourer too . . . is protected from the full pressure . . . . Even here, the large-scale or plantation farmer is becoming increasingly dependent on cotton-picking and weed-burning machinery. . . . Where such machines may be used, some use of machinery of judgment is not inconceivable' (Norbert Wiener, *The Human Use of Human Beings, Cybernetics and Society* (Boston, 1950), p. 186). When the book appeared the critics said that his predictions were of a fantastic nature. Recently, however, it has been seen that Wiener correctly assessed the trend of affairs. Two examples may be given:

(a) 'It's high time that we recognize the fact that small and medium-sized manufacturers stand to benefit from automatic control just as much as do the mass producers' (*A.C.*, Sept. 1954, p. 36).

(b) 'By no means limited to the process industries, automatic control is continually finding new areas of application in the office, retailing, and the service industries, as well as in all fields of manufacturing. It is the realization that new uses for control exist, and the unfolding of unlimited new potentialities with each new area of application that gives genuine newness to the idea of automatic control' (*A.C.*, Nov. 1954, p. 36).

Both these statements are made by John Diebold, author of *Automation: The Advent of the Automatic Factory* (1952), to which we have frequently referred.

in the United States the conveyor-belt system was introduced only into those industries which now appear most likely to adopt automation. But it is the conveyor-belt which is the characteristic feature of modern industry. In the leading industrial states the relationship between the wage-earners and the salaried staff in large concerns has undergone a significant change since the early years of the twentieth century. Before the first World War the wage-earners still played some part in the whole process of manufacture. Now they are more concerned with tasks which cover only a tiny fraction of the whole process. Initiative is no longer required and the work is boring. The men on the assembly line tend to become indifferent if not hostile to the success of the manufacturing operation as a whole.[1]

The fact that the introduction of 'rationalised' but boring assembly-line methods in the great industries of today has left its mark on the whole of modern society makes it appear likely that the widespread adoption of automation might well have similar results. The probability of this development is strengthened by the fact that the principle of automation is simply the principle of conveyor-belt 'rationalisation' pushed to its logical conclusion. We may see an ever-growing proportion of the population turned into a sort of 'surplus population'. In the major industrial states the typical wage-earner will be easily replaceable by somebody else and therefore—from the point of view of the average worker—he will always be in danger (in time of peace) of losing his job.

Another characteristic feature of the age of rationalisation in industry has been the widening of the gulf between a small group of highly qualified 'managers', engineers and specialists on the one hand and the vast mass of wage-earners on the other. The reason for this lies not only in the personal qualities of the two groups but also in their technical and administrative training. The activity of the 'hands' is now generally confined to carrying out quite elementary operations or in following simple instructions, the very

[1]See Georges Friedmann's penetrating report on the experiences of a French industrial worker in *Où va le travail humain?* p. 40 *et seq.* See also C. R. Walker and R. H. Guest, *The Man on the Assembly Line* (Cambridge, Mass., 1952), p. 141 *et seq.* According to the census of occupations the proportion of unskilled workers in the United States has declined sharply—both absolutely and relatively. But this does not invalidate our argument because the wage-earners classified as 'semi-skilled' in the official statistics are in fact unskilled workers who have had rather more schooling and have picked up the job on which they are working rather more quickly than their workmates.

purpose of which they have no need to understand. Hitherto various factors have combined to disguise the nature of this ever-widening gap between two sections of society. These factors include the activities of those industries which provide 'culture' for the masses; the large-scale output of luxury goods for the masses; the continued improvement in the standard of living; and the increasing tendency for people to think alike owing to the efficiency of modern methods of influencing the minds of the masses. In the age of automation these social trends might be expected to continue in a 'free' private-enterprise society in an exaggerated form. A new sort of society, based upon authoritarian or military principles, might be evolved.[1]

We shall expect to find an *economic general staff*—the real masters of both machines and men—at the apex of the social pyramid. Only this relatively small group, associated with its 'corps of officers', will be in a position to take a comprehensive bird's eye view of all the technical and economic problems that a society has to solve. They alone will be in a position to take the major decisions on all questions of economic policy. With the help of electronic computers they will be able at any time to secure all the up-to-date information that is needed to reach such decisions. From these machines, too, they will be able to discover whether it will be possible to carry out some complicated plan and the computer will tell them what the cost of the plan will be. Only on this basis will it be possible to take far reaching overall decisions with the maximum confidence.

Since so much information about future trends will be available it is clear that those who will in future manipulate the economy will be in a very powerful position. A possible danger lies in the fact that these leaders of society in the new age of automation will tend to ride roughshod over the vast mass of the workers. The temptation to do so will be a strong one since the man in the street is incapable of exercising any judgment of his own: he can be all too easily influenced by modern methods of propaganda: and if

[1]This outline of the possible structure of society in the age of automation naturally omits many details. We have, for example, ignored the position of the capitalists. In a future 'automation society' the capitalists would either be absorbed by the leading group in society or they would lose their economic functions. And we have not discussed the actual ways in which the group wielding effective powers in the new economy will in fact exercise these powers.

he does become a little restive his complaints can be satisfied by getting a few more consumer goods on the market so as to raise his living standards.

Just as the day-to-day running of an army is in the hands of *officers* so the day-to-day running of society in the future will be controlled by engineers, administrators and public relations officers. This group—from the senior officers to the subalterns—would naturally be composed of men who have high technical qualifications and the ability to think for themselves. Today engineers working on automatic machinery are expected to be able to do more than solve problems by 'routine methods'. He cannot let his imagination go rusty. He should be 'a creative engineer'.

> 'Fortunately, machines now grind out a lot of engineering results. . . . In this way, machines can relieve engineers of a lot of slogging. It's up to each of us to see that the hours of routine that they save are converted to so many hours of creative thinking. Every engineer ought to concentrate on recognizing needs and problems and breaking them down to computer routines. This takes thought. Thought takes time.'[1]

The modern engineer who aspires to be a 'control engineer' has to be able to do more than set up computers and similar devices. That is only the first part of his job. In recent years more has been expected of him. He should have a sound knowledge of theoretical physics: he should have a wide general knowledge of all the machinery that is being used in the branch of manufacture in which he is engaged: he should have a detailed knowledge of the working of the firm in which he is employed. And what is more the modern 'control engineer' is expected to appreciate fully 'the dynamics of industrial processes, of the whole economy, and of human beings'. Above all he can no longer think in terms of isolated problems. He must consider every separate problem as part of a greater 'system':

> 'After he solves the individual control problems, he must, so to speak, put the plant back together again and make it an integrated control system.'[2]

What qualifications of a *personal* nature are demanded of the leaders in the age of automation? This will depend upon the organisation of the concern which employs them. They are a

[1] 'Let Him Think', leading article in *C.E.*, Dec. 1954, p. 23.
[2] *C.E.*, Oct. 1954, p. 27.

group of specialists whose duty it is to make detailed plans and to prepare 'programmes' for operating a system of computers. A preliminary selection will have to be made and the factors that will play a decisive part in the choice will be technical qualifications and practical experience.

> Out of this group we selected individuals for specialized computer training by means of psychological tests. We were looking for high intelligence and ability to think logically and reason abstractly. And particularly for the leadership of such a group we wanted someone with enthusiasm, vision, foresight, energy, and an optimistic point of view; he should be willing to take risks and to devote his entire energies and thoughts to the task at hand.[1]

The 'officers' of an automatic factory should be persons who are completely confident of their own powers and are optimists by temperament. There can be little doubt that such 'officers' will be forthcoming.[2]

Engineers appear to be taking a different view from formerly of the unskilled workers with whom they have to deal. It seems as if engineers now tend to regard these men as a much less reliable and skilful factor in production than automatic machinery. They consider the unskilled workers to be temperamental and difficult to handle. They often regard the men as a necessary evil. They sometimes look upon them as an unqualified nuisance. This attitude may be seen in the following statement:

> '. . . men, by definition, are difficult and tricky things to play around with. You have employee-relations men, time-study men; you have training and education directors; you have personnel men, washroom men, cafeteria men. You have got a public-relations problem. That all costs money. My point is this: that if we could take some of the money . . . and apply that money for some research *to get the men out of there entirely*, we would be far better off in the long run'.[3]

A similar point of view was expressed by Gerard Piel when he said that the introduction of automation into a particular oil refinery was not due to any desire to dismiss the two men who had hitherto worked the controls in the semi-automatic plant. In his opinion the advantage of automatic controls over human control was that

[1]R. F. Osborn, 'G.E. and UNIVAC', *H.B.R.*, July-Aug., 1954, p. 105.

[2]An investigation has been made concerning the marriage histories of several thousand graduates of the Illinois Institute of Technology. It was found that—for sample marriages in 1939, 1944 and 1949—over 90 per cent of the graduates were married and none of the marriages had been dissolved. On the other hand one quarter of the marriages in the United States end in divorce. See *C.E.*, Sept. 1954, p. 9.

[3]Statement of a delegate at the Round Table conference organised by *Fortune* in 1953: see *Fortune*, Oct. 1953, p. 180 (italics supplied).

they have the advantage of performing tasks which are beyond human capacity. Just as power-driven machinery freed industry from the limitations imposed by nature on the continuous use of manual labour, so the introduction of automatic controls will make industry independent of the natural limitations of the human nervous system.[1]

Even the engineers admit that in certain respects a human being is superior to an automatic machine. He is a 'multi-channel device' whereas the machine has the attributes of only a 'single-channel device'.[2] As long as the machine is only a 'single-channel device' it will still be necessary for human beings to play a part in working automatic machinery. The inevitable consequence is that the electronic part of the system must be so adjusted that it can cope successfully with instructions in which there may be an element of human error.[3] But the aim of those who are thinking on these lines is ultimately the liberation of technology from human limitations.

These statements may serve to illustrate the point of view of the automation-engineer concerning men and machines. His attitude is perhaps not surprising as his life is devoted to mastering the forces of nature. There is nothing new in this attitude of mind. This can be seen by comparing the views expressed in writings of modern 'technocrats'[4] with what has actually taken place in totalitarian countries. It is of course notorious that there are engineers who think along the same sort of lines as totalitarian rulers. As far as social relationships are concerned the coming of automation is not bringing with it something new. On the contrary it is developing something which has been known before. Shortly before the outbreak of the second World War F. G. Jünger described the modern technologist as one who

'. . . claims to be a realist, and to face the hard facts of reality.

[1]Gerard Piel, 'Science in the next Fifty Years' in the *Bulletin of the Atomic Scientists* (reported in *Die Zukunft*, Vienna, Nov. 1954).

[2]The human being can use all his senses at the same time. His brain will register signals sent by all his senses and can link them together before reaching a decision. The computers work extremely rapidly but can perform only one function at one time. In this respect the human intelligence is superior to the 'brain' of the electronic machine. See *Fortune*, Oct., 1953, p. 188.

[3]J. Greene, 'Man as a Servo-Component' in *C.E.*, Oct. 1954, p. 58 *et seq.*

[4]See the discussions at the 'Semaine Sociologique' held in Paris in 1948 to discuss the social aspects of 'technocracy' G. Gurvitch (ed.), *Industrialisation et Technocratie* (Paris) 1949.

But if he is a realist, it is only in his own particular sphere of specialised knowledge. He may appear to limit his claims to his chosen field, but this really disguises his almost limitless lust for power. He hides the full extent of his far-reaching plans and ambitions, which are ultimately to be seen in terms of power over his fellow human beings. The edifice which he has constructed . . . is one which, in a centralised society, enables the master of the machine to be also a master of men. The power to which he can aspire is truly colossal.'[1]

The *non-commissioned officers* in a society dominated by automation will be the semi-skilled workers—some better qualified than others—who will maintain and service machinery. Those workers—skilled and unskilled—who have as yet not been made redundant by machines will belong to the same social group. The differences between the incomes and standards of living of salaried workers and skilled artisans—which are already disappearing—will vanish altogether:

'The relative social status of different groups and the prestige claims of one group over another are hardly likely to endure. . . . There will be less and less room for the unskilled person, and people will be called on more and more for creative activity which machines cannot give. We shall require more educated people in the broadest sense.'[2]

There are wide divergencies of opinion concerning the qualifications required by those who maintain and service automatic machinery. Some argue that these mechanics will rise in status to become 'junior engineers'. Others say that most of the tasks required from those who will look after automatic machinery in future can be learned by the younger generation of semi-skilled mechanics. And this argument is strengthened by the fact that in a fully automatic factory the repair of defective machine parts takes place in special workshops. All that the maintenance men have to do is to select the correct spare parts which are always available.[3] There is, however, a very wide measure of agreement concerning one aspect of the future of this important group of workers in the age of automation. In sharp contrast to modern assembly-line work the job of looking after automatic machines will lead to a new relationship between the men and the machines. Men are not chosen to work on a conveyor belt because they are

[1]F. G. Jünger, *op. cit.*, p. 163.
[2]Sir Ben Lockspeiser, *op. cit.*, p. 261.
[1]For the former argument, see *B.W.*, Sept. 1954, p. 84; for the latter, John Diebold, *Automation. The Advent of the Automatic Factory* (1952).

intelligent, alert or likely to be interested in the job.[1] But these are the very qualities that will be required when looking after automatic machines. It will cause no surprise to discover that psychological tests designed to select men for work of this kind try to find out if the candidates possess 'a fundamentally optimistic outlook'. This is the relatively small group of workers who will undoubtedly gain immensely from automation since they will obtain relatively interesting jobs in place of the dull routine of the conveyor-belt. But those who have no misgivings about the social consequences of automation fail to realise how small this group of workers will be.

Norbert Wiener is among those who view with some concern the social consequences of automation. In his standard work on *Cybernetics* he drew attention to the possibility that some highly disagreeable results might follow from the widespread adoption of automation. He shows that electronic devices may supplant the human brain—at any rate in its simpler and more routine operations.

> Of course, just as the skilled carpenter, the skilled dressmaker have in some degree survived the first industrial revolution, so the skilled scientist and the skilled administrator may survive the second. However, taking the second industrial revolution as accomplished, the average human being of mediocre attainments or less has nothing to sell that it is worth anyone's

This is obviously an exaggeration. Wiener observes an existing trend and pushes it to its logical conclusion without taking into account any of the factors which will oppose and modify the trend. To get a fairer picture of the social dangers that automation is likely to bring about—to look ahead for a reasonable and not a very remote period—it is necessary to examine the problem in rather more detail.

We begin by asking ourselves to what extent—and in which particular industries—automatic machines are in fact likely to

[1]Georges Friedmann mentions a Belgian factory in which precision instruments are made. He states that the tests devised to select female workers for repetitive jobs aim at choosing girls with 'stereotyped minds'. 'Dès qu'une ouvrière manifeste une rapide compréhension des procédés, dans la consigne qui lui est donné pour éxécuter un test, elle est éveillé. . . . Voyez-vous, dans le choix que nous avons à opérer, il faut parfois se méfier de celles qui réussissent trop bien les tests: elles ne s'habitueront pas, à la longue, à des tâches très élémentaires.' (*Où va le travail humain?* p. 335.)

[2]Norbert Wiener, *Cybernetics* . . . (1948), pp. 37-38.

replace human labour within the next ten or twenty years.[1]

In this connection a distinction may be made between manufacturing industry, administration and services.[2]

(a) *Manufacturing industry in the widest sense*. Under this heading we include the production of power, the production of raw materials, the manufacture of semi-finished and finished goods, transport.

(b) *Administration*. This includes work done by officials, clerks, etc., in public offices and private businesses. We include the office work done in banks, insurance companies, and wholesale businesses.

(c) *Services*. Following the practice of the American statistics we distinguish between professional and personal services. Professional services are those requiring high qualifications on the part of those who render them—e.g. services of independent professional men; services of public bodies connected with education, health, defence, internal security, etc.; services of highly qualified engineers, technicians, etc. Personal services include various services rendered to the final consumer and requiring high qualifications, e.g. the services of salaried persons in retail trade.

This is of course only a very rough-and-ready classification, but we think that it will serve our purpose.

Automation can be fully introduced into those branches of manufacturing industry in which goods are mass-produced. These industries range from the production of raw materials and auxiliary raw materials to all types of power production; from the manufacture of non-agriculture finished articles for mass-consumption to the various industries concerned with the collection and dissemination of news and information. The technique of automation can partly replace existing methods and can supplant skilled workers in certain other industries. These include mining, transport and building and farming—in none of which

[1]In this discussion we ignore the possibility of a third World War. We agree with Wiener that—assuming that the world survives such a conflict—another war would drastically reduce the time that it would normally take to introduce automation into a highly industrialised country such as the United States. See Norbert Wiener, *The Human Use of Human Beings; Cybernetics and Society* (revised edn., Boston, 1954, pp. 160-161).

[2]We have adopted this classification in order to make the maximum use of American occupational statistics.

there is any large scale mass-production of identical products.[1]

It is very generally agreed that automatic devices can successfully perform a variety of routine jobs in offices—in so far as the work is concerned with the preparation and the handling of masses of facts and figures (e.g. lists of stocks). It may be confidently anticipated that automation will be rapidly introduced into many branches of routine administration. And this does not apply merely to big public and private concerns. We have already seen that as smaller and cheaper computers come on to the market so smaller firms and public authorities will be able to introduce automation into their offices.

Automation may be expected to make least progress in the field of professional and personal services. But even here the influence of automation is being felt. These occupations cannot wholly escape from the influence of the movement towards rationalisation.

We are now in a position to make a rough estimate what occupations will remain open to the vast mass of the labour force not belonging to the 'economic general staff' or to the class of 'officers' or 'non-commissioned officers' in the age of automation. In so far as they find employment in the professional occupations to which we have referred they will be expected to enjoy a social status similar to that enjoyed by members of the 'economic general staff' and the senior 'officers' in the automatic plants.

But the group of relatively highly-skilled workers who will in future be employed in automatic factories will obviously form only a minority of the total labour force. We have shown that, with the spread of automation, the size of this group—as a proportion of the total labour force—may be expected to decline. The vast majority of the workers, having had only a normal elementary education and not being trained, will have to take jobs which can be learned quickly. There is a danger that as the number of jobs available for skilled men diminishes young people will hesitate to embark upon long courses of training which may not seem worth while. It seems probable that at the very time

[1]Reports coming rapidly to hand show that branches of industry which were at one time not regarded as suitable for automation are in fact beginning to adopt automatic or semi-automatic machines. See below, pp. 150-51. We do not propose to discuss here either the economic and social changes which may be expected to follow from the development of 'photosynthesis', or the probable effects upon farming in the near future of the manufacture of food products from seaweed.

when the introduction of automation into the more advanced branches of industry is freeing the assembly-line worker from the soul-destroying drudgery of the conveyor-belt, an ever-increasing number of other workers will be drifting into equally dull and monotonous jobs. Their social status will be a poor one and they may suffer from a feeling of inferiority. They will have no feeling of security since they will realise that they could at any time be replaced from the large reservoir of unemployed. This group will include (i) unskilled workers, (ii) skilled workers who have become redundant because of automation, (iii) the over-forties. These will be the victims of technological unemployment in the age of automation—even though this 'unemployment' may for a time be disguised because of positive action by the State.[1] The social status of these men will also decline because it will be anticipated that—with the fall in the numbers of skilled men in the all-important industries producing goods for the masses—the influence of the trade unions will decline.[2]

Today American trade unionists have established certain rules —similar to guild regulations long ago—which try to preserve a man's 'right' to his job (e.g. 'last in, first out'). But in many cases these bulwarks against unemployment will be valueless when fully automatic machinery is introduced. The most powerful weapon of the trade-unionists is the strike. But the strike will lose much of its effectiveness in the age of automation. It is probable that the production of an automatic plant could continue despite a strike and that the highly qualified engineers and administrators in charge of the plant—traditionally hostile to the 'rank and file' —would side with the management and not with the men. The possibilities concerning industrial disputes in the age of automation are seen in the following report about a strike in two atomic plants in the United States. The strike lasted only a few days:

[1] '. . . rapidly changing technology favors the young man, recently trained in new theories and techniques. . . . We can't overlook the fact that oldsters still have to play. . . . Creating the opportunity for both oldsters and youngsters to move into a better job—an upgraded job—may become an issue of importance comparable with that of higher wages in a job classification that soon may not exist' (Gordon S. Brown in *C.E.*, November 1954, p. 19).

[2] At a conference of American trade unionists in the motor industry the chairman stated that according to an economist one man would (within the next 10 years) be doing the work which now needs five men to do. This would mean that 200,000 men could produce as many motor cars as the 1,000,000 motor-car workers now members of trade unions. See *B.W.*, Nov. 20, 1954, p. 166.

> 'Controls were the heroes during the recent atomic energy strike at Paducah and Oak Ridge. When operating and maintenance workers walked out for three days, a handful of supervisory workers kept up full-scale production of fissionable uranium-233. . . . Only because of centralized and remote controls were these few men able to run the multi-million-dollar uranium enrichment plants. . . . If the strike had been prolonged, however, lack of maintenance would have reduced output.'[1]

This concludes our brief sketch of the probable economic and social changes that may be expected to occur in the age of automation unless the State intervenes. All these changes represent a sharpening of trends which have long been evident in advanced industrial societies. For some time there has been a tendency for the labour force to be split into two groups. The first group—a small minority—consists of highly-qualified technicians and administrators who enjoy a social status similar to that of professional men (doctors, lawyers, etc.). The second group—the vast majority—consists of people who have only an elementary education and have not got the brains or the training to understand the workings of either a modern economy or a modern society. Moreover their work is to a great extent 'unproductive' in the sense used by the classical economists. What would happen as more and more automatic machines are introduced? The minority of 'production engineers', administrators, highly skilled operatives and others working on the automatic machines would themselves be able to produce everything that they—and indeed the vast majority of those people not engaged in actual 'production'—required to maintain and to increase their living standards. They would also produce enough to provide for the maintenance of the process of industrial production. On the other hand the majority of the labour force would have to buy these things with their labour from the minority. Such a class structure would be a very insecure foundation for a free society. The great power of the minority coupled with the ignorance and weakness of the majority might well lead to the establishment of an authoritarian in place of a democratic form of government.

[1] *C.E.*, Sept. 1954, p. 9. It will be recalled that automatic telephone exchanges go on working even although telephonists go on strike.

PART II

DEVELOPMENT OF AUTOMATION IN 1955

'Congress is probing it. Harvard is assessing it, the British Parliament is considering it, cartoonists are lampooning it, Labour feels bound to criticise it, possibly out of failure to understand it, while management wonders: "Hadn't we better do something about it?" Authors term it "a major technological revolution", "evolution, not revolution", "the new horizon", or "the cliché of the year".'[1]

'My major premise is that we are now in a critical situation which might, hopefully, be described as pregnant or, apprehensively, as explosive.'[2]

[1]R. K. Mueller, Vice-President of the American Management Association in *Keeping Pace with Automation* (*A.M.A.* Special Report, No. 7, New York, 1956), p. 5.

[2]E. G. Nourse, formerly chairman of the President's Council of Economic Advisers, in *Hearings before the Subcommittee on Economic Stabilisation. . .* (U.S. Congress, 84th Congress, 1st Session, Washington 1955), p. 622.

Chapter III

THE SITUATION IN 1955

(I) DEFINITION OF 'AUTOMATION'

In the year 1955 the question of automation was one of the most important topics discussed in the United States. Hardly a week passed but somewhere a lecture was given or a conference was held on the subject. Quite apart from the journals which specialised on these problems the daily newspapers and popular magazines devoted much space to automation. In October 1955 a committee of the United States Congress spent a fortnight in listening to evidence on automatic and technical progress.[1] In 1955 well-attended automation exhibitions were held in New York, Chicago and Los Angeles. Among certain organised workers there was considerable anxiety conerning the progress of automation. In the latter part of 1955 a public opinion poll in Detroit showed that—after the danger from Soviet Russia—it was automation that was causing people most concern.[2] Another enquiry showed that three-quarters of the workers believed that automation would lead to redundancy and unemployment and that the drawbacks of automation far outweighed its advantages.[3] The American Federal Secretary of Labour told the Congress committee, to which we have referred, that the word 'automation' engendered a whole host of fears in the minds of the workers—

> 'fear of change, fear of technology itself, fear of displacement, fear of unemployment, fear of machines, fear of science in general.'

He added that in this sense there was nothing new about automation. People had always feared these things in one form or another ever since the first caveman was afraid of fire.[4]

[1]See below, p. 109 *et seq*.
[2]*The Economist*, Nov. 5, 1955, p. 481.
[3]A. F. Vinson, Vice-President of the General Electric Company, in *Automation and Industry* (Schenectady, New York, 1955).
[4]*Hearings*, pp. 262-63.

In other industrial countries, too, increasing interest was shown in the problem of automation. In Europe newspapers and journals discussed the new industrial revolution.[1] In the summer of 1955 a conference was held in England which had as its subject of discussion 'The Automatic Factory—What does it Mean?' The conference lasted for three days and was addressed by leading scientists and businessmen.[2] Representatives of the British workers discussed the problem at the annual conference of the Trades Union Congress.[3] It will be seen that British trade unionists take a rather different view of automation from their American colleagues.

In considering the probable economic consequences of automation the 'pessimists' have recently been accusing the 'optimists' of concentrating their attention exclusively on the long-term results of the introduction of automatic machinery. The 'pessimists' argue that the problem which must be faced is how to avoid the grave social dislocations which may be expected 'in the short run' when automation comes. The 'pessimists' do not deny that eventually automation will play an important part in securing a higher standard of life and improved working conditions. They are, however, concerned lest grave economic crises and serious suffering for the workers should occur in the period of transition from the present system of industrial production to the new system of automation. We will give one illustration of the sharp differences between the 'pessimists' and the 'optimists'. In a widely distributed pamphlet, entitled *Calling all Jobs. An Introduction to the Automatic Machine Age*, the (American) National Association of Manufacturers gave the 'optimistic' view of automation in its extreme form:

> 'We stand on the threshold of a golden tomorrow. Let the worker face what is to come with hope in his heart, not with fear in his mind. Automation is a magical key of creation, not a blunt instrument of destruction, and the worker's talent and skill will continue to merit reward in the fairyland of the world to come. For the expanding, dynamic economy of America, the sky is indeed the limit. . . . Guided by electronics, powered by atomic energy, geared

[1] See, e.g. an article on 'Die Revolution der Roboter' in *Der Spiegel*, June 27, 1955, and articles in the *Daily Mirror*, June 13 to June 18, 1955.

[2] For this conference, which was held in Margate, see below, p. 112 *et seq.*

[3] *Report of Proceedings of the 87th Annual Trades Union Congress* (1954), p. 247 *et seq.*, and p. 380 *et seq.*

to the smooth, effortless workings of automation, the magic carpet of our free economy heads for distant and undreamed-of horizons. Just going along for the ride will be the biggest thrill on earth!'[1]

The American trade unionists on the other hand protested vigorously against this point of view. They admitted that it was possible to compare the first industrial revolution with the second. But they argued that the employers would be ignoring all the lessons of history if they failed to see that the first industrial revolution brought with it great distress for the workers. The American trade unionists claim that they do not oppose automation. They realise that eventually automation will bring great advantages with it. Nevertheless their anxieties concerning the immediate future are not allayed when the employers say that 'all will work out well in the long run because we have managed to live through radical technological changes in the past. Human beings do live long enough for us to be satisfied with assurances about the long-run adaptation of society to automation. And while it is true that radical technological improvements have been introduced in the past, it is well to remember that they were accompanied by vast social dislocations, recurring depressions, and human suffering.'[2]

It is by no means easy to make an impartial comment upon this controversy since hitherto no one has given a detailed account of the extent to which automation has actually taken place in the United States. It is true that by the end of the year 1955 there existed a few reports on automation in particular industries. But no government department, no association of employers, no trade union organisation had prepared an accurate report on the extent to which automation had actually been introduced into American industry as a whole. And no information was available concerning plans for automation in the immediate future. The Department of Labour was able to provide only two 'case studies' for the Congress committee which investigated automation in 1955. Representatives of employers and trade unionists provided Congress with useful information concerning particular industries. The employers, however, were decidedly reticent concerning their plans for the future—perhaps because they did not wish to

[1]*Calling all Jobs. An Introduction to the Automatic Machine Age* (National Association of Manufacturers, New York, Nov. 1954), p. 21.

[2]*Hearings*, p. 106.

alarm their employees. It is remarkable that in the discussion on automation the Congress of Industrial Organisations—the leading association of trade unions in the United States—relied for its evidence concerning the spread of automation largely upon reports in newspapers and business journals.[1]

However, evidence is available which makes it clear that automation is making rapid progress in industry. This can be seen from the remarkable progress of the electronics industry; the huge sums that are being invested in automatic and semi-automatic machines; the immense improvement in the efficiency of the devices upon which automatic machines depend; and the ever-increasing use that is being made of 'closed-circuit' methods of production.[2] All reports agree that every important American industry—with the single exception of agriculture—is actively considering the introduction of automatic machines in its plants and of electronic computers in its administrative offices.

The remarks made by a director of the Ford Motor Company show that in Europe, too, automation is making greater progress than is generally supposed:

> 'All you have to do is look across the water and see what they are doing in France, Germany, and England in automation. . . . The Renault plant in Paris is more highly automatic than anything we have got in this country in the automotive business.'[3]

Automation is making rapid headway in all the big German motor vehicle plants, steelworks, etc.[4] The Austin Motor Company claims that its car assembly lines represent the most advanced practice in the world. The company has not gone over to completely automatic assembly. This would be possible from a technical point of view but it would not be advantageous from the financial point of view.[5]

The 'optimistic' attitude towards automation appears to have proved itself in 1955 in one very important respect. In that year

[1]*Hearings*, p. 114-17.
[2]For example see details given below, p. 130 *et seq.*
[3]*Hearings*, p. 66.
[4]The report of the machine tool firm Gildemeister & Co. A.G., Bielefeld, for the financial year 1954-55 states: 'There is in the U.S.A. an increasing drive towards automation, which has now spread to England. It will certainly affect us and we foresee an increasing demand for our machines when our customers become fully aware of these trends. Our plant extension program and development policy are based on this fact' (p. 14).
[5]*Margate Conference*, p. 199.

the total number of persons employed in the United States earched record heights *despite* the advance in automation. The number of persons gainfully employed was over 70,000,000. On the other hand the average number of unemployed never exceeded 4 per cent of the civilians in employment. Even the alarmist representatives of the trade unions could not point to any mass unemployment in 1955 although they could draw attention to individual causes of 'technological unemployment' due to the introduction of automatic methods of industrial production. The situation at the end of 1955, as seen by leading trade unionists, was summed up in the following statement made by the United States Secretary of Labour before the Congress Committee on automation.

> 'The Chairman. . . . You don't know of any real displacement problems caused by automation, so far, do you?
>
> 'Secretary Mitchell: Well, I do not, Mr Chairman. We have, as I said, these pockets of unemployment, but those cities in which we have such problems have been the result of sick industries, shall we say, for some long period of time. We have a chronic situation, which is not exclusively the result of technological change, or what might be called automation. . . . Certainly, when you look at the high level of employment, and the relatively low level of unemployment nationally, it is difficult to comprehend how great dislocations could be laid at the door of automation.'[1]

In the first part of this book we explained why, in certain circumstances, the rapid introduction of automation was likely to lead to technological unemployment. We shall discuss below whether any modification of this point of view is necessary in the light of the experience of 1955.[2]

Meanwhile two controversies concerning automation show no signs of abating—(i) Which branches of industry will be run by automatic machines in the future? (ii) How quickly will automatic machines be introduced in the immediate future? Some people persist in repeating the old argument that the industries in which automatic machines will be introduced in the next 20 years represent only 8 per cent of the labour force in the United States—i.e. about 5,000,000 workers—and that certainly no more than half of these workers will become redundant because of automation.[3] In fact this argument has long ceased to have any

[1] *Hearings*, p. 269. [2] See below, p. 187. [3] See below, p. 148.

force whatsoever. Automation is already being introduced into several branches of industry which lie outside the 8 per cent to which reference has been made.[1] Indeed it has recently been shown that automatic machinery can be used for 'job lots'—i.e. the manufacture of relatively small quantities of goods. The discussion concerning the range of industries capable of having automatic machinery has been confused because some people equate 'automation' with a 'completely automatic plant' and fail to appreciate the fact that even *partial* automation can cause serious technological unemployment.

We turn now to the question of the speed with which automation may be expected to be introduced. It is clear the events have already shown the falsity of at any rate some of the arguments used by those who believe that the introduction of automation will take place slowly. It has been repeatedly stated that the redundancy caused by installing big computers will be largely counter-balanced by the need to employ large numbers of highly-qualified persons to undertake the work of 'programming'—i.e. to prepare the 'instructions' for the 'giant brain'. In fact it is now known that methods have already been devised for carrying out much of the 'programming' automatically.[2]

Again it is plain that automation is being speeded up by the 'irresistible pressure' of economic and military competition. All experts are agreed that in all types of plants in which automation is introduced the financial advantages and the gains in efficiency are so great that the technically backward plants (which fail to adopt automatic methods of production) are bound to be forced out of business. A frank statement of the position is this:

> 'In the big economic picture, the economics of automation are harsh, but simple: automate or die.'[3]

The armaments race between the Great Powers is also a significant factor in hastening the introduction of automation. Certain modern weapons can be produced only by automatic methods. The most complicated electronic devices are used in the manufacture of aircraft, anti-aircraft guns and guided missiles.

[1] See below, pp. 150-1.
[2] See below, p. 127.
[3] W. C. Newberg, President of the Dodge Division, Chrysler Corporation, in *The Economies of Automation* (Detroit, 1955, Golden Anniversary Meeting of the Society of Automotive Engineers).

In the next war the belligerent country which survives may well be the one which can achieve the highest output of military and civilian products with relatively low man-power. The great significance of military needs in promoting a rapid adoption of automation may be seen in the great interest recently shown in this problem in Soviet Russia.

> 'In a broadcast from Moscow it was stated that a new Ministry for Automation has been set up. A government edict has established two new departments under the existing Ministry for Machinery and Instrument Construction—(i) the Ministry for Instrument Construction and Automation, and (ii) the Ministry for Machine Construction.'[1]

An impartial observer summed up the position at the end of 1955 as follows:

> 'There is no central clearing house for information on how machines are taking over the direction of machines from the men who made them and told them how to operate. There is no exchange of data on a regular basis. There is nothing but advance—so rapid as to stagger the imagination of those who study the great new science of automatic controls. Some of the progress is hidden behind a security veil, since it concerns defense matters. More is not disclosed because the producers of civilian goods . . . are moving too rapidly to pay attention to questions.
>
> But there is no question that the advances being made and that the world is on the threshold of tremendous changes in its working and production methods.'[2]

(II) DISCUSSIONS CONCERNING AUTOMATION IN 1955

In 1955 a large number of books, pamphlets, reports and lectures on automation appeared. No success, however, attended efforts to secure some agreement on the meaning of the term 'automation'. There have been an incredible number of interpretations of the word. On the one hand there are those who say that the word has been invented by those who want to make our flesh creep with a new sensation. They argue that automation is not a new thing at all. It is simply the continuation of an age-old process—which began in the days of Neanderthal man—by which

[1] *Frankfurter Allgemeine Zeitung*, January 23, 1956. See also below, p. 110.

[2] W. M. Freeman, 'Automation Rise Heralds New Era' in *N.Y.T.*, January 3, 1956.

men have improved the tools that they use.[1] At the other extreme are those who see in automation a process of world-shaking significance. They argue that automation will completely revolutionise both methods of manufacture and the whole structure of human society. And behind this dispute concerning the meaning of 'automation' lie interests that are fundamentally opposed to each other.

This discussion about the meaning of 'automation' recalls the long-drawn-out arguments about the meaning of 'capitalism' in German-speaking countries. In this controversy, too, there were those who argued that there was nothing new in 'capitalism' at all. The word meant no more than the use of machines instead of tools in the process of manufacture. The protagonists of this point of view argued that it was pointless to talk about 'capitalism' as if it were a new and special phase of human development. After all, men had used 'means of production'—i.e. 'capital'—since the dawn of history. No doubt those who argued in this way had an axe to grind. This controversy about the meaning of 'capitalism' took place at a time when the existing social and economic order was coming more and more under fire from the socialists. What could be simpler than to try and take the wind out of the sociologists' sails by arguing that what they were attacking was a myth?

The heat with which some people argue today that 'automation' is a myth can be explained in a somewhat similar fashion. We have seen that the American trade unionists have taken advantage of the coming of automation to make far-reaching demands. They have asked for a guaranteed annual wage, a reduction in working week, and a 'fair share' of the advantages to be gained from automation in the shape of higher pay and lower prices. The ground would be cut from beneath the feet of the trade unionists if it could be proved that 'automation' was really nothing new at

[1] 'I think . . . the first use of automation I can remember was perhaps little David when he slew Goliath with the slingshot. It was better than throwing rocks' (D. J. Davis, Vice-President—Manufacturing, Ford Motor Company, *Hearings*, p. 65).

'Automation is a new word, and to many people it has become a scare word. Yet it is not essentially different from the process of improving methods of production which has been going on throughout human history—ever since men first took up jagged pieces of flint to perform operations better than they could be performed with bare hands' (M. G. Munce, Director of the National Association of Manufacturers, *op. cit.*, p. 398).

all—that is only normal technological progress which has been going on since the beginning of time.[1]

We propose to examine the commonest definitions of automation and to see how far they are opposed to each other and how far they have something in common. We hope that this will throw new light upon some of the problems that we have been discussing. There are three main types of definitions:

(a) Automation is only a new name for the age-old process of mechanising human labour. Recent changes in technique and in methods of production should not give rise to anxiety. The use of the term 'automation' confuses the issue and the word should be dropped.

(b) Automation is a fundamentally new method of production which has one or two definite characteristics which differentiate it from old methods—e.g. the *control* of one machine by another machine.

(c) Automation is a method of production by which machines perform certain functions hitherto performed only by human beings. Above all certain functions of the human brain have now been taken over by the machine and the 'direction' or 'control' of machines are more and more in the hands of the machine.

We will now give some illustrations of all three points of view:

(a) Henry Ford II, President of the Ford Motor Company declared that the word 'automation' was

> '. . . nothing more than a handy means of describing something industry has been doing for years—improving the methods of production. Automation was called technology during the industrial revolution . . . Automation takes the burden of brute labor off men's backs and makes the worker a manager of the machine to which he is assigned. It raises the worker's dignity. It is good for America because the fruits of it are good for everyone included.'[2]

R. W. Burgess, the director of the United States Bureau of the Census, stated:

[1]Those who try to minimise the significance of automation are, of course, also hoping to dispel the anxieties of workers who fear that they will lose their jobs through the introduction of automatic machinery.

'For reasons of labor relations many an industrialist pooh-poohs reports that automation will eliminate jobs; it is neither profitable nor practical. Detroit machine maker X claims that he can cut a man off the payroll for every $5000 a manufacturer invests in his automation machinery' (*Time*, March 19, 1956, p. 46). The writer goes on to suggest that for every job destroyed by automation a new and better-paid post will become available, but he brings forward no evidence to support this assertion.

[2]*F.M.M.*, Sept. 1955, p. 91.

'I think that we can say that "automation" is a new word for a now familiar process of expanding the types of work in which machinery is use to do tasks faster, or better, or in greater quantity. For a century or so we have been adjusting to more and more mechanisation. We have thrived and grown great partly because of this, certainly not in spite of it.'[1]

The managing director of one of the biggest concerns in the American electronics industry criticised 'erroneous' statements concerning automation, which in his opinion was 'only a more recent term for mechanisation which has been going on since the industrial revolution began'.[2] A leading English consulting engineer warns employers against regarding automation 'as some entirely new trick, tool or animal that can be used to provide magic solutions to industrial problems—especially those of management'. He also stated that 'A new word is being used for something that has been practised and consistently developed since the Neolithic period. . . . For many managers in industry it may be best to regard automation as the natural development of mechanisation. . . .'[3]

(b) An automation engineer states that, in view of the rapidity of the changes brought by automation, he cannot define the phenomenon. He considers that automation has two aspects—(i) the 'automatic conveyor-belt' which is a new method of manufacturing goods, and (ii) the feedback and computer technique which may be regarded as a 'new technology':

'These things bear on and augment each other and begin to form a pattern . . . that will have a profound effect on our future. This is the important factor—it is no single machine or component or science—but the bringing together and integrating of knowledge and know-how from many places that results in a tool more powerful than any one device or science by itself could ever achieve. This combining . . . may not only be the key to the factory of the future, but it may be the key to all progress of the future.'[4]

E. G. Nourse, the former chairman of the President's Council of Economic Advisers, criticises

'the cliché that automation is nothing new, just more mechanization.

[1] *Hearings*, p. 82.

[2] D. G. Mitchell, *Hearings*, pp. 169-70.

[3] F. Garner, 'Automation—some problems for the manager', in *The Automatic Factory—what does it mean?* (Report of the Conference held at Margate, June 16–19, 1955: The Institution of Production Engineers, London), pp. 40-41.

[4] K. R. Geiser, *What is Automation?* (Syracuse Conference), p. 7 *et seq*. The author is the chief engineer of the Computer Department of the General Electric Company.

It has its roots in mechanization, to be sure, but something new was added when electronic devices made possible the widespread application of the feedback principle.

The three earlier phases of industrialism, mechanization, continuous process, and rationalization, all continue but have been given a new dimension.'[1]

Recently three characteristics of automation have been emphasised:

'1. The linking together of conventionally separate manufacturing operations into lines of continuous production through which the product moves "untouched by human hands" . . . (integration) . . .
2. The use of "feedback" control devices, or servo-mechanisms, which allow individual operations to be performed without any necessity for human control . . . (feedback technology) . . .
3. The development of . . . computing machines . . . (computer technology).'[2]

The managing director of the British National Research Development Corporation defined the 'revolutionary technical advance' associated with automation by referring to four factors—the first three being the same as those mentioned above.

'Such then are the four component factors which enter into my concept of "automation"—transfer machinery, control engineering, communication engineering, and mechanical assembly . . . the first and fourth components may be mere extensions of what is meant by mechanisation, while the second and third involve eliminating the human operative from the feedback loop and are qualitatively different. The first and fourth may accordingly eliminate muscles only. The second and third eliminate nerves and brains.'[3]

In a speech on the practice of automation John Diebold—himself one of the inventors of the word—complained that 'automation' was now being used in so many different ways that the term was in danger of losing its usefulness. He suggests that the word should cover all the methods of production and all the new techniques associated with the idea of 'automation':

'Automation is much more than the technology of feedback . . . it differs from mechanization in the very way it regards the problem of production. Automation requires us to view the production processes as an integrated system and not as a series of individual steps divided according to the most economic distribution of human skills—or

[1]*Hearings*, p. 619.
[2]G. B. Baldwin and G. P. Schultz (Massachusetts Institute of Technology), 'The Effect of Automation on Industrial Relations' in *M.L.R.* (Washington), June 1955.
[3]The Earl of Halsbury, 'Technical and Human Problems of the Automatic Factory' (*Margate Conference*, p. 24).

> even of individual machines. Automation is a way of thinking, a way of "looking at . . ." as much as it is a way of doing or a specific technology. It is an attitude—a "philosophy" of production, if you will—rather than a particular technology or electronic devices. It is something of a conceptual breakthrough, as revolutionary in its way as Henry Ford's concept of the assembly line.'[1]

The editor of the journal *Automation* has proposed a somewhat similar broad definition and he was optimistic enough at the end of 1955 to believe that his views had been generally accepted. He understands by the term 'automation'

> ' "continuous automatic processing". And by processing is meant or implied all industrial processes or services including the closely related area of data processing, especially as it ties in with industrial or commercial enterprise. It is a method of manufacturing, processing or . . . services, based on the idea of continuous or programmed operation rather than the more common separate or single-stage methods of operation.'[2]

(c) M. H. Aronson, in a vigorous address to the American Industrial Association entitled *Automation and Economics: A Counter-attack on Anti-Automation Propaganda*, criticises the folly of pretending that there is no satisfactory way of defining 'automation'. He argues that it is absurd for everyone to have his own private meaning of 'automation'. Aronson considers that 'automation' is a synonym for 'automatic controls' and everyone knows what they are. He also puts forward a more precise definition: 'Automation is the substitution of mechanical, hydraulic, pneumatic, electric, and electronic devices for human organs of decision and effort.'[3]

Aronson points out that his definition makes it clear that the conception of 'automation' includes many types of machines and instruments. Electronic devices are by no means the only form taken by automation. For Aronson the essential feature of automation is that it will eventually make human labour superfluous. In particular automation will save that type of physical and mental labour which may be described as 'routine, exhausting, dangerous, trifling or monotonous'.[3]

A pamphlet issued by an American trade union of transport workers purports to describe the effects of the second industrial

[1]John Diebold, *Applied Automation. A Practical Approach*, p. 3 (New York, 1955: mimeographed).

[2]R. W. Bolz, 'Design for Automation' in *Automation*, November 1955, p. 35.

[3]M. H. Aronson, *Automation and Economics: A Counter-Attack on Anti-Automation Propaganda*, presented at the annual meeting of the American Industrial Association, Atlantic City, April, 27, 1955.

revolution on the American workers. Here it is stated that

> 'Automation . . . means simply that machines are controlled by other machines, instead of men. . . . Automation is not mechanization. Mechanization means replacement of human labour by machines while automation is replacement of human control by machines. In mechanization a man thinks for the machines; in automation a machine thinks for a machine. In mechanization a machine does the work but a man regulates it; in automation a machine does the work, but another machine regulates it.'[1]

The Congress of Industrial Organisations suggests a somewhat similar definition of automation:

> 'Automation is the accomplishment of a work-task by an integrated power-driven mechanism entirely without the direct application of human energy, skill, intelligence, or control.'[2]

The following description of automation combines the characteristics of the second and third definitions:

> 'Automation means a continuous and integrated operation of a production system using electronic equipment to perform routine functions and regulate and co-ordinate the flow and quality of production. In its broadest usage it would include the operation of the productive and administrative processes of an industrial firm. Direct human labour would largely be eliminated from production, being retained mostly for systems analysis, programming, equipment maintenance and adjustment, and managerial decision making.'[3]

An examination of these various definitions of automation shows that we are far from having reached agreement on this question. Most of those holding opinions listed under the three main types of definition would agree that 'automation' means more than introducing one or two automatic machines or electronic devices into a plant which continues to be run on traditional lines. Even those who look upon 'automation' as an entirely new method of industrial production would hesitate to say that installing an electronic computer—the very symbol of automation—or a machine controlled by an automatic device would in itself not be sufficient to bring about an industrial revolution if, in other respects, traditional methods of manufacture continued to be employed.

[1] A. Weiss, *What Automation means to you. A Summary of the Effects of the Second Industrial Revolution on the American Worker* (International Brotherhood of Teamsters, Chauffeurs, Warehousemen and Helpers, American Federation of Labour, 1955), p. 2.

[2] T. F. Silvey, 'The Technology of Automation' in *Congressional Record*, June 15, 1955.

[3] W. S. Buckingham, jun. (of the Georgia Institute of Technology), 'Industrial Significance' in *The Challenge of Automation* (Washington, 1955), p. 32.

even of individual machines. Automation is a way of thinking, a way of "looking at . . ." as much as it is a way of doing or a specific technology. It is an attitude—a "philosophy" of production, if you will—rather than a particular technology or electronic devices. It is something of a conceptual breakthrough, as revolutionary in its way as Henry Ford's concept of the assembly line.'[1]

The editor of the journal *Automation* has proposed a somewhat similar broad definition and he was optimistic enough at the end of 1955 to believe that his views had been generally accepted. He understands by the term 'automation'

' "continuous automatic processing". And by processing is meant or implied all industrial processes or services including the closely related area of data processing, especially as it ties in with industrial or commercial enterprise. It is a method of manufacturing, processing or . . . services, based on the idea of continuous or programmed operation rather than the more common separate or single-stage methods of operation.'[2]

(c) M. H. Aronson, in a vigorous address to the American Industrial Association entitled *Automation and Economics: A Counter-attack on Anti-Automation Propaganda*, criticises the folly of pretending that there is no satisfactory way of defining 'automation'. He argues that it is absurd for everyone to have his own private meaning of 'automation'. Aronson considers that 'automation' is a synonym for 'automatic controls' and everyone knows what they are. He also puts forward a more precise definition: 'Automation is the substitution of mechanical, hydraulic, pneumatic, electric, and electronic devices for human organs of decision and effort.'[3]

Aronson points out that his definition makes it clear that the conception of 'automation' includes many types of machines and instruments. Electronic devices are by no means the only form taken by automation. For Aronson the essential feature of automation is that it will eventually make human labour superfluous. In particular automation will save that type of physical and mental labour which may be described as 'routine, exhausting, dangerous, trifling or monotonous'.[3]

A pamphlet issued by an American trade union of transport workers purports to describe the effects of the second industrial

[1] John Diebold, *Applied Automation. A Practical Approach*, p. 3 (New York, 1955: mimeographed).

[2] R. W. Bolz, 'Design for Automation' in *Automation*, November 1955, p. 35.

[3] M. H. Aronson, *Automation and Economics: A Counter-Attack on Anti-Automation Propaganda*, presented at the annual meeting of the American Industrial Association, Atlantic City, April, 27, 1955.

revolution on the American workers. Here it is stated that

> 'Automation . . . means simply that machines are controlled by other machines, instead of men. . . . Automation is not mechanization. Mechanization means replacement of human labour by machines while automation is replacement of human control by machines. In mechanization a man thinks for the machines; in automation a machine thinks for a machine. In mechanization a machine does the work but a man regulates it; in automation a machine does the work, but another machine regulates it.'[1]

The Congress of Industrial Organisations suggests a somewhat similar definition of automation:

> 'Automation is the accomplishment of a work-task by an integrated power-driven mechanism entirely without the direct application of human energy, skill, intelligence, or control.'[2]

The following description of automation combines the characteristics of the second and third definitions:

> 'Automation means a continuous and integrated operation of a production system using electronic equipment to perform routine functions and regulate and co-ordinate the flow and quality of production. In its broadest usage it would include the operation of the productive and administrative processes of an industrial firm. Direct human labour would largely be eliminated from production, being retained mostly for systems analysis, programming, equipment maintenance and adjustment, and managerial decision making.'[3]

An examination of these various definitions of automation shows that we are far from having reached agreement on this question. Most of those holding opinions listed under the three main types of definition would agree that 'automation' means more than introducing one or two automatic machines or electronic devices into a plant which continues to be run on traditional lines. Even those who look upon 'automation' as an entirely new method of industrial production would hesitate to say that installing an electronic computer—the very symbol of automation—or a machine controlled by an automatic device would in itself not be sufficient to bring about an industrial revolution if, in other respects, traditional methods of manufacture continued to be employed.

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[2] T. F. Silvey, 'The Technology of Automation' in *Congressional Record*, June 15, 1955.

[3] W. S. Buckingham, jun. (of the Georgia Institute of Technology), 'Industrial Significance' in *The Challenge of Automation* (Washington, 1955), p. 32.

There can be no doubt that automatic production is a phase in the evolution of technology. Ever since Adam Smith drew attention to the advantages of the division of labour and ever since the introduction of the steam engine revolutionised industry and transport there have been many similar advances in technology. But it would not always have been wise to call these technical advances 'new methods of production'. The introduction of electricity and of the combustion engine no doubt fundamentally changed the force of the great industrial countries—and indirectly affected the fortunes of nearly the whole human race —but these changes did not have social consequences of anything like the same significance as the movement towards 'rationalisation' and the widespread introduction of the conveyor-belt system in the inter-war years. The real importance of 'automation' lies in the fundamental changes which it will bring about in the structure both of the economy and of society.

In the first part of this book we did not discuss the various definitions of automation but simply considered the salient features of this method of industrial production. We are now in a position—admittedly with some reservations—to suggest the following definition:

Automation is a technique of industrial production, combined with a method of processing data, introduced since the second World War. With the aid of the most advanced techniques and devices—but with certain economic limitations—this method of production attempts to perform by machinery all the functions hitherto performed by human beings. The machines are 'controlled' by machines.

However inadequate this definition may be, it does at least attempt to give preliminary indication of the complexity of the phenomena embraced by the term automation. Moreover, our definition does emphasise that automation is a strictly contemporary phenomenon which is only in its infancy.

Chapter IV

TWO ENQUIRIES INTO AUTOMATION IN 1955

(I) ENQUIRY OF THE CONGRESS OF THE U.S.A.

In the second half of October 1955 automation was the subject of an official enquiry in the United States. This was undertaken by a sub-committee which reported to the 'Joint Committee on the Economic Report'. The evidence submitted was printed under the title *Hearings before the Subcommittee on Economic Stabilisation.*[1] The sub-committee met fifteen times to examine 36 witnesses. These witnesses including leading representatives of industry, the trade unions and the government as well as scientific and technical experts. The evidence and the report—657 pages in all—represent the most valuable material so far published about automation. The material includes not only evidence given before the committee but also a large number of important documents concerning (i) particular aspects of automation, (ii) case-studies, (iii) special enquiries into various problems of automation, such as the first study of productivity in 1939-53 and the methods used in calculating output per man-hour.[2]

The importance attached to the enquiry by those who addressed it may be seen by the fact that a great deal of detailed research was undertaken in preparation for the presentation of written and oral evidence. Thus forty people were busy for many weeks in preparing the evidence submitted by the managing director of one of the biggest American concerns.[3]

[1]*Automation and Technological Change: Hearings before the Subcommittee on Economic Stabilisation of the Joint Committee on the Economic Report* (Congress of the U.S. 84th Congress: first session, Washington, 1955) and *Automation and Technological Change: Report of the Subcommittee on Economic Stabilisation to the Joint Committee on the Economic Report* (Congress of the U.S., Washington, 1955).

[2]'Trends in Output per Man-Hour and Man-Hours per Unit of Output—Manufacturing 1939-53' (U.S. Department of Labour, Bureau of Labour Statistics). *Hearings,* pp. 301-34.

[3]*B.W.*, Oct. 22, 1955, p. 30.

The official American enquiry investigated such significant economic and social implications of automation as:

'(i) the extent of possible and probable displacement of personnel,

'(ii) the possible shifts and distortions which may arise in the distribution of mass purchasing power,

'(iii) the equitable distribution of the expected gains in productivity,

'(iv) the effect upon our business structure,

'(v) the effect upon the volume and regularity of private investment'.[1]

Witnesses gave their views in detail on these matters but the committee did not reach any very wide measure of agreement upon them. Nevertheless, Senator Wright Paterson, the chairman of the subcommittee on economic stabilisation, declared:

> ' . . . Strange as it may seem, we have not had one witness to appear before this committee who resisted automation, or genuine progress. Everyone has been in favour of it. They just want to make sure that the dislocations and displacements are taken care of in such a way that the workers will be provided for on the theory that society is being benefited generally by automation and progress, and that society, therefore, should make the impact less severe.'[2]

The members of the committees were agreed (i) that the evidence submitted was insufficient to enable them to obtain a reliable picture of the extent and consequences of automation in the United States, and (ii) that official statistics were inadequate to throw much additional light on the problems raised by the coming of automation. Representatives of all political points of view were agreed in expressing anxiety concerning the failure to train sufficient scientists, engineers and technicians in readiness for the age of automation. It was alarming that Soviet Russia should be training twice as many engineers as the United States and actually three times as many technicians.[3]

[1]*Hearings*, p. 2.

[2]*Hearings*, p. 270. See also *Report*, p. 4 *et seq.*

[3]*Hearings*, p. 586: The Chairman: Are you disturbed, Doctor [Astin], by reason of the information that has been brought to our attention recently that in this country, only 27,000 engineers will be graduated next year, whereas Russia will graduate 50,000; and only 50,000 technicians will be graduated in this country next year, whereas in Russia they will graduate 1,600,000?' Cf. *Report*, p. 8 (note 2): 'After the close of the hearings a report of the National Science Foundation entitled *Soviet Professional Manpower* by Nicholas De Witt gave statistical substantiation to indications that in technical fields the number of Russian graduates currently exceeds those in the

But as soon as the committee began to consider its agenda in detail it proved to be impossible to secure agreement among its members. There were irreconciliable differences on every conceivable issue—from the attempt to define what 'automation' meant to the problem as to whether or not the insatiable nature of human demands would provide a sort of 'automatic market' for every conceivable increase in industrial productivity. Of the many questions which divided the committee a few may be mentioned—(i) Does automation represent a new industrial revolution or simply a revolutionary phase in technical advance? (ii) Will automation bring with it 'technological unemployment' or a shortage of labour? (iii) Is an economy in which automation has been introduced more or less stable than an economy in which it has not been introduced? (iv) If automation is introduced will there be more 'upgrading of labour' than 'downgrading of labour' or vice versa? (v) Will automation be a friend or a foe of the medium-sized and small business? (vi) Is automation likely to be introduced slowly or with ever-increasing rapidity? (vii) Will the four-day week have to be introduced soon? Will this be necessary to preserve full employment and to make sure that all workers get a 'fair share' of the fruits of automation? Or is there no prospect of seeing a four-day week in the United States in the immediate future, since the insatiable demand of American consumers for more and more goods can be met only if people are prepared to go on working for five days a week?

We propose to discuss these problems later. At this point we shall merely give the main findings of the committee. The committee stated that

> 'while in the interests of precision, there is a natural inclination to narrow the term, it is clearly wrong to dismiss automation, however, as nothing more than an extension of mechanization. We are clearly on the threshold of an industrial age, the significance of which we cannot predict and with potentialities which we cannot fully appreciate. . . . We have certainly not yet seen the full impact of these new

United States. The report concludes: '. . . We must bear in mind that during the last two and a half decades the Soviet Union has made enormous strides towards building up its specialised manpower resources. As a result of its efforts, it has reached a position of close equivalence with or even slight numerical supremacy over the United States as far as the supply of trained manpower in specialised professional fields is concerned. . .".'

technologies. . . . We don't know what all this will add up to, but we might very well be wrong to think of it as simply "more of the same" technology which has always characterized American industry.'[1]

The committee also thought that although at the moment the situation of the labour market was a favourable one there was no guarantee that at some future time—in less favourable circumstances—the coming of automation would not prejudice the chances of the 250,000 people who come onto the labour market every year of finding jobs.[2]

The committee took the view that employers, trade unionists and the government shared the responsibility of seeing that the sacrifices which were unavoidable should be shared in an equitable manner. The committee recognised that, on the whole, businessmen realised their social responsibilities in a 'free' economy.

'The sub-committee has, unfortunately, found evidence that some of those busy in advancing the technical side of labour-saving machines are still apparently unaware of the overall significance which their activities have to the economy.'[3]

Finally, the committee came to the conclusion that the problems of automation could not be dismissed as being of little significance. Still less could it be argued that they had already been solved. On the contrary vigilance was essential and the problems of automation must be carefully studied. At the moment, however, no new legislation appeared to be required. The Employment Act of 1946 was in force and this could be regarded as a permanent foundation for future measures that might be necessary to deal with problems raised by automation.[4]

(II) CONFERENCE OF THE INSTITUTION OF PRODUCTION ENGINEERS IN ENGLAND

In June 1955 a well-attended conference of the Institution of Production Engineers—which has 10,000 members—was held at Margate. Many experts met to discuss the question: 'The Automatic Factory—What does it mean?'[5] It is clear, from the detailed

[1] *Report*, pp. 3-4.
[2] *Report*, p. 4.
[3] *Report*, p. 12.
[4] *Report*, p. 12 *et seq.*
[5] *The Automatic Factory—What does it mean?* (Report of the Conference held at Margate, June 16-19, 1955: Institution of Production Engineers, London, 1955).

report of its proceedings, that the discussions at this conference reached a high level. Most of the delegates were engineers and they devoted a good deal of their time to a consideration of the economic and social effects of automation.

In the opening address the speaker declared that the term 'automatic factory' was a misnomer. It was 'misleading' and indeed 'dangerous' to think that automation meant merely a completely automatic plant. No absolutely automatic plant exists at the moment. None can ever be built, because a human being must press the button which puts the machinery in motion even if that person is sitting in an office a hundred miles away.[1] Nevertheless another speaker stated: 'An electronic and automatic age is with us. It is not, I am quite certain, still many years in the future.'[2]

At this conference, as at the subsequent discussion before the committee of the U.S. Congress, no agreement could be reached on the question whether automation represented revolutionary change or whether it was no more than the continuation of certain well-established technical trends.[3]

The aim of the conference was to enable the delegates to obtain a picture of the existing state of automation and at the same time to 'show . . . what the industrial scene might well be like in 1984'. Many speakers emphasised the fact that automation was not a nightmare to be feared. It was a pratical means by which Britain could double its standard of living within twenty-five years—a possibility recently envisaged by a British Chancellor of the Exchequer.[4] Industrial production by automatic means would not —according to one speaker—bring with it in the 1980s an Orwellian world dominated by 'Big Brother'. On the contrary it would create a society 'where man will have achieved greater moral and material advancement, and exercised greater power over insecurity, drudgery and inefficiency'.[5]

Four main topics were discussed at the Margate conference of the Institution of Production Engineers: (i) technical aspects of automation, (ii) present extent of automation, (iii) future develop-

[1] *Op. cit.*, p. 8.
[2] *Ibid.*, p. 141.
[3] *Ibid.*, p. 214.
[4] *Ibid.*, p. 15 (Mr. R. A. Butler).
[5] *Ibid.*, p. 8.

ments of automation, and (iv) economic and social consequences of automation.

Little beyond what was already known in the United States emerged at the Margate conference when the first two topics were discussed. Perhaps the most interesting aspect of the discussion was the emphasis laid upon combining the use of radio-active materials and electronic devices. British industry has obviously made striking progress in this particular field.[1]

The close connection between scientific research and practical achievement was shown in the discussion on the existing position and future prospects of automation. As might be expected the delegates mentioned many advantages of automation in industry with which we are already familiar in the light of what has happened in America—higher productivity, lower costs, greater uniformity and higher quality of goods, and improved conditions of work. In addition certain advantages of automation would apply with particular force to the British economy:

> 'We have to import half our food and many of the raw materials for our manufactures. To do this we have to export one-fifth of our national product. . . . Forty per cent of our engineering products need to be exported to help pay for our imports. . . . In the field of standard products we cannot compete against two classes of rival. Firstly, we cannot compete against those who are prepared to accept a lower standard of living than we enjoy. Secondly, we cannot compete against those who are prepared to accept a lower standard of leisure than we expect. . . . How can we defend our standard products, our automobiles and textiles . . . against the competition of our rivals? Only by technique, the technique of manufacture. Provided always that our standard products are made by more advanced techniques than are those of our competitors, we can compete by means of any combination of quality and price which will make them attractive to purchasers.'[2]

Reference may also be made in this connection to the lack of sufficient highly skilled workers and to the problems raised by an aging population. As the proportion of old people in the total population increases so the 'producing' population declines in relation to the population as a whole. The 'producers' have to support an ever-growing number of old age pensioners. Automation would help Britain to support its aging population. One speaker told the assembled engineers that the introduction of auto-

[1] *Ibid.*, pp. 122-9 (lecture on 'Atoms, Electrons and Automation').
[2] *Ibid.*, p. 26.

mation would benefit them personally since it was the only effective method of defeating inflation. The real value of the pensions that his hearers would one day draw would decline unless a halt were called to inflation. Only the increase in productivity—i.e. output per man-hour—which automation could bring about would prevent a fall in living standards in the future owing to the increasing proportion of old age pensioners in the population:

> 'You are kidding yourselves, the younger of you, if you believe that the pension rights which you imagine you are accumulating will ever mature on the scale you have planned for. Your pensions will be paid, of course, but in an inflated currency caused by the rise in the price of productive workers in short supply. For inflation is the defence of the present against the past, of the young against the old, and of the debtor against his creditor. Only one factor can safeguard your future as pensioners against the fate of the creditor who has fallen into the hands of his debtor—an increase in individual productivity. Let the productivity of future generations rise, and your pensions can be paid at their real value. Remember this in your assessment of the importance of what we are met here to discuss—Automation.'[1]

In addition to the many technical and administrative difficulties standing in the way of the introduction of automatic methods of production, three personal factors were emphasised by speakers at the Margate conference—fear, ignorance, and indolence.

Automation was feared both by workers (who thought that their jobs were in danger) and by management (which declined to face either the heavy capital investment involved or the many new technical problems which had to be solved). This natural distaste of automation was strengthened by the fact that businessmen simply did not realise how 'extremely primitive' were the methods of production in British industry. Moreover many firms which realise that they are backward, from a technical point of view, do nothing about it because there is not enough competition to drive the inefficient firms out of business.[2] There is obviously a big difference here between the situation in Britain and in the United States. From another point of view, however, Britain faces difficulties similar to those which we have already encountered in the United States. In Britain, as in the United States, there is a serious lack of adequately trained engineers and technicians. One delegate stated that bearing in mind differences in the size of the

[1] *Ibid.*, p. 26 (The Earl of Halsbury).

[2] *Ibid.*, p. 70.

two labour forces the United States was able to avail itself of the services of nearly three times as many technically qualified persons as were available in Great Britain.[1]

With regard to the economic consequences of automation the 'optimists' seem to have been in the majority at the Margate conference. But some delegates warned their audience that the introduction of automation would not be achieved unless serious difficulties were successfully overcome. These included technical unemployment; increased danger of slumps; decreased elasticity of productive capacity (which might perhaps be corrected only at the expense of complete freedom of consumer choice); increased danger to output owing to strikes (since a handful of skilled men could force a huge automatic plant to close down).[2]

Trade unionists argued that the introduction of automation had so far not led to any serious difficulties with regard to workers being forced to change their jobs. Probably automation had led to an increase rather than to a decline in the number of jobs available. But who could offer a guarantee that this state of affairs would last for ever? It would be reasonable to suppose that there would be a speeding up of the rate at which automation would be introduced in the future. The favourable circumstances of 1955—above all, full employment—might change for the worse.[3] Several speakers drew attention to the changing importance of wages and salaries as an item of cost in industry in the age of automation.[4]

The delegates at the Margate conference showed considerable interest in the social consequences of the introduction of production by automatic methods. British industry consists largely of small firms, of whom 75 per cent employ between 100 and 150 workers. Speakers argued that these small firms would benefit from automation because new devices and methods would enable them to secure the maximum output from existing men and machinery.[5]

[1] *Ibid.*, p. 60 (C. L. Old, 'The Engineer and the Automatic Factory—A Challenge to the Technical College'). In 1949 some 14,000 degrees, certificates and diplomas were awarded in Britain in science and technology. In the United States the comparable figure was 110,000.

[2] *Ibid.*, p. 66-71 and pp. 203-6.

[3] E. Fletcher, Secretary, Trades Union Congress Scientific Advisory Committee, 'The Automatic Factory: How will the Trade Unions react?' (*Ibid.*, p. 134 *et seq.*).

[4] See below, pp. 228-41.

[5] *Ibid.*, pp. 161 and 216.

Several speakers discussed the influence that automation would have upon the main groups of people engaged in industry. References were made to a new 'manager type'. The new managers would have to make much greater efforts than their predecessors to impart to their colleagues—at all levels—a real understanding of what their plans were and how they hoped to carry them out. Great emphasis was laid upon 'team work'—'We are getting past the day of the brilliant idea one thinks of in one's bath.'[1] The managing director and his staff will have many new kinds of problem to solve in the age of automation. But new electronic computers will help them to solve such problems.[2] One speaker said that an investigation in one concern showed that only 12 times in 35 days did the managing director work undisturbed in his office for an interval of more than 23 minutes.[3] The new technique of automation would enable the managing director to devote far more than 23 minutes for all of his important problems. The managing director of the future must have higher qualifications than his predecessor:

> '. . . we need a new breed of executive, who is something of an accountant, a mathematician, a scientist, and a production engineer, in addition to possessing some business knowledge particular to the individual concern.'[4]

No one doubted that the engineer would play an increasingly important role in the factory in the age of automation. But there were dangers that the new position of the engineer might lead to totalitarianism.[5] Some speakers referred to the other classes of workers in the automatic factory—below the highly qualified engineer at the top—and also mentioned the 'cross-grained minority' of redundant workers outside the factory.[6]

The final report of the conference drew attention to the fact that it was a landmark in the history of an association of engineers when it held a conference at which so much emphasis was placed not upon technical questions but upon wider economic and social problems. Most of the speakers had been fully aware of the significance of the social consequences of automation.[7] The view that

[1] *Ibid.*, p. 216.
[2] *Ibid.*, p. 42 *et seq.* and see also below, pp. 129, 222-3.
[3] *Ibid.*, p. 20.
[4] *Ibid.*, p. 141.
[5] *Ibid.*, p. 66.
[6] *Ibid.*, p. 27. See below, p. 217.
[7] *Ibid.*, p. 214.

'the overall factor in the present situation is the sociological one' was taken by a leading businessmen at the conference. He stated that an eminent technologist had told him that 'the real problem here is a problem of management of men, and that all technology took an important but definitely a second place in the situation'.[1]

[1] *Ibid.*, p. 215.

Chapter V

PROGRESS OF AUTOMATION 1955

In this chapter we shall describe the new automatic machines and devices which came into use in 1955. The achievements of many of these machines and devices are so extraordinary that one might imagine that they sprang from the fevered imagination of a writer of science fiction rather then from sober reports and articles.

A detailed description of these inventions from the pen of one who is not himself an expert would be somewhat inadequate and would not be of great interest to readers who are probably concerned with the economic and social consequences of automation rather than with technical details. In the circumstances we shall be brief. We cannot, however, refrain from giving a few of the most striking examples of new machines and electronic devices so as to show what new vistas for the future are being opened up by these great technical advances.

One example of the progress that is being made in the introduction of new methods of production in industry is the ever-increasing use of electronic methods for controlling machine tools. In 1954 it seemed as if this technique was still in the experimental stage. Yet in 1955 it was already being put to practical use. With regard to the application of automatic devices in the office, as distinct from the factory, perhaps the greatest advance in 1955 was the progress made in 'automatic programming' for computers and in solving the complex problems of registering and filing the vast masses of documents which continually accumulate in public and private offices.

A characteristic example of the way in which automation can help to rationalise methods of production is 'Operations Research' which we shall describe below. With the aid of electronic computers the results of this 'research' are quickly available. In future

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such devices will be essential in big concerns when management has to take decisions of vital importance.

We shall discuss in detail only a few of the many new automatic machines and devices that have recently come on to the market. These examples may serve to illustrate modern tendencies in automation and may indicate some of the future possibilities of this method of production in industry. We shall deal with the achievement of the fully automatic assembly line: the automatic regulation of a highly complex electric network: and the most recent progress in the development of transfer-machines. With regard to office equipment we shall confine our attention to a recent report on the most up-to-date computer and to the use of automatic 'readers' and 'book-keepers' in banking.

(i) NEW METHODS

Automation Machine Tools (Digital Methods)

One of the most serious drawbacks of early automatic machines was their inflexibility. This even applied—and applies to some extent today—to 'Detroit automation' where automatic devices are used to work and co-ordinate a number of separate specialised machines. These specialised machines are usually unique and are built to order for a manufacturer to perform a particular task. To adapt such a machine to some other task is generally very expensive. The cost of building, installing and servicing a special machine of this kind is very great. Every time a change of any importance is made in the article produced by the firm using the machine—indeed every time that any substantial technical progress is made in the plant—the highly specialised automatic machines lose much of their former value. Their use may have to be abandoned although they have been in use for only a comparatively short time. It seems clear that automatic machinery of this kind can be profitably used only in industries where it is known for certain beforehand that, for some time to come, a very large number of articles of the same type are going to be produced. In such an industry both the capital cost of installing specialised machines and also the running costs can be spread over a very large number of units of production. Yet even in the motor vehicle industry—in which these conditions are fulfilled—attempts are being made to construct relatively small automatic machines which will turn out quickly simply-constructed and small vehicle parts. These small specialised machines are just as 'automatic' as the bigger machines and have the great advantage that they continue to be useful even if the make-up of the finished product is changed.[1]

The need to secure much greater flexibility in automatic factories has led to the invention of a surprising and large number of new electronic control devices. We have already discussed some of the early attempts to construct such devices. One such device, which has passed from the experimental stage, is the 'record-playback' device. This apparatus, having been 'taught' by a skilled human operative, can effectively control the working of a lathe.[2] Already the next step has been taken and computer-controlled machine tools have been invented to replace automatic machine tools controlled by skilled engineers.

The possibilities for the future of such devices—which are capable of being adapted to almost any normal mechanical operation[3]—are of such significance when considering the probable extent of automation and the probable speed of its introduction that we shall discuss them in more detail.[4]

No new principle is involved. The principle upon which computer-controlled machine tools are built has already been used in the mechanical loom and the automatic piano. What is new is the linking of this principle with electronic devices. This new method is called 'numerical control'. The results are achieved in three steps:

(i) First, 'instructions' have to be given to the apparatus as to how the machine tool is to be controlled. These 'instructions' (to be stored in the 'memory' of the machine) take the form of numerical symbols and they are recorded on punched cards or on a magnetic band. The control-device can 'instruct' the machine-tool to move to within a hundredth of a centimetre.

[1] *Automation* (Cleveland, Ohio), November 1955, p. 29.

[2] See also above, p. 33. ['The General Electric Company (U.S.A.) has developed a technique of control known as "record playback", in which the behaviour of the machine under the control of a skilled operator is recorded on magnetic tape and is subsequently played back so as to provide automatic control without a human operator' (*Automation* (Department of Scientific and Industrial Research), 1956, p. 18)].

[3] *Hearings*, p. 199.

[4] For a detailed description see *C.E.*, Sept.-Oct., 1955; *Hearings*, p. 199 *et seq.* and a valuable contribution by D. T. N. Williamson (of Ferranti Ltd., Edinburgh) to the proceedings of the *Margate Conference* (pp. 144-53) entitled 'Computer-Controlled Machine Tools'.

(ii) Secondly, a 'servo-mechanism' passes on to the machine-tool the 'instructions' of the control device.

(iii) Thirdly, there is a device which gives immediate information concerning any error made by the machine tool. Even the most trifling mistake is recorded.[1]

These methods may be summarised as follows:

'. . . the transferring of blueprint information into an electronic gadget that is in a sense a computer, in fact, largely a computer, that can then translate this information to the machine, get the feedback information, and immediately correct the machine, so that it can run a boring mill, or an ordinary mill, or a lathe, or punch press, or anything.'[2]

If minute exactness is not required it is possible to employ an electronic device which—without using a 'numerical code'—will check the working of a machine tool with reference to a blueprint or even a model.[3]

Progress on these lines has been astonishingly rapid. Only a few years ago manufacturers concerned with the production of machine tools made merry over the high cost of electronic devices. They said: '. . . "Pretty soon we'll be selling you the machines to attach to the controls." Today it's no joke. The machine tool has become an accessory of the computer. . .'[4]

To show the uses to which this new technique can be put we may refer to a milling machine which is used mainly in the production of aeroplane parts. Here the human operator has little to do. An automatically controlled loud speaker tells him when his services are required. By introducing a computer-controller the time taken by the milling machine to do a job has been halved.[5]

Another milling machine weighing 200 tons is being built. A report on this machine also illustrates the possibilities concerning the automatic control of automatic machinery. It is stated that the machine will make aeroplane parts up to three metres in length. The following description of the machine may be of interest:

'Engineers and mathematicians must first convert a blueprint's

[1] *Hearings*, p. 605.
[2] *Hearings*, p. 201.
[3] *C.E.*, Sept., 1955, p. 115.
[4] *B.W.*, Oct. 1, 1955, p. 87.
[5] *Fortune*, August 1955, p. 158. Another example is a boring-machine which bores to within 0.0005 of an inch. It is controlled by a punched band and is suitable for producing a medium number of articles. See *Automation* (Cleveland, Ohio), Sept. 1955, p. 69.

dimensions and formulas into a sort of numerical code. The coded information is fed into a computer. In effect, the mathematicians tell the computer they want to cut a piece of metal at a certain depth and a certain angle, and ask for operating commands. The computer is programmed for all the machine's movements. It punches the proper commands in numerical form onto a tape—which is fed into a control unit that runs the machine.'[1]

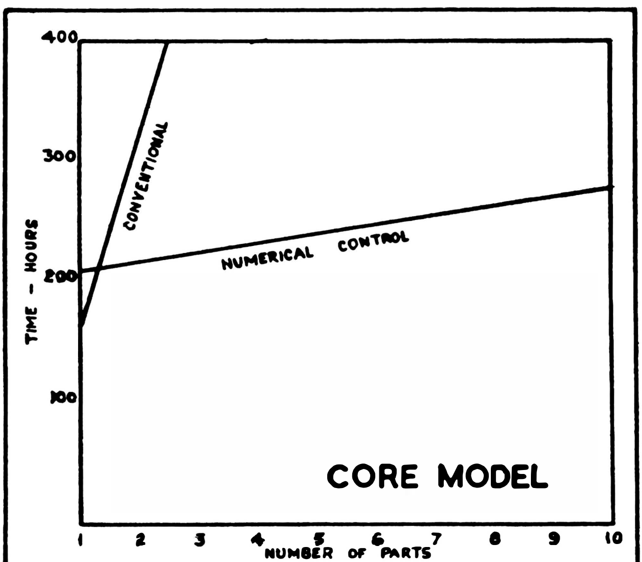
It is estimated that this automatic milling machine will cost over a million dollars. Yet it is expected to pay its way because of the great saving in labour costs. Moreover the new machine can be quickly adapted to changes in production and production of high-quality aircraft parts can be stepped up without having to wait for qualified engineers to become available.

This is a point of importance which should be emphasised. Although the product of the plant is one of high quality, hitherto

[1] *B.W.*, April 2, 1955, p. 25.

DIAGRAM III[1]

Comparison of Unit Costs for making Components (core models) by Conventional Methods and by Numerical Control.

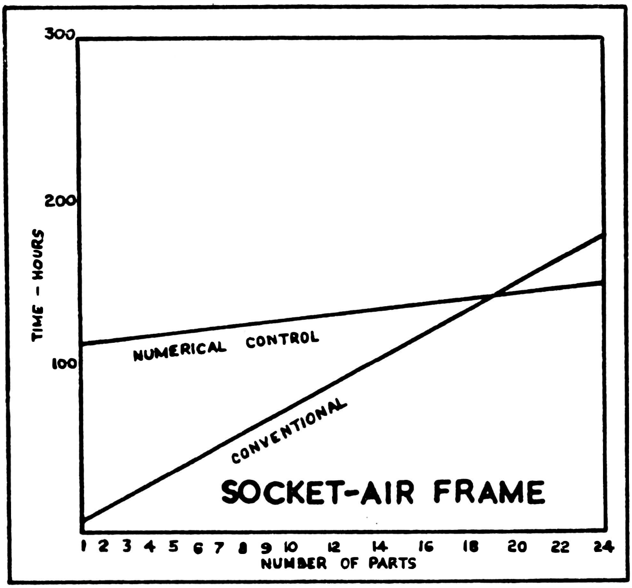


1. *Hearings*, p. 211. In this case it pays to use numerical control when more than one component is being produced. Data from the Massachusetts Institute of Technology Servo-mechanisms Laboratory.

made by highly skilled men, nevertheless the computer-controlled automatic milling machine can do the work. It is also important to bear in mind the fact that this new technique can be applied not only to plants with a huge output of mass-produced standardised units but also to plants which are making relatively few units of one kind. We refer the reader to Diagrams III and IV.

DIAGRAM IV[1]

Comparison of Unit Costs for making Components (air frame sockets) by Conventional Methods and by Numerical Control.



1. *Hearings*, p. 211. When producing this component it is cheaper to use numerical control only if more than 19 or 20 components are being manufactured. Data from the Massachusetts Institute of Technology Servo-mechanical Laboratory.

On these two diagrams one line represents the cost of production by conventional methods in which the machines are installed, controlled and serviced by human beings. The other shows production costs in a plant with computer-controlled automatic machines. These costs include the expense of working out the 'programme' for the computer, the sinking fund (depreciation account), and so forth. It will be seen from the first example (Diagram III) that the two lines cross after one automatic machine has been installed but before two automatic machines have been installed. That means that the computer begins to pay as soon as it controls more than one automatic machine. And it is immaterial whether the second and subsequent automatic machines are installed at the same time as the first automatic machine or not. Once the computer has received its 'instructions' on a magnetic band it 'remembers' them for ever and it can work many new automatic machines in addition to the first. Our second example in Diagram IV—a genuine example from an actual plant—is of a computer which will pay when it controls about twenty or more automatic machines.[1]

Diagram V shows the savings in costs that have been made by installing computer-controlled machine tools in a particular factory. The initial capital cast was considerable, but savings were soon effected since only one-fifth of the skilled workers were retained and there was a very considerable increase in production. In fact production costs were practically halved. The figures upon which the graphs are based show the lowest possible savings which may be anticipated since 'very conservative' estimates were made of savings in wages and the cost of the computer was greatly overestimated since this device controlled only two—instead of the usual 10-15—machines.[2]

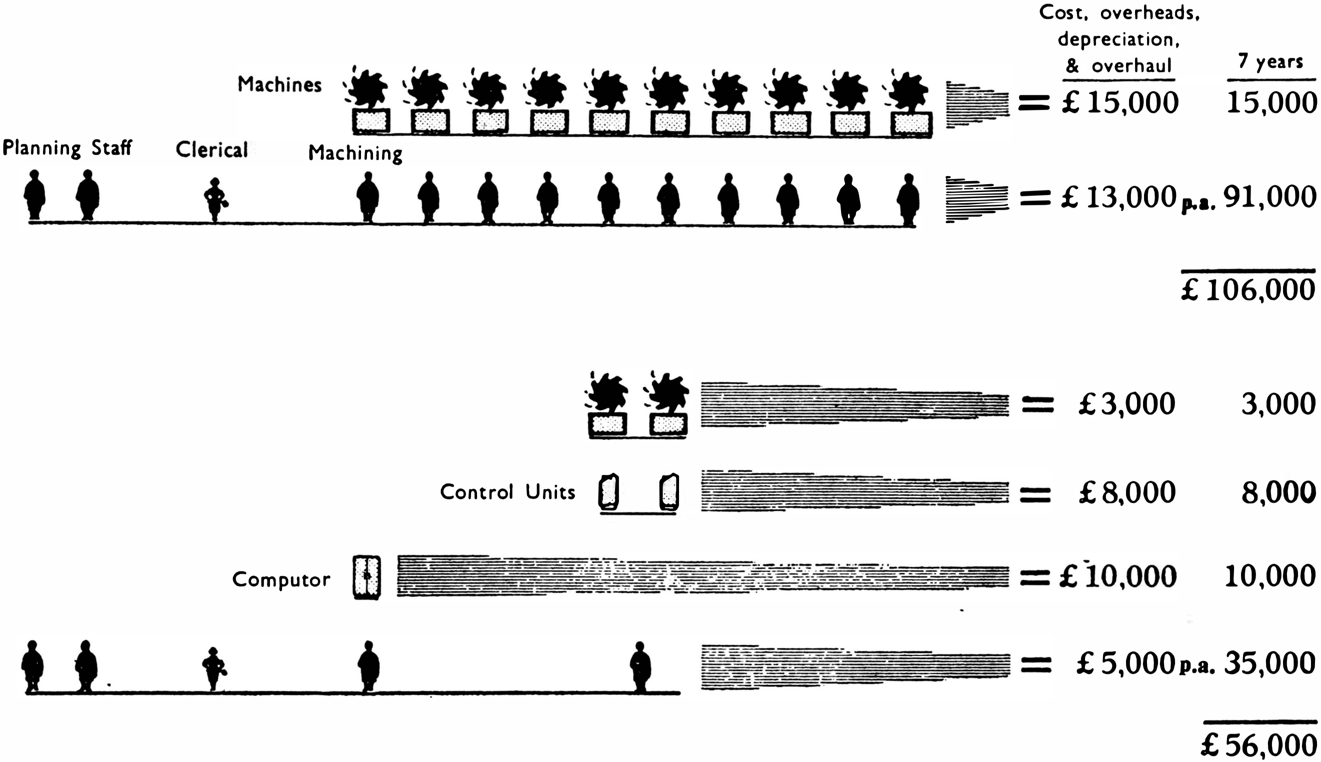
Another consequence of the increasing use of computer-controlled machine tools may be mentioned. This development has accentuated what might be called the 'move from the shop-floor to the office'. A part of the process of industrial production is being transferred from the workshop to the office. The possibilities of this trend may be seen by studying a description of a new technique of

[1]H. S. Gleason, 'Parts Fabrication Conventional or Numerical' in *Hearings*, pp. 209-12. Diagrams III and IV are reproduced from this paper. The information given by Gleason also illustrates the limitations of computer-controlled automatic machinery particularly in plants where output of standardised units of production is exceptionally large.

[2]*Margate Conference*, pp. 144-53 (D. T. N. Williamson's paper). The diagram (*op. cit.*, p. 153) is printed by kind permission of the writer of the paper. Mr Williamson states that although the diagram gives a general picture of the use of the new methods of production it does not claim to be precise in every little detail. Moreover, to simplify matters, a number of factors in the situation have been left out of consideration when assembling data for the diagram. He points out, too, that the costs given for the machines and devices are only approximate estimates.

DIAGRAM V[1]

Diagram comparing the economics of the use of computer-controlled milling machines with conventional methods.



1. Reproduced from *The Automatic Factory. What does it Mean ?* (Report of the Conference held at Margate, June 16 to 19, 1955: Institution of Production Engineers) p. 153. The author thanks the Institution of Production Engineers for permission to reproduce this diagram.

production. Here the programme of work for a large number of machine tools is worked out in the office on punched cards. The holes on the punched cards are based upon the decimal system and not upon a special 'code'. Consequently there is no need to 'translate' a coded instruction for the benefit of the machine. The 'instructions' go straight to the machine and can be 'read' by the machine. This is one of many examples which show the truth of the saying that as automation progresses so 'the traditional separation between office and factory is fading'.[1]

It is to be expected that further advance in the technique of computer-control will be made and that in the future medium-sized and small firms as well as big concerns will be in a position to install electronic devices of this kind. We shall discuss this matter again later.[2]

Automatic Programming for Computers

Those who use electronic computers find that the initial 'programming' includes (a) the preparation of the 'instructions' which are going to be given to the computer, and (b) the 'translation' of those 'instructions' into a form—e.g. punched cards, a magnetic band—which the computer can 'understand'. The difficulties to be overcome in preparing a 'programme' of work for a computer have sometimes been exaggerated.[3] Nevertheless there is no doubt that this process may take a long time and may therefore be expensive.[4] It was often pointed out that if the units of production of a plant were relatively small in number the money saved by installing a computer might be very largely—even entirely—swallowed by the

[1]D. B. Schneider, 'Take a Card for Machine Tool Control' in *Automation* (Cleveland, Ohio), Oct. 1955, p. 36.

[2]See below, p. 234. 'Why put numerical control on a turret lathe? First, because a turret lathe is a highly complex, multi-operation machine requiring skilful operation and constant attention. Numerical control minimizes both the skill requirement and the need for constant operator attention. Previous automatic turret lathes, using mechanical or electrical controls, are too costly to set up for short runs. Tape gives more versatility, is easily made, and can be stored for future use. Numerical control opens a wide field of turret-lathe applications not previously considered practical.' (J. R. Nichols, 'Tape gives turret lathe short-run flexibility', *American Machinist*, August 1, 1955).

[3]*Hearings*, p. 74 *et seq.*

[4]Before automatic programming was invented it was estimated that the cost of setting up a code-book for a computer varied from one dollar to ten dollars for each word. Of course a single 'code-word' would have several equivalents in normal words. Since code-books for a big 'programme' could contain up to 10,000 code-words its cost would obviously run into many thousands of dollars. See also *G.M.S.*, p. 28.

cost of producing the 'programme' of work for the computer. Attempts to find a solution to this problem have continued for many years and 'automatic programming' is now an accomplished fact. Step by step a whole library of 'computer dictionaries' has been built up. Each code-word represents a standard 'instruction' to the computer. A 'dictionary' which is suitable for a particular type of programme is stored in the 'memory' of the computer. The actual programme is fed into the computer by so-called 'pseudo-code' in ordinary language. The computer automatically translates the 'instructions' in normal pseudo-code language into the 'language' understood by the machine. And these 'instructions' which the computer can 'understand' are transferred to a new magnetic band. The accuracy of the 'translation' from pseudo-code normal language to 'machine language' is automatically controlled. This saves the very long and wearisome process of checking the accuracy of the 'instructions' to be fed into the computer. The manufacturers of the computer which we have been describing claim that the time for preparing a programme of work for the machine can be reduced from months to days by means of 'automatic programming'. It is stated that the time taken to get a 'programme' ready can be reduced by 85 per cent. Moreover costly mistakes, due to human errror, are completely eliminated by the machines.[1] The application of automation to 'programming' for computers greatly increases the value of this technique and it will in the future be particularly valuable for the solution of certain types of problems which do not have to be solved very frequently.

Automatic Filing

Another development in automation in 1955 was the 'storing' of documents. The computer can at any time reproduce instantly the information 'stored' in this way. In an eight-hour day up to 100,000 separate data can be handled by the computer. The information in the documents is transferred by special devices to punched cards or electro-magnetic bands. From these cards and bands they are automatically 'memorised' by the machine. The

[1]This is a description of the UNIVAC II computer. See G. M. Hopper, 'Automatic Programming for Computers' in *System Magazine*, Sept.-Oct. 1955, p. 3 *et seq.* Similar methods of 'automatic programming' can also be used for the IBM computers.

documents recorded in this way can be reproduced in any order ('random access').[1]

Automatic Processing of Data ('Operations Research')

In industry management is sometimes faced with problems in which the effects of a considerable number of interdependent factors have to be considered simultaneously. A very detailed analysis of the data may be necessary before it can be decided which combination of factors will give the best result. In the past management has often taken a decision of this kind without a really thorough examination of all the issues involved. It will no doubt in future be possible to obtain quickly the best solution to problems of this kind by using computers working on mathematic principles (linear equations). We give in simplified form the following actual example from the world of business.

> 'A firm possesses 260,000 articles of a particular kind. This stock is scattered in lots of different sizes in four separate warehouses a long way from each other. The whole of the 260,000 articles have to be sent to 51 places and each order is for a different number of articles. The following information was given to the machine—the number of articles in each of the 51 orders; and the cost of sending the articles by each of 204 possible routes.'

A demonstration was given to show how the IBM 701 computer could give an answer to this practical problem. In less than ten seconds the computer produced a typed report stating the number of articles to be sent to each destination. For each journey the route was given so as to cut costs to the minimum. In this demonstration an actual problem was given in simplified form. The solution of this problem had saved a big American concern a large sum of money.[2]

The automatic processing of data already takes place on a considerable scale in the production of aircraft. It is being used also at the planning stage in other industries and in offices. We have already mentioned that computers have been used for military purposes—to solve tactical and strategic problems—and this automatic processing of data is based upon the same principles as the examples given from the world of industry. It has even been stated that in the Korean War a decision of very great importance was

[1]Prospectus of the UNIVAC File Computer.
[2]*IBM Elektronisches Data Processing Centre in New York* (mimeographed report) (Zurich, 1955). For another example see below, pp. 133-4.

taken by a computer. Data concerning costs were fed into the machine which decided which of several possible decisions would be the least expensive.

(ii) NEW DEVICES

Assembly by Automatic Machines

Until recently complete automation in industry was, to a great extent, confined to the following operations—(i) the control of continuous processes in the making of chemical products, oil products, rolled plates, etc.; (ii) the manufacture and inspection of separate parts of a product; (iii) the packing, storing and despatch of raw materials and finished products. But the assembly of parts —an all-important aspect of modern industries making mass-produced goods for large markets—had (with relatively few exceptions) to be done by hand. In recent years, however, automation has come into its own as far as assembly work is concerned. Since 1955 a device known as AUTOFAB has been on the market. It assembles automatically the electronic components of air defence computers.[1]

Another model, designed for private industry, assembles ten electrical components onto a printed circuit board at the rate of 20 circuits per minute. In an eight-hour day 9,600 assemblies are completed. The machine does its own inspecting and delivers only perfect assemblies ready for use. The makers of the machine are not without some justification in claiming that this is the 'world's most revolutionary assembly line'.[2]

For ten years work has been done on automatic assembly machines. Until recently the practical difficulties in the way of constructing such machines appeared to be insuperable. But the solution of the problem now appears to be in sight.[3]

It is not possible to reconcile statements that have been made

[1]This machine was built in the Mechanical Division of General Mills Inc. (U.S.A.). It is characteristic of modern trends in the structure of industry that this well-known food processing firm should employ 2,200 workers in its machine shops. Originally this department was concerned only with designing and building automatic and continuous food processing and packaging machinery to deal with goods manufactured by the firm. See *Hearings*, p. 365 *et seq.*

[2]*S.A.*, April 1955, p. 1—advertisement. See also *A.C.*, May 1955.

[3]G. H. Kendall and J. A. Host, 'Assembly by Automatic Machines' in *Automation* (Cleveland, Ohio), May 1955 and June 1955.

concerning the extent to which these new machines save labour. For example it has been stated by trade unionists that only one foreman and two workmen would be needed to carry out over 200,000 assembly jobs in a forty-hour week. This estimate agrees with the figures which we have given for the output of the AUTOFAB machine. This appears to be confirmed by evidence concerning the labour saved when automatic assembly was introduced into a radio factory in one of the Eastern States of the U.S.A. Formerly 200 workers were engaged in assembling radio sets. Then automation was introduced and machinery was used to assemble the sets. Today two workers can do the work formerly done by 200 workers. They assemble 1,000 radio sets in a day.[1] These statements, however, were challenged by the makers of the AUTOFAB machine in evidence given before the Committee of Congress in 1955. But the manufacturers of the machine did not submit any alternative statistics concerning the redundancy likely to be caused by automatic assembly.[2] A good example of the successful linking of the most modern nethods of production with the latest automatic devices is the recent development of automatic methods in one of the processes for the manufacture of electronic devices themselves.[3]

Diagram VI shows the four main stages leading to the adoption of fully automatic assembly.

1946-51. All assembly work, including wiring and soldering, was done by hand: 125 skilled workers were needed.

1952. Wires all soldered at once: some saving of labour secured this way.

1953. 'Printed circuits' replaced wires. Only a single operation was needed to introduce the printed circuit into the machine. Ninety people could now do the work formerly done by 125.

1956. Assembly completely automatic by an AUTOFAB machine. Only 40 workers are now needed. Automatic soldering will soon be introduced.

And so we shall soon see the end of the paradoxical situation that the very industry which has made automation possible should itself depend to a great extent upon skilled craftsmen.

[1] *Hearings*, p. 109 and p. 124.
[2] *Hearings*, p. 272.
[3] 'TV Goes to Automation' in *B.W.*, June 8, 1955, and E. L. Van Densen, 'Electronics Goes Modern' in *Fortune*, June 1955, p. 132 *et seq.*

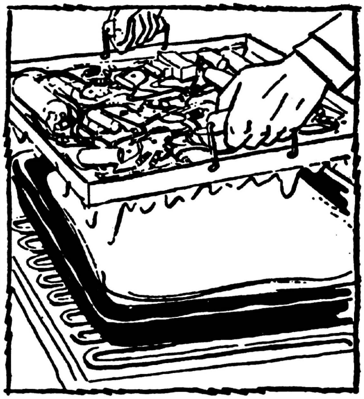
DIAGRAM VI

Main Stages in the Development of the Automatic Assembly of Electronic Devices.[1]

1946

HAND ASSEMBLY
HAND WIRING
HAND SOLDERING

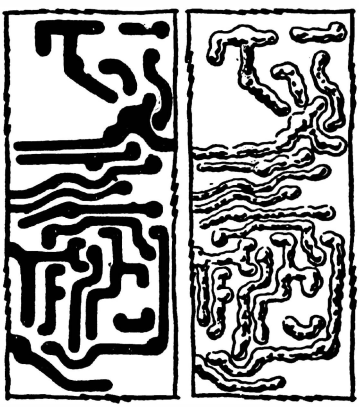
Some companies still use these old techniques today. A fast production line must have about 125 workers.



1952

HAND ASSEMBLY
HAND WIRING
DIP SOLDERING

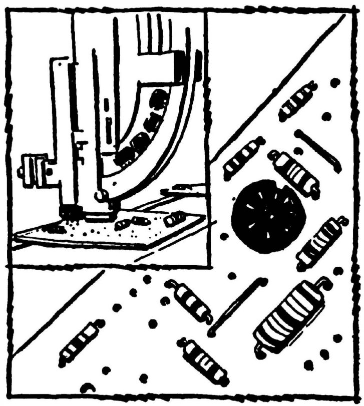
Hand soldering is eliminated. A tank of molten solder does the job in one operation. Production is faster, with fewer people on the line.



1953

HAND ASSEMBLY
ETCHED WIRING
DIP SOLDERING

Hand assembly is reduced, because wires don't have to be connected. They're etched onto a board. Production line can operate with about 90 workers. Many companies have not yet come this far.



1956

MACHINE ASSEMBLY
ETCHED WIRING
DIP SOLDERING

Machines do the assembly work. Production line drops to about 40 people. Displaced workers move to other jobs in the plant. Only one company has come this far, but 1956 will be the year for several others.

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1. Reprinted from *Business Week*, June 18, 1955, by kind permission of the publishers.

An imposing automatic plant for assembling motor cars has been built by the Chrysler Corporation in Detroit. It came into operation towards the end of 1955. This was the first occasion on which automation had been successfully introduced into the assembling of motor vehicles.

> 'The first "automated" production facility of its kind in the country the line consists of 280 operating stations, spread over one-quarter-of-a-mile. Cylinder blocks are fed into one end of the machine, right cylinder heads at another point, and left cylinder heads at a third. As these castings move along the line automatically, one engine part after another is added. At the end of the line, completely assembled engines—ready to run—are taken off.'[1]

This automatic plant assembles 1,200 motor vehicles in an eight-hour day. It is not known how much labour has been saved by introducing automation into this plant. It is, however, reported that assembly costs have been halved. The automatic assembly plant cost 2,500,000 dollars, and it is claimed that this sum will soon be recovered by savings in the cost of production. In the circumstances it is hardly surprising that the two big rival motor manufacturers of the U.S.A.—which have hitherto used automation only to produce motor vehicle parts—have now ordered automatic assembly plants similar to the one installed by the Chrysler Corporation.[2]

It is significant that the firm which built the automatic motor vehicle assembly plant for the Chrysler Corporation has established a new department to make similar plants for other industries.[3]

Electronic Device to Control an Electricity Network[4]

The Goodyear Electronic Differential Analyser (GEDA) is a machine which automatically controls the production and distribution of electricity of nine scattered power-stations which together serve a region of 9,000 square miles. The machine is at Massillon in Ohio. Its closed circuit links 35 steam turbines which have a weekly output of 100 million kilowatt-hours.

Formerly, although the control of output and distribution of electricity was centralised it was in the hands of human operators. Those responsible for controlling the system obtained their information from instruments and then took appropriate action

[1] *Barron's*, January 23, 1956. See also *Hearings*, p. 494 *et seq.*
[2] *Barron's*, January 23, 1956. [3] *Barron's*, January 23, 1956.
[4] *N.Y.T.*, Aug. 18, 1955, and *C.E.*, Oct. 1955, p. 20 *et seq.*

on the basis of tables of instruction. The devices for controlling the output and distribution of electricity at the various power stations were worked by hand.

The new electronic device which has now been installed to do this work automatically solves the problem—which human operators could never completely solve—of securing the absolutely maximum efficiency of performance from the electricity network. Normally human intervention in the control of the system is now no longer necessary.[1] In taking its 'decisions' the device takes the following matters into consideration—(i) the demand for electricity, (ii) the possible output of each of the 35 power stations, (iii) the most efficient way of linking older and newer power plants, (iv) the cost of coal at each of the power stations, (v) the calorific value of the coal burned at each generating station, (vi) the nature of the coal (wet or dry), (vii) the peculiarities of the transmission lines, (viii) the extent to which heavy loads, bad weather and other difficulties may affect the efficiency of the various power lines.

The differential analyser also performs a large number of calculations—e.g. (i) estimates of the cost of supplying power to other electricity concerns, (ii) estimates of amount of electricity that the network would have to supply in certain given circumstances. It is thought that, owing to the savings for which it is responsible, this machine will pay for itself in only two years.

Many power stations are already controlled by electronic devices. But the Goodyear electronic differential analyser appears to be the first machine to control an entire network of power stations. If it proves to be successful there can be little doubt that similar differential analysers will be introduced elsewhere.

Transfer Machines

We have already come across 'linking devices' which have played an important part in the development of automation. An article which is a process of manufacture can, without human intervention, be automatically moved from one machine to another. These devices are known as transfer machines. Both the machine from which the object is transferred and the machine to

[1]This is a practical example of the completion of the 'closed circuit' which we discussed above. See pp. 14-15.

which it is moved—by the transfer machine—are controlled and operated automatically. The best-known example of transfer machines in actual use is Ford's automatic car plant in Detroit. This type of automatic plant is known as 'Detroit automation'.[1] The various automatic machines in the Ford plant are fitted with electronic devices so that the quality of the work done by the machines is continually being checked. The Detroit system can be adapted to the manufacture on a large scale of any product which —like a motor vehicle—is composed of a large number of complicated parts.[2]

The significance of transfer machines is this: if existing methods are used (without such machines) the time taken in moving motor car parts from one plant to another is greater than the time taken in the actual process of manufacture. This is illustrated by the following table.

TIME TAKEN TO PERFORM VARIOUS MANUFACTURING OPERATIONS IN THE HEAVY SECTION OF THE AMERICAN ELECTRICAL INDUSTRY[3]

Operation	Percentage of total productive man-hours
Assembling	27·3
Materials handling[4]	26·8
Machining	21·7
Testing	12·9
Finishing	4·5
Other	6·8
Total	100·0

[1]The word 'automation' was invented by D. S. Darder, a director of the Ford Motor Company. Even today the motor industry in the U.S.A. regards automation as simply 'the automatic handling of discrete parts between progressive processing operations'. See E. Weinberg, 'The Meaning, Outlook and Implications of Automation' in *M.L.R.*, Feb. 1955.

[2]An example may be given of these uses of Detroit automation in a different industry. A transfer machine has been made to produce the chassis of typewriters. The various machines and devices which make up the Detroit type of transfer machinery are 33 metres long. They carry out 200 separate operations to make a typewriter chassis. See *Automation* (Cleveland, Ohio) Dec. 1955, p. 62. According to the report of the managing director of the International Business Machines Corporation a typewriter chassis can be made in one minute. By the old system three or four hours would be necessary.

[3]E. Weinberg, *op. cit.*

[4]Does not include materials-handling work performed by skilled labour as part of normal activities.

The automatic transfer of materials in the process of manufacture is a great improvement upon manual transfer and enables automatic machinery—particularly machine tools—to be used to the best advantage. At first the new method suffered from the drawback that if an automatic machine developed a defect or if a machine had to be moved for repairs the whole process of manufacture was delayed. Modern transfer machines have overcome this difficulty. The automatic plant works in sections and if one section is out of action owing to a breakdown the remaining sections go on working for a time. This is called 'sectionalised automation'.

In view of the exceptional importance of this type of automation from the point of view of displacing human labour we quote a full description of an automatic plant. At the end of 1955 this was the most fully developed example of 'Detroit automation'.

> 'It is a [transfer] machine for making V-8 cylinder blocks for one of the automobile companies. It is 350 feet long, and performs 555 operations. The parts enter the machine at the left, where the operator is standing. They are automatically transferred from station to station, located and clamped, different operations are performed at each station, the parts progress toward the rear and then cross over and come up on the right-hand side and, when the 555 operations are completed, they are ejected at the right.
>
> 'This machine is operated by a crew of 3 men, 1 direct labour operator, and 2 toolsetters. . . .
>
> 'The toolometer keeps an account of every operation that the tool performs. When the programme for the tool expires, the toolometer reaches its zero point, and shuts off that section of the machine that the tool is operating in. The toolsetter proceeds to that section to change the tool. As soon as the section stops, the work is banked up ahead of the interrupted section and conditioned parts are fed into the section that follows the stopped section. This permits some production without stopping the entire machine, while one tool is being changed. When the toolsetter has changed the tool, he resets the toolometer to its starting position and the section goes back into operation. . . .
>
> 'Sectionalized automation . . . is used for the mass production of complex parts. It would not be profitable to use sectionalized automation on parts of simple design . . . nor would it be profitable to use it on job-lot production.'[1]

[1]Evidence of R. E. Gross (Executive Vice-President of the Gross Company) in *Hearings*, p. 493. Descriptions of this type of machinery (for the layman) are given by P. Bezier in a paper to the *Margate Conference*, p. 73 *et seq.* ('Automatic Transfer Machines') and J. A. Hunt and J. B. Jay, 'Automatic Linking Devices' *op. cit.*, p. 160

OFFICES

Electronic Computers (and Supplementary Devices)

In 1955 the two firms which make giant computers both announced details of new machines. The achievements of these machines are of an even more fantastic character than those described above (p. 20). The tables below (pp. 141-2) will give the reader an idea of the speed with which the machine receives information (input), does its work and delivers its results (output). The immense 'memories' of the UNIVAC II (Remington Rand Company) and the EDPM 705—the Electronic Data Processing Machine of the International Business Machines Corporation—are remarkable achievements.

The pedigree of the computer family (p. 139) shows how vigorously Western countries are pressing forward with the manufacture of electronic computers,[1] especially when one remembers the long gaps in experiments on such automatic machines between 1842 (when Charles Babbage concluded his efforts to make an adding machine) and the end of the second World War. It was in 1946 that the first electronic computer (EMAC), embodying principles of modern research, was successfully completed.[2]

The effective development of electronic computers fall largely in the decade 1946 and 1956. Up to the year 1949 only a single giant computer had been delivered to a business firm. Most of the computers represented on p. 138 are used for scientific or military research. Yet it is estimated that by 1957 some 400 giant computers will be in use in American private industry.[3]

This seems to be a very high estimate. Certain practical difficulties may prevent private firms from installing giant computers quickly. Thus when private firms order a giant computer they make it a condition that the manufacturer of the machine

et seq. [See also *Automation* (Department of Scientific and Industrial Research, 1956), pp. 15-16, where it is stated that 'the first true transfer-machine was built in the Morris Motors factory at Coventry in 1924'.]

[1]Little is known of the extent to which electronic computers have been developed in Soviet Russia and her satellites. It is likely that the computers in use behind the Iron Curtain have been copied from the Princeton Computer. Most computers in West European countries have been derived from this model.

[2]L. Couffignal, *Les Machines à Penser*, p. 32 *et seq.*

[3]*Hearings*, p. 291.

shall keep the order a secret so as to prevent the employees of the firm becoming unduly alarmed. In November 1955 at a conference attended by 1,500 computer experts, held in Boston, it was estimated by a government expert that the value of electronic computers in the United States—in actual use or on order—amounted to about one milliard dollars.

At the end of 1955 the following giant computers were either in use in the United States or likely to be on sale soon:[1]

Firm	Computer	Cost $	Number in use	Number on order
International Business Machines Corporation	EDPM	over 1,000,000	20	200
Remington Rand Division of Sperry Rand Corporation	UNIVAC FACTRONIC	over 1,000,000	30	?
Burroughs Corporation	Computer based upon one used for military purposes	750,000	announced for summer of 1956	
Radio Corporation of America	BIZ MAC	3,500,000	in preparation	
Datamatic Corporation	DATAMATIC 1,000	1,500,000	announced for 1956	

It is particularly significant from the point of view of extending the use of electronic computers that rather smaller machines are now being built at a lower cost than the giant computers.[2]

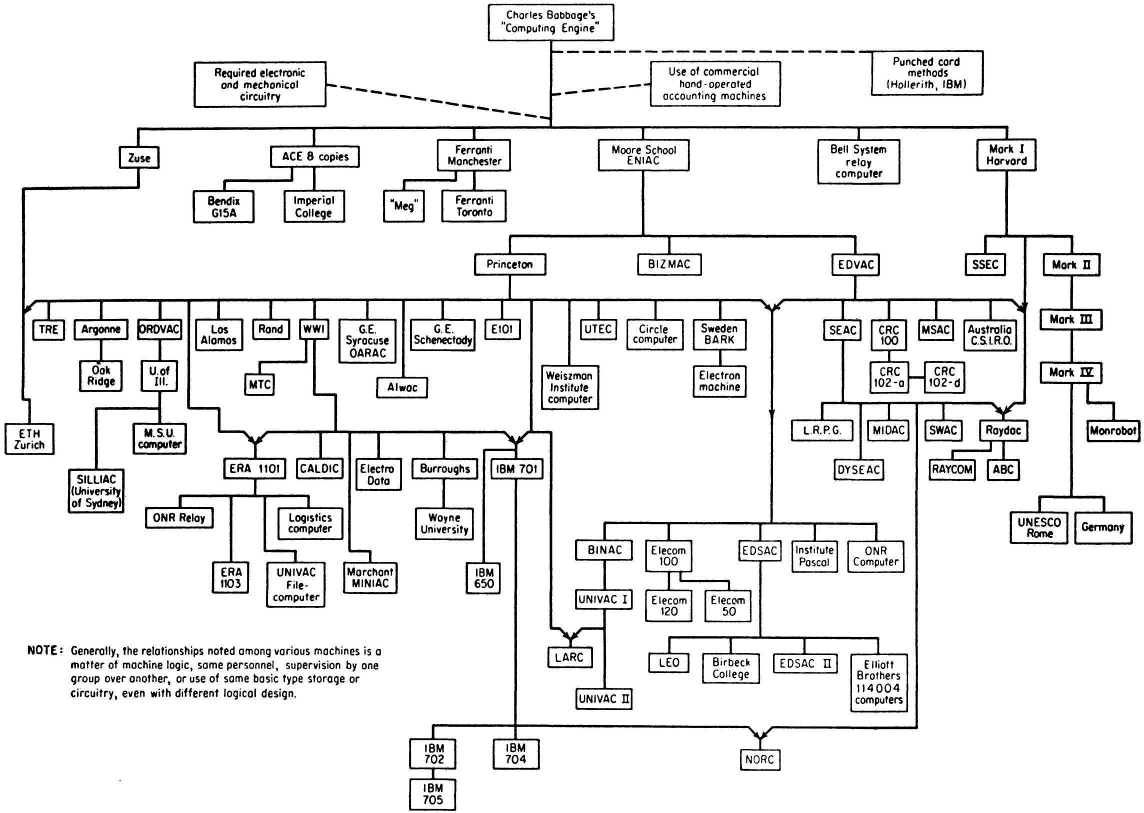
[1] *W .J.*, Nov. 11, 1955

[2] See W. Kaeslin, 'Magnettrommelrechner' in *N.Z.Z.*, Sept. 21, 1955. By the end of 1955 there were already 200 medium-sized computers of one make (IBM 650 type) in use and about another 1,000 were on order. The price of the medium-sized and small computers varies from 50,000 to 300,000 dollars:

'The moder te-priced machines differ from the large-sc le systems primarily in

DIAGRAM VII

The Computer Family Tree[1]

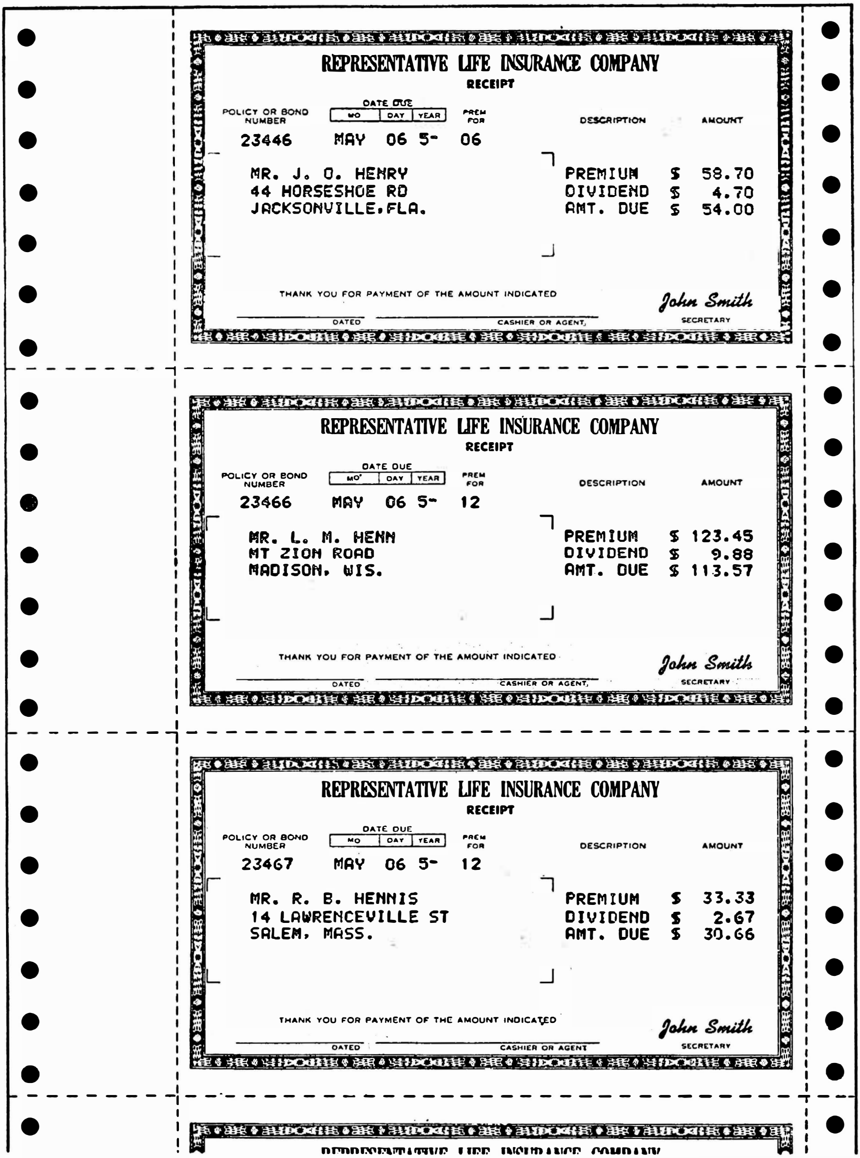


NOTE: Generally, the relationships noted among various machines is a matter of machine logic, same personnel, supervision by one group over another, or use of same basic type storage or circuitry, even with different logical design.

[1] J. W. Carr and A. J. Perkis, 'A Comparison of Large Scale Calculators' in *Control Engineering*, Feb. 1956, p. 86 (Reproduced by permission of the publisher).

DIAGRAM VIII

Combined Demand Notes and Receipts for Life-Insurance Premiums calculated automatically by a Computer made by the International Business Machines Corporation of New York. These documents are printed by a high-speed press at the rate of two hundred a minute.[1]



REPRESENTATIVE LIFE INSURANCE COMPANY
RECEIPT

POLICY OR BOND NUMBER	DATE DUE MO	DAY	YEAR	PREM FOR	DESCRIPTION		AMOUNT
23446	MAY	06	5-	06	PREMIUM	$	58.70
					DIVIDEND	$	4.70
					AMT. DUE	$	54.00

MR. J. O. HENRY
44 HORSESHOE RD
JACKSONVILLE, FLA.

THANK YOU FOR PAYMENT OF THE AMOUNT INDICATED

DATED — CASHIER OR AGENT

John Smith
SECRETARY

REPRESENTATIVE LIFE INSURANCE COMPANY
RECEIPT

POLICY OR BOND NUMBER	DATE DUE MO	DAY	YEAR	PREM FOR	DESCRIPTION		AMOUNT
23466	MAY	06	5-	12	PREMIUM	$	123.45
					DIVIDEND	$	9.88
					AMT. DUE	$	113.57

MR. L. M. HENN
MT ZION ROAD
MADISON, WIS.

THANK YOU FOR PAYMENT OF THE AMOUNT INDICATED

DATED — CASHIER OR AGENT

John Smith
SECRETARY

REPRESENTATIVE LIFE INSURANCE COMPANY
RECEIPT

POLICY OR BOND NUMBER	DATE DUE MO	DAY	YEAR	PREM FOR	DESCRIPTION		AMOUNT
23467	MAY	06	5-	12	PREMIUM	$	33.33
					DIVIDEND	$	2.67
					AMT. DUE	$	30.66

MR. R. B. HENNIS
14 LAWRENCEVILLE ST
SALEM, MASS.

THANK YOU FOR PAYMENT OF THE AMOUNT INDICATED

DATED — CASHIER OR AGENT

John Smith
SECRETARY

1. Reproduced by kind permission of the International Business Machines Corporation of New York. The machines can also calculate and print wage slips, salary cheques etc.

The following facts may give the reader some idea of the efficiency of modern giant computers. The information has been supplied by the two American firms which were building computers for private industry in 1956.[1]

	UNIVAC II Fac-tronic	IBM 705 EDPM Electronic Data Processing Machine
INPUT		
On magnetic band		
Number of symbols per second	20,000	15,000
On punched cards (80 *to* 90 *holes*)		
Cards per hour	14,400	15,000
VOLUME OF WORK PER SECOND		
(including finding of data in the 'memory' of the machine)	11-figure numbers (plus initial symbol)	5-figure numbers[2]
Additions	5,000	8,400
Subtractions	5,000	8,400
Multiplications	525 (11 x 11)	1,250 (5 x 5)
Divisions	270 (11 : 11)	550 (6 : 4)
Logical Decisions	5,000—8,500	29,400
'MEMORY' OF COMPUTER		
Magnetic Core		
(Number of Symbols)	24,000	20,000 to 40,000
Supplementary Symbols up to	120,000	60,000 per magnetic drum[3]

speed of operations, e.g. 500 operations per second as versus 5,000 or more, and in slower or less versatile input-output provisions, e.g. 500 characters per second as versus 10,000 to 15,000.' (Report of the National Bureau of Standards in *Hearings*, p. 589.)

[1]See the statistics given below (pp. 142-3) relating to a computer used for defence purposes (Livermore Automatic Research Computer).

[2]The length of the words can be varied as required. If 11 figures are used the amount of work done by the machine is similar to that of the UNIVAC II.

[3]Up to 30 magnetic drums can be added to this giant computer so that its maximum memory is over 1.8 million symbols!

	UNIVAC II Fac-tronic	IBM 705 EDPM Electronic Data Processing Machine
OUTPUT		
On magnetic band (Number of symbols per second)	20,000	15,000
Capacity of Magnetic band	2,880,000 symbols[1] (36,000 punched cards each with 120 holes)	3,000,000 symbols (24,000 punched cards each with 90 holes)
On express printer (Number of lines per minute)	600 (130 symbols per line)	1,000 (120 symbols per line)
On punched cards (Cards per minute)	120	100
RENT PER MONTH (IN U.S.A.) including) necessary supplementary apparatus)	27,000 dollars	26,500 dollars

The latest development of the UNIVAC computer is the Livermore Automatic Research Computor. The Atomic Energy Commission of the United States has placed an order worth nearly 3,000,000 dollars with the Livermore research laboratory for the construction of this computer. It is stated that the new computer will be able so solve many problems simultaneously. It will solve these problems at a speed 1,000 times greater than that of previous electronic computers. The new computer will be able to solve problems in three dimensions. In a few days it will perform calculations which the existing UNIVAC computer takes up to two years to complete. The most recent UNIVAC computer has a 'memory' capacity of 120,000 symbols. The new Livermore computer will be able to remember 200,000 symbols. Moreover an indefinite number of additional 'memories' can be attached to

[1]Allowing for intervening spaces.

the Livermore computer. The input or output of the 'memory' of this machine will be 500 words per minute.[1]

From time to time there are references in the literature on the subject to teething troubles in the use of giant computers. It is clear that these are only minor difficulties which can soon be overcome. Thus one of the earliest computers was expected to perform a particular task within two hours. In fact the machine took much longer than that. The reason appears to have been that—for experimental reasons—the task set to the machine was far more complicated than it would ever have been in the world of practical affairs.

The firm which was using this computer was not worried about this incident. The managing director stated that his board had ordered 23 electronic computers, of which six were 'monsters', each costing over 1,000,000 dollars.[2]

How important these great computers are for solving problems concerning industrial production may be seen from the fact that some firms have found that a computer working 24 hours a day is insufficient for their needs and they have to use additional machines (situated hundreds of miles away) to get the necessary work done.[3]

The development of supplementary appliances has kept pace with—or has even advanced more rapidly than—the development of the great computers themselves. The efficiency of high-speed printers, which print from electro-magnetic bands, has increased so that now 120,000 symbols (1,000 lines of 120 symbols each) come off the press in a minute.[4] These devices are already on sale. We have had experience of 5,000 or more symbols (i.e. two pages of typing) having been printed in a second.[5] In this connection it may be appropriate to comment on the criticism

[1] *Systems Magazine*, Sept.-Oct., 1955.

[2] R. B. Cole, ' "Brain" Trouble. Electronic Computers can create Problems as well as solve them', in *W.J.*, Nov. 11, 1955.

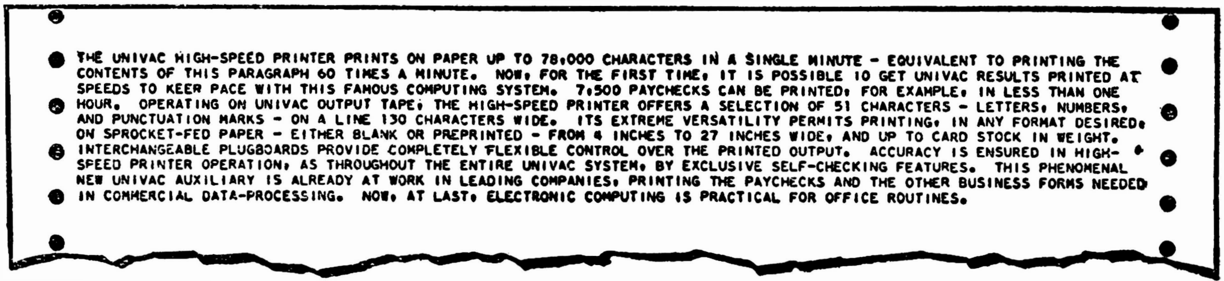
[3] 'Computing 32 Hours a Day', in *B.W.*, January 1, 1955.

[4] See Diagram IX. The older type of speed-printer could print 'only' 78,000 symbols every minute. The high-speed printer which can print 120,000 symbols a minute is the IBM High Speed Printer. The insurance premium receipts produced in Diagram VIII were made out by this high-speed printer.

[5] *G.M.S.*, No. 178, p. 25. This sounds too good to be true—but the statement is made by the Director of the laboratory for numerical calculations at the Massachusetts Institute of Technology.

DIAGRAM IX

Example of one second's Output by a high-speed Printer[1]



THE UNIVAC HIGH-SPEED PRINTER PRINTS ON PAPER UP TO 78,000 CHARACTERS IN A SINGLE MINUTE - EQUIVALENT TO PRINTING THE CONTENTS OF THIS PARAGRAPH 60 TIMES A MINUTE. NOW, FOR THE FIRST TIME, IT IS POSSIBLE 10 GET UNIVAC RESULTS PRINTED AT SPEEDS TO KEER PACE WITH THIS FAMOUS COMPUTING SYSTEM. 7,500 PAYCHECKS CAN BE PRINTED, FOR EXAMPLE, IN LESS THAN ONE HOUR. OPERATING ON UNIVAC OUTPUT TAPE, THE HIGH-SPEED PRINTER OFFERS A SELECTION OF 51 CHARACTERS - LETTERS, NUMBERS, AND PUNCTUATION MARKS - ON A LINE 130 CHARACTERS WIDE. ITS EXTREME VERSATILITY PERMITS PRINTING, IN ANY FORMAT DESIRED, ON SPROCKET-FED PAPER - EITHER BLANK OR PREPRINTED - FROM 4 INCHES TO 27 INCHES WIDE, AND UP TO CARD STOCK IN WEIGHT. INTERCHANGEABLE PLUGBOARDS PROVIDE COMPLETELY FLEXIBLE CONTROL OVER THE PRINTED OUTPUT. ACCURACY IS ENSURED IN HIGH-SPEED PRINTER OPERATION, AS THROUGHOUT THE ENTIRE UNIVAC SYSTEM, BY EXCLUSIVE SELF-CHECKING FEATURES. THIS PHENOMENAL NEW UNIVAC AUXILIARY IS ALREADY AT WORK IN LEADING COMPANIES, PRINTING THE PAYCHECKS AND THE OTHER BUSINESS FORMS NEEDED IN COMMERCIAL DATA-PROCESSING. NOW, AT LAST, ELECTRONIC COMPUTING IS PRACTICAL FOR OFFICE ROUTINES.

1. The UNIVAC high-speed printer also checks spelling errors. (Reproduced by permission of the Remington Rand Company.)

that 'Electronic equipment is technically more advanced than our understanding of its use'.[1]

It has been argued that one of the fundamental mistakes in applying the new electronic devices has been that

> 'Their use has been primarily on a piecemeal basis. . . . For computers are typically being applied to mechanise segments of processes —segments that are now performed manually or are only partially mechanised. In very few cases is the entire flow of information being analysed, mechanised, and treated as a system.'[2]

In this connection it has been observed:

> 'But the full implication of these machines' ability to "remember" are just beginning to catch on. It's possible to feed huge quantities of raw data into these machines—far more than any human mind could hold—and then direct the machines to tap this undirected stockpile of data and come up with specific answers.'[3]

Electronic Recording Machine Accounting (*ERMA*)

The importance of machines of this kind will be appreciated when we consider that in the United States most business transactions are settled not in cash but by cheque. Every month a person who has a banking account receives a statement from his bank and at the same time cancelled cheques are returned to him. Accounts may not normally be overdrawn. On current accounts no interest is paid. On the contrary the client pays the bank a service charge, unless he maintains a permanent credit in the bank—the size of which will vary according to the number and value of cheques normally drawn in a month. The bigger banks are kept very busy recording payments into and payments from the individual accounts of large numbers of clients.

The various electronic accounting machines of the ERMA type have introduced automation into the book-keeping side of banking. The Stanford Research Institute worked for five years on such a machine on behalf of the Bank of America. In the autumn of 1955 the machine was put into operation at one of the

[1] *G.M.S.*, No. 178, p. 31.

[2] *A.C.*, July 1955, p. 48.

[3] *B.W.*, Oct. 1, 1955, p. 87. One of the newest uses of computers is automatic translation from a foreign language. The necessary theoretical investigations are now so far advanced that a leading expert has said that within five years a translating computer will be able to produce something much better than a mere 'word for word translation'. See W. N. Locke, 'Translation by Machine' in *S.A.*, January 1956, p. 33; W. N. Locke and A. D. Booth, *Machine Translation of Languages* (New York, 1955); R. Werner, 'Zur Geschichte der Übersetzungsmaschine' in *N.Z.Z.*, January 22, 1956, and *C.E.*, Aug., 1955, p. 114.

main branches of this bank:[1] 'Where previously 50 book-keepers had been required to service the accounts, nine operators and ERMA now perform the same work. It also performs daily book-keeping on 50,000 individual banking accounts.'[2]

A bank official records on a punched card (a) if a payment is being made into or out of an account, and (b) the amount of the cheque. Then the computer performs the following operations:

(i) It identifies the account (printed in magnetic colour).

(ii) It finds (on the calculating part of the machine) previous payments into and out of the account.

(iii) If the cheque is an outgoing one the machine decides whether the account is sufficiently in credit to enable the cheque to be paid. If the cheque cannot be met the machine rejects it and goes on to deal with the next cheque.

(iv) If an outgoing cheque can be made the machine deducts the necessary sum from the account. If the account is overdrawn by paying the cheque the machine informs the bank official.

(v) Once an outgoing cheque has been paid the machine inscribes the new credit on a magnetic drum.

(vi) Later the individual transactions are transferred to a magnetic band in such a way that monthly accounts can be made up.

(vii) Monthly and annual statements of each client's account are provided by the computer.

(viii) At the end of each month the service charge is automatically deducted from each client's account. An express printer makes out a monthly account for every client and also prints his address so that the account can be sent to the client by post.

(ix) Every month the machine sorts out all incoming cheques so that (when they have been cancelled) they can be sent back to clients.

The Bank of America was so satisfied with this machine that 32 more accounting computers were ordered for its main branches. The accounts of 500 branches can be dealt with automatically

[1] See *ERMA Electronic Recording Machine: Accounting* (issued by the Stanford Research Institute, Menlo Park, California). See also E. L. Van Deusen, 'The Coming Victory over Paper' in *Fortune*, Oct. 1955, p. 139 *et seq.* and ' "Automation" im Bankbetrieb' in the *N.Z.Z.* Feb. 14, 1956.

[2] *A.C.*, Nov. 1955, p. 29.

and the services of only a fifth of the clerks now employed will be required.

The ability of this—and similar—electronic machinery to 'read' figures at the rate of 1,000 per second makes automatic book-keeping of travellers' cheque possible. Since such cheques are in fixed amounts all that is necessary is to 'feed' into the machine information concerning the number of travellers' cheques of each denomination. After each operation there is an automatic check to see if the computer has read the number correctly: a badly printed cheque can be discovered in this way and it is automatically ejected by the machine so that a bank official can inspect it.

A computer, made by a private firm, has been installed in one of the big New York banks solely to deal with travellers' cheques. This machine can 'read' 7,200 travellers' cheques in an hour, and can transfer this information to punched cards. It has handled 130,000 cheques. A skilled punched-card operator, using normal office apparatus, can handle up to 700 cheques an hour—and that is an exhausting job—so that 23 clerks would be needed to handle 130,000 cheques. The computer is worked by two or three operators who obviously have a much easier time of it than the 23 clerks who formerly worked by hand.[1]

Electronic 'reading' devices are at present only in their infancy. One day they may play an important part in business in dealing with accounts, invoices and countless other aspects of book-keeping.[2]

[1] *A.C.*, August 1955, p. 28 *et seq.*

[2] The German Federal Post Office is planning to introduce automation into its arrangements for handling letters and parcels. Plans to this end were announced at a conference of all major postal regions (*Oberpostdirektionen*) held at Ulm. In future the sender of a letter will have to put a particular symbol or number on an envelope according to its destination. When the letters are handled by an electronic machine the symbol will be 'read' and the letter will be automatically sorted. This will greatly reduce the time spent in sorting letters. Small local post offices will be relieved of the task of sorting letters.

Chapter VI

ECONOMIC CONSEQUENCES OF AUTOMATION

(i) New Uses of Automation

In order to be able to form some judgment upon the probable economic and social consequences of automation it is obviously important to appreciate the extent to which automatic devices can be used in the economy. The more limited the range of industries into which automatic machines can be introduced the more restricted will be the social and economic effects of automation. And the contrary is also true. We have seen that there is a wide gulf between those who think that fundamental changes in the structure of society will follow in the wake of automation and those who think that automation will not change society any more than many previous advances in technology. It is not surprising that the two camps differ also in their views on the extent to which automation will spread in the immediate future. We have seen that in 1952 Diebold estimated that in the United States only a minor sector of the economy would be influenced by automation and that no more than 8 per cent of the labour force would be affected. This estimate was soon out of date but it has been frequently repeated. It has been argued that in the next 20 years only about a half of this 8 per cent of the American labour force would in fact feel the effects of automation. Hence only 125,000 American workers would be affected in a year.[1]

This attempt grossly to minimise the social consequences of automation cannot be defended upon either theoretical or practical grounds. Those who hold this point of view often base their arguments upon the fact that at one time there appeared to be insuperable difficulties in the way of introducing complete

[1]See above, p. 60 *et seq.*, and p. 99 *et seq.*

automation into certain branches of industry. Even if this is true it will still be possible to introduce *partial* automation on a large scale in these industries. It would be just as sensible to argue that the conveyor belt system could not be introduced into a plant because one part of the process had to be done by skilled craftsmen. Even in the motor car industry—where the conveyor belt system and the minute division of labour associated with it has had its greatest successes—some independent skilled craftsmen survive.

It is true that at the moment there are only a very few completely automatic plants in existence. But that does not detract from the significance of the ever-increasing number of concerns in various industries which are introducing partial automation both in their plants and offices. Partial automation may well be the most characteristic feature of technical progress in the twentieth century—just as the most significant advance in the nineteenth century was the widespread adoption of power-driven machinery (despite the fact that handwork by individual craftsmen survived in many factories). It is the type of production which bears the brunt of the output that is really important. Today even in the Ford Works only 6 per cent of the labour force is employed in the automatic plants and in the immediate future only 30 per cent of the workers will be affected by automation. But as we are clearly only in the very opening phases of a great change in methods of industrial production it is hardly possible to prophesy with any certainty how far these changes will go.[1]

In the modern world there are many factors favourable to the increased use of automation. Every report of the introduction of a new automatic machine is surely symptomatic of the birth of a new era in industry.[2] All the available evidence suggests that electronic calculators and automatic machinery will ultimately affect economic and social developments in the decades following the end of the second World War to the same extent that the combustion engine and the conveyor belt affected people's lives in the inter-war period of 1919-39.

We have seen that so far no systematic survey has yet been made in the United States concerning the extent of automation.

[1]*Hearings*, p. 57 and p. 61.
[2]See above, pp. 34 *et seq.*, and 100 *et seq.*

If one wishes to estimate the future development of automation it is necessary to know to what extent automatic machines and electronic devices are already in use. But this information can, to a great extent, be obtained only in almost casual references to new machines in the press and in learned journals. There would appear to be some theoretical justification for regarding every report concerning the installing of new automatic machines as a sign of future development on these lines. This is because scientists and experts in technology hold the view that it is possible to introduce automation into certain important aspects of non-agricultural production and office administration—namely repetition processes and certain kinds of 'decisions' for which a human brain was once essential.

The following is a list—admittedly incomplete—of American industries in which automatic machines and electronic devices have already been introduced.

Production of Raw Materials and Durable Goods[1]

Agricultural machinery
Aircraft
Armaments
Cast-iron products
Cement
Chemical Industry
Electrical equipment (household)
Electronic devices
Furniture
Glassware
Metal Refineries
Mining
Motor vehicles
Oil industry
Radar equipment
Refrigerators and other articles of household equipment
Rubber industry
Steelworks
Tannery products
Typewriters and other office equipment

Non-Durable Goods

Bakery products
Cigarettes
Corn-milling machinery
Electric bulbs
Food-processing industry
Jam-making industry
Munitions
Non-alcholic beverages
Paper industry
Pharmaceutical products
Printing (newspapers and periodicals)
Textiles
Woodworking equipment

[1]In alphabetical order in the German edition.

Communications, Power and Services

Atomic energy
Automatic lifts
Postal services (letters and parcels)
Power Stations
Railways
Reservation of seats
Telegraph service
Telephone service

Offices

Book-keeping
Control of stock in warehouses
Invoices
Notices
Payment of Wages
Registration
Recording of cheques (banking)
Translations

Public Administration and Research

Checking of income-tax returns
Manipulation of research data, including correction of errors
Calculations
Public finance (e.g. rates)
Solution of meteorological problems

Military Affairs

Aircraft (including remote control of guns)
Anti-aircraft guns
Control of stocks
Planning development of technical advance in armaments
Solution of tactical and strategic problems

For lack of better information it has unfortunately been necessary to some extent to compile this list from sources which may not always be as reliable as one would wish. Moreover, it is not clear from some of the reports whether the new machines are really automatic or represent merely technical developments of the traditional kind. Nevertheless, however imperfect, this list does show on how very wide a front automation is advancing—a front much wider than that assumed by some writers on the subject. It is probably not an exaggeration to suggest that—outside agriculture—there is hardly a single large business concern in the United States which is not giving serious consideration to the possibility of benefiting from the advantages of automation.[1] Again, what is going to happen to those industries which cannot adopt automation? Their productivity will naturally be very much less than that achieved in branches of manufacture which have adopted automation. Such a discrepancy between output levels in different industries will give a great impetus to research. Every effort will then be made to overcome the difficulties—which now appear insurmountable—that stand in the way of introducing automation into commerce, finance, farming and the 'service industries'.[2]

We will now give a few more recent examples of the introduction of automation.

INDUSTRY AND TRANSPORT

1. *Motor Vehicles*

'Detroit automation' by which the conveyor belt system is being replaced by transfer-machines and 'transfer roads' is being introduced into all the big European plants in which motor vehicles are made.[3]

2. *Breweries*

It is reported that the introduction of automatic devices for turning barley into malt will increase the efficiency of the process and will greatly improve the quality of beer. Since supplies of barley may vary considerably and may react in a different way in the fermenting process it is essential that temperature, moisture

[1]There are possibilities for automation even in agriculture. 'Operations research' (processing of data by a computer) could presumably be used on the big estates which supply 85 per cent of the agricultural products marketed in the United States. The manager of a big farm, ranch or plantation has to make decisions which grow in complexity from year to year. Several agricultural colleges have prepared plans to undertake research concerning the extent to which an electronic computer could be used to solve such problems. A modern computer could quickly tell a farmer what combination of factors would best suit his future needs—factors such as (i) available labour, (ii) stock, (iii) buildings. Of course, agricultural prices fluctuate considerably and cannot be accurately forecast. Nor is it yet possible to give an accurate long forecast of the weather. Even with these drawbacks the computer could be a more reliable guide when taking a decision 'than any choice arrived at by budget analysis, rough estimating, intuitive judgment, or all three'. ('I.B.M. down on the farm', in *Fortune*, June 1955, p. 101).

[2]*S. F. Symp.*, p. 169.

[3]H. Müller, *Arbeit an den Transferstrassen des Opel-Motorenbaus* (mimeographed) (Rüsselsheim, 1954); 'British Motor Corporation' in *Auto* (Bern), June 10, 1955; P. Bezier (of the Usines Nationales Renault) on 'Automatic Transfer Machines' at the *Margate Conference*, p. 73 *et seq.*

and length of fermentation should be strictly controlled. The various stages of the manufacture have to be carried out at different speeds but these stages all combine to form a continuous process.[1]

3. *The German Chemical Industry*

Rapid progress is being made in introducing automation into the German chemical industry. For example it is stated in the annual report of a large chemical concern,

> 'Important progress has been made in automation. . . . Despite the big capital outlay involved automation has led to a reduction in costs. Automation has brought about certain changes in the structure of our labour force. . . . The repair workshops have become of relatively greater significance'.[2]

4. *Dressmaking*

A surprising—but simple—adaptation of the technique of the computer is being introduced into dressmaking. The manufacture of ready-made garments for women is a large and important induscry in the United States. The turnover (at factory prices) of this industry amounted to over three milliard dollars in 1955. In the autumn the industry begins to produce the garments that will be sold in the following spring. Production plans have recently been based upon experience of sales in various regions such as South California and Florida. In this way the trends in public taste are being discovered at an earlier date than formerly. This method has proved to be successful. At one time the industry lost money by failing to forecast consumer demand. Now such losses have been greatly reduced.[3]

This example illustrates the advantages to be obtained from the *speed* with which the computer makes its calculations. It is possible to forecast consumer trends even in an industry where demand is notoriously changeable.

5. *Aircraft Construction*

In comparison with plants turning out standardised mass-produced goods an aircraft works manufactures only a relatively

[1] B. W. Hackstaff, *General Engineering in Grain Bulk Handling* (American Society of Mechanical Engineers, New York, 1955); 'Advancing Continuous Malting', Oct. 1955, p. 66 *et seq.*

[2] *D.Z.*, Dec. 3, 1955.

[3] *W.J.*, Oct. 28, 1955.

small number of airframes. Nevertheless in the building of aircraft there are operations which have to be repeated time and time again. Drilling and riveting, for example, were formerly done by hand. They are now done mechanically by a tool controlled automatically by a punched strip. The controlling mechanism weighs 5,000 lbs. The part of the aircraft upon which the automatic tool works is of the same weight.[1]

6. *Production of Coke*

Coal is weighed and sorted into different grades. The control machine can check 520 tons of coal an hour and can estimate the total weight to within one per cent. In this way it is possible to select from the various kinds of coal the correct mixture needed to make any particular type of coke that is necessary for the production of iron and steel.[2]

7. *Plastic Packing-material*

A method of packing goods in a transparent plastic material has been discovered. This plastic protects the goods against damp and is a better packing material than grease-proof paper or tinfoil. In an automatic factory in the United States the production of this plastic packing material has increased from 130,000 rolls in 1953 to 5,000,000 rolls in 1955. The material is manufactured by a continuous process and only automatic machinery is used. The final product is very flimsy. A human hair is 16 times as strong as the plastic material. Yet in the process of manufacture the material moves about 600 metres and is handled by ten different machines. The working of the machines is automatically controlled. The packing and storing of the rolls of plastic material is also done with the aid of automatic devices. Orders are handled in the office by a computer and the necessary information is sent to the warehouse so promptly that the rolls can be dispatched to the customer on the same day. A beginning has been made in the development of

'. . . automatically controlled order stencilling machines which will

[1] E. W. Berger, 'Automatic Positioning speeds Drilling and Riveting' in *Automation* (Cleveland, Ohio), Sept. 1955, p. 52 *et seq.*
[2] *W.J.*, Jan. 11, 1956.

read printed product identification on the carton, electronically count the correct number of cartons of each product variation ordered, and stencil the cartons thus automatically selected to fill the order. The stencil, by the way, is already being cut on a Teletype printer earlier in the day as a by-product of the remote order data processing system.'[1]

8. *Automatic Marshalling Yards*

A new marshalling system for railway goods yards has been devised in the United States. An electronic machine automatically controls the speed of the waggons so that they can be safely coupled together. The machine also 'memorises' a long list of stations to which railway waggons may be sent. Each waggon is automatically assigned to its correct train.[2]

9. *Television Cathode Tubes*

These highly complex pieces of apparatus are manufactured entirely by automatic machinery. Even the testing of the finished product is done by an automatic device. The presence of an engineer is only necessary when he is giving instructions to an operator who is supervising the test. Normally there is no need for an engineer to be there at all. The advantages of automation are well illustrated by the following statement concerning the efficiency of automatic machinery for making television cathode tubes:

'One of the greatest costs in the electronics industry is . . . a thing that we call in the industry shrinkage. We put dollars worth of raw materials into one of these big picture tubes and if it isn't right when this comes off the last process, the whole thing goes into the scrap pile, except for the glass envelope. . . . This shrinkage is the greatest single menace of the industry. The amazing thing is that fully automatic machines don't make shrinkage. The machine stops when you put a bad part or bad process in. . . .'[3]

10. *Liquid Rubber*

A new plant in the United States for the production of liquid

[1] *A.C.*, Sept. 1955, p. 16 *et seq.*

[2] 'Automatic freightyard shuffles cars quickly yet gently' in *C.E.*, January 1955, p. 29 *et seq.* See also *Hearings* (p. 456 *et seq.* and p. 543 *et seq.*) for details concerning the automatic marshalling yards which have already been put into operation by several American railway companies.

[3] *Hearings*, pp. 175 *et seq.*, 193 (D. G. Mitchell, chairman and president of the Sylvania Electric Products, Inc.).

rubber inclues all the most modern automatic control technique: 'The result—greater efficiency and productivity, lower costs, improved product, and stronger competitive position.'[1]

11. *Steel*

In many branches of the steel industry the technique of 'continuous production' is followed. The more such processes are speeded up the more difficult it is for the human worker to keep up with the pace of the machine. As soon as 'feedback' and 'sensory' devices were invented they were quickly introduced into steel works. Today there are numerous machines 'designed to note . . . the current state of the production processes, to make comparisons, render routine decisions, and to take the indicated corrective action to compensate for any deviation from standard. . . . Similar stories of progress could also be presented for the modern primary rolling mills, wire mills, rod mills, and pipe mills.'[2]

The thickness of steel plates can be ascertained to within 0.00015 inches by means of X-rays. Any inaccuracy is automatically corrected by an electronic device. Formerly this sort of testing had to be done at very frequent intervals by human workers who used measuring equipment which gave far less accurate results than X-rays. And the rollers had to be adjusted manually if any error were discovered: 'Over a long, high-production shift, this is difficult and more or less erratic. Human reactions, too, are thought to be slower and less precise than those of the electronic system governed by the X-ray gauges.'[3]

12. *Loading and Dispatch of Ore*

'. . . A Remington Rand electronic ore-car data processing machine does in minutes a job that took humans from one to three days. It weighs . . . ore cars at the rate of five or six a minute, figures the net weight of ore in each car and the total for all cars in an order. Simultaneously, it transmits the date to the . . . docks and the ore mines 90 miles away. The machine also punches this information on tape, which is fed into automatic typewriters for the rapid prepara-

[1] *A.C.*, Sept. 1955, p. 21.
[2] W. K. Scott, 'Automation in the Steel Industry' in *S.F. Symp.*, p. 64 *et seq.*
[3] *B.W.*, Dec. 3, 1955, p. 146.

tion of ship waybills. With prompt ore weight data the mines know exactly how much ore is needed to fill a ship and dockers are able to route cars to the proper loading platforms. Guesswork is eliminated from the job of providing different grades of ore in correct amounts to meet steel mill requirements. . . .'[1]

13. *Printing of Newspapers*

'The Washington plant [of the *Wall Street Journal*] is a milestone in newspaper production. Never before in this country has a daily paper gone to press with the same news and advertising in widely-separated cities. The development has been made possible by a new system for the remote-control, automatic setting of type. . . . Skilled operators in New York . . . translate news stories into a narrow, perforated paper tape. This tape is fed into machines which duplicate the original tape at the distant printing plants. The duplicate tape at these plants is then fed into a device which operates the type-setting machines. This electronic method of news transmittal reduces the time lag between getting the news and delivering it to readers, and also minimizes human error in the typesetting process.'[2]

14. *Cement*

'The new $1-million plant of the X-Company . . . uses no manual labour at any point of the process. By the use of punched cards and electronic controls, it can turn out ready-mixed concrete under any one of some 1,500 different mixing formulas. . . . The plant also has a system of belt conveyors to carry the materials to the two material storage bins, from which the electronic controls direct them to the mixer as needed. . . . Quality control of the product will approach 100 per cent accuracy . . . the new pushbutton control system . . . can measure, and compensate for, a plus or minus of moisture in the aggregate that goes into the mixer. And if the customer's order calls for a dry-mix . . . the controls will automatically route the . . . materials to the waiting truck. . . .'[3]

15. *Cigarettes*

Automatically controlled machines ensure that all cigarettes contain exactly the same quantity of tobacco. These new machines make cigarettes very much more quickly than the conventional machines.[4]

[1] *W.J.*, Jan. 11, 1956.
[2] *W.J.*, Nov. 30, 1955.
[3] *B.W.*, April 16, 1955, p. 80 *et seq.*
[4] *W.J.*, Jan. 11, 1956.

16. *Office Work*

A. *Electronic Computers in Public Administration (U.S.A.)*:[1]

So far over fifty large and medium-sized electronic computers have been installed in the head offices of departments of the United States Federal administration. Many computers are on order for government departments. Some work 'seven days a week, 24 hours a day and they have replaced hundreds of officials'. Salary and wages cheques for 100,000 post office employees in New York and Chicago are calculated and typed by one computer. The cost of producing monthly unemployment statistics in the U.S.A. has been cut by one half by using computers. In future the first check upon 6,000,000 income tax returns will be made by an electronic apparatus which will sort out those returns which have not been fully completed at the rate of 6,000 an hour.

Electronic computers are being developed to deal with the statistics of the U.S.A. population census of 1960. It will be possible for UNIVAC computers to 'read' microfilms of the completed census forms. It is estimated that whereas it took 1,400 clerks a year to handle the returns of the last census, only 100 operators—working for five months—will be required to deal with the returns for 1960. Similar methods have been used in connection with the census of firms in the U.S.A.:

> 'This is a complicated job involving reports from more than 3 million establishments. If these reports were all complete and self-consistent, and if we made no errors in our office work, the job of getting out the census reports would be laborious but straightforward. Unfortunately, some of the reports do contain omissions, errors, and evidence of misunderstandings. By checking for such inconsistencies we eliminate, for example, the large errors that would result when something has been improperly reported in tons instead of hundredweights. Perhaps one-third to one-half of the time our Univacs devote to processing these censuses will be spent checking for such inconsistencies and eliminating them.
>
> 'As an example, let me describe one of the checks we apply to reports on the production of animal feed. In this industry practice varies among manufacturers with respect to the units they use to measure production. Some manufacturers keep production records by hundredweights and others keep such records by tons.
>
> 'On the census questionnaire we requested the respondents to

[1]See *Hearings*, p. 72 *et seq.* and p. 575 *et seq.*; *N.W.*, Jan. 9, 1956; and *W.J.*, Feb. 17, 1956.

report production by hundredweights. We know, however, that some respondents will report tons. Because the value of the commodity is also reported to us, we can use our Univacs to detect such misunderstandings. In effect we tell our computer, in the case of this illustration, that the wholesale price value of poultry feed per hundredweight usually falls between $1.50 and $9. The Univac is instructed to compute, for each report of production of poultry feed, the average unit value and to compare this with the value range.

'Obviously, if production has been reported in tons instead of hundredweights, this computation will result in an excessively high unit value. When this happens, our computer is instructed tentatively to assume that the production was reported in tons, not hundredweights, and to multiply the reported amount of production by 20—the appropriate factor to convert tons to hundredweights—and then recompute the unit value. If this recomputed unit value satisfies the check, the electronic computer has thus automatically corrected an error in reporting. If it still does not satisfy the check, our computer lists the report as one requiring inspection and correction by a subject-matter expert before we can include it in our tabulations. Such exercise of the ability to choose and to act in different ways according to conditions is, I think, a good example of automation.

'Similar checking procedures are applied to the approximately 7,000 product lines for which we have reports. In a like manner we check to see whether such relationships as annual man-hours and number of production workers, or value of shipments and cost of labour and materials, are within reasonable limits for the industry and area involved.'[1]

Experts in the American War Department believe that milliards of dollars could be saved by using computers to deal with the handling of the stores of the armed forces. The inspector-general of ordnance of an aircraft establishment attached to the American navy uses a computer to handle 90,000 different aircraft parts which are stored in 13 depots in different parts of the world. The computer decides automatically which depot has requirements surplus to its needs which can be forwarded to another depot which needs the aircraft components in question. The computer 'decides' when to order new aeroplane parts. It calculates what are the requirements of a depot and it places the necessary orders before the danger of a shortage arises. This sort of 'electronic planning' will no doubt one day be a commonplace in industry. Before long the computer will be 'fulfilling orders' for customers.

[1] *Hearings*, pp. 76-7. (Report of the Director of the Bureau of the Census).

The American army is installing a computer in Detroit which will cost 4 million dollars to make. It will take over the stores in which parts of tanks and motor vehicles are kept. Another computer has been ordered by the army which will control the issue of shoes, shirts, etc., to quartermasters as they are required. It is expected that the new method will put an end to demands from quartermasters for garments that they think they need but which are in fact in excess of their requirements.

The American air force plans to operate a large number of computers which will one day be able to deal automatically with 1,200,000 orders for aircraft parts which are made every day from stations all over the world. It is obvious that great savings will be made by the introduction of automation. Since the American army maintains stores in various parts of the world valued at 20 milliard dollars, the air force must also have very large stores to deal with.

The American postal authorities are experimenting with a new machine which will be able to 'read' typed or printed town names on envelopes. In a year's time it is hoped that letters destined for twenty different cities will be sorted automatically.[1]

In April 1956 social security arrangements for 120,000,000 Americans will be dealt with by electronic computers in Baltimore. A hundred claims can be calculated in a minute. The machine has to make its 'decisions' in the light of complicated data concerning (i) the incomes of the claimants during the period that they have been insured, and (ii) complex administrative rules concerning eligibility to grants.

The American Patent Office is also introducing electronic computers. Although the staff of the office has recently been increased it still takes two years to decide which of the 120,000 outstanding claims for patents should be granted. If all patents granted up to the end of 1956 were recorded in the 'memory' of a computer it would be possible for the machine to state at once whether a new patent claim had any similarity with a patent already granted. It would take minutes to do what now takes a full day.

B. *Payment of Wages*

We summarise a detailed description of the working of a giant

[1] *W.J.*, Feb. 17, 1956.

UNIVAC computer which calculates the weekly wages of 12,000 men.

Both 'input' (information fed into the computer) and 'output' (information given by the machine) are recorded on electromagnetic bands. An electronic apparatus, capable of dealing with 15,000 cards an hour, transfers information recorded upon punched cards to these magnetic bands with absolute accuracy.

(a) *Input:*

(i) Magnetic band for 'Programme' of work. This band controls the whole process.

(ii) Magnetic band on which is recorded information concerning the work done by each employee in a particular period.

(iii) Magnetic band on which is recorded permanent data about each worker—e.g. his works number, his name, his basic wage, regular fixed additions and deductions from the basic wage, and accumulated totals (e.g. of deductions for tax purposes) where necessary. This magnetic strip is automatically renewed after each pay-day.

(iv) Magnetic band recording the appointment of workers, the resignation of existing staff, and changes in basic wage rates.

(b) *Output:*

(i) New 'basic' magnetic band—the starting point of calculations for the next pay day.

(ii) Pay-day magnetic band—records all relevant information for calculating wages.

(c) *Functions of the computer:*

(i) Puts into correct order all the data on magnetic band on which is recorded the work done by each employee.

(ii) Puts into correct order all information about changes on staff and in basic wage rates.

(iii) Calculates for each worker his or her gross pay and net pay. All this information is transcribed (in the correct order) onto a new magnetic band.

(iv) For each pay-day all necessary information is transcribed onto a new magnetic band; accumulated totals calculated when necessary.

(v) With the aid of a high-speed printer a cheque or wages-slip is made out showing gross pay, deductions and net pay.

(d) *Time taken:*

The computer takes about an hour and three quarters to produce the final 'pay-day magnetic band' for 12,000 workers. Altogether some 120,000 items (basic wage, additions, deductions, gross pay, net pay, etc.) are recorded. It take about four hours to print the cheques and wage-slips.[1]

C. *Storage and Dispatch of Goods*

Automation is being increasingly used to control the storing and dispatch of both semi-manufactured goods and finished goods. New methods enable a greater control than before to be exercised over these functions. More is involved than mechanical dispatch. It is possible to sort the goods, to pick what has to be sent, to complete invoices and to make out lists of goods sent out of the warehouse. The apparatus used has to be sufficiently elastic to be able to handle all kinds of goods from bottles to baths. It will be possible to sort mailbags mechanically with complete accuracy and if the sorting office is near the railway station time will be saved. The mailbags could be sorted automatically and sent to the proper platform and the proper mail coach for dispatch.[2]

An enquiry sponsored by the Twentieth Century Fund discovered that costs of distribution account for 59 per cent of the price of consumer goods. Automation may well reduce substantially the ratio of distribution costs to the total cost of production. In an automatic warehouse goods can be sorted and put in their proper places by the aid of electronic devices:

> '. . . The degree of efficiency achieved through this process is almost beyond belief. Even to the experienced material handling expert, it is intriguing to watch the almost human action of the automatic case selectors unerringly taking off any one of six different packs onto six different accumulator belts, and then to watch one palletizer automatically change its interlocking pattern . . . to efficiently utilize the cube of the pallet, with proper interlocking features.'[3]

[1] F. Maier, 'Neue Wege in der Verwaltung durch Verwendung der Elektronentechnik' in the *National-Zeitung* (Basel), May 5, 1955.

[2] *Automation* (Cleveland, Ohio), May 1955, p. 27 and August 1955, p. 5.

[3] R. C. Waehner, 'Movement in Automation' in *Automation* (Cleveland, Ohio), July 1955, p. 100 *et seq.*

The following observations of a leading American expert concerning the future possibilities of automation are of particular interest in this connection:

> 'The *Baltimore Sun* has labelled automation as "the cliché of the year".
> However, I seriously question how many competitive businesses can calmly say, "Automation will never bother me!" . . . no one can write a prescription for a general dose of automation. . . . What we need most in dealing with the potentialities of automation is a willingness to face the facts and to go through the hard mental labor of solving the necessary equations in terms of each individual company's strengths, weaknesses, ambitions, and bankroll.'[1]

The Electronics Industry in the U.S.A.

The development of the industry which manufactures the most important devices for computers and automatic machines illustrates current trends in the progress of automation. In 1955 the turnover of this industry in the United States—manufactured products and services[2]—amounted to about 9½ milliard dollars.[3] The expansion of output of the electronics industry is very significant. Its turnover was nineteen times greater in 1955 than it had been in 1940. But in this period the number of people employed in this industry increased at only half that rate. Statistics for 1952-3 show that although there has been a steady expansion of output in these three years the number of persons directly engaged in the industry has remained steady.[4]

Recent statistics concerning the electronics industry show that nearly 600 million dollars worth of electronic devices were used in industry. It is expected that the turnover of the electronics industry will double within the next five years. In 1955 the electronics industry produced goods valued at 2½ million dollars for the armed forces. The number of firms making electronic products has

[1]P. B. Wishart (Managing Director of the Minneapolis-Honeywell Regulator Company), 'Automatische Produktion und der kleine Geschäftsmann' in *S.F. Symp.*, p. 163 *et seq.*

[2]Turnover in the electronics industry includes (a) various kinds of devices and pieces of apparatus—including wireless and television equipment; (b) services—such as those rendered by networks of radio stations; and (c) commercial dealings. Some writers seem to forget (b) and (c). In 1955 the output of the electronics industry was estimated at about five milliard dollars (factory prices).

[3]*Hearings*, p. 180 *et seq.*

[4]*Hearings*, p. 289.

increased fivefold since 1939. At the beginning of 1955 there were 3,600 such firms in the United States.[1]

These statistics show how important military orders have been for the development of the electronics industry. The electronics industry has been very active because of the demands of the armed forces. This demand has greatly encouraged research. Eventually civilian industry will get the advantage of the great capacity of the electronics industry.[2]

Accounts of the future plans of the electronics industry conjure up visions of Orwell's *1984*. A new sort of television is promised for the future:

> '. . . the present television picture tube will be replaced by a thin, flat screen that can be hung on the wall like a picture. That will be "mural television", with the screen under complete control of a little box. . . . The electronic light amplifier and tiny transistors—also products of recent electronic developments—will eliminate the need for using the picture tube and all other electron tubes in a television set.'[3]

(ii) The Problem of Technological Unemployment[4]

Automation probably made greater progress in the United States in one year in 1955 than it had made in the previous five years. It is not surprising therefore that considerable use has been made of the employment statistics for 1955 by those who are concerned with the problem as to whether automation brings technological unemployment with it or not. Certain aspects of this problem we propose to discuss in due course. Our own belief is that if automation is introduced in an unregulated manner in a 'free' economy there are serious dangers to the stability of both the economic and social structure which will have to be faced. In the circumstances we must examine very carefully all arguments advanced against this theory.

[1] *I.A.*, Jan. 1956, p. 7. See also below, pp. 240-1.

[2] See *Hearings*, p. 169 *et seq.*; U.S. Department of Labour: *Studies of Automatic Technology*, No. I, 'A Case Study of a Company Manufacturing Electronic Equipment' (in *Hearings*, p. 279 *et seq.*); D. Sarnoff, 'The Fabulous Future' in *Fortune*, Jan. 1955; D. Sarnoff, 'New Developments in Electronics', lecture to the annual conference of the American Institute of Electrical Engineers, Jan. 31, 1955.

[3] D. Sarnoff, *op. cit.*, p. 7.

[4] See also above, p. 60 *et seq.*

Employment, Unemployment and Output in the U.S.A. between 1952 and 1955

There was a boom in the United States in 1955. The gross national product (387.4 milliard dollars) was a record. In the last quarter of 1955 a gross national product amounting to nearly 400 milliard dollars per annum was achieved and the national income reached the colossal total of 322 milliard dollars.[1] In the second half of 1955 the labour force was over 70,000,000. Three million out of these seventy million were in the armed forces. The highest figure for the civilian labour force (65,200,000) was recorded in October 1955. About 8,000,000 people were employed in agriculture and over 57,000,000 persons were in non-agricultural employment. The highest unemployment figure recorded in 1955 was 3,300,000 in January while the lowest was 2,100,000 in October. By December the figure had gone up to 2,400,000 but this was only a normal season increase. The number of persons unemployed was 5.3 per cent of the total civilian labour force in January 1955; 3.2 per cent in October 1955; and 3.6 per cent in December 1955.[2] The figure for August 1953 had been only 1.9 per cent.

Although the level of unemployment—measured as a percentage of the total civilian labour force—was not as low as it had been in August 1953 when it was very near to the lowest figure ever recorded. Any arguments based upon these statistics of unemployment in the United States must take account of the fact that some of those classified as 'employed' were on short-time or were absent from work because of a strike or because of illness.[3] A relatively high proportion of the unemployed were in the higher age groups. A number of the unemployed had formerly been engaged in the mining or transport industries.[4]

A comparison between the American employment statistics of August 1954 and August 1955 shows that in the civilian sector of the economy the labour force had increased by 2,200,000[5] and the number of unemployed had declined by one million. In other

[1] *Economic Report of the President . . . to Congress* (Washington, D.C.), 1956, p. 174.
[2] *Economic Report* . . . 1956, p. 183.
[3] *Economic Report* . . . 1956, p. 183 (note 2).
[4] *N.Y.T.*, Jan. 3, 1956.
[5] This expansion of the civilian labour force by 2,200,000 includes 300,000 men discharged from the armed forces.

words, in those twelve months work for over 3 million additional persons had been found in the American economy.[1] These statistics show that in 1955 automation did not cause any marked technological unemployment. An examination of the employment statistics for manufacturing industry—that sector of the American economy most affected by automation—shows that 1955 was a year in which there was an exceptional expansion of productivity.

COMPARISON BETWEEN (I) RECIPIENTS OF WAGES AND SALARIES IN INDUSTRY IN THE U.S.A., AND (II) INDICES OF INDUSTRIAL PRODUCTION 1952-55[2]

	Total number of persons engaged in non-agricultural work	Manufacturing Industry						Indices of industrial production 1947-9=100		
		Millions			1947-9=100					
		Total	Durable Goods	Non-Durable Goods	Total	Durable Goods	Non-Durable Goods	All Industries	Durable Goods	Non-Durable Goods
1952	48·3	16·3	9·3	7	109	115	102	125	136	114
1953	49·7	17·2	10·1	7·1	115	125	103	136	153	118
1954	48·3	16	9·1	6·9	107	113	101	127	137	116
1955	49·4	16·6	9·6	7	111	119	102	140	155	126

Redundancy Owing to Automation in the United States

Between 1952 and 1955 the number of persons engaged in industry in the United States remained virtually constant but the index of production increased by 11 per cent. In the sector of the industrial economy devoted to making durable goods the output was much the same in 1955 as it had been in 1953, but about 500,000 fewer persons were employed. Unfortunately statistics do

[1]*Economic Report* . . . 1956, p. 182.
[2]*Economic Report* . . . 1956, pp. 188, 194.

not tell us how many of these 500,000 workers became redundant because of 'normal' technical progress.[1]

At the time of writing no detailed employment statistics for 1955 are available for those branches of industry in which most progress in automation has been made. We have to rely therefore upon isolated examples of technological unemployment due to automation which have been reported. These examples are given for illustrative purposes only. It is not possible to say how far the cases to which we refer may be taken as typical of industry as a whole.

Most of the trade union representatives who appeared before the Congress committee on automation in 1955 expressed their concern lest automation should lead to unemployment but few of them produced any figures in support of their argument. The chairman of the union of electrical technicians remarked that a number of people whom he called 'Pollyanna optimists' had appeared before the commission and had spoken about the huge expansion of the electrical manufacturing industry without supporting their statements with actual statistics:

> '. . . They have preferred to hide behind generalities and sales promotion clichés. Let's look at the facts.
>
> From 1947 through the first half of 1955, the output of goods in the electrical manufacturing industry, as a whole, soared 87 per cent. But the total number of wage and salary employees in this industry rose only 20 per cent in that period. In other words, production rose more than four time faster than total employment.
>
> How was this astonishing feat accomplished?—through rapid improvements in routine mechanization and the early introduction of automation within the industry.'[2]

Later the same witness (J. B. Carey) declared that it was only in the last two or three years that automation had really gained a foothold in the electrical manufacturing industry.

[1] *Economic Report . . .*, 1956, pp. 188, 194. We are faced once again with the inadequacy of the official statistics to which attention has already been drawn. See the admission of the Director of the U.S. Census that no statistical information is available from which it would be possible to estimate either the extent to which automation has been adopted in various branches of industry or the rate of progress of automation (*Hearings*, p. 91).

[2] *Hearings*, p. 222 (J. B. Carey). This witness added that in eight years the number of 'production workers' in the electrical manufacturing industry had increased by only 14 per cent. Output had expanded six times more quickly than the number of 'production workers'. On the other hand the number of workers not *directly* engaged in production (engineers, scientists, salesmen, etc.) had increased by 46 per cent in the same period (*Hearings*, p. 223).

Consequently, although productivity had made astonishing strides since 1947, this is hardly relevant to the problem which we are considering.

On the other hand the statistics for the period covering 'the introduction of automation'—i.e. 1953, 1954, and the first six months of 1955—are of real significance:

> 'In the electrical manufacturing industry as a whole, the total number of wage and salary employees declined 9 per cent between 1953 and the first half of 1955. Even more significant is the 13 per cent decline in production-worker employment, in that period, while the number of non-production employees increased only 1 per cent.
>
> The beginnings of automation in the electrical manufacturing industry, have helped to cut the employment of production workers, while the employment of professional and clerical employees has moved up slightly. But the spread of automation in the offices will cut the manpower requirements for clerical operations within the next few years.'[1]

Statistics of employment and productivity in various branches of the *electrical manufacturing industry* bear out the same general conclusion. An extreme case is that branch of the industry which manufactures 'communication equipment' (i.e. wireless, television, radar, etc.). Here there has been a decline of 11 per cent in the total labour force, a decline of 16 per cent in the 'production workers' and an increase of 3 per cent in the 'non-production workers'.[2] In the electro-technical industry automation has been rapidly introduced in the period under review. In the circumstances it would not be unreasonable to argue that these recent changes in the pattern of the labour force have probably been largely caused by automation.

The views of Walter Reuther on this problem are of some importance. He is chairman both of the trade union of *motor vehicle* workers and of the Congress of Industrial Organisations. He believes that automation causes technological unemployment and the evidence that he brings forward to support this point of view cannot be ignored.[3] He told the Congress commission on automation that—in view of the forthcoming growth of the available labour force and in view of future technical progress

[1] *Hearings*, p. 224 (J. B. Carey).
[2] *Hearings*, p. 225 (J. B. Carey).
[3] *Hearings*, pp. 97-149 (W. Reuther).

—about 4,000,000 new jobs would have to be filled *every year* in the next five years. But, under cross-examination, he admitted that the workers who had become redundant owing to the introduction of automation into certain branches of the motor vehicle industry had been found new jobs by their own firms. Nowhere in his evidence is there any proof (based upon statistics) that automation has so far led to technological unemployment in the motor vehicle industry.[1]

The American *chemical industry* has for years been a pioneer in the adoption of automation. Detailed employment statistics for this branch of manufacture are available. They show that between 1947 and the middle of 1955 production increased every year (on the average) by 7 per cent although the total number of 'production workers' remained virtually constant.[2] On the other hand the number of 'non-production' employees rose by more than 50 per cent in the period under review.[3]

Telephones. The 'Bell System' telephone companies in the United States had a staff of over 600,000 in August 1955. Representatives of their trade unions have no difficulty in showing that since the 1930's the increase in the number of persons employed by the telephone companies has been much less than the expansion of the business. They have to admit, however, that although the services of most of the telephone operators were replaced by automatic exchanges between about 1940 and 1950, nevertheless the total number of jobs in the industry practically doubled in that period.[4] Mr Beirne has had to bolster up his warnings about redundancy by resorting to forecasts of future developments.

[1]*Hearings*, p. 129 and p. 146 (W. Reuther). In October 1955, when the Congress commission was conducting its enquiry, the production of the American automobile industry achieved a record. An output at the rate of nearly 8,000,000 motor vehicles a year was attained. Since that date output has declined to the more normal rate of 6,500,000 motor vehicles a year. At the time of writing (February 1956) there are 65,000 unemployed in the industry. It is not yet possible to say if this is merely a temporary decline from the high level of output reached in the autumn of 1955 or if it represents a permanent change in the general trend of production. Nevertheless it seems that it may not be so easy in the future—as it has been in the past—for the motor vehicle industry to absorb its own workers who become redundant owing either to automation or to 'normal' technical progress.

[2]An increase of 1.3 per cent occurred in eight years.

[3]*Hearings*, p. 153 (O. Pragan, Director of research and training in the trade union of chemical workers). The total number of workers in this industry rose from 694,000 to 791,000 but of the additional 100,000 employees only 7,000 were 'production workers'.

[4]*Hearings*, p. 340 (J. A. Beirne, chairman of the telephonists' trade union).

He 'projects' the number of jobs 'lost' between the boom-year 1953 and the recession year 1954 (i.e. 1.6 per cent) into the next decade and in this way he attempts to justify the view that—in view of the technical improvements which have been planned—the staff of the companies operating the 'Bell System' will be reduced by 200,000 by 1965.[1]

Railways. There have been substantial staff reductions on the American railways since the end of the second World War. Including short-time working and enforced extensions of holidays employment in this industry has declined by more than one third—from 1,600,000 to 1,060,000—during the last eight years. But only a very small part of this reduction in staff can be ascribed to automation. As an example of jobs lost by automation mention may be made of the automatic coupling together of goods waggons in marshalling yards which has led to some reduction in employment.[2] The factor of real importance in cutting down staff on the railways in the United States has been the complete overhaul of the entire railway system since 1946. In the last ten years rationalisation and technical improvements in the railways have been introduced at a capital cost of no less than ten milliard dollars.[3]

We propose to give some now more examples—in addition to those already mentioned in the first part of this book—of loss of jobs due to automation.

(i) 'X of the Bureau of Labour Statistics said that the new electronic computers had eliminated many jobs and that those hardest hit were young women in routine clerical work.'[4]

(ii) 'Charles R. Walker, director of technology, and industrial research at the Yale University, said . . . a recently automated steel plant was producing four times as much steel pipe with one-third the number of men previously employed.'[5]

(iii) 'Even for technicians automation will bring some jolts. With robots giving orders to other robots and telling one another when they are wrong, the most skilled workers are likely to find themselves made superfluous by machines unless they have the adaptability

[1]*Hearings*, p. 340 *et seq.* (J. A. Beirne).
[2]*Hearings*, p. 471 (W. P. Kennedy, chairman of the railwaymen's union).
[3]See above, p. 155.
[4]*Hearings*, p. 456 (W. P. Kennedy).
[5]Report of conference of the society of Applied Anthropology on 'Men and Automation' held at Yale University, Dec. 28 and Dec. 29, 1955 (In *N.Y.T.*, Dec. 28 and Dec. 29, 1955).

to move to other and radically different assignments . . . for instance, automatic testing equipment was designed recently to check the reliability of military electronic devices. One girl with no technical training is able to run the new equipment. It took seven technicians with a high degree of specialization and fourteen semi-skilled workers to do the same testing job before.'[1]

(iv) 'Starting in August, officials of the Treasury disbursing office, which writes the Government checks, will press a button to start new equipment that will automatically verify for payment, "remember", and later tally 225,000 checks each day. By June, 1957, the machine will handle the million checks Uncle Sam writes each day. Savings: At least $2,225,000 a year initially, with bigger economies later. Some 300 workers will be able to do a job that now requires 750.'[2]

(v) 'The Treasury Department's Bureau of Public Debt . . . has slashed its work force from over 9,000 in 1946 to a present 3,100. The explanation: Use of machines to streamline paper work . . . they're considering the installation of an electronic data-processing machine that . . . will "remember" the names of holders of Government bonds, automatically issue interest checks and indicate when bonds have reached maturity'.[3]

(vi) A recently-published doctoral dissertation from the University of Chicago

'. . . revealed that in 12 cases of automation ranging from chocolate refining to railroad traffic control the reduction in employee requirements ranged from 13 to 92 per cent with an average reduction in employment of 63.4 per cent. . . .'[4]

(vii) 'Chicago's Commonwealth Edison [an electric power company] has started billing its 1·8 million customers with an electronic computing system, manned by 270 people, that does in two days what a few months ago took nearly 500 clerks a full week.'[5]

(viii) 'An [oil] industry spokesman says that a refinery that employs eight hundred people without modern instrumentation could do the same job with twelve people if instrumentation were utilized to the fullest possible extent.'[6]

[1] *N.Y.T.*, April 8, 1955. The report adds that all these employees have been found jobs in the same factory. This is in accordance with the declared policy of big American firms.

[2] *W.J.*, Feb. 17, 1956. [3] *W.J.*, Feb. 17, 1956.

[4] *Hearings*, p. 34. These twelve cases are obviously not necessarily representative. The average figure of 63.4 per cent should be applied to industry as a whole. See also D. G. Osborn, *Geographical Features of the Automation of Industry* (Chicago, 1953). Other enquiries come to the conclusion that compensatory factors are usually of importance. See e.g. J. W. Wright's remarks in *H.B.R.*, Nov.-Dec. 1955, p. 28: '. . . in 12 out of 13 of the particular plants I have studied, the number of people employed today is higher than it was prior to automation'.

[5] *N.W.*, Dec. 12, 1955, p. 38.

[6] R. Bendiner, 'The Age of the Thinking Robot and what it means to us', in *The Reporter*, April 7, 1955, p. 14.

(ix) It is stated that a well-known insurance company (the Prudential) 'is counting on its electronic computer to replace sixty to seventy-five other machines along with their operators—two hundred in one department alone.'[1]

(x) A savings bank in Philadelphia has installed an electronic machine which in 33 hours calculates the annual interest due to 290,000 clients. Formerly this task was performed by a large staff equipped with conventional office equipment, and it took three weeks to complete.[2]

(xi) The Stuttgart municipal savings bank has already installed several electronic computers. The bank reports:

> 'Whereas formerly several dozen clerks worked for over three months at the end of one year and the beginning of the next to complete the accounts the machine now does this work in 80 hours. . . . Another task formerly done by 13 clerks working all day is now performed in only one hour. . . .'
>
> 'When money is deposited in respect of a loan account the machine records in one operation (i) how much has been paid in, (ii) the interest on the account to date, (iii) the balance of the account. The machine records any failure to make regular payments and it automatically closes the account when the last payment has been made.'
>
> 'There was no reduction in the staff but virtually no new appointments have been made since automation was introduced two years ago although there has been a substantial increase in the work of the savings bank.'[3]
>
> (xii) 'The Alliance Insurance Company of Munich installed the largest "giant brain" in Europe early in March 1956. It was purchased in the United States and sent to Germany by air. This Magnet Computer is the first of its kind to be put to practical use. . . . This machine takes only 150 hours to perform calculations which take 25 men a whole year to do. With the aid of conventional office machines the task would take more than 1,000 hours to perform.'[4]

(xiii) An expert of the Stanford Research Institute reported on an enquiry which indicated '. . . that production of 4,000 assemblies per day would require about 200 employees if automatic techniques were used as compared with nearly 1,800 if conventional techniques were used. It must be recognised that these findings were based on consideration of only one electronic assembly—a six-tube, high-reliability piece of equipment.'[5]

[1] *The Reporter*, April 7, 1955, p. 14. [2] *W.J.*, June 17, 1953.
[3] *Welt der Arbeit*, February 10, 1956.
[4] *Rhein-Neckar-Zeitung* (Heidelberg), March 8, 1956. [5] *Hearings*, p. 228.

(xiv) It is reported that an electronically and hydraulically-controlled machine weighing 225 tons can lay down runways at aerodromes in only a fraction of the time required by conventional methods of construction. In 3¼ hours it can perform a complicated mechanical job which normally takes 60 hours. It is fitted with panels which have 60 different controls and are operated by two push-buttons. Its mechanical grabs can handle 250 cubic inches of metal in a minute.[1]

(xv) A wholesale firm which supplies 560 shops

'. . . has ordered 2 medium-sized electronic "brains" for two of its warehouses. They will:
Turn out a daily inventory in 50 minutes—a job now taking 1 person 40 hours;
Take a complete book-keeping inventory in 30 minutes, against 240 man-hours now required;
Notify buyers automatically when warehouse stocks of any product have run out;
Type out purchase order automatically when stocks of any item reach a minimum re-ordering level;
Tell warehouse personnel exactly where they can find any product, and how much of it is there;
Carry out billing sales analysis and general accounting functions.
The machine is described by its developer as a "high-speed idiot", but if it makes an error it is able to discover the slip itself through a series of self-checking devices.'[2]

(xvi) The following extract is from a report on an exhibition of machinery in Chicago:

'In terms of the acceleration in production and the decreasing need for labour, some of the results achieved in Chicago were truly staggering; one automatic hardness-testing machine examined parts at the rate of 1,200 an hour as compared with a rate of some 200 to 400 an hour achieved by a skilled human inspector.'[3]

(xvii) It is stated that 'even a telegraphist can be replaced by a machine. A new electronic device . . . can automatically type messages which have been received by radio in the international morse code. . . . The operation of the machine is automatically adjusted if there is any change in the speed at which the radio message (in morse) is received.'[4]

The following example shows what can happen to the staff

[1] *N.Y.T.*, June 16, 1955.
[2] *Hearings*, p. 116 (citing *W.J.*, April 1955).
[3] *Economist*, Sept. 17, 1955, p. 947.
[4] *N.Y.T.*, Jan. 9, 1956.

in a plant engaged in an industry in which there is full employment. One is bound to conclude that automation is the cause of what happened. A motor vehicle plant cancelled its contract with a firm which had formerly supplied it with certain motor vehicle components. The reason given for this decision was that a new automatic plant could supply these components more cheaply. The 'redundant' firm closed down its workshops in Detroit and moved to New Jersey where it manufactured different articles:

> 'The Detroit plant is down, the buildings and machinery are for sale, and the five thousand employees at this plant started looking for jobs last summer. . . . The younger workers gained employment far more easily than the old. Racial and sexual discrimination appear to be less important in this instance than discrimination on the basis of age. . . .
>
> One woman, 49, with 25 years senioirty . . . looked for work, found none, exhausted her unemployment compensation, and now spends her time around the home. She is no longer even listed as unemployed. Automation in her case meant her involuntary retirement from the Detroit labor force at a time when younger women were being hired in auto plants.
>
> Two negroes, one 33 and one 55, attempted to find jobs at the same shops. The 33-year-old found work at a Chrysler plant after six months of job hunting, was again laid off and found another job at a different Chrysler plant within a week. The 55-year-old, however, stated he had been told, "We're not hiring" at both of these plants, at the same time his 33-year-old friend was hired. The 55-year-old finally got a job the other day after 11 months of unemployment. He is a sweeper at 15 cents an hour less than he used to receive at Murray as a packer-crater. He is on the night shift where formerly he was on the day shift. He lost his pensions rights and other benefits. His 12 years of Murray Body seniority are gone—he is a probationary employee at the new plant.
>
> A 52-year-old die-setter and a 62-year-old mill-wright told much the same stories except that neither of them had found jobs when they were interviewed two months ago.'[1]

This example confirms previous experience of the fact that, at a time of full employment, it is the older workers who are the first to suffer from technological unemployment.

Compensation for Redundant Workers

Employers in the United States do not deny that automation

[1]J. A. Stern, *Possible Effects of Automation on Older Workers* (lecture held at the University of Michigan, Ann Arbor, June 28, 1955) (mimeographed).

—like any other form of technical progress in industry—leads to unemployment. They have clearly admitted that

> 'It would be idle to contend that automation will not bring about . . . tremendous changes in our manufacturing practices, just as the development of ingenious mechanical devices to do the farmer's work brought about, and is still bringing about, enormous changes in many aspects of agriculture. The enormous increase in the efficiency of our farmers has meant that we can get along with fewer farmers than we used to have.'[1]

M. G. Munce, who made this statement in evidence before the Congress enquiry into automation, was representing the National Association of Manufacturers. It is not without significance that the representative of an organisation which has strongly condemned those who take a gloomy view of the social consequences of automation here implicitly admits that automation has effects upon industry similar to those which mechanisation is having upon agriculture. No one can reasonably doubt that in the long run it is an excellent thing that so much of the drudgery has been taken out of agriculture and that the American farmer has been able to produce ever-increasing quantities of foodstuffs and raw materials. Nevertheless in the 'free' economy of the United States this vast increase in farming output has not been an unmixed blessing. There has been chronic 'over-production' with the result that—except during the second World War—American agriculture has suffered a long-drawn-out crisis. But we are concerned for the moment with the redundancy caused in American agriculture by technical improvements. The number of persons gainfully employed in agriculture in the United States has declined from 10,300,000 to 6,700,000 in the last twenty-five years. In 1930 those gainfully employed in agriculture were about one fifth of the total American labour force. In 1955, however, those gainfully employed in agriculture were less than one tenth of the total labour force. And many of those who still earn their living on the land are able to do so only because the United States government pours milliards of dollars into American agriculture every year.[2] In 1955, a boom year for industry, the state of American agriculture was far from satisfactory.

[1] *Hearings*, p. 400 (statement by M. G. Munce).

[2] The employment statistics for American agriculture are taken from *Economic Report* . . . 1956, p. 182. Between the middle of 1952 and the middle of 1955 the value of agricultural products purchased by the United States government in an effort to

The fact that technical improvements in American farming has led to a sharp decline in the agricultural labour force is, of course, no proof that automation in industry would necessarily have the same result. The supporters of the 'compensation theory' have not been slow to draw attention to the fact that the redundant farm workers in the United States have apparently found little difficulty in securing new jobs—indeed often better-paid jobs—in the towns.

The census returns show that fewer people were employed on American farms and in American households in 1950 than in 1940:

> 'Much of the work formerly done manually in these places is now done more efficiently by machinery either in shops or on the farm or in the home. Where did the farm and household workers go? If they did not drop out of the labor force, they probably went into the industries where employment was expanding.'[1]

The Congress committee which investigated the problem of automation in 1955 heard evidence from one manufacturer after another who stated that although some workers had been rendered redundant in certain departments of their factories, owing to the introduction of automation, these employees had not been dismissed but had been found jobs in other departments. Indeed the Congress committee was frequently told by such witnesses that there had been a net *increase* in the size of their staffs after automatic machinery had been installed.

Dr Cledo Brunetti, who is a recognised American expert on automation, told the Congress committee:

> I believe that automation will add 15 million new jobs in the next 10 years. Perhaps you may want a word of explanation, and if you do, I will be glad to give it to you later. I would like to go on and make my final point: We do have times when machines go into plants and there has to be a relocation of workers. We do have these problems. We do have temporary setbacks in labour, number of jobs. We know that. We have got to face that squarely and try to do something about it.
>
> Now, industry is keenly aware of its responsibility in the integration of machines and men. Now personnel and industrial relation leaders are not standing still and letting somebody else do this,

maintain farm prices rose from 1.2 milliard dollars to 6 milliard dollars. See *Economic Report*... 1956, p. 55. Between the middle of 1952 and the middle of 1955 the expenditure of the United States Ministry of Agriculture—which consists largely of subsidies to farmers—amounted to 915 milliard dollars. See *Stat. Abstr.* 1955, p. 350.

[1] *Hearings*, p. 80.

but are alert to the problem, and forward-looking industries are now developing programmes to retrain their personnel in advance of any new step introducing a machine with labour-displacing potential. In fact, this has been going on for a long time, because labour costs money to hire and train, and every company has a certain amount of money invested in each worker, and no manager wants purposely to see his workers leave the company.

Now, I thought you might be interested, and I think we can tell it best by our own programme: General Mills has been carrying on a retraining programme for many years. We have continually introduced new and better machinery whenever it was available. New machines at General Mills have meant only reassignment of affected people to other tasks. Frequently they have gone to higher paying jobs. We have found it necessary to lay off people in the past but it has never been due to a new machine. It has been due entirely to the market.[1]

The complexity of the problem may be gathered by a statement made before the Congress committee by one of the directors of the Ford Motor Company.

'We have found that, where applicable, automation has supplanted heavy, dangerous, and unpleasant work, with easier, more pleasant, and more interesting work. Moreover, the number of skilled higher-paying jobs has increased substantially, in both relative and absolute terms. Finally, and this is of prime importance, these jobs became safer for our employees. . . . On the cylinder block machining operations, which were most significantly affected by automation, the frequency of accidents decreased 60 per cent from 1950. In addition, automation inevitably brings vast new work opportunities to those who are willing to work and learn.

Very frankly, we cannot trace in precise detail the extent to which and manner in which automation and other measures to improve efficiency have affected our overall employment figures. Employment volume is affected by a large number of factors, including, among others, product improvements, changes in product mix, and a myriad of make-or-buy decisions on components. The fact is, however, that Ford Motor Co.'s non-defense employment has increased, not decreased. During 1954, total man-hours worked were 14 per cent greater than in 1950, an increase greater than the increase in our unit production. Our non-defense employment continues to be higher than in 1950.'[2]

The available evidence of redundancy due to automation is contradictory. On the one hand we have quoted many instances

[1] *Hearings*, p. 384. See also C. Brunetti, *The Meaning of Automation* (Minneapolis, 1955).

[2] *Hearings*, p. 57.

of workers losing their jobs when automatic machines or devices are introduced. On the other hand we have seen that many employers told the Congress committee in 1955 that their own experience suggested that automation does not lead to unemployment and that their staffs have increased rather than decreased.

Criticism of Fairless's Denial that Automation causes Redundancy

The 'optimists' who denounce as 'shameless propaganda' and 'a miserable swindle' any attempt to warn the world that automation leads to technological unemployment use statistics to support their case. The views of a leading American industrialist—author of the choice expressions we have just quoted—deserve detailed examination because both his arguments and his conclusions have frequently been quoted with approval in the United States. Benjamin F. Fairless, the chairman of the board of directors of the United States Steel Corporation, declared:

> 'So automation has become a menacing word—a kind of modern bogey-man with which to frighten our people. . . . There is nothing new about automation except the word itself. . . . Suppose we think for a moment of the three outstanding examples of automation that we have seen in our lifetime. . . .'[1]

Mr Fairless gave three examples. First, despite the introduction of automatic exchanges the number of persons employed by the telephone companies had increased by 79 per cent between 1940 and 1952. Secondly, despite the introduction of 'amazing electronic brains' into offices in the United States the employment of book-keeping clerks had increased by 71 per cent between 1940 and 1950. Thirdly, employment in the American motor car industry had doubled in 14 years. Mr Fairless then turned his attention to those sections of the economy—such as agriculture and mining—in which the labour force had declined:

> 'Now where are these men to go? Has automation made it tougher for them than it used to be? Let's . . . see for ourselves just what really has happened in the last fifteen years or so—say from 1939 through 1953. Well, here are the facts:
>
> 'During this period the population of the United States has increased 22 per cent. But the total number of jobs has grown by 35 per cent. . . . And in the field of manufacturing itself—where automation has advanced most rapidly—employment has gone up

[1] B. F. Fairless, *Our One Indispensable Weapon* (a talk at the annual dinner of the Greater Johnstown Chamber of Commerce, February 11, 1955), p. 5 *et seq.*

73 per cent, or more than three times as fast as the population.

'The record clearly shows, moreover, that this rapid increase in employment has occurred chiefly because of mechanisation—*not in spite of it*!'[1]

Apart from the obvious danger of drawing conclusions from overall statistics covering the whole country over a lengthy period of time, there are four reasons for rejecting Mr Fairless's 'proofs' which are alleged to be based upon population and occupation statistics:

Fairless equates 'automation' with 'mechanisation' and so misses the whole significance of the unique features of automation. Secondly, his argument is based on the U.S. census returns of 1940 and 1950 but—except for the oil and chemical industries—the really important advances in automation have occurred since the year 1950. Only two or one electronic computers had been installed in private offices in 1950—a fact which invalidates Fairless's argument concerning the book-keepers and the 'electronic brains'. Thirdly, it must be remembered that the period 1939-49 was one of post-war reconstruction, and that since 1950 the American economy has been dominated by the rearmament drive. A large sector of American industry has completed important armament orders in recent years. Consequently it is obviously inaccurate to ascribe the increase in the American labour force in the years 1939-53 simply to technical progress. Fourthly, a comparison between the growth of the labour force in industry and the growth of population between 1939 and 1953 is almost valueless because the first year of this period (1939) was largely still dominated by the economic world depression and 9,500,000 people were out of work (excluding those on short time). On the other hand the period closed with a boom year in which—as will be explained later—industrial output in the United States was artificially fostered in every way possible. On the other hand if we compare the years 1946 and 1955—and economic conditions in those years were sufficiently similar to make a reasonable comparison—a very different picture from that given by Fairless emerges. In this period, following immediately after the end of the second World War, the number of persons gainfully employed in industry grew—not quicker but—more slowly (14.5 per cent) than the

[1]Benjamin F. Fairless, *op. cit.*, p. 8 (italics supplied).

growth of the population (17 per cent). In the same period (1946-55) the number of persons employed in agriculture—the other important sector of the economy in which rapid technical progress was being made—declined by about 50 per cent.[1]

If, despite all these difficulties, an attempt is made to use census statistics to throw light upon the consequences of automation in the post-war period we find that the actual situation is quite different from that depicted by Fairless. Contrary to the impression left by his analysis of the statistics the fact is that in the nine years 1946-55 the number of new jobs in industry increased at a less rapid rate—not at a more rapid rate—than the increase in population. And industry did not absorb the workers in agriculture, transport and mining who became redundant. Industrial share of the civilian 'labour force' (with similar unemployment figures for 1946 and 1955) remained much the same throughout the period 1946-55 (25 per cent).[2] Owing to the complexity of the problem it may be doubted whether population statistics can throw much light on the influence of unemployment upon the labour market. But the statistics certainly cannot be used to bolster up Fairless's contention that automation leads to a net increase in the number of jobs available in industry.

Criticism of Drucker's Forecast of a Labour Shortage in the U.S.A.

There is another statistical 'proof' that automation does not lead to technological unemployment which deserves examination. Automation, it is said, far from causing redundancy actually creates employment.

During the American Congressional enquiry, one witness stated:

> '. . . automation . . . may be a lifesaver at this particular time in our history when we are finding a more rapid relative increase in total population over the next decade than in the work force. . . . Automation in every conceivable direction, from blue print to the shipping

[1]For these statistics see *Economic Report* . . . 1956, p. 182 and p. 188.

[2]It is notorious that for many years private and public offices and the 'service industries' have been responsible for the greater part of the increase in the total number of jobs in American industry. It is very probable that, owing to the introduction of automatic devices in offices, these industries will not in the future be able to provide as many new vacancies as has been possible in the past.

> dock, is the only answer to this situation . . . we desperately need automation to maintain our standard of living with the onrush of our population.'[1]

Ralph J. Cordiner, the president of the biggest firm in the American electrical manufacturing industry (General Electric) has announced that—in view of the shortage of labour of all kinds to be expected in the next ten years—his concern will have to double its output in that period with only an 11 per cent increase in its staff. He added that the United States as a whole

> '. . . will require about 40 per cent more goods and services by 1965, with only 14 per cent more people in the labour force. To produce 40 per cent more goods and services with only 14 per cent more people, either everyone must work harder and longer, which is neither a realistic nor a good solution, or industry must be encouraged to invest in more productive machinery and methods. Faster progress in the newer field of automation seems to us to be the only available solution to this problem, particularly in situations where we have exhausted the known economic possibilities in the more familiar field of simple mechanisation.
>
> 'From all that we can foresee, it appears that there will be a shortage of men and women to fill the work opportunities in the coming decade.'[2]

These arguments are based upon statistical projections and estimates which were made by Peter F. Drucker. They appeared in the well-known American monthly, *Harper's Magazine*, in March 1955.[3] Drucker's views have been echoed in many articles and speeches and were put forward by several representatives of industry who appeared before the Congress commission on automation.

How does Drucker justify a point of view so diametrically opposed to our own? His argument runs as follows:

> 'We start with a paradox: there are going to be more people, *and hence more jobs*, but not more people to fill the jobs. It is more than possible, in fact, that a continuing feature of the next two decades

[1] *Hearings*, p. 202 and p. 204 (evidence of R. C. Tait, president of Stromberg-Carlson Division of General Dynamics Corporation).

[2] *Hearings*, p. 427 and *Automation—Friend or Foe?* (General Electric, New York, 1955). A few months later Mr Cordiner admitted, in a speech on March 5th 1956, that his estimates might have to be revised. See below, p. 187.

[3] P. F. Drucker, 'America's Next Twenty Years, I. The Coming Labour Shortage' in *Harper's Magazine*, March 1955. We quote from the pamphlet in which all three of Drucker's articles on 'America's Next Twenty Years' are reprinted.

will be a labour shortage—and that the basic problem of the period will not be unemployment but inflation.'[1]

According to Drucker's statistical projections the total population of the United States will increase from about 162 millions in 1954 to over 190 millions in 1956. But owing to the relatively low birth rate in the 1930's the age group between 20 and 65 will grow by only seven millions. On the other hand at the end of the period there will be 6,000,000 more people over 65 and at least 16 millions under 20. Drucker considers, however, that the seven millions between 20 and 65 will not all be added to the industrial labour force. He thinks that 3,000,000 of the younger people in the age group 20 to 65 will be absorbed by the Universities. This is partly because of the general social trend towards high standards of education and partly because increased automation will demand the services of more and more highly qualified employees.[2]

Drucker argues that, assuming his forecast of population trends in the United States to be correct, the total additional labour force available in the next ten years will be only about 4,000,000 —i.e. 6 per cent of the labour force today.[3] So modest an expansion of the American labour force would obviously be insufficient to provide a population which has grown by 30 millions with the goods and services required not only to maintain the existing standard of living but to improve it to the extent that might be expected in the light of developments in the last twenty-five years. Drucker estimates that, on the average,

> 'a company that intends to maintain its competitive position in its own industry will have to be able, ten years from now, to produce two-fifths more than it does today without much, if any, increase in its hours worked.'[4]

Moreover, according to Drucker, the modest expansion of the population of working age in the United States will be reduced because

> '. . . total hours worked will continue to decline as a result of longer vacations, more holidays, and a shorter workweek.'[5]

[1] P. F. Drucker, *op. cit.*, p. 2 (italics supplied).

[2] P. F. Drucker, *op. cit.* We are concerned here only with Drucker's estimates for the next decade (1955-65).

[3] Drucker's forecast of population growth is less than half as great as the estimate made in the General Electric Co.'s pamphlet, *Automation—Friend or Foe?* (New York, 1955).

[4] P. F. Drucker, *op. cit.*, p. 4.

[5] P. F. Drucker, *op. cit.*, p. 3.

This means—Drucker goes on to argue—that in the next ten years the productivity of the industrial worker in the United States will have to be increased by at least 40 per cent so as to bridge the gap caused by lack of a sufficiently large labour force. This increase in productivity will have to be secured by more automation, by a thorough rationalisation of the entire economy and above all by an increased division of labour. Only such a policy, ruthlessly pursued, could shield the United States from

> '. . . the population revolution [which] . . . will prove a strain, a burden, and perhaps even a threat to social and economic stability.'[1]

We hope to have no difficulty in showing that Drucker's views are erroneous.[2] His initial argument is wrong. Even in the United States a rapid increase in population does not necessarily mean that there will be an equivalent increase in the available jobs. Such an argument arbitrarily assumes that the 'demand' for goods brought about by an increase in population is accompanied by the necessary increase in purchasing power. Where would this additional purchasing power come from? It could come only from increased productivity from existing jobs or from the productivity of newly created jobs. If the expansion in output comes from new jobs then new jobs must exist—and Drucker has argued that they will not exist—as an essential preliminary to the creation of additional purchasing power. History teaches us that a 'demand' for additional goods is effective only if accompanied by additional purchasing power.

Drucker's theory is based upon a paradox. He argues that in the next ten years the ever-growing population of the United States can be supplied with an 'adequate' quantity of goods and services only if output per head is increased. Is it really true that the expanded labour force of the future will be incapable of meeting this demand only if productivity is greatly increased? Is it really ture that this means that there is no danger of technological unemployment in the United States in the next ten years?

In reply to Drucker we may draw attention to a forecast of

[1]P. F. Drucker, *op. cit.*, p. 6.

[2]See *Hearings*, p. 623 (note i) for a warning by Edwin G. Nourse against too readily accepting the optimistic views of the so-called 'faith healers' who argue that the dangers facing the American economy in the future will be overcome in the natural course of events by the growth of population.

the growth of the American population which was made by the Bureau of the Census in 1952. Events have already confirmed the accuracy of this forecast.

BUREAU OF CENSUS FORECAST 1955-1965[1]

	1955 (millions)	1965 (millions)	Percentage Increase
(i) Total Population	165·2	189·8	14·3%
(ii) Population of Working Age (14 and over)	118·8	137·2	15·5%
(iii) Labour Force	68	78·1	15%
Labour Force as a percentage of Population of Working Age	57%	56·7%	

This forecast of the American Bureau of the Census—based like Drucker's forecast upon a mathematical projection—does not suggest that there is any danger of the United States having to face a labour shortage in the immediate future. On the contrary the official forecast suggests that there will be a rather more rapid percentage expansion of (i) the population of working age, and (ii) the labour force, than of the total population. If output per head were to increase in the same proportion there would obviously be a danger of technological unemployment.

It is, however, possible that the forecast of the Bureau of the Census does not take sufficient account of future changes in the structure of the population of the United States. This official estimate probably underestimates—while Drucker probably overestimates—the reduction in the labour force that may reasonably be anticipated in view of the probable tendency of young people to study longer at Universities and technical colleges. This possible error in the official forecast, however, in no way increases the reliability of Drucker's estimates. In fact Drucker wholly ignores the high degree of elasticity of the

[1]*Labour Force* (U.S. Department of Commerce, Bureau of the Census: Current Population Reports) (Washington, D.C.), December 10, 1952.

labour force. Moreover he confines his attention to the age-groups between 20 and 65 years of age. At the time of the most recent census in the United States (1950) 8,100,000 persons were gainfully employed in the age-group from 14 to 50 and in the age-group over 65. Indeed about 13 per cent of the total labour force fell within those two age-groups. There is another factor in the situation which may compensate for the underestimation—in the official forecast—of the reduction in the labour force due to the increased student population. As automation becomes more common it will probably be found that some experienced workers in the higher age-groups will be employed on such responsible tasks as supervising automatic processes. Moreover, once the difficulties of transition have been overcome, there may be new jobs for elderly workers in automatic factories:

> 'In some respects, however, automation changes job content in a manner which may make the older worker a more desirable job candidate than a younger worker. Characteristically, an automated job is one on which physical effort has been eliminated or greatly reduced. . . . The operator is a machine attendant, or watchman or caretaker. His responsibility is greatly increased as the amount of machinery under his control is much larger than formerly. . . . The decreased physical effort and increased responsibility on most automated jobs make the mature, responsible, reliable worker a better choice in many instances than the husky adolescent.'[1]

Drucker can also be criticised for comparing the growth of the population and of the labour force in absolute figures. One might well be impressed by the statement that in ten years time the total population of the United States will have increased by about 30,000,000 while the labour force will have increased by only 7,000,000 (probably 10,000,000 in fact). A crude comparison of this sort ignores the fact that the output of workers of different age-groups varies considerably. It also ignores the fact that in order to maintain output at a proper level to maintain a growing population it is necessary for the *ratio of expansion* of total population and labour force to remain constant. The effect obtained by contrasting by an increase of 30,000,000 in the population as compared with only 7,000,000 (or 10,000,000) in the labour force is somewhat reduced when it is realised that a false assumption has been made. Drucker is really assuming that a new

[1]James Stern, *op. cit.*

producer is necessary for every new consumer. In fact, since the dawn of history the output of every individual producer has been increasing.

We have seen that Drucker argues that it will be necessary for the gross national product to increase by 40 per cent in the next ten years if the traditional American standard of living is to be maintained. It may be remarked that Drucker himself appreciates the difficulty of measuring output:

> 'Despite all the emphasis we have given to productivity in recent years, we really know very little about it—and we certainly do not know how to measure it.'[1]

There are serious difficulties in measuring not only 'productivity' but also a 'traditional' or 'adequate' standard of living. The latter is estimated by dividing the sum total of available goods and services by the population which gives us the 'standard of living per head of population'. But such an estimate gives us only a high problematic 'standard of living' since its present level and future improvement include a vast expenditure on armaments.[2]

Even if it were accepted that an increase of 40 per cent in the gross national output in the next ten years was a desirable—even a necessary—aim it cannot be proved that the available labour force could not achieve this output. Should the average increase in output per head be no more than 2½ per cent per annum[3] it would be a relatively simple matter to secure a 40 per cent expansion in the gross national output with a labour force that had increased by 10 per cent. Owing to the advance in automation and to the coming of other improved methods of industrial production it is, however, certain that output per head will undoubtedly incresase at a more rapid rate than 2 per cent per annum. The official estimate of increased productivity is 3

[1]P. F. Drucker, *op. cit.*, p. 5.

[2]See C. W. Boyce, 'What automation means to America' in *F.M.M.*, Sept. 1955—a thoughtful article which has had a considerable influence on public opinion. By using statistical methods similar to those employed by Drucker, Boyce comes to the conclusion that in order to secure an 'adequate' improvement in the American standard of living the gross national output will have to be doubled between 1955 and 1975. He considers that in 1975 there will be a grave labour shortage (between 9,000,000 and 21,000,000 jobs not filled) unless the extension of automation greatly increases output per head.

[3]See above, p. 63.

per cent per annum.[1] If this estimate is correct and if other factors in the situation (such as the maintenance of the forty-hour week) do not change it seems clear that the services of a large part of the expanded labour force would not be needed to achieve an increase of 40 per cent in the gross national output in the next ten years. It is indeed surprising to find this point of view confirmed by one of the leading exponents of the theory that the U.S.A. is threatened by a shortage of labour:

> 'To produce 40 per cent more goods and services with only 14 per cent more people, either everyone must work harder and longer, or we must be willing to embrace change and invest more in productive machinery and methods. . . . In the past ten years, we have in fact increased our national output (measured in constant dollars) by 37 per cent, with an increase of only 13 per cent in the work force.'[2]

Thus our analysis of this aspect of Drucker's theory shows that his 'evidence' and arguments really emphasise factors in the situation which will tend to promote—not a labour shortage—but technological unemployment in the United States in the immediate future.[3]

Criticism of Compensation Theory

We have seen that the attempts to prove by statistical evidence and by 'projections' that automation will not lead to unemployment have failed. We now propose to discuss the problem—How can the contrary theory (the view that automation may well bring technological unemployment in its train) continue to be held despite the fact that no large-scale unemployment occurred

[1]It was after the appearance of Drucker's article that the American Ministry of Labour published for the first time the results of its investigations into increased productivity in the industry of the United States during the period 1939-53. At the same time the Ministry of Labour explained the principles underlying its statistical methods. This study was called *Trends in Output per Man-Hour and Man-Hours per Unit of Output—Manufacturing 1939-53.* In the period of rationalisation after the first World War average annual rate of increase had been nearly 7 per cent (*Hearings*, p. 317 and p. 319).

The Economic Department of the McGraw-Hill Company estimates that the average annual rate of increase in productivity in the U.S.A. in 1954-55 was 5 per cent (*C.E.*, Dec. 1955, p. 35). Another estimate suggests that there was a sharp increase in productivity in 1954-55 and that the increase to be expected for 1955-60 might—in view of the spread of automation—be just as sensational as the increase achieved in the 1920s (*B.W.*, Dec. 10, 1955, p. 68).

[2]R. J. Cordiner, *Long-Range Planning—New Dimension in Our Economy* (mimeographed speech of March 5, 1956), p. 9.

[3]It may be added that Drucker's statistical methods are far too crude for him to hope to secure satisfactory results.

in 1955? We must again turn our attention to the question—Why do the many cases of redundancy owing to automation not add up to substantial unemployment? Can it be that the supporters of the 'compensation theory'—whose views we criticised in the first part of this book—may be right after all?

The answer to the last question is in the negative. It will be remembered that according to the compensation theory the price-mechanism is the decisive factor in securing an automatic balance in the stability of the economy. Supporters of this theory argue that when labour is saved owing to automation, costs of production decline and hence prices fall. Other things being equal, this fall in prices increases purchasing power. The additional demand for goods—fostered by increased purchasing power—leads to the creation of new jobs. We have already criticised this theory on the grounds that it underestimates the significance of the time factor that it ignores the long delays which may occur before a 'new' demand becomes effective, and that it leaves many complicated factors in the situation out of account. For the moment, however, we are concerned only with the simple fact that—with trifling exceptions—the increase in the efficiency of labour in 1955 did *not* lead to any *fall* in prices. On the contrary there was a slight *rise* in prices.[1]

It seems that in the year 1955 the onset of technological unemployment owing to automation was warded off by the conjuncture of three compensatory factors—(i) the boom in American industry which we shall discuss below, (ii) the relatively slow speed of automation (from the point of view of its effects on the whole economy); and (iii) the efforts of big concerns to 'find' work for men who had become redundant owing to automation. The adoption of such a policy was due partly to the development of an increased sense of social responsibility among the big industrialists and partly to pressure from the trade unions.

(i) In 1955 record outputs were achieved in many important branches of the American economy. This was particularly noticeable in those branches of industry—e.g. oil, chemicals and mass-produced goods—in which automation was making most rapid progress. If the record production figures of 1955 could be regarded as being the result of 'normal' economic expansion

[1]Food prices fell: see *Economic Report* . . . 1956, p. 123.

there might be some justification for the 'compensation theory'. It might be argued that in future years, too, those rendered redundant by automation would have little difficulty in finding new jobs. But 1955 was not a year of 'normal' economic expansion. It was an abnormal boom year—which was bound to be followed by a recession—and the great business activity was due to a number of exceptional circumstances. In 1955 capital investment was running at an unusually high rate and it was artificially fostered by remissions in taxation. In 1955 there was an exceptional extension of credit—particularly to purchasers of dwelling houses and durable consumer goods;[1] a tremendous confidence (unknown since the 1920's) in the unlimited possibilities of the future; and finally the enormous public expenditure of Federal and State governments and of local authorities (76 milliard dollars or 20 per cent of the total national output). These, and other factors, led to a boom in 1955 which was inevitably followed by a recession.[2]

It is the very essence of a 'free' economy—particularly if automatic processes of manufacture are an integral feature of that economy—that overproduction in many branches of the economy should be an inevitable feature of a period of boom. There was at any rate one witness before the Congress enquiry on automation who appreciated the dangers arising from this situation. This was Edwin G. Nourse, who declared:

> 'I strongly suspect that we have already built up at many spots a productive capacity in excess of the absorptive capacity of the forthcoming market under city and country income patterns that have been provided, and employment patterns that will result from this automated operation. We are told on impressive authority that we

[1]At the end of 1954 credit to consumers in the United States had reached the high figure of 30 milliard dollars. A further six million dollars had been added by the end of 1955. See *Economic Report* . . . 1956, p. 210. In 1955 three out of every five motor cars sold in the United States were sold on credit terms. Repayment could generally be made in small instalments spread over 30 to 36 months. Considerable credit had been given by American loan banks at this time. About two thirds of these loans (repayable between 26 and 30 years) were mortgages granted to ex-service men to enable them to buy houses. The same applied to loans for which no definite arrangements for repayment were made (*op. cit.*, p. 36 *et seq.*). The official *Economic Report* mentioned various measures taken by the government to restrict the granting of too much credit.

[2]See *Economic Report* . . . 1956, p. 167 and p. 197. In the last quarter of 1955 capital was being invested in buildings and machinery (excluding the agricultural section of the economy) at the record rate of 30 milliard dollars a year.

have not been making adequate capital provision for re-equipping industry in step with the progress of technology. This is probably true if it means making full application of electronic devices and Univac controls generally throughout our industrial plant. But we have not yet demonstrated our ability to adjust the actual market of 1956-57, and later years, to the productivity of the production lines we have already modernised. They have not yet come to full production, but as they do we see incipient unemployment appearing.'[1]

Other witnesses before the Congress committee commented upon the fact that in recent years (except for the slight recession of 1954) there has been a very rapid expansion of industrial output—an expansion to some extent artificially fostered by exceptional measures. They pointed out that this boom has played an important part in making it easy for workers rendered redundant by automation to find new jobs. The leading trade unionist, Walter P. Reuther (president of the Congress of Industrial Organisations) told the Congress committee in 1955 that in the immediate future it would be urgently necessary to maintain a balance

'. . . between our growing ability to create greater and greater economic wealth . . . and . . . the ability to expand purchasing power in the hands of millions and millions of American families, so that we can maintain this dynamic expanding balance: Greater productive power, greater purchasing power, still greater productive power, still greater purchasing power, always achieving a dynamic expanding balance at higher and higher levels of economic achievement, ever higher economic plateaus. . . . We got in trouble in 1929 because there were powerful groups in America resisting the efforts needed to keep this dynamic balance. . . . Unless those pressures are offset by a stronger counterpressure, then they will do the damage in the period ahead that they did in the period before 1929.'[2]

Reuther may be wrong in accepting both the under-consumption theory of unemployment and the remedies recommended by its advocates, but he is right when he points out that there is the closest possible connection between an ever-expanding economy and the achievement of economic stability. W. S. Buckingham has aptly described 'our modern industrial economic system as being like a jet plane which cannot go slow without falling out of the sky'.[3]

[1] *Hearings*, p. 623.
[2] *Hearings*, pp. 122-3.
[3] Walter S. Buckingham, jun., in *The Challenge of Automation* (Washington, 1955), p. 35.

If there should be any decline in the rate of expansion of the American economy accompanied (as it probably would be) by a continued extension of automation,[1] then

> 'Change the level of unemployment by a few percentage points, and the problem of displacement changes from a relatively manageable question of adjustment to a social catastrophe of alarming proportions.'[2]

(ii) We suggested that a second reason why there had been no technological unemployment in 1955 owing to automation was the fact that up to the present the new process of manufacture has seriously affected only a relatively small sector of the whole American economy. It is important to remember that in the private sector of the economy automation is still only in its infancy. But all the available evidence suggests that automation will soon be very rapidly extended in the private sector of the economy. No one knows how rapid this development will be. And there are factors in the situation which may delay automation. For example, it may take years to plan and construct an automatic plant and to install all the machinery.[3] But it is known that a substantial share of the gigantic capital investment in the United States in recent years has been earmarked for automation. It is reasonable to suppose that these automatic plants—for which the money has been raised—are now being built and that they will come into operation within the next few years.[4] In those circumstances it could easily happen that the present favourable

[1]See also *Hearings*, p. 632: '. . . Technological change will continue in time of recession also, and perhaps be accelerated. . . .'

[2]G. B. Baldwin and G. P. Shultz, 'The effect of Automation on Industrial Relations' *M.L.R.*, June 1955, p. 13.

[3]'Lead time for construction and design of a modern factory is now from one and one-half to three years. This time will be extended, perhaps to five or ten years for the more complex equipment of an automatic factory, and it may be obsolescent by the time it is in production. This is perhaps the most concrete example of the need for long-range planning. . . . It also argues for building maximum versatility into the integrated production unit . . .' (*G.M.S.*, No. 178, p. 15).

[4]This point of view was also expressed by the Congress committee of 1955: 'We have certainly not yet seen the full impact of these new technologies. It may be expected, moreover, that the capital and research invested in their advancement will only begin to be felt in the years ahead. The 'lead time' of research and investment is always long. The evidence before the subcommittee suggests, therefore, the importance of public policy looking ahead 3 to 5 years or longer when the fruits of accelerated technological advancement and postwar investment begin to accumulate and compound. We don't know what all this will add up to, but we might very well be wrong to think of it as simply "more of the same" technology which has always characterized American industry' (*Report*, p. 4).

situation in the American economy—i.e. a rapid expansion of production accompanied by only a relatively slow introduction of automation—might be dramatically reversed. In that case there would be a slowing down in the rate of economic expansion —or even an absolute decline in output—accompanied by a rapid expansion in the adoption of automatic processes.

(iii) The third reason why there has been no technical unemployment in the United States in recent years is the co-operation of employers and trade unions to prevent redundancy. This policy has obviously been facilitated—one might go so far as to say that it has been made possible—by the industrial boom. But there is a paragraph in the report on automation by the Congress committee which suggests that in the United States there are not so many employers as is generally supposed who concern themselves with the future of their redundant workers.

> 'It is easy for those in business who are absorbed by cost reduction to forget that automatic production, if it means fewer and fewer jobs and a disregard of human costs and hardships, will in the end be damaging to the foundations of our free society. . . . While most industrialists . . . have demonstrated understanding of the social responsibility of free business, the sub-committee has, unfortunately, found evidence that some of those busy in advancing the technical side of labour-saving machines are still apparently unaware of the overall significance which their activities have to the economy. Government . . . is concerned with levels of unemployment, with the impact of technological changes upon our business structure, and with the maintenance of mass purchasing power. Enlightened businessmen are concerned about these things also.'[1]

That such 'indifference' has not had more serious consequences is due to the particularly favourable opportunities that exist at the moment for the absorption of redundant workers.

It is frequently reported that workers who lose a job succeed in getting another. That does not mean that the new job is always —or even generally—as good as (let alone better than) the old job. Sometimes when a redundant worker gets a 'new' job it is at the expense of a fellow-worker who has lost that job. It is said that under present circumstances the 'redundant' worker is not 'dismissed': '. . . the worker displaced is the one not hired'.[2] When applied to the introduction of automation into offices this

[1] *Report*, pp. 11-12.
[2] *B.W.*, Oct. 1, 1955, p. 99.

means that '. . . when the machines take over, the offices won't have to resort to wholesale firing—they'll simply not fill vacancies. The one who is displaced is next year's girl graduate.'[1]

The fact that women workers tend to change their jobs more frequently than men also enables automation to be introduced smoothly into American plants without the danger of mass unemployment. This is particularly evident when the firm concerned is expanding and when it has available a considerable number of jobs which do not demand a very high degree of skill.[2]

A leading trade union official, after emphasising the fact that automation is still in its very early stages, draws attention to three typical ways in which employment may be affected:[3]

'(1) Where a machine is put in and destroys jobs and job classifications, the people who lose their jobs have employment elsewhere in the same company, either under the Union contract or by the arrangements the company works out for public relations reasons:

'(2) The machinery is put in and for its operation new people have to be hired. More employees have to be added to the payroll, but the production increases tremendously, far out of proportion to the people added, and

'(3) the new machinery is put in, a substantial number of people have their jobs destroyed, and the company attempts to lay them off or fire them, especially when they've got much seniority and are along in years.'

Mr Silvey gives examples of all three cases. In the first case the firm was able to pursue a particular policy because of the existence of an expanding market. The firm found new jobs at existing wages for redundant workers but new employees had to accept lower rates of pay. In the second case the part of the plant affected by automation increased its output elevenfold by doubling the number of workers and reducing the number of shifts from three to two. The case illustrated by Silvey was one in which the

[1] *B.W.*, Oct. 1, 1955, p. 92. It is possible to adopt this policy because female labour in offices is highly mobile. When automation is to be introduced into an office no new permanent appointments are made. Only temporary clerks, typists, etc., are engaged. When the automatic machines are installed it is only the temporary staff which has to go, and the dismissal of a temporary worker is not regarded as 'redundancy'.

[2] K. G. van Auken, *The Department of Labour and Automation Research* (mimeographed lecture) (Washington, 1955), p. 10.

[3] Ted F. Silvey (National American Federation of Labour and Congress of Industrial Organisations headquarters staff), lecture on *Imperatives for Future Research* (manuscript) (Washington, 1955).

number of jobs was reduced from 32 to three. The 29 redundant workers were dismissed but their trade union succeeded in persuading the firm to re-engage them a few months later in another department at approximately similar rates of pay.

This concludes our reflections on the possibility of automation in industry leading to large-scale technological unemployment. We have attempted to indicate the complexity of the problem. We do not claim to have made a comprehensive analysis of all the issues involved. Much more research would be required before this could be done with any hope of success.

Our examination of reports available concerning the effect of automation in the United States in 1955 leads to a negative conclusion. We have found no evidence in these reports which could lead us to alter the view that we have expressed concerning the danger of mass unemployment owing to automation. In 1955 the redundant workers did find new jobs but that does not mean that their successors in later years will always be equally fortunate. If there were a slowing down or a cessation of the continued expansion of the American economy it is indeed doubtful if even the combined efforts of government, industry and organised labour could stem the flood of technological unemployment unless all three agreed to make planned and fundamental changes in the entire structure of the American economy. Today government, industry and trade unions in the United States are agreed that concerted action in pursuance of so drastic a policy is neither necessary nor desirable. We have referred to various means that have been suggested in various quarters to combat technological unemployment. They include the guaranteed annual wage, the reduction of the working week, and the raising of rates of pay in proportion to the increase in output brought about by automation. Such policies must be regarded as palliatives since they do not involve any radical planning of an economy undergoing a profound change. But the American trade unions appear to be satisfied that measures of this kind will in themselves be sufficient in the future age of automation to maintain that 'dynamic stability' between productive capacity and market demand which is needed to maintain full employment.

The Congress committee on automation had few concrete suggestions to offer as to what could be done to alleviate redundancy due to automation. After repeatedly expressing the view that 'only a relatively small—though quite perceptible—part of the labour force was likely to be directly affected' the committee went on to declare that

> '. . . increasing numbers of workers will feel the impact of automation. At the same time, large numbers of individuals in the professional and service industries . . . will not be significantly affected by added automation, however it may be defined. The same will be largely true of those in trade, finance, entertainment, government—of purchasing agents, shipping clerks, salesmen, actors, and bus drivers.'[1]

An examination of the statistical information concerning the occupations which have just been mentioned, as well as of the reports on the progress of automation in offices (whether run by public authorities or private firms) shows that this statement in the Congress report does not take us very much further in elucidating the problem under consideration.

The point of view very generally held in the United States at the present time (August 1955) is perhaps best summarised in a report on a two-day conference held at the University of Yale by the Society for Applied Anthropology to discuss 'Man and Automation'. The report stated that those who attended the conference held different views concerning automation. They were not agreed on the influence that automation was likely to have on the level of employment. Some thought that a large number of people would lose their jobs owing to automation. Others expressed the opinion that life in both offices and factories would become exceedingly dull if, as a result of automation, the operative of the future would sit watching a control panel to see if a light flashed, or would simply listen for a warning signal from the machine. At the close of the conference the representatives of management and men agreed that, in the long run, automation would be a blessing to humanity. But they expressed anxiety concerning the dislocation to the economy that would be caused by redundancy due to automation.[2]

(iii) Automation and Economic Stability

The spread of automation may be expected to have a profound influence upon the structure of the economy quite apart from

[1] *Report*, p. 7.
[2] *N.Y.T.*, Dec. 23 and Dec. 29, 1955.

promoting increased output per head and carrying with it the danger of technological unemployment. Here again opinions are divided. Some think that, after the difficulties inevitably associated with a period of transition have been overcome, automation will bring with it an era marked by a 'new stability'.[1] Others fear that automation will lead to instability and rigidity in the economy. One difficulty in assessing the merits of thsese two opposing points of view is that both the optimists and the pessimists agree that the situation is influenced by certain factors. But they differ on the ways in which these factors will influence the future development of the economy.

Automation as a Stabilising Influence

It has been suggested that fluctuations in the level of employment lead to instability in the economy. This is because fluctuations in the volume of employment lead to fluctuations in the demand for consumer goods. And this in turn affects programmes of capital investment and therefore the demand for producer goods. John Diebold considers that automation will help to stabilise the volume of employment. He writes:

> 'Traditionally, when in depressed circumstances, firms have tended to maintain prices and decrease production—and consequently employment. In an automated firm, however, with the consequent decrease in direct labour and increase in capital costs . . . adjustment may very well be different. The advantages of labour lay-offs will be less apparent, and output will more likely be maintained, because of fixed capital charges. As a result, changes in demand will, in all likelihood, affect prices rather than output and employment. Thus greater stability of employment is seen to be a likely consequence of automation.'[2]

Similar effects are expected to follow from the fact that the introduction of automation into a plant—or even into part of a plant—has to be planned a long time in advance. Once the work of installing automatic machinery has begun it cannot be interrupted without losing much of the capital invested in the new process. The ordering of new machines and other capital equipment will go on 'regardless of temporary ups and downs in annual

[1] Peter F. Drucker, *The Promise of Automation*, p. 12.
[2] *Hearings*, p. 11.

sales. Thus investment in automation will increasingly serve as a general stabilizer in our economy.'[1]

It is also alleged that other factors will tend to promote stability in the age of automation. These are improvements in the running of a plant and in the distribution of its products which will be brought about by the data-processing of computers. These electronic devices, too, will enable managements to secure a better overall picture of market conditions. Both official and private bodies which specialise in providing information of this kind will be able to give their clients a better service. In the years to come it may be anticipated that governments will be more ready than they have been in the past to intervene promptly when a recession threatens to turn into a slump. Both management and men will be more ready than before to make concessions in the hope of avoiding a depression. The new policy of governments, industry and organised labour is not due to automation but its adoption is facilitated by automation.

Automation as a Disturbing Influence

It is true that a plant into which automation has been (wholly or largely) introduced does not enjoy the same freedom to meet a fall in demands for its products by reducing its staff as does a firm in which the bill for wages and salaries forms a very high proportion of its total production costs. In an automatic plant on the other hand wages and salaries are a relatively minor item. Most of the workers in such a factory are engaged in supervising and in repairing automatic machinery or in handling the finished product. Their services are required even if the plant is producing only a fraction of the goods that it could produce if it were working to full capacity. Moreover in an automatic factory—as distinct from a works run on traditional lines—the workers are a sort of 'capital investment'. Some of the workers have been trained by the firm. Even if they had contracts which allowed the firm to dismiss them at short notice it would be most unwise for managements to do so because when normal production was resumed it might be difficult, if not impossible, to start the plant going again since suitably qualified operatives might not be available. Management has drawn the logical conclusion from these facts.

[1]*Hearings*, p. 434 (R. J. Cordiner, President, General Electric Company).

It is now generally accepted that, in an automatic factory, most of the wages bill is now regarded as an item of 'fixed costs' (capital expenditure). Traditional methods of business accounting are having to be adjusted to meet this new situation.[1]

Even although it is likely that the majority of the workers in an automatic factory will in future enjoy a security that they never had before—and will therefore be able to maintain their purchasing power—nevertheless this circumstance does not in itself eliminate fluctuations in demand. It is rather curious that the very writers who argue that the automatic factory will promote security of employment and maintenance of purchasing power for its workers—leading to a general stability in the economy—are also the writers who point out that in the immediate future only a small percentage of the labour force will be directly affected by automation. In the non-automatic sector of the economy—a much larger sector than the automatic sector—the danger of unemployment is as great as ever. Indeed the spread of automation—the gradual growth of the automatic sector of the economy—may in itself increase the danger of mass unemployment in the non-automatic sector of the economy.

The total demand for goods in any economy is, for various reasons, subject to considerable fluctuations. Today in the United States there is a factor in the situation which might lead to rapid decline in the demand for mass-produced luxury goods (produced by industries which are adopting automation fairly quickly). These goods form the great majority of that group of products which people postpone buying the moment that confidence in the stability of the economy is shaken. In an economy based upon a relatively high standard of living the expansion—indeed the maintenance—of a steady demand for consumer goods largely depends upon people saving relatively little and spending most of their incomes on goods which enable them to enjoy a standard of life which is superior to the mere satisfaction of basic needs. If confidence is shaken it is possible that people might suddenly decide to save a little more and spend a little less. And the reduction in spending would fall on luxuries, not necessities. For this reason it should not be assumed that the demand

[1] *Margate Conference*, pp. 48, 135 and Peter F. Drucker, *op. cit.*, p. 12.

for consumer goods will always expand—or indeed will always remain stable.[1]

The automatic method of production could easily clash with the elasticity of demand. Since a great deal of money is sunk in capital costs in an automatic plant and in training workers, such a plant can pay only if its productive capacity is being used virtually to the full. The closing of an automatic plant—or even a reduction in output—is normally accompanied by heavy financial losses. In such a situation there would be a sharp conflict between the needs of the automatic plant and the situation with regard to the goods which it produced because the possibility of producing goods was very much greater than the possibility of consuming them.

An analogy may be drawn between an automatic plant and a firm where the cycle of production can be interrupted only at a heavy financial loss.[2] Faced by falling demand the owners of an automatic plant can adopt the classic remedy of reducing prices. But this method can be successful only if (despite a decline in confidence) the market is not already completely saturated. There are other ways of meeting the situation. Attempts—typical of industries making mass-produced goods for a wide market—are made by intensive advertising campaigns to create new demands. Attempts are made to cut production costs (by more automation) and to produce cheaply new—or apparently new—types of goods. Attempts are made to produce goods that do not last too long so that customers can soon be persuaded to buy yet another 'latest model'.[3] The following statement (made to the Congress committee on automation in 1955) by a typical industrialist illustrates the point of view of those whose livelihood depends upon finding a market for the ever-increasing deluge of goods that flows from automatic plants:

> '. . . every time that you build an automatic machine, the thing opens up new vistas of . . . products that you can make available, that you never dreamed of before, and if you believe, as I do, *that the human being never becomes saturated with things*—there are always other things he wants, if he can afford to buy them. . . .'[4]

[1] *Hearings*, p. 36.
[2] T. F. Silvey, *op. cit.*, p. 12 *et seq.*
[3] Peter F. Drucker, *op. cit.*, p. 9.
[4] *Hearings*, p. 191 (italics supplied)—evidence of D. G. Mitchell, head of Sylvania Electric Products, Ltd.

This belief that human 'demands' can have no limits has become a positive article of faith in the United States. It is used to justify heavy capital expenditure on industries producing goods and services—particularly luxuries—for the masses. Automation benefits from this belief and also encourages it.[1] A British observer has pointed out how such a state of affairs would affect society in general:

> 'There could be a vast competitive race to speed up production more and more in automatic factories; to create bigger and better purely *technical* solutions of production problems; to condition men to want more and more of the goods that were being poured off the production lines. . . . Such an approach would not create a feeling of plenty, but a feeling of dissatisfaction.'[2]

Certain *economic* consequences of automation deserve examination. Consumption, artificially fostered by the technical needs of automation, might expand in a violent manner which is quite unnatural because it bears no proper relationship to the level of the progress made by society. In such circumstances that aspect of social life dominated by consumption might be dangerously vulnerable to any distorting influence. This might lead to a chain reaction—growing like a snowball—which could easily precipitate a serious economic crisis. This process could be set in motion if any important group of consumers were 'saturated' with goods for which they are able to pay.[3]

The establishment of automatic plants has to be planned a long way ahead and it is not possible to know what fluctuations

[1]The situation in the American motor car industry at the end of 1955 may serve to illustrate the methods that are used to secure an extended market because production has expanded. Representatives of the American car dealers complained to the Congress committee on automation (1955) that they were forced by the manufacturers to take more cars than they could sell. Too many cars had been produced. The car manufacturers replied that they had invested milliards of dollars in automatic plants and that they could get their money back only if they secured mass-sales (See *Kiplinger Washington Letter*, Feb. 4, 1956).

[2]*Margate Conference*, p. 68. See also the views expressed by Vannevar Bush before the Congress committee on automation:

> 'I have been told for a long time that human wants are unlimited, and hence it is impossible to saturate a market overall; that it is possible to saturate it in detail but not overall. On the other hand I have a feeling that there is a limit to which men will work in order to secure goods and services for their needs and their enjoyment. I know quite well, personally, I might have worked hard when I was young to be able to buy an automobile. I might have worked hard even to buy a second car, but I wouldn't work to buy a third one. I would go fishing' (*Hearings*, p. 632).

[3]See above (p. 189, n. 1) for the extent to which credit is being granted in the United States today.

in the demand for goods will affect the market when the plant is ready to go into operation. From one point of view this situation may be regarded as having a stabilising influence on the economy. But it is also true that this situation promotes and aggravates a permanent tendency towards overcapitalisation. New automatic plants, which normally employ far fewer workers than the machines which have been replaced, might come into operation just at the wrong moment and could increase the supply of goods at the very time when the market has been saturated.

The view that the pace of automation in some way regulates itself is entirely erroneous. It has been argued that, since automation costs money, 'American industrialists will erect automatic plants only if they think it profitable to do so'. If demand falls, the pace of capital investment in automation will automatically adjust itself to the fall in demand.[1] But in fact it is notorious that technical progress may take place not only when trade is booming but also when there is a depression. In view of the very considerable savings in costs which can be gained by introducing automation it is not unreasonable to suggest that it is just during a period of slack trade that automatic plants are most likely to be installed.[2] Another reason why it is probable that automation will be accelerated during a slump is the strength of the trade unions. Organised labour may be strong enough to prevent wages reductions during a slump. Employers, prevented from cutting costs in the wages bill, are encouraged to cut costs by introducing automatic machinery.

Ever since machine production first began to replace handicraft production the question has had to be faced—How can a permanent dynamic balance be secured between continually growing productivity and the effective demand for goods? For generations certain economists and leaders of the workers have argued that wages and salaries must be sufficiently increased to create an adequate and effective demand for the goods that are coming onto the market. And for generations the employers have answered that wages are an important item in the costs of production and that if those costs are too high then the business cannot make a profit and must eventually close down. Each party is right

[1]C. W. Boyce, *op. cit.*
[2]*Hearings*, p. 631 *et seq.* (Edwin G. Nourse.)

if one accepts the premises upon which their arguments are based. One party assumes the existence of an economy in which there is no opposition between the interests of capital and those of labour. The other party argues that in a private enterprise economy there is an inevitable rivalry between capital and labour and the workers must look after their own interests. In practice the employers—despite all appeals that they should consider the welfare of society as a whole—never pay wages any higher than they have to pay in the light of the state of the labour market and the power of trade unions. If they do pay more—as in the case of the Ford Works when Model T was being produced—it is because the circumstances are quite exceptional. In every surviving private enterprise economy the employers continually move heaven and earth to keep wages (per unit of what is produced) down to the absolute minimum. And when they do raise wages they do not necessarily take into consideration the needs of the whole community by making sure that this new spending power is counterbalanced—let alone more than counterbalanced—by the simultaneous introduction of more efficient methods of production.

The same sort of thing happens when automation is introduced. The trade unions—basing their arguments on the 'underconsumption' theory—demand that the workers should receive the greatest possible share of the additional profits made by means of the increased efficiency of the new method of production. But this very demand causes the industrialist to speed up the introduction of automation which enables him to economise on a wages bill which continually threatens to rise. It is by no means easy to see how a 'dynamic stability'—which everyone wants—can be secured under such circumstances in a continually expanding economy. The uninterrupted expansion of output plays a decisive role in maintaining this stability. So it is obvious that the increased use of automatic machinery presents a serious threat to the stability of a private enterprise economy where self-interest reigns supreme.

Chapter VII

NEW LIGHT ON THE SOCIAL CONSEQUENCES OF AUTOMATION

(I) THE WORKERS

It has been seen that there are many interesting and important aspects of automation. There are the technical marvels of electronics. There is the ever-widening field of economic activity in which automation can increase the individual worker's output to an astonishing extent. There is the fact that by automation certain economic functions which until recently could be performed only by human beings can now be performed by machines more quickly, more accurately and more cheaply than ever before. Moreover, goods of better quality can be produced by the new methods than by the old. Nevertheless the ultimate significance of automation lies in the social consequences that will follow from the introduction of what might be termed a 'fourth dimension' in the process of mechanisation. It is already possible to see that the consequences of automation will be as significant both to society and to individuals as were the great changes brought about by the first industrial revolution of the eighteenth and nineteenth centuries.

It is possible that the effects of automation upon human beings may not be quite so revolutionary as many people today expect—and some people fear. The effect of the changes that automation will bring about may be no more than to force everybody to see things that have long existed but which have hitherto been appreciated only by the few. A long time ago a few far-seeing observers realised that industrialisation tends to make men resemble machines and to make machines resemble men. A hundred and twenty years ago the poet Heinrich Heine visited England and wrote:

'It was uncanny to contemplate the extraordinary efficiency of machines which have taken over functions formerly performed by human beings. . . . I was equally perturbed by the precision, the fixity, the exactness and the punctuality with which the Englishman regulates his life. In England machines seem to resemble human beings and, what's more, the people resemble the machines. In England wood, iron and brass appear to have usurped the spirit of man, while soulless human beings, like empty ghosts, mechanically go through the motions of performing their accustomed daily tasks.'[1]

What would Heine have written had he lived in the modern age and had seen electronic devices perform so much of the 'brain work' which has for so long been the sole prerogative of human beings? What comment would he have made about a computer which can work out theoretical problems to a logical conclusion more efficiently than a human mathematician?

It is all very well to argue that 'giant brains' are stupid in the sense that they are obviously wholly incapable of *original thought.* The fact remains that they share this disability with the vast mass of human beings. Moreover, much so-called 'original' thinking involves no more than taking the sort of decisions that computers take—with their positive or negative impulses—on the basis of instructions previously fed into the machines.

As electronic computers become ever more efficient the sphere of original work by human beings will inevitably contract. But obviously no one supposes that the monopoly of the human brain in inventing new computers and in maintaining and directing existing computers will ever be broken.[2]

Changes in technical knowledge have always changed man himself. This is particularly true of the machine age of the last hundred years. The ultimate influence of progress mechanisation upon human beings still lies in the future. We can only guess, in a very general way, at certain possibilities. Three factors deserve consideration—(i) the continual reduction of man's physical labour, (ii) the necessity of increasing the average level of intelligence by improving educational facilities, and (iii) the probability of eventually securing a substantial reduction in the working week. We propose merely to indicate how the automatic method

[1]Heinrich Heine, *Der Salon*, Vol. III (in *Sämtliche Werke*, edited by E. Elster) (Leipzig and Vienna, n.d.) p. 353.

[2]See J. G. Kemeny, 'Man viewed as a machine' in *S.A.*, April 1955, p. 58 *et seq.* The author, who was one of Albert Einstein's assistants, discussed the theoretical possibility of making a machine that can 'reproduce' itself. See also Vannevar Bush in *Hearings*, p. 606 *et seq.*

of production may be expected to reverse the existing tendency of machines to dominate human beings.

In the first part of this book we drew attention to an alarming possibility. We tried to explain why, in our view, one ultimate result of the continued advance of automation might be the spread of authoritarian forms of government. It may be useful to indicate some specific ways in which our lives and ways of thought may in future be affected by the spread of automation. This of course is only one aspect of the social consequences of the new industrial revolution. Another social change that may be expected to follow in the wake of automation may be the abolition of poverty and soul-destroying drudgery. And this change will affect not only the advanced industrial states but also—in the not too distant future—every country in the world. Such a policy may indeed appear to be Utopian in the light of the strains and bitter conflicts which result from the very low standard of living of the vast majority of the human race, yet the abolition of poverty need not be just a dream if only the world would use its reasoning powers to make sensible use of the economic assets at its disposal.

Two social results of automation have already become apparent and they have already been publicly discussed. They are (i) the problem of the extent to which educational facilities should be improved in the atomic age, and (ii) the problem of how men will use the abundant leisure which a good many people (perhaps wrongly) think will very soon be 'enjoyed' by workers as a consequence of the spread of automation.

As far as education in the age of automation is concerned there are two points to be considered. In the first place it would appear to be urgently necessary to overcome a grave shortage of engineers and technicians.[1] Secondly the educational system as a whole will have to be radically changed in order to give children a training suited to an 'automatic age'. It has often been pointed out that the curricula of our schools are designed to fit boys and girls to take their places in the traditional system of production. It is possible that technical schools and colleges are training their students in skills that may already be out of date when they enter industry when their studies are completed. It is argued that

[1] *Report*, p. 7 *et seq.* and *Margate Conference*, p. 57 *et seq.* and p. 114 *et seq.*

what the young industrial worker of the future needs is a good basic knowledge of mathematics and science. More specialised training could come later if necessary.[1] A general raising of educational standards would be required for two reasons. First, if the normal working week is reduced in automatic factories, the employees will have more leisure and it is desirable that they should use this extra free time wisely. Secondly, an automatic plant demands from the worker a greater sense of responsibility than the factory run on traditional lines, and this too can be acquired as a student. It has been said that it will be necessary to teach people how 'to get more out of life and to be better citizens'.[2]

The way in which the worker uses the additional leisure time gained by technical progress has long been a matter in which society has taken a lively interest.[3] Rapidly growing industries —of importance to the national economy—serve to supply the largely artificially created demand for goods and services brought about by the increased leisure which follows the reduction of working hours.[4] In the United States they are called 'leisure industries' and it is expected that they will be able to absorb a considerable proportion of the workers rendered redundant by automation! George Soule has recently examined the problem of the effects of increased free time upon society. He points out that while in the past there has been a 'leisured class', in future there will be 'leisured masses'. He stresses the dangers inherent in this situation. 'Technology' (he writes) 'has mastered the art of saving time, but not the art of spending it'.[6] It is obvious that this problem will become more serious as automation spreads.[7]

Except for the possible danger of technological unemployment

[1] *B.W.*, Oct. 1, 1955, p. 99 *et seq.*
[2] *B.W.*, Oct. 1, 1955, p. 99 *et seq.*
[3] D. Riesman, *Individualism Reconsidered* (Glencoe, Illinois, 1954), p. 179 *et seq.*
[4] According to recent estimates the American public spends about 32 milliard dollars in leisure-time activities—i.e. twice what is spent on motor cars and half what is spent on food. See an article on 'Leisure' in *Business in Brief* (quarterly journal of the Chase Manhattan Bank), Jan. 1956, and *Economic Report* . . ., 1955, p. 171.
[5] See Fourastié's remarks on the part played by 'The Tertiary Sector of the Modern Economy' in *Le Grand Espoir du XXe Siècle* (Paris, 1952) p. 40 *et seq.*
[6] George Soule, *Time for Living* (New York, 1955), p. 100.
[7] For example, this aspect of the problem

'. . . led a Pittsburgh minister to call automation a challenge to the church. He warned that churches must supply guidance for lengthened leisure time, suggested Thursday night services' (*A.C.*, Sept. 1955, p. 5).

no aspect of automation has caused more discussion than its effects upon the actual nature of the work that will be done in the factories of the future. Some people think that—after initial difficulties have been overcome—the great majority of the workers in an automatic plant will have lighter, more interesting, less dangerous and better paid work than they have now. Other people however argue that most of the skilled and semi-skilled will find that they have been 'down-graded'. They will lose their present jobs and have to take less interesting work of a kind that they were not originally trained to do. Such experience as we have of the introduction of automation is not sufficient to enable us to decide which of these two views is the more correct. The general opinion—based upon limited evidence of technical progress in industries engaged in mass-production—is that 'up-grading' is more likely to occur than 'down-grading':

> 'One look at the industries that are virtually "automated" now . . . should show that they have plenty of employees, that they pay the highest wages, and that there is little room in them for unskilled or untrained labour. Mass production upgraded the unskilled labourer of yesterday into the semi-skilled machine operator of today—and in the process multiplied both his productivity and his income. In just the same way, automation will upgrade the semi-skilled machine operator of today into a highly skilled and knowledgeable technician —multiplying his income again.'[1]

This argument has frequently been used. It occurs, for example, in a report to the Congress committee on automation (1955) made by the American Secretary for Labour.[2]

But it is one thing for new jobs to be available demanding high qualifications and ability to shoulder responsibility and it is another thing to find men capable of holding these jobs. It has been pointed out that 'automation will not up-grade people, it will only up-grade jobs'.[3]

Some very interesting evidence concerning the selective character of up-grading will be found in a report of the introduction of automation by the Ford Motor Company into some of its plants:

[1] Peter F. Drucker, *op. cit.*, p. 10.

[2] 'The effect of technological developments, including the one termed 'automation', can be seen pretty clearly by looking at the historical record . . .' etc. (*Hearings*, p. 264).

[3] G. B. Baldwin and G. P. Schultz, *op. cit.*, p. 11.

'We found in our plants the best and the brightest people in the working force and trained them to do such jobs.'[1]

It was pointed out at the Margate conference on automation (1955) that the problem of 'up-grading' is greatly influenced by the ages of the workers concerned:

'We up-grade the agricultural labourers into tractor operators, engineers and electricians. This is only true if we interpret it statistically and socially. After a certain age you cannot up-grade an individual by turning him from a labourer into an engineer. You can, however, do what you please with his children and grandchildren, You can have as many engineers in the community as you please, provided there is a sufficiency of fathers employed at a level of productivity which will support their education.'[2]

It is very doubtful whether those who secure jobs will in fact ensure such high wages as this suggests. The available evidence concerning the effect of automation on wages gives much more modest figures. A report of the American Department of Labour, for example, states that 'Pay rates for the automation jobs were set at 5 to 15 per cent above the straight-time hourly rates for unskilled assemblers because of some differences in working conditions and increased responsibility'.[3]

It is sometimes stated that the advantages of 'up-grading' to the worker have been exaggerated. In a report—one of a series on automation planned by the U.S. Department of Labour—it is pointed out that much more detailed information will be needed before it will be possible to say

'to what degree maintenance functions are really growing, and to what degree there is a movement upward from semi-skilled to semi-professional workers. These are the kind of conclusions made in every other "dope story" about automation which you read today; they should be tested.'[4]

The only detailed statistical investigation which is available concerning the problem of up-grading covers a number of metal-

[1]*Syracuse Conference*, p. 84.

[2]*Margate Conference*, p. 25.

[3]*Hearings*, p. 285. A report on the introduction of automation into the offices of an insurance company states that the employees who became computer operators secured on the average a wage increase of nearly 15 per cent (*Hearings*, note to table on p. 298). See also the following observations on the possibility of introducing automation into the watch-making industry:
'Production requiring the finest sort of manual skill . . . is undergoing a revolution. . . . With the rise of modern techniques production-line workers capable of manufacturing watches or other close-tolerance miniaturized items can quickly be taught in a matter of days, or at most, weeks' (*N.H.T.*, Special supplement, Feb. 8, 1956).

[4]K. G. van Auken, jun., *op. cit.*, p. 14.

working plants into which automation was introduced.[1] This enquiry was carried out by the *American Machinist* in 1955. A questionaire drawn up by this journal was answered by 1574 firms. Of these firms 22 per cent had introduced automation in some form or other.[2] After automation had been introduced the size of staff showed no change in about half of the firms concerned. In a quarter of the firms automation led to an increase in staff (on the average by 21 per cent) and in a quarter of the firms the number of workers declined (on the average by 16 per cent). The majority of the firms gave two reasons for introducing automation. One was to save on wages,[3] and the other was to increase profits.[4] In the circumstances it is safe to argue that even in those firms in which the size of the staff remained steady or actually increased the output per worker was greater than before.

HOW AUTOMATION AFFECTS EMPLOYMENT[5]

	Increased maintenance force	More skilled maintenance force	Less skilled maintenance force	Increased engineering staff
	%	%	%	%
1000 employees and over	13	53	4	29
500-999 employees	18	36	0	32
100-499 employees	27	38	4	23
All plants	19	40	5	21

[1]*American Machinist*, Special Report No. 402—'1574 Companies report 56 Plans' (August 29, 1955). The results of the enquiry should be treated with caution because the investigators did not differentiate as clearly as they should have done between automation and mechanisation.

[2]The percentage varied from 10 per cent in firms employing under 50 workers to 53 per cent in firms employing over 1,000 workers (*American Machinist*, August 29, 1955, Special Report No. 402, p. 158).

[3]89 per cent of the firms mentioned this motive.

[4]Over 75 per cent of the firms mentioned this motive.

[5]*American Machinist*, August 29, 1955 (Special Report No. 402).

This table throws a significant light on the problem of up-grading particularly when it is read in conjunction with a table of rates of wages paid at the plant. It is not surprising to find that when automation is introduced and output increases there is change in the wage-structure of the plant and that a number of workers are up-graded. But what gives food for thought is the fact that in 81 per cent of the cases no increase in the number of workers engaged in maintaining and supervising the machines was necessary. In 60 per cent of the cases no higher—sometimes even lower—qualifications were demanded from those engaged in this work. In 79 per cent of all the firms—actually 71 per cent of all plants employing over 1,000 workers—it was not found necessary to employ additional engineers.

There is ample evidence that when automation is introduced it does not necessarily mean that most of the new jobs require higher qualifications on the part of the workers. The following typical example comes from the evidence laid before the Congress committee on automation in 1955:

> 'Senator O'Mahoney: Well, as automation proceeds, will it be necessary to demand a higher standard of intelligence, or a better education of the operator than is now required?
>
> 'Dr Walsh (Professor, Chemical Engineering, Case Institute of Technology, Cleveland, Ohio): I do not think so. The operator will operate with his standard of intelligence, as we get the run-of-the-mill people. There will be a natural selection, and where the operator is required to have a higher standard of ability, or intelligence, natural selection will take care of the person, but, on the average, I would say "No".'[1]

It is not denied that automation does often demand a higher degree of technical knowledge on the part of the workers. But it is necessary to point out that this probably applies only to a minority of the workers. It is a mistake to think that the vast majority of the workers fall into this category.

Let us now consider the fate of those workers who, after a course of training, secure a higher qualification and are employed in an automatic factory. Here again the evidence is unfortunately both scanty and conflicting. Employers generally argue that their workers are very reluctant to be trained for a new kind of job in

[1]*Hearings*, p. 485. See also *Hearings*, pp. 67, 74, 93, 157, 285 and 297.

an automatic factory '. . . but after they were there a day, you couldn't get them back in their old jobs'.[1]

On the other hand trade union representatives suggest that

> 'there are workers who can't keep up with automation. Such as Stanley Tylak. Tylak, 61, and for 27 years a job setter at Ford, was shifted from the River Rouge foundry machine shop to the new automated engine plant. He was given a chance to work at a big new automatic machine.
>
> 'Simply, straightforwardly, he told his story: . . . "You had to watch all the time. Every few minutes you had to watch to see everything was all right. And the machines had so many lights and switches—about 90 lights. It sure is hard on your mind. If there's a break in the machine the whole line breaks down. But sometimes you make a little mistake, and it's no good for you, no good for the foreman, no good for the company, no good for the union."
>
> 'And so Stanley Tylak, baffled by the machine he couldn't keep up with, had to take another job—at lower pay.'[2]

An enquiry into the emotional and social reactions of workers in steelworks in which automation has recently been introduced shows that this is by no means an exceptional case.[3] The steelworkers had formerly used traditional methods and machines and now the plant is worked by remote control. They found that their work was easier. But that was not all.

> 'They admitted that their muscles were not tired and that physical drudgery had been lifted from their shoulders. . . . But they complained that nervous fatigue, from just standing and watching the machine, had been substituted.'[4]

It must be admitted that in both these cases automation had not been *fully* introduced into the plants. The machines do not give the worker a signal when they require attention. Consequently the workers have to watch these machines very carefully. It is about this *incomplete* form of automation that a foreman was complaining when he said that 'in the old mill you controlled the machine; now it controls you'.[5] In a plant in which automation is *complete* the machine tells the worker when he has to take action and this greatly reduces the nervous strain on the worker. But in the second example which we gave—the steel works which was

[1] *Hearings*, p. 63.
[2] *Hearings*, p. 103 (quoted from a report in the *New York Post*).
[3] The enquiry was undertaken by C. A. Walker, Research Director in technology and industrial relations at Yale University. See *N.W.*, January 16, 1956.
[4] *N.W.*, January 16, 1956 (U.S. edition), p. 41.
[5] *N.W.*, January 16, 1956 (U.S. edition), p. 41.

not completely automatic—the workers eventually adapted themselves to the new machines and the physical strain was reduced. Only a minority of the workers asked to be transferred to other—non-automatic—departments. Nevertheless, the men who stayed in the automatic plant were not entirely satisfied with their conditions of work. Their work did not seem to give them any real satisfaction.

In conclusion, it may be said that the available evidence is insufficient to balance the pros and cons of the effects of automation on the workers. Nor is it possible to pass any final judgment on the question as to whether the workers in an automatic plant or office who improve their position as a result of the introduction of automation obtain any real satisfaction from their new work.

On the other hand it should be remembered that while automation may deprive some skilled and semi-skilled workers of jobs which they have performed for many years it is also true that automation spares workers from much soul-destroying drudgery. Memories of the mass unemployment of the 1930s are still strong and many men value *any* job, even one which may be regarded as derogatory to human dignity—simply because it is a job. Now automation may abolish jobs of this kind. Any such jobs cannot be down-graded any lower than they are already down-graded. The next step down is unemployment—and possibly a long period of unemployment at that.

If automation is introduced in a planned and sensible way it may indeed enable man to master economic processes in a way that he has not done before. All man's functions in making the economic system work may be up-graded. But in the immediate future the position is different partly because automation is being introduced into a free private enterprise economy under the pressure of cut-throat competition and the demands of re-armament. In fact the people who are going to be genuinely 'up-graded' are the very groups we described when dealing with the 'automation hierarchy' of the future.

In the following sections we propose to make some additional comments on this 'automation hierarchy'.[1]

[1]See above, p. 83, *et seq.*

(II) THE STRUCTURE OF THE LABOUR FORCE

There can be no doubt that in the age of automation the engineers and technicians will exercise a dominating influence not only at every stage of production on the shop floor but also on the management side of industry. They will continue to perform their traditional functions. They will still be responsible for technical planning, for solving problems of production, and (in particular) for introducing new devices and better methods at every stage in the process of production. But in the age of automation they will be faced with additional responsibilities such as the problem of integrating the workers into a new and unfamiliar system of industrial production. We shall have occasion to draw attention to the all-important role that the morale of the workers plays in the success of an automatic plant. The introduction of automation into a particular plant may be desirable to secure greater efficiency but it may be difficult to make this change because of the difficulty of getting the workers to adapt themselves to the new method of production: 'The effect on labour will enter in design, installation, even operation of automatic controls. It begins to look like the engineers will soon be required at the collective bargaining table.'[1]

New difficulties may arise owing to the fact that when the process of rationalisation is pushed to its logical conclusion by the introduction of automation it is the engineers who inevitably have a very important say in every aspect of the new process of production. It has been pointed out that friction may then be engendered in such a situation because many scientists and technicians—ignorant of the social and economic factors which influence the smooth working of a plant—may

> '. . . tend
> gerous to industrial relations tha
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> on any other subject.

The exceptional position held by engineers and similar experts in an automatic plant may be seen from the qualifications which

[1] *C.E.*, Sept. 1955, p. 53. [2] *Margate Conference*, p. 134.

they have to possess. An examination of the announcements of vacancies for posts of this kind in American technical journals will make this clear. Salaries and pensions are usually fixed by agreements between employers and trade unions or professional bodies. Employers try to fill vacancies by holding out other inducements. They offer good living conditions and good leisure-time facilities.[1] The most attractive conditions are naturally offered to experienced men with high qualifications, but the engineer who is only at the beginning of his career has no cause to worry about the future. Before 1939 in the United States there were not enough jobs available for all the engineers. Careers masters and appointment boards tried to dissuade young men from entering the profession. Now a newly qualified science or engineering graduate may have the choice of ten jobs on leaving the University. And students who have completed only a two-year course at a technical college appear to have an even larger number of posts from which they can make their choice.[2]

We have already drawn attention to the serious political consequences which might follow from the fact that it is engineers who will play a dominating role in industry in the age of automation. Other observers share our own fears:

> '... The small number of engineers with the ultimate control of these automatic factories could ... hold society up to ransom: the ransom being control of man's consumption and habits in the interests of the machines. The automatic factory, then, will provide an open sesame to Huxley's "Brave New World".'[3]

The various groups of 'non-commissioned officers' in the industrial society of the future—they are the groups below the engineers—will have very similar qualifications. In these groups of workers were included:

(a) Supervisors.

(b) Machine-minders responsible for servicing and repairing automatic machinery.

[1]We give as an example an announcement of a vacancy for a post made by an armaments firm. It is typical of many. The advertisement states that in the post: 'Your big advantage is that you begin by drawing on the empirical data, produced by ... research pioneering—and you have freedom of expression while developing your own ideas. You'll use the finest equipment—work with world-recognized engineers and scientists ... unique engineering organizational techniques—plus our liberal Patent and Suggestion Award programs' (*C.E.*, November 1955, p. 48).

[2]*W.J.*, March 24, 1955.

[3]*Margate Conference*, p. 66.

(c) Persons responsible for handling computers and other electronic devices.[1]

All these three groups of workers—a new type of technician—are known as 'semi-skilled engineers' in the United States. In an automatic plant they play an only slightly less important part than the fully-qualified engineer. It is these semi-skilled engineers who will, in the future, largely supersede the fully-qualified engineers of the present day. Many older skilled workers are justifiably concerned as to whether they will be able to acquire the skills which will be necessary before they can undertake their new duties in the age of automation.[2]

The foreman in an automatic plant controls far fewer workers than he does in a non-automatic plant. But his duties are no lighter since in an automatic plant it is absolutely essential for good relations to be established between management and men. The whole process of industrial production in the age of automation depends upon keeping the workers 'in good spirits'. Much depends upon their zeal and conscientiousness. In fact more depends upon the semi-skilled or even the untrained engineer in the automatic plant than upon his opposite number in the non-automatic factory. In a conveyor-belt plant the men who 'bridge the gap' from one part of the process to another can easily be replaced and, up to a point, the conveyor belt itself 'controls' this type of worker. But the position of the small number of workers who look after automatic machinery is different. In a sense they have greater responsibilities even than skilled craftsmen.[3] In an automatic plant any slackness on the part of those who control, maintain and service the machinery may lead to a breakdown of the whole process of production. Moreover the most senior supervisor in control of an automatic plant has great responsibilities and must be prepared to take prompt decisions when there is no time for him to consult a colleague. He must make up his own mind what to do. The way in which automatic plants normally operate does not provide for assistant-supervisors who could, in certain circumstances, take important decisions.[4]

[1] We differentiate between these qualified workers and the untrained machine tenders. Eventually a higher proportion of the men tending automatic machines may have come from the untrained than from the fully-qualified men.

[2] *Fortune*, Nov. 1955, p. 74.

[3] *Margate Conference*, p. 201 *et seq.*

[4] Peter F. Drucker, 'The Automation Challenge to Management' in *Automation* (Cleveland, Ohio), October 1955, p. 102.

The opinion has been expressed that 'the working-class aristocrats'[1] of the future—the relatively small group of men who will be serving the automatic machines—

> '. . . will be keen and intelligent men; they will have little to do, much of the time; but will ever be on the alert and quick in action when action is required. They will, without doubt, be members of a trade union, but of which union is a matter for speculation.'[2]

For the successful functioning of an automatic plant it is essential that the workers' interest in their jobs should be maintained. One serious obstacle which prevents this interest in the work from being maintained is the fact that—from the very nature of the automatic system of production—it is hardly possible to measure the results of the efforts of the individual worker. There is no positive measuring rod by which to gauge the efficiency of a worker in an automatic plant. There is only a negative measuring rod. The efficiency of the worker lies in keeping a watchful eye on the machinery and seeing that nothing goes wrong. It is the smooth and uninterrupted working of the plant that goes to the credit of the worker. Another reason why workers may lose interest in their jobs in automatic factories is that they may have absolutely nothing to do for hours at a time. This may mean that the unusually intelligent worker—the very type of man who will be needed in the automatic plants of the future—will almost certainly find his new job a very boring one. The only way to 'maintain the morale' of workers in automatic plants is for management to do everything possible in its power to make it clear to their employees that the workers in the age of automation have a vital function to perform. It will be necessary to try and get the workers to identify themselves with the firm for which they are working. All those working in an automatic plant must be animated by a strong *esprit de corps*:

> 'The workforce per plant may be smaller, but the people it comprises will be more curious and imaginative and will want to be kept well informed
>
> direct human contribution to product creation will be accompanied by an increased need for recognition of workers as people and more tolerance for the constructive non-conformist.'[3]

Such very limited evidence is as yet available covering the

[1]The term has been used by W. B. Gibson in *S.F. Symp.*, p. 168.
[2]*Margate Conference*, p. 201.
[3]*G.M.S.*, No. 178, p. 121.

way in which those employed in an automatic plant work together clearly indicates that the sketch which we have given of a hierarchy of workers is correct. All these employees, from the most senior to the most junior member of the staff, are united in the conviction that they belong to a superior caste of workers. That attitude has much more in common with a totalitarian way of life than with a democratic way of life.

Little has so far been written about the probable social consequences of automation and little thought has been given to the problem of the future of those workers who have dull routine jobs in industries which, for one reason or other, automation will be long delayed or may never come at all. A speaker at the Margate conference on automation (1955) said that these men were members of a class

> '. . . destined to become increasingly isolated in the social sense and the psychological sense. . . . This is the class of those whom the upgrading process has by-passed.
> stevedore. The one is engaged in the dirtiest, hardest and most dangerous occupation in the world. The other in the next most dangerous. . . . The most human problem in the automatic factory [is] the problem of the one toiling human left over after the factory has been automatised.'[1]

The speaker assured the conference that in a future 'world of engineers, administrators, scientists and artists' only a tiny group of workers would survive as a 'cross-grained minority' because they have been left out of the paradise of automation. While we do not share this speaker's optimism concerning the small size of this group of future helots, we agree that the fate of the underdog in the social structure of the automatic age is one of the most serious problems that will one day have to be faced.

(III) THE MANAGERS

> 'Since the exchange of goods first became known as business, this activity has been guided by an art described in terms ranging from "business intuition" to "the seat of one's pants". Industrial complextiy has made this approach more and more unsatisfactory; the pace of automation has made it obsolete. A business science is growing—and adopting automation as its own.'[2]

The 'science' of management has been studied for a long time,

[1] *Margate Conference*, p. 27.
[2] R. L. Sisson, 'Business Systems can be engineered' in *Automation*, (Cleveland, Ohio), December 1955, p. 54.

and much has been written on the functions and qualifications of modern management. Today the manager of a firm finds that his responsibilities are continually being increased. In the eyes of the general public the figure of the manager of a great concern has been growing in stature; more and more is expected from him. Modern business trends, which will be accentuated by the coming of automation, in both industrial production and administration, are raising the status of the 'captain of industry' to still greater heights. It is the manager who is at the same time a qualified engineer who reigns *primus inter pares* among the great administrators running big business today. Master of himself, he rules others with firmness and tact. It is he who, carefully weighing all the factors in any situation, takes the final decision. It has even been suggested that his rise to eminence will be the most significant social change brought about by the introduction of automation. The growth in the responsibilities of the individual manager and the new functions that he has to fulfil are changes of major importance.[1]

What are the new responsibilities that the manager of an automatic plant will have to undertake? Drucker is not very helpful when he writes that the manager of the age of automation will have to possess, in an exceptional degree, the ability 'to think, to analyse, balance and synthesize, to decide and to act purposefully'.[2] Every manager—indeed everybody holding high office in business or public administration—has always had to possess these qualities. There is obviously nothing new in all this.

All those who are acquainted with automation, and the problems to which this new method of industrial production give rise, appear to agree that in future major decisions in business can no longer be taken simply by the managing director (or his advisers) acting on flashes of intuition. In an automatic plant a snap decision, based on mere intuition, might lead to a mistake which would have disastrous financial consequences. To decide on intuition means to decide without being in possession of all the facts.[3] A false step might lead to heavy losses and even to bank-

[1]P. F. Drucker, 'The Promise of Automation', *op. cit.*, p. 10.
[2]P. F. Drucker, *op. cit.*
[3]L. R. Groves, 'The Impact of Automation on Top Management' in *Keeping Pace with Automation* (American Management Association Special Report No. 7, New York, 1956), p. 133.

ruptcy if only because of the large size of so many undertakings. The kind of problems upon which these decisions—of far-reaching consequence—have to be taken include problems concerning investments, the question of where and when to obtain raw materials, the sales policy of the firm, advertising campaigns, the manufacture of new products, and the decision as to whether or not to adopt improvements in an age of very rapid technical improvements. Decisions concerning the disposition of investments alone in the United States are concerned with sums amounting annually to many hundreds of millions of dollars. And the same applies, though on a somewhat smaller scale, to the big European concerns.[1]

In a big concern the problems of management will become more complicated in the age of automation because—so far as many important aspects of the firm's activities are concerned—plans for the future must be made many years in advance. It is impossible to cancel a plan without heavy financial loss. We have already pointed out that this applies to the introduction of automation itself. To plan, instal and start up an automatic—or even a semi-automatic—plant may take several years. It also takes a long time to change over an office from traditional methods to electronic computers.[2]

There is a further complication to be considered. When a firm plans output for the future it has to estimate what the market is going to be like many years ahead. In addition industrialists planning for the future have to remember that markets will have to be found for the greatly increased output that naturally follows the introduction of automation. This expansion in output will obviously lead to overproduction unless effective steps are taken to ensure that wider markets are available in the future:

> 'The lag in time between decisions and sales is increased, of course, by the technological complexity of new products and new plants. Nowadays, many managers find themselves committing funds for research, development, engineering design, and capital expansion that cannot produce income for five to ten or more years. They have to deliberate levels of price and pay, themselves complex considerations easily influenced by many still unknown factors, and they have to weigh as rationally as possible the effect of these levels

[1]For an example of this see below, p. 225, n. 1.

[2]For a detailed example see *Hearings*, p. 290 *et seq.* (U.S. Department of Labour report on the introduction of a big computer into the offices of an insurance company).

upon distant levels of production and the even more distant shape of the market.'[1]

The bigger the concern, the more far-reaching are the decisions taken by the management, and the more numerous are the factors which have to be remembered when deciding upon any course of action. The manager of an industrial plant has to bear in mind the fact that a change in the methods of production used by his firm will ultimately involve seeking the co-operation of the firms who will one day be launching these goods onto the market. And many thousands of firms may be involved. Factors influencing future demand which will have to be considered include changes in the size and distribution of the population: changes in the size of groups of people engaged in various occupations: the movement of people from the centre of towns to the suburbs or from rural to urban districts. Moreover, continual attention has to be paid to reports of experts concerning trends in the buying habits of the public. Another problem which is becoming ever more pressing to modern management in the United States is how to use to the very best advantage the continually increasing sums that are being spent upon advertising. It is necessary to find names for new products which will have real selling power. Advertisements have to be devised in such a way as to tickle the palates of the jaded American public and to entice people continually to increase their demand for goods. It has been argued that there is no limit to the possibility of expanding this demand and that the Americans can be persuaded not merely to maintain but to increase their present high standard of living.[2] In a number of branches of industry management has also to bear in mind the needs of national defence. Many firms have regular contracts to supply goods to the armed forces. Other firms are well aware of the fact that in an emergency they may have to change over quickly to fulfil the needs of rearmament or of a war economy.[3]

[1]H. Maurer, 'The Age of the Managers' in *Fortune*, January 1955, p. 85. In this article examples are taken of the time taken to produce new products and also the cost of doing so. It took twelve years to put *nylon* goods on the market and the cost was 27 million dollars, while 50 million dollars had been spent before the first television set was on sale to the public.

[2]See above, p. 199 *et seq*.

[3]Mr Ralph J. Cordiner, who is one of the most successful business executives in the United States, has recently drawn attention to the remarkable extent to which the introduction of automation forces management to take a long view with regard to the

All this already places very heavy responsibilities on the shoulders of managers in great modern concerns. No wonder that ulcers are an occupational disease among senior business executives! But so far we have really discussed only those aspects of the manager's functions which might be described as 'technical' in the broadest sense. We have by no means exhausted the duties of a modern manager. He is intimately concerned with problems involving human relationships both inside his establishment and beyond its walls. This includes the wide field of 'public relations'. A manager has to maintain contact with government departments, professional and trade associations, the firms which supply his concern with raw materials, the firms which buy the goods which his plant produces and—last, but not least—the general public. He has to keep his finger on the pulse of public opinion. Senior business executives have to engage in negotiations of all kinds and on occasion they must try to influence opinion by public pronouncements. Above all the modern manager has to maintain personal contact with the workers of the firm and with their trade union representatives. Negotiations between managements and trade unionists may be outwardly conciliatory in form but this disguises very hard bargaining behind the scenes. The leaders both of employers and trade unionists cannot start negotiating until they have assembled an imposing array of statistical tables and detailed reports to support the arguments they propose to put forward. Both sides have to decide what demands made by the other party can be accepted and what concessions may have to be made. They must know exactly what the probable consequences—both now and in the future—will be if a complicated wages agreement is accepted. These are problems which the senior executives of a big concern cannot be

integration of plans for production and plans for the future deployment of the labour force. Mr Cordiner writes:

'Automation compels us to tie into one package our plans for marketing, product design, manufacturing facilities, distribution and promotion, pricing, and above all, timing. We cannot afford to build these great machines and intricate manufacturing systems and have them stand idle. We cannot afford the ups and downs of seasonal selling, but must plan our products and promotion to sell all year long. Above all, we cannot afford the ups and downs which result when business decisions are based on daily shifts in the wind in place of long-range planning' (*Long-Range Planning—New Dimension in our Economy* (speech delivered on March 5, 1956) (mimeographed) p. 8).

expected to tackle with any confidence without detailed investigation, or 'operations research'.

At one time the raising of capital was among the most important problems which faced the industrialist. Today as far as the big American—and other—businesses are concerned this question has lost much of its former significance. It is becoming more and more common for these great concerns to raise new capital out of their own profits or by watering stock and not to rely upon the investing public.

In 1951 the American joint stock companies (excluding banking and insurance companies) covered about 85 per cent of their new capital (18.1 milliard dollars out of 21.6 milliard dollars) from their own resources. The following estimate has been made for the year 1956:

	milliard dollars
Total investment	27·5
Stocks written down in value	16·5
Taken from profits	10·0
New shares and debentures	1·0

So for 1956 it was estimated that the joint-stock companies in the United States (again excluding banking and insurance companies) would themselves provide over 95 per cent of their capital requirements.[1]

Fortunately new aids in administration—such as electronic computers—are helping the modern manager to shoulder ever-greater responsibilities.[2]

The way in which the taking of weighty decisions is helped by new techniques may be illustrated from a sphere of activity to which we have not yet had occasion to refer. This is the medical profession. In an American hospital, which specialises in operations on the heart, the work of surgeons has been facilitated by installing an electronic machine:

> 'When a patient comes in, he is put through a long series of examinations and tests. In addition, the entire life background is checked. Such facts as age, education, mode of living, social standing, type of business or job, and history of previous illnesses and attacks are only a part of the information taken down and placed on a punched card. Then, when the doctor arrives at the point of decision, the

[1] *B.W.*, Dec. 3, 1955, p. 75 *et seq.*

[2] L. R. Groves, *op. cit.*, p. 3 *et seq.*

patient's card is run through the electronic sorter with the cards of previous patients. Within a few minutes the doctor has in his hands the cards of all patients with similar heart symptoms, within the same age bracket, and within the same income or job class. Furthermore, he knows the type of treatment or surgery that was indicated and the results of the treatment. He can then—after considering the risk reflected in these case histories—make a wise decision based on facts, not intuition. Without effort on his part, the machine reviews his and others' past experience. It does it better, quicker, and with little strain on the doctor . . . it is hard to determine just how much time the doctor would require to get at the facts he needs to make his decision.'[1]

Of course the surgeons, officials and managers will have to go on making their own decisions and must continue to accept responsibility for them. No electronic device can take those responsibilities off their shoulders. Electronic devices, however, with their infallible 'memories', can quickly give them completely reliable information that will help them to take their decisions. And they can do more than this. Provided that, from a logical point of view, the 'instructions' fed into the electronic computer are both accurate and comprehensive the machine is able to bring together innumerable combinations of facts that have never been related to reach other before. By using the computer

'Plant executives would conceivably have more time for decisions beyond the machine's capacity, aided by a broader base of processed fact and use of probability theory applied, perhaps, by the computer and ejected in the form of alternate decisions in order of preference.'[2]

The larger the concern the more necessary does it become for decisions to be taken in the light of facts which are considered not in isolation but in relation to each other. And these 'facts' include not only information about the past but trends for the future. It is on the basis of an analysis of individual aspects of these interdependent facts that sound decisions concerning future policy can be taken. The association between those responsible for assembling and analysing facts (with the aid of electronic devices) and those who take decisions in the light of those facts is becoming ever closer.[3]

[1]L. R. Groves, *op. cit.* [2]C. E. Knight and C. H. Fawkner, *op. cit.*, p. 16.

[3]Decisions taken by big concerns have to take into account (a) the private interests of the firm itself, and (b) the national interest. The possibility of reconciling these two interests is made easier by using electronic devices. For five years the Federal Reserve Board has been engaged in research on methods of estimating national wealth etc.: see *Federal Reserve System. Flow of Funds in the United States* 1939-1953 (Washington, 1955).

There are of course difficulties in practice in using computers to solve problems of management. One is that senior administrators may be positively overwhelmed by the multitude of facts which computers make available. Moreover the assumptions that are made—both of economic facts and economy theory—when preparing 'instructions' for the computer are inevitably liable to human error. Again, the machine may not be properly instructed as to which departments in a huge business organisation should receive particular results worked out by the machine.[1]

The analysis that we have made of the changing functions of management in big modern business concerns may be summarised as follows:

> 'The man of daring and imagination who relied on hunch supported by experience has become a technological casualty. The shrewd bargain has given way to the carefully calculated risk. The increasing size and complexity of business enterprises precludes the top executives from having knowledge of the details of the firm's operations. Decisions must be made by groups who rely on reports from . . . and other departments. Top executives today are forced to view their functions as consisting of planning, controlling and co-ord ting the firm's operations and harmonizing the interests of the firm with those of employees, investors, suppliers, and customers. Because of the high degree of interdependence in the economy the decisions of these executives intimately affect the lives of millions of people.'[2]

The last sentence of this statement must be taken literally when considering the position of the manager who is responsible for running a great modern business. It has been estimated that a major decision on the part of the directors of the largest American motor car manufacturers directly affects the lives of over 500,000 of their own employees (wage earners and salaried staff), another 400,000 persons associated with the firm in marketing motor vehicles, and a further 1,000,000 people employed by the 21,000 firms which supply materials to the company. The largest

[1]The extent to which instructions are sent out 'automatically' may be gathered from the following statement:

'In this management-by-information system a continuous semi-automatic flow of facts may, on reaching the data-processing and control device, be

1. Short-circuited back to operations in the form of simple commands based on computer decision, or
2. Siphoned off by management as correlated fact for decisions of an abstract nature and for general surveillance, and
3. Passed direct to the next data-processing step, still in computer language' (C. E. Knight and C. H. Fawkner, *op. cit.*, p. 17).

[2]*Hearings*, p. 31 (W. S. Buckingham, jun.).

American mail order house obtains its goods from some 10,000 firms employing altogether 1,600,000 workers. The second largest American company which manufactures electrical goods maintains over 100,000 selling agencies. The firms supplying this company with materials employ far more workers than the company itself. In the United States every fourth person in receipt of a salary or wages is employed by one or other of the 200 largest companies. It is not unreasonable to estimate that for every one of these employees two other persons are in the service of firms which supply these 200 companies with raw materials, goods and services. So it is probable that any major decision taken by the heads of the 200 largest American companies would powerfully affect the lives of three quarters of the wage earners and salary earners in the country.[1]

What part will automation play in the development of the functions and status of the managers of great business concerns? It will speed up and accentuate certain trends that can already be clearly seen. And it will hasten the coming of what has been called 'management by information evaluation'. Although automation will from one point of view tend to concentrate authority at the top in the large business concerns it is also true to say that the significance of team-work remains of great importance. The heads of departments, the engineers, the seniors administrative assistants and the various specialists must all work closely together if maximum efficiency is to be maintained. We have already drawn attention to a remarkable paradox. On the one hand automation is continually being extended in industrial plants, in business offices and in public administration. Yet at the same time heavier demands than ever are being made on the men and women who operate automatic plants and electronic computers. At all stages of production the maintenance of morale is becoming of ever increasing significance. It is the duty of the managing director to see that everybody in the service of the firm—from the senior administrative assistants to the men on the shop floor—identifies himself wholeheartedly with the company

[1]See H. Maurer, *op. cit.*, p. 85. An example may be given of the significance of a single decision taken by one of the great American companies. Early in 1954, despite the fact that a recession in trade seemed likely to occur, General Motors announced their decision to expand their plant. For the economic significance of this decision, see *Time*, January 2, 1956, p. 40 *et seq.*

and its policies. The more that he succeeds in doing this the more smoothly will the whole complicated system work. And it must be remembered that so complex an organisation as a great modern business is singularly susceptible to serious interruption from some comparatively minor cause.[1] He must possess the gift of amalgamating into a single effective plan, the ideas and suggestions put forward by the various 'teams' of specialists. But in addition to the ability of handling men the senior administrators of modern business houses must have exceptionally high technical qualifications as well.[2]

Anyone who assumes responsible executive functions in a great concern today must be prepared to identify himself body and soul with the organisation that he serves. His colleagues will expect from him clarity of thought and judgments of a decisive character. His views of political issues and cultural questions should be those with which they can sympathise. In short the senior executive must identify himself with his colleagues in such a way that everyone associated with the company feel a personal satisfaction in being a member of a team engaged upon a common enterprise. The manager of a firm should not be linked with the firm simply through his salary and future pension. For better or worse his whole personality must be identified with the company.

These aspects of management naturally influence big firms when they appoint young men to junior posts because these may be the senior executives of the future. Those responsible for making such appointments do not look merely at the technical qualifications of the candidates. They try to assess the personality of candidates. They enquire into the family history of candidates. And they try to appoint young men and women who show a willingness to identify their own futures with the company they wish to serve. In this way a homogeneous class of senior executives is being created by the big American concerns today. This class has many of the characteristics of a ruling group. Those who belong to this class think alike on fundamental questions. They

[1]*Margate Conference*, p. 201 (F. G. Woollard). See also p. 216 above.

[2]The managing director of one of the leading American chemical trusts has said that in modern business 'specific skill in any given field becomes less and less important as the executive advances through successive levels of responsibility. . . .' (H. Maurer, *op. cit.*, p. 87).

have the pride and exclusive feelings of a ruling class whose members have to solve similar problems and overcome similar difficulties. They are linked by the knowledge that they hold great power in their hands and that—both from an intellectual and a material point of view—they are the superiors of the vast mass of the population. This new social class controls (directly or indirectly) all the mass media of influencing public opinion. It is no accident that in the United States the services of advertising experts are being used to an ever-increasing extent. The new ruling class of course does not confine its activities to economic affairs alone. The qualities that are needed to make an efficient business executive are also, to a great extent, the qualities that are needed in the senior officers in the armed forces and the senior officials in public administration. There is naturally nothing surprising in the fact that former senior army officers and leading government officials are appointed to responsible and highly paid jobs in industry.

As the use of automatic methods of production increases the influence of engineers within the ruling group of managers will increase. And so the way in which engineers think about and act upon the problems of harnessing the forces of nature and the labour of human beings to economic ends will become of ever greater significance in the future. The resulting attitude of mind to both material and spiritual matters coincides with the authoritarian tendencies in all phases of management to which we have already drawn attention.[1]

(IV) THE SIZE OF COMPANIES AND PLANTS

For many years in the United States there has been widespread concern at the ever-growing sector of the economy that is being dominated by gigantic firms and combines. Numerous investigations in recent years have again and again made it clear that, in spite of legal action to prevent the growth of powerful trusts, the influence of the great combines has continued to grow. Quite recently the share of the really big concerns in the output of both industry and agriculture has expanded in an unmistakable manner. At one time the *turnover* of the giant trusts ran into milliards of dollars. Now it is the *profits* of these huge combines

[1] See also pp. 89-90 above.

that have actually reached totals of such dimensions.[1] Again in recent years more and more medium-sized and small firms have been swallowed up by the very big companies. And firms which have already achieved a substantial turnover and profits have amalgamated. Anti-trust legislation has not prevented this development.

It is well known that in recent years American agriculture has, on the whole, not shared the advantages of the boom in trade. But it is not so well known that 85 per cent of the agriculture output that comes into the market is produced by a third of the farms and plantations. This third of the agricultural units of production has prospered. The remaining two-thirds of the farmers—the men who suffer from overproduction—send to market only 15 per cent of the total agricultural output of the United States.[2] The farms concerned are, to a considerable extent, family concerns and—thanks to mechanisation—their volume of output compares favourably with that of the average small European farm. Nevertheless most of these American family farms do not pay well and they are rapidly declining.

In view of this tendency in industry, agriculture and also—though to a lesser extent—in trading the problem of the influence of automation on the size of units of industrial production is obviously one of considerable importance.

The Congress committe on automation (1955) paid considerable attention to the future of small firms and big business. Much of what we propose to say on this subject is based upon the *Hearings* of this committee. No final agreed decision was reached by the committee on the question as to how automation was likely in the future to affect 'small business' and 'big business'. The final report of the Congress committee stated that the evidence it had received did not enable it to offer any pronouncement upon a problem which was bound to arouse 'the gravest concern'. The report stated that

> 'The impact of automation upon the structure of our business society and the relative position of large and small business is a matter of

[1]The General Motors Company was the first American firm to announce a profit of a milliard dollars in a single year (after paying taxes). In 1955 General Motors sold cars valued at nearly 12.5 milliard dollars and made a profit of about 1.2 milliard dollars.

[2]*Hearings*, p. 67.

utmost concern. . . . There can be little doubt but that large business may find some advantage. . . . Small business unquestionably has its problems in the contest for survival. . . . The trend toward automatic machinery may result in making these difficulties even greater, but it is far from clear that automation itself is going to add a wholly new and overwhelming set of survival problems of its own.'[1]

It would appear that 'big business' rather than 'small business' would secure by far the greatest benefits from automation. The leading American companies have had no difficulty in raising the huge initial capital which is required to install automatic machinery into a plant. Very often the introduction of the automatic process of production cannot be accomplished merely by adding certain devices and replacing a few machines. It is necessary to write off the entire existing plant and to start afresh with completely new automatic machines. Only firms capable raising new capital on a really large scale can do this. We have seen that in the modern world—especially in the United States—the very big firms secure new capital out of profits and rarely ask the outside investor for support.[2] This obviously gives 'big business' a great advantage over 'small business' in getting the money needed to introduce automation. Attention has already been drawn to the fact that automatic machinery is particularly suitable for making mass-produced goods on a large scale. And it is 'big business' which has in its hands the production of most of this type of goods. Mass production postulates the existence of a mass market. We shall, at a later stage, give an example to illustrate the point that for a medium-sized firm the advantages of introducing automation may well be jeopardised by the failure to command a sales organisation capable of reaching a sufficiently large public. It should also be remembered that only the big firms can afford to conduct large-scale research and keep on the staff a considerable number of experts. And it is the work of specialists in research departments of firms which often paves the way for the replacement of the conveyor belt by automation. The large staff of able senior administrative officers which a big firm can afford to maintain also contributes to the successful introduction of automatic machinery into a plant. Again, when it comes to finding new jobs for workers rendered redundant by automation 'big

[1]*Report*, p. 10.
[2]See above, p. 221 *et seq.*

business' has an advantage over 'small business'. Since it is rare for all the plants run by a very big firm to turn over to automatic methods of production at the same time it is usually possible to find work in the conveyor belt plants for those who have lost their jobs in a new automatic plant.[1]

An important problem facing big business in the United States today is one of organisation. Should a big concern follow a policy of centralisation or decentralisation? Automation will probably prove to be an important factor in the situation. In recent years there has been much discussion concerning the possibility of securing the advantages of centralisation in business organisations without having to put up with the drawbacks associated with an over-bureaucratic form of administration. There appears to be a danger of concentrating output and administration in such huge plants and offices that the very size of the concern raises virtually insoluble technical and human problems. On the other hand decentralisation also has its drawbacks. If important decisions are left to departments or to outlying plants the head office may lose its effective oversight control over the business. Such a state of affairs might, in certain circumstances, cause the firm serious financial losses.[2]

From one point of view automation can be used to secure a measure of decentralisation because one—though by no means the only—way of organising a business on those lines is to prevent too many employees from working together in an unwieldy unit of production. Now automation reduces the number of persons engaged on a plant. Moreover, many of the factors which influence the localisation of a non-automatic plant do not apply to an automatic plant. This, too, may facilitate decentralisation. The maximum advantages both of decentralisation and of automation would appear to be secured if automation is introduced

[1]The reader might expect us to mention at this point the very high cost of the big electronic computers which many small and medium-sized firms cannot afford to install. But it is not a matter of urgency for firms of this size to use an electronic computer. The workshops and offices of a relatively small firm are of a size which can be quite efficiently supervised without the aid of a computer. There is no real need to install a very expensive machine to handle the volume of data which represents the business done by the average small firm. Moreover, smaller and cheaper electronic computers will probably soon be on the market.

[2]The report of the Congress enquiry into automation (1955) specifically states that it is not always possible to decentralise a business. The possibility of effective decentralisation depend to a considerable extent upon the kind of product that is being made.

by a firm into its workshops and administrative offices simultaneously. The Congress committee on automation (1955) was told of a case in which automation made it possible 'to have your cake and eat it'. By introducing automation a firm was able to have all the advantages of decentralisation[1] and yet the headquarters of the firm retained undisputed control over essential matters in its own hands.[2] A report by D. G. Mitchell —in which this example is given—discusses the significance of all this to the complex administration of a modern state and to the application of rational planning to a capitalist economy.

Mitchell puts forward various arguments in favour of decentralisation in public and private administration. He considers that initiative, power and responsibility should be delegated from the top of an organisation to the bottom. The administrators halfway down the scale should be made to accept responsibility for decisions at a certain level.[3] In this way the central administration can be saved from the burden of reaching decisions on numerous matters of relatively minor importance. Such decisions, if taken at the top, might well be of a somewhat arbitrary character. Mitchell argues that a number of sociological advantages can be gained in business by limiting the size of the unit of production. He suggests that if plants employ no more than 700 men they can often be established in small towns where the transport difficulties of big cities do not occur. It would be possible for plants of this size to draw their workers largely from the immediate vicinity—and this could be done if the plant had automatic machinery and needed only a small number of operatives.[4] Mitchell points out that in a relatively small plant one can establish quite a different relationship between management and men compared with what happens in a big plant. The manager of a large plant cannot walk '. . . through the plant and call them by their first names, Tom, Joe, Harry, and he cannot really know what they are doing'.[5]

[1]C. E. Knight and C. H. Fawkner, 'The Impact of Automation on the Company Organisation' in *G.M.S.*, No. 178, p. 11 *et seq.*

[2]*Hearings*, p. 183 (D. G. Mitchell, chairman and president of the Sylvania Electric Products Inc.).

[3]*Hearings*, p. 183.

[4]'Decentralization, as we run it, could not be accomplished without mechanization. These are highly mechanized plants, with few employees, with a small supervisory force watching over them' (*Hearings*, p. 184).

[5]*Hearings*, p. 184.

We have already seen that when automation is introduced it is of vital importance (contrary to the position when work is done on the conveyor belt system) that there should be a positive relationship between the workers and the task upon which they are engaged. A high standard of morale is essential to the efficiency of an automatic plant.[1] Mitchell suggests that this, too, can be achieved by establishing plants in small towns, where it is relatively easy for the worker to play a part in the life of the community:

> 'A decentralized plant, operated as an integral part of the community, seems to breed . . . an awareness of community responsibilities and a desire to do something about them. Whether it is a fund-ra
> or anything else, everyone seems to get behind them and views them as part of his individual responsibility.'[2]

Mitchell concludes by expressing his conviction that such small plants would be 'more efficient' than large plants because the whole body of employees from the manager to the youngest worker would strive to make it so.[3]

The undertaking which Mitchell is discussing employs 26,000 workers and salaried officials in 43 separate plants, 16 laboratories and 15 warehouses. These 74 establishments are situated in 40 different places—24 establishment are in Pennsylvania, 15 in New York and 11 in New England, while the rest are scattered over the Middle States, the South and the West coast. It might well be asked how the board of directors of a concern which sprawls over a large part of the North American continent can perform its functions properly. The firm solved this problem in the autumn of 1955 when it set up a central office to amass data concerning the output of all its plants and the marketing of all its products. A private information service was established which had its headquarters in the little town of Camillus near Syracuse in New York State. Twenty thousand kilometres of telephone wires link 51 places with this office and here a giant computer has been installed. All the necessary data concerning production, purchases, sales, goods dispatched, finance and many other matters

[1]See above, p. 217. [2]*Hearings*, p. 184.

[3]'The working force at that plant doesn't work any harder, but does work more effectively. It isn't the machine that does it; the machine only makes it possible for us to set up an autonomous operation . . . the attitude—that is the key to the situation' (*Hearings*, p. 185).

are collected, classified and co-ordinated by the computer. In this way the board of directors—as well as heads of separate plants—can get a bird's eye view of the affairs of the firm at any particular moment. But the computer is not yet working to full capacity and it is intended to use it for market research, the analysis of goods produced and for other purposes.[1]

Industrial output can never be completely automatic so long as decisions taken by the producers of raw materials and the purchasers of finished articles play an important part in the working of our economic system. It is true that the very big firms are able to influence the demand for their goods by great advertising campaigns and that they can estimate future demand with some accuracy by conducting research into the preferences of their consumers. Nevertheless even big business has to adapt itself to changes in the demand of the buying public. Even in a centralised authoritarian economy the nature of industrial output will depend, not only upon the decisions of political bodies, but also—if only to a limited extent—upon the views of consumers. When public demand changes it is necessary for industry to adapt itself quickly to a new situation. And that adaptation must be made in the light of numerous factors that influence the situation. The bigger the share of the market that has been gained by a particular firm the more essential is it that a sound decision should be taken. And this can be done by the aid of an electronic computer which can bring together quickly and accurately information concerning the changes that should be made in output storage, and the sending of goods to customers.[2]

In view of the very great advantages which big business secures in a highly-competitive world by adopting automation in its entirety it may be assumed that the trend towards the growth of large concerns will receive a powerful stimulus from automation. It seems clear, too, that automation will be an important factor in rapidly strengthening the position of the big concerns as against the medium-sized and smaller businesses.

This point of view has been vigorously criticised. Some people have argued that the medium-sized and small firms will find a

[1] *Hearings*, p. 189.

[2] C. C. Hurd, *Centralised Control and the Factory of the Future* (mimeographed Oct. 1955).

strong ally in automation. They say that in a number of industries automation will for the first time enable the smaller firms to compete on more level terms with their bigger competitors. One argument which is put forward in support of this point of view is of a negative character. It is said that the automatic method of industrial production leads to a certain rigidity in the economy. Difficulties arise in adapting production quickly to changes in demand. It has been suggested that the smaller firms, with their more flexible organisation, will be able to turn out quickly goods which big business either cannot or will not produce. Very large firms which are interested solely in the mass-production of goods for a mass-market frequently decline to sink capital in order to make goods which might not yield a good profit because their manufacture cannot conveniently be fitted into the normal routine of their methods of production.

Moreover it must be remembered that nearly all the very large concerns which make mass-produced commodities—the motor vehicle industry for example—buy from other firms many accessories to their main product. This is because the big manufacturers have neither the organisation nor the time to make for themselves all the accessories that they require.[1] Another sphere of activity which is open to the small firm is to specialise in the servicing of the ever-growing number of electronic devices which are being installed in industrial plants and in offices.[2]

The hopes raised by arguments of this kind were clearly expressed by Vannevar Bush to the Congress committee on automation (1955):

> 'But the fact that flexibility is decreased is to me a very interesting matter. For the mere presence of automation is producing in this country opportunity for small industrial units to prosper in a way that I feel is very healthy from the standpoint of our whole industrial situation. . . . They can prosper in fields where there are large, well-managed companies operating primarily for the reason that . . . they can get close to their customers and meet their needs intelligently, and they can change rapidly with the times and the trends. The point that I wish to make is that if large manufacturing companies turn to automation in extreme form, they thereby not only

[1] An American company which makes electronic products uses 55,000 separate parts. 'Can one manufacturing company become efficient in the production of all these, let alone have the capital to set up these lines, or even what is more to have the management capability to handle all this in one big business?' (*Hearings*, p. 379).

[2] Peter Drucker, *op. cit.*, p. 11.

make a market for small companies of this sort but they also increase their own rigidity and render it more possible for the small industrial unit to prosper by reason of its inherent flexibility. . . . Thus automation may have some effects that tend to increase the size and relative proportion of production of large units, but it also has important effects in just the other direction.'[1]

Even in the technical sphere there seems reason to hope that the automatic process of industrial production will put into the hands of medium-sized and small firms a weapon which will help them in their struggle for existence in an economy organised on highly competitive lines. Smaller computers are coming onto the market which will enable medium-sized firms to secure the advantages of this aspect of automation.[2] Again the 'numerical control' method of operating certain machine tools will probably also come within the reach of the smaller companies.[3]

It has been seen that only big firms commanding large capital resources can introduce 'transfer machines' into their plants and so operate a conveyor belt on automatic lines. But another aspect of automation—the electronic device ('numerical control') for operating machine tools automatically—is less expensive.[4] It has frequently been argued that it will take a long time before automatic machine tools are introduced into all engineering works.[5] Nevertheless an examination of current technical journals shows that a large number of these automatic devices are coming into use every day. The introduction of such electronic devices into smaller plants will greatly reduce their costs and will also improve the quality of their output.

In different branches of industry the division of firms into 'large', 'medium-sized' and 'small' is made on very different principles. The capital resources and turnover of a 'large' textile company would be regarded as a 'small independent firm' in the huge American motor vehicle industry. The 'independent' car manufacturers together produced only 4.4 per cent of the cars

[1] *Hearings*, p. 615 (Vannevar Bush, president of the Carnegie Institute (Washington)).

[2] It might be argued that the expense of purchasing even a relatively small electronic computer would be too great for some of the smaller firms. But their needs are being met by the establishment of 'computer centres' at which small firms can, in effect, hire a computer at a reasonable rent to perform a particular task.

[3] See above, p. 121, n. 4.

[5] *Automation* (Cleveland, Ohio), Oct. 1955, p. 25.

[4] *Hearings*, p. 9.

made in the United States in 1955. Evidence laid before the Congress committee on automation (1955) showed that these independent companies were—from both a technical and a financial point of view—in a position to introduce many aspects of automation production into their plants. Since the productive capacity of 'transfer machines' is limited—e.g. sixty motor-blocks an hour—the small firm would need to instal only one machine of this kind. And by purchasing a single machine the firm concerned would secure all the advantages to be gained from this type of automation.[1]

It might therefore be argued that there is no reason to believe that the smaller and medium-sized firms have much to fear from the advent of automation. Certain automatic devices are within their reach. Such a conclusion would, however, be somewhat premature since it ignores an important factor in the situation. Big business has an enormous and a growing advantage over small business in capturing new markets. A representative of the American 'independent' firms told the Congress committee on automation (1955):

> 'Automation, in our view, does not in itself present a major problem for the relatively smaller producer in the automobile industry. Automatic processes do not, *per se*, require extreme size. . . . The problem of such a [smaller] manufacturer is to secure and maintain, in the face of the marketing strength and advertising expenditures of its larger competitors, the sales volume needed to permit to it enjoy the advantages of automation and to create the earnings necessary to make the capital investments required for the purchase of automatic facilities.'[2]

It is the problem of the market that makes nonsense of the alleged 'neutrality' of automation in the struggle between the big firm and the little firm. This may be seen only too clearly by examining the fate of the 'independent' American motor vehicle manufacturers in 1955 when production in the United States reached the record figure of nearly eight million cars. The Studebaker-Packard Corporation could boast that its automatic

[1]This, of course, applied only to the wages saved on redundant workers and the depreciation of the machines. The huge concerns secure a further advantage from automation since they can spread the high cost of supervising and servicing automatic machinery over several plants.

[2]*Hearings*, p. 417. It may be noted here in passing that the representative of the smaller companies assumes, as a matter of course, that the big firms can raise the capital they require out of their own resourc s.

plant embodied the most recent technical knowledge and was a model of efficiency. It had a productive capacity of 470,000 cars a year in 1955. This represented 6 per cent of the total American car production. But *actual* output amounted only to 182,033 cars —i.e. 2.29 per cent of the total production in the United States.[1] In this case it is very doubtful if the heavy investment made in automatic machinery was justified from an economic point of view. Nevertheless, owing to the very great superiority of automatic over traditional methods of production—they are more efficient and save costs in the long run—it seems inevitable that the small and medium-sized firms will be virtually forced to adopt automation and then try by all means within their power to secure and maintain

> 'the necessary sales volume to justify the operation of an automatic line at or near its capacity.'[2]

An examination of the facts and opinions laid before the Congress committee on automation (1955) makes it clear why the committee hesitated—in the light of the information at its disposal—to attempt to reach a final conclusion on this question. Nevertheless—as in other discussions concerning the future of small and medium-sized firms—certain points seem to emerge reasonably clearly even although the available data is both incomplete and of a provisional nature. In this connection care must be taken not to confuse problems connected with the size of *plants* with those concerning the size of *firms*.

The size of a plant or an office is normally measured by the number of persons employed in it. Throughout the last hundred years steady technical progress has tended to bring about a progressive increase in their size. The coming of automation would seem to have slowed down or even to have reversed this trend. The arguments (which we have already summarised) in favour of decentralisation in industry appears to us to be valid for all branches of industry into which automation can be introduced.

[1]*Hearings*, p. 416 *et seq.* and *N.W.*, Jan. 23, 1956, p. 31.

[2]*Hearings*, p. 417. At the end of April 1956 it was reported that this firm had been working at a loss owing to the lack of armament orders. In the previous year, on the other hand, the output and profits of the American motor-car industry had reached record heights. The same reports stated that

> 'The military equipment is needed, but officials also want to make sure that the company's facilities will be available in an emergency.' *Report on the Business Outlook* (Washington, D.C., April 26, 1956).

On the other hand the size of a firm (as distinct from a plant) is usually measured by its capital resources or by the value of its output. It is by no means certain that the coming of automation will enable the small and medium-sized firms to hold on to—let alone to improve upon—their existing position in competition with their larger rivals.

The social significance of changes in the size of units of industrial production is clear. A policy of decentralisation could have significant cultural and political consequences since it would be a reversal of a long established trend towards the crowding together of workers in every larger plants which has led to the development of the 'mass mind'. The problems of industrial organisation, leadership of management, and 'human relations' in industry would, in such circumstances, take on a new aspect.

Ever since the industrial revolution began there has been a tendency for the economy to be dominated by the larger as distinct from the smaller firms. This tendency, culminating in the rise of great trusts, has had significant social consequences. In this connection we are not concerned with any comparison of units of industrial production—by the number of workers, the capital invested or the annual output—but we have to consider the amount of capital in the hands of a single company or trust. In the light of all the available evidence there seems to us to be no doubt that the expansion of automation will encourage that 'concentration of economic power and of financial control over the production and distribution of goods and services'[1] which the majority of Americans distrust and fear.

It seems probable that the advantages that automation might be expected to bring to the smaller and middle-sized firms are not so substantial as might be supposed. We do not propose to examine this problem in detail but we suggest that the following points deserve consideration.

The financial strength of big concerns is so overwhelming that they are obviously in a far better position than small firms

[1]This is what the 'Temporary National Economic Committee' was officially asked by President Roosevelt to investigate in 1938. The enquiries of this committee continued for a long time. Even today the information which it brought together concerning the structure of the economy of the United States has not been adequately used. When the Congress committee on automation met in 1955 a suggestion was made that the investigations begun before the second World War by the Temporary National Economic Committee should be resumed. See *Hearings*, p. 47.

to secure every possible advantage from automation in their multifarious industrial activities. The appearance on the market of cheaper electronic devices for use in factories and offices will not alter the fact that only the big concerns have the money to maintain the expensive research departments which are essential if the fullest benefit is to be gained from automation.[1] The really large firms have other advantages as well. They can secure the maximum possible expansion of productive capacity from automation. They can push their expanding output onto the market with all the means which modern advertising techniques place at their disposal. It is here that the big concerns have a decisive advantage over their smaller competitors. The large companies are also in a stronger position when trade is slack or when there is a serious business depression. They can get temporary credit for running expenses to a greater extent than relatively small firms. There are further factors in the situation to which brief reference should be made. The big concerns can attract the most highly qualified engineers and technicians because they have better laboratories than small firms and can offer their senior employees higher salaries and greater chances of promotion. From this point of view small firms are in a relatively weak position. This may be illustrated by quoting a statement made by the managing director of a leading firm in the electrical manufacturing industry:

> 'Some of the big ones, General Electric and General Motors, and others, go to some colleges and say, "We will take your entire graduating class, no screening or anything. We will take every graduate." That makes it a little hard for some of us smaller companies.'[2]

Another reason why automation brings great advantages to big concerns is because this technique of industrial production still further strengthens the hold already possessed by these firms over the market for mass-produced goods. The final report of the Congress committee on automation (1955) does not strike a very hopeful note for the small firms when it declares: 'While big

[1]In the United States in 1953 (the last year for which statistics are available) over five milliard dollars were spent in scientific and technical research. About half of this money came from private industry. Over 70 per cent of the research work was done in the laboratories of the 375 biggest American concerns. Over 15,000 other firms —associated with government institutions, Universities and other bodies—were responsible for the rest of the research.

[2]*Hearings*, p. 205.

business fights for mass markets, smaller business may capture the business left behind'.[1]

It is obvious that there are few prospects of the small firms retaining a neglected market of this kind should big business think that profits could be made from its exploitation.

There is yet another factor which will tend to strengthen the economic power of big business. And this is actually a factor in the situation which some people argue will work to the advantage of the smaller firms. This is the fact that the small firms do a good business in supplying the big companies with accessories. It seems likely that the small firms which concentrate on this type of business will gradually become economically dependent upon the big firms upon which they depend for a market. They may well become economic satellites of big business but they still have to risk their own capital and in the event of a slump they are unlikely to get much help from the big firms with which they are becoming so closely associated. What is happening is similar to what has already taken place as far as the distribution of goods is concerned. The fate of the American motor car dealers and petrol stations should serve as a warning to the small firms which supply big business with accessories. It is true that—particularly in the United States—certain car dealers and petrol stations have accumulated not inconsiderable financial resources. But only if it could be proved that their financial position was typical of all firms of this type could it be argued that the firms which make accessories for big companies have enough capital to retain their economic independence in the future.

J. A. Bright, writing in the *Harvard Business Review*,[2] argues that in some branches of industry the small firm will be able to take advantage of the savings in costs which can be secured by introducing automation. Such firms, he thinks, can continue to compete successfully with big business. The small firms which are most likely to be successful are those which rely upon a local, rather than a national, market. The transport costs are naturally much smaller if only a local market is supplied. Small firms also have a chance against their larger competitors because they are

[1] *Report*, p. 10.

[2] J. A. Bright, 'Thinking ahead: some effects of Automation' in the *Harvard Business Review*, Nov.-Dec., 1955, p. 27 *et seq.*

frequently able to adapt themselves to changing market conditions more quickly than big business.

On the other hand Bright thinks that small firms which continue to produce conventional goods by traditional methods have little chance of competing successfully with big companies which have introduced automatic methods of production. Bright's conclusions concerning the fate of the small firm in the new age of automation will hardly make pleasant reading for the little man in American business:

> '... He (the small producer) will have to make his living by producing the fastest or the finest, not by direct competition. His situation *parallels that of the independent cobbler*, who cannot compete with the modern shoe factory, but who may make a good living on custom tailored shoes.'[1]

In conclusion it is probable that the social consequences of automation, in so far as they affect the size of firms, were correctly stated by W. Reuther when he told the Congress committee on automation (1955) that the progress of automation would mean

> '... that big firms will grow even bigger, while small- and medium-sized competitors are squeezed against the wall.'[2]

Reuther argued that this process could be stopped—and that the decline of the small firm in the United States could be arrested—by government intervention. That seems to us to be a highly dubious remedy.[3]

(v) AMERICAN TRADE UNIONS AND AUTOMATION

We have already discussed in the first part of this book the attitude of organised labour in the United States to automation. The present views of American trade unionists have been admir-

[1]J. A. Bright, *op. cit.*, p. 163 (italics supplied).

[2]*Hearings*, p. 112 (W. Reuther).

[3]The argument is sometimes put forward—we have mentioned it above, p. 234—that the revival of the electrical manufacturing industry in the United States augurs well for the future of small firms. In our opinion this is not a sound argument since it is based upon a projection into the future of exceptional boom conditions. An expert has expressed the view that what he calls a 'shake out' of this industry is to be expected:

> '... it is generally conceded that the electronics industry, during this maturing phase, will go through a "shake out". Opinions differ, but some believe—and I am inclined to agree with them—that upwards of 80 per cent of the companies or divisions now in electronics will be merged, consolidated, or will "go by the board" during the next five years. This is a normal evolutionary process from which will emerge mature electronics companies, or entities. . . .' (C. B. Thornton (managing director of Litton Industries Inc.), 'Economic and Social Implications of Automation' in *S.F. Symp.*, p. 179).

ably summarised by the former president of the Congress of Industrial Organisations who subsequently became vice-president of a joint organisation representing both the American Federation of Labour and the Congress of Industrial Organisations:

> 'We know that you cannot hide from technological progress. We know, too, that the labor movement, which is itself a progressive movement, must not stand in the way of scientific improvements.
>
> We have, therefore, welcomed automation as a new step in man's progress towards the production of abundance and the establishment of a better and richer life for all people. At the same time, however, we are committed to the proposition that the transition to automation must not result in the dislocations and human suffering that accompanied the first industrial revolution more than 100 years ago. or that followed the introduction of mass production techniques after World War I. . . .
>
> Science and technology are giving us the tools for economic abundance. We intend to do all in our power to see to it that these tools will help in our power to see to it that these tools will help to bring peace, freedom, and improved living conditions, as well as a greater measure of security and leisure, to mankind everywhere.'[1]

These arguments were repeated by all the trade union leaders who appeared before the Congress committee on automation in the autumn of 1955. They hotly denied assertions that American organised labour was opposed to the automatic method of industrial production.[2] All they insisted upon was that there should be no repetition of what had happened at the time of the first industrial revolution and during the period of rationalisation between the two World Wars. On those occasions it was the workers who had suffered all the drawbacks that come when technological progress alters the structure of industry. On this occasion the American workers demanded that, from the very start of the new industrial revolution, they should get—through higher wages, shorter hours and lower prices—a fair share of the new wealth which automation will create because it is so much more efficient than the traditional methods of production. The notion that the workers can gain these advantages from automation is based upon the assumption that the 'underconsumption' theory is correct. Moreover, the trade union leaders argue that

[1] *The C.I.O. News*, July 4, 1955, p. 5.

[2] 'There has been a great deal of propaganda. Even the Secretary of Commerce has misrepresented the position of American labour with respect to automation. He would have you believe that we are opposed to automation. We are not. We welcome any development that will lighten the burden of human labour' (*Hearings*, p. 120).

higher wages, shorter hours and lower prices will keep the balance between productive capacity and consumption and so help to maintain the stability of the economy.[1]

Another argument put forward by trade union leaders runs as follows: If in England in the middle of the eighteenth century it had been possible to foresee the social evils that would follow in the wake of industrialisation, and if England had had a democratic constitution at that time

> '. . . the working people could have been secured against the great social costs of industrialization without any significant loss of incentives, technological progress or capital accumulation.'[2]

We have already discussed some of the remedies put forward by American trade unionists to ward off the danger of technological unemployment due to automation. Perhaps the most important of these demands was the 'guaranteed annual wage'. In the year 1955 considerable progress was made in certain branches of manufacture—particularly in the motor car industry—towards the achievement of this reform. The three largest motor companies reached an agreement with their workers (which was to last for three years) which provided for certain payments to workers who lost their jobs. During the first four weeks of unemployment a former employee would be paid a sum equal to 65 per cent of his former net-wage. For the next twenty weeks a worker would draw 60 per cent of his old wage from his former employer. In calculating these payments unemployment benefits would be taken into account. If this agreement were accepted by the courts it would come into force in June 1956. As security for the payment of a 'guaranteed wage' for nearly six months of involuntary unemployment the firms concerned set up trust funds of between 55 and 130 million dollars. Money is paid into these funds on the basis of 5 cents for every hour worked by every employee. The motor firms have no financial liabilities beyond this.[3] It is expected that in 1956 similar agreements will be signed in the steel and electrical industries.[4]

[1]See above, p. 76 *et seq.*

[2]W. S. Buckingham, jun., 'The Challenge of Automation', *op. cit.*, p. 31 *et seq.*

[3]*Economist*, June 11, 1955, p. 937 *et seq.*, and June 18, 1955, p. 1046 *et seq.*

[4]A closer approximation to a 'guaranteed annual wage' was secured in August 1955 by the steel workers employed by the two leading American firms which make tins for preserves. By this agreement a worker who loses his job will get 65 per cent of his average net wage (including unemployment benefit) for 52 weeks. See *Economist*, August 20, 1955, p. 623.

It has been pointed out that such agreements do not give the workers a guaranteed annual wage. The payments for which they provide run for less than six—and not for twelve—months and the payments are not fully guaranteed since the firm's liability ceases if the trust fund is exhausted. Nevertheless there can be little doubt that the agreement represents a very considerable advance from the point of view of the trade unions. It goes a long way to establish a principle—quite novel in a private enterprise economy—that employers have a definite responsibility for the financial security of people who have worked for them for a particular length of time.

We do not propose to discuss in detail the truly revolutionary economic and social changes that would follow from the universal acceptance of this principle.[1] The principle is certainly no Utopian idea. President Eisenhower has suggested on several occasions that unemployment benefit in the United States should be raised so that for the first 26 weeks that a man is out of work he should get a grant equal to 50 per cent of his former average weekly wage.[2]

One further point deserves to be mentioned in this connection. If in a private enterprise economy the employer is to be saddled with the responsibility of guaranteeing the wages of his workers he will have a new incentive to introduce automation into his works as quickly as possible. Already relatively high wages encourage manufacturers to reduce labour costs by installing automatic machinery. The universal adoption of the principle of the guaranteed annual wage would promote further automation so as to avoid this liability as far as possible.

In 1955 little was heard in the United States of the demand for a shorter working week. This was because it was to a great extent a boom year of full employment. Moreover the trade unionists in the United States have accepted the fact that many basic needs of the

[1]Peter F. Drucker (*op. cit.*, p. 12 *et seq.*) discusses some of the economic difficulties of adopting this principle. The problems that a guaranteed annual wage would raise for the trade unions themselves are discussed by H. J. Ruttenberg in an article in *Harper's Magazine* (Dec., 1955, p. 29 *et seq.*) entitled 'Pay by the Year. Can the Unions afford it?' The author of this article appears to have been the first to suggest the establishment of a guaranteed annual wage. He is now the director of an engineering works.

[2]*Ec. Report*, 1956, p. 93.

American people are as yet by no means satisfied.[1] They agree that some of the increased industrial productivity made possible by automation should be used to provide such essential requirements as schools, houses, hospitals, roads and works to prevent floods.[2] This would seem to imply that the American labour leaders accept the view that it is by means of a huge programme of public works that workers rendered redundant by automation should be found employment.

Reuther has said that 'we need to be thinking in terms of a 35-hour week, a 30-hour week, a 4-day week' only when 'the tools of production make it possible to satisfy our basic economic and material needs with fewer and fewer hours of work'.[3]

In Britain not only the Trades Union Congress but also associations representing office workers and salaried workers have shown considerable interest in the problems raised by automation. There was full employment in Britain in 1955. Hardly any office workers lost their jobs because computers or other electronic devices were introduced. Most of these workers were found other jobs by the firms which employed them. The trade unions take the view that automation must be closely watched but they consider that—if management and men co-operate—the problems raised by this new technique of industrial production can be solved.[4]

After receiving a report on the progress of automation the International Confederation of Free Trade Unions (which unites the free trade unions of the world) decided to ask the economic and social council of the United Nations to investigate the whole problem. For the guidance of its members the International Confederation of Free Trade Unions advocates the following policies as necessary to deal with the problem inherent in automation:

(a) measures aiming at making the introduction of automation

[1]Article on 'Labour's Dilemma' in the *Economist*, November, 1955, p. 48.

[2]In this connection it should be remembered that the proportion of the American population which has a standard of living *below* the 'normal' or 'adequate' in the United States is still as big as it was five or ten years ago. This social group—with a family income of under 2,000 dollars a year—embraces about one-fifth of all American families. See G. Colm, *Technology and Economic Progress* (mimeographed lecture: Los Angeles, 1956).

[3]*Hearings*, pp. 133-4. (W. P. Reuther).

[4]*Trades Union Congress Report*, 1955, p. 247 *et seq.*; article on 'Gewerkschaften und Automatisierung' in the *F.A.Z.*, Sept. 23, 1955; and article by John Walton on 'Die Automation kommt ins Büro' in the *Kölnische Rundschau* (Cologne), Jan. 13, 1956.

a gradual process, with each step taken in close consultation with the free trade unions;

(b) increases in wages to ensure that increased purchasing power matches increased productive capacities;

(c) reduction of working hours;

(d) guaranteed wage systems and other safeguards for individual workers, including those for seniority rights; and

(e) programmes of training and re-training on the job, within industry, and in government-sponsored schools and colleges.[1]

A comparison of these principles with the demands of American organised labour shows that there is no difference of opinion between the trade unionists of Europe and of the United States on these issues. In Europe industry is by no means so highly capitalised as in the United States. And the European manufacturer often supplies a smaller market than his American counterpart. In the circumstances the European trade unionist has less reason—at any rate in the immediate future—to be alarmed as his American colleague at the possible evil consequences of automation. Nevertheless the following newspaper extract shows that in Britain, too, the workers are fully aware of the fact that automation may be inimical to their interests: 'The joint committee of trade union representatives in the British motor car industry agreed to accept the introduction of automatic transfer machines only on the following conditions—shorter hours, higher wages, no redundancy.'[2]

[1] *Free Labour World* (monthly publication of I.C.F.T.U.) Feb. 1956, p. 43.

[2] *F.A.Z.*, October 13, 1955. Early in May 1956 there was a serious labour dispute in a British motor works owing to the threat of redundancy from automation. The 11,000 workers in the plant came out on strike because the firm had dismissed 3,000 employees in the tractor department of the works, where the introduction of automation was imminent. The management had originally hoped to absorb the redundant workers in the motor car department of the plant, but this proved to be impossible owing to a recession in the motor trade (*F.A.Z.*, May 3, 1956).

Chapter VIII

AUTOMATION—BLESSING OR CURSE?

Norbert Wiener was the first to appreciate the significance of the social changes that would probably follow the widespread adoption of automation. Even during the second World War he recognised that the coming of automation heralded a second industrial revolution. He saw that despite its marvellous technical achievements automation carried with it a grave threat to the economic and social stability of modern society. He saw mass unemployment looming ahead. He saw that many highly skilled occupations were doomed. He saw how strong a weapon automation could be in the hands of an authoritarian administration. Like some American atomic scientists he feared that modern technical achievements would be used in the wrong way and so do untold harm to humanity:

> Those of us who have contributed to the new science of cybernetics thus stand in a moral position which is, to say the least, not very comfortable. We have contributed to the initiation of a new science which, as I have said, embraces technical possibilities for good and for evil. We can only hand it over into the world that exists about us, and this is the world of Belsen and Hiroshima. We do not even have the choice of suppressing these new technical developments. They belong to the age. . . . There are those who hope that the good of a better understanding of men and society which is offered by this new field of work may anticipate and outweigh the incidental contribution we are making to the concentration of power (which is always concentrated, by its very conditions of existence, in the hands of the most unscrupulous). I write in 1947 and I am compelled to say that it is a very slight hope.[1]

We do not share Wiener's gloomy forebodings. In view of advances that have been made both in pure science and in practical technology, it seems reasonable to suppose that the

[1]Norbert Wiener, *Cybernetics, or Control and Communication in the Animal and the Machine* (1948), pp. 38-39.

widespread introduction of automation in industry will bring with it good as well as evil. It may be proper at this point once again to draw attention to some of the evils that might be expected if—without recognising its limitations in the modern economy—we allowed automation to be introduced whenever it appeared to be profitable to a firm to do so. The social consequences of automation cannot be ignored because a group of individuals might make money from it. Those who do so resemble the feckless sorcerer's apprentice who set forces in motion of which no responsible sorcerer would ever approve. The too rapid introduction of automation might bring with it social catastrophe that only a totalitarian government would be strong enough to handle.

We know what an important part the modern press, films and radio play in moulding public opinion in totalitarian states, although these are inventions of comparatively recent origin. To these mass media television must now be added. And now the scientists and engineers have produced new automatic machines and electronic devices. Here are fresh tools with which to influence the minds of the masses. As early as December 28th 1948 Father Dubarle, a Dominican monk, wrote an article in *Le Monde* on 'Cybernetics' in which he discussed, from a theoretical point of view, the possibility of constructing a '*machine à gouverner*'. He had in mind an electronic computer which would tell an administrator what measures in a given situation would be most likely to achieve a particular political object. Wiener has suggested that certain physiological prerequisites are still lacking for the successful functioning of such a machine. He states however that, in a sense, a '*machine à gouverner*' is on the way, since computers—constructed according to the Neumann-Morgenstern 'theory of games'—are already in existence which tell the operator what steps should be taken (in given circumstances) to solve certain military problems. Wiener remarks that the danger of such a machine is that it might 'be used by a human being or a block of human beings to increase their control over the rest of the human race'.[1]

But we should not despair. Human freedom is not necessarily doomed. If only automation is deliberately used to promote the welfare of the human race it could help to banish poverty rela-

[1]N. Wiener, *The Human Use of Human Beings* (revised edn., Boston, 1954), p. 181.

tively quickly from the face of the earth. And this could be done on a scale that has hitherto been regarded as a mere Utopian dream. It is, however, easy to show that this aim can never be achieved if we leave the direction of these new powers entirely to private enterprise and to the workings of a 'free' market as envisaged by the classical economists. If that were allowed to happen millions of men would be sacrificed, for there would be no place for them in the new economic system. There would be a destruction of human productive powers compared with which the ravages caused by unemployment in the world economic depression of the early 1930s would be negligible. It is possible that *in the long run* the mechanism of the 'free' market—supplanted by that degree of State action in the fields of social welfare and economic policy which is now regarded as inevitable in modern industrial countries—would find new jobs for workers made redundant by automation and might bring about a general rise in the standard of living.

The validity of this argument is not seriously questioned. But to consider these problems only from the long-term point of view can lead to totally erroneous conclusions. This is particularly likely in the present instance when a knowledge of history can give us no guidance as to the probable reactions of those whose lives will be affected by automation. A study of the economic and social development of the United States in the past shows that, in former times, those who had to adapt themselves to industrial changes had neither the will nor the ability to make an effective resistance. Looking back upon these events today we tend to make the mistake of imagining that since the workers did not actually revolt the process of industrial change was one of unsensational and steady progress. The *Hearings* of the Congress committee on automation (1955) gives a striking example of this.

M. G. Munce told this committee that in his opinion there was no reason to suppose that automation would bring with it large-scale technological unemployment. In support of this point of view he argued that in the past 'as one field of employment declines other employment opportunities increase'. He pointed out that although the number of persons gainfully employed in American agriculture had declined there had nevertheless been an increase in the total number of persons gainfully employed in the United States.[1]

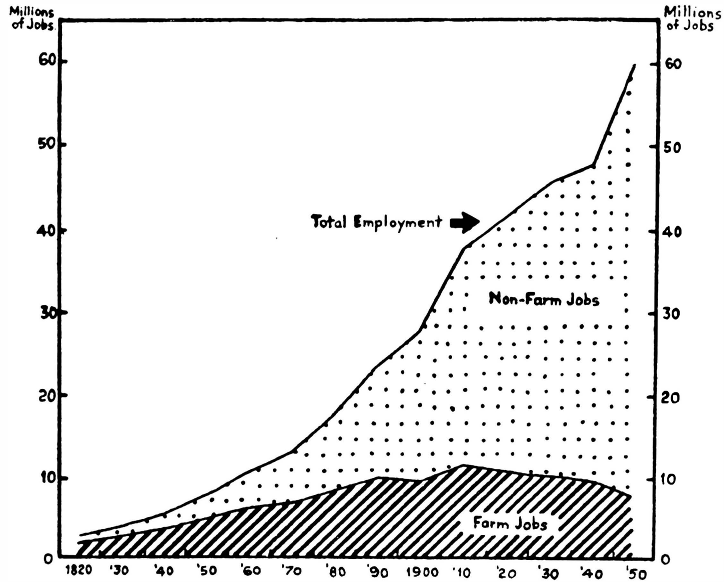
Diagram X clearly shows that from 1820 to 1950 there has been a continuous increase in the total number of persons gainfully employed in the United States in spite of the fact that, during this period, there has been a sharp decline in the number of persons gainfully employed in agriculture. It is true that between 1909 and 1939 the rate of expansion of employment was not so great as it had been in 1820-1909 or as it was to be in 1939-1950. Nevertheless the diagram does give the impression of a strong economy which has the power of providing continually increasing opportunities of employment in spite of the rapid progress of mechanisation. All this is quite true in the long run. But Munce is not justified in drawing from these facts the conclusion that the large numbers of workers who are likely to be rendered redundant in the widespread introduction of automation will necessarily be easily absorbed by the American economy. Munce's diagram does not show us the transitional stages in the movement towards great mechanisation. It cannot reveal the sum total of avoidable human sufferings, of avoidable loss of productive capacity, and of the productive capacity which was technically possible but never came to fruition. And it was these factors in the situation which in the 1930s rocked the entire American economy and the whole of American society to their foundations. It is true that we are drawing attention to phenomena which are often significant only 'in the short run'. But 'the short run' may last for many years and the phenomena may have serious repercussions upon all aspects of public and private life.

Wiener has recently argued that the employer's increased sense of responsibility will play an all-important role in determining the social consequences of the introduction of automation. This increased sense of responsibility may be due to a recognition on the part of employers that in the great industrial countries of the world the workers are no longer prepared passively to put up with years of unemployment and suffering. They will almost certainly offer vigorous resistance—even although they may be told that such resistance will not be to their advantage and will permanently injure the economy. Nor are the workers, in such

[1]*Hearings*, p. 397 *et seq.*

DIAGRAM X

Persons gainfully employed in the United States in all Occupations. 1820—1950[1]



1. *Hearings*, p. 408. The heading of the diagram as originally printed reads: 'As one field of employment declines other employment opportunities increase.'

circumstances, likely to be impressed by the argument that in the long run the mechanism of the free market will one day produce a stable economy again which will benefit all sections in the community.

> 'In the past, some people thought depressions were undesirable but were as unavoidable as a periodic house cleaning. Now we know by bitter experience that our economic and social structure probably would not survive many such house cleanings.'[1]

But if public opinion were strong enough it would be possible by sensible government planning to introduce automation reasonably quickly, so that the new technique of production would benefit everybody. In such circumstances the advent of automation would really be a blessing. But some facile optimists think that the blessings can be secured not by careful planning beforehand but simply by leaving things to the uncontrolled mechanism of the 'free' market. Planned automation would lead to a situation in which it would be possible to say that automation was not likely

> 'to cause redundancy. The object of automation is to reduce the wages bill and to cut down the cost of production. Automation should set workers free to take up jobs which do not satisfy primary needs but are nevertheless valuable to society. These latter tasks have hitherto been neglected for lack of manpower.'[2]

We cannot, in these concluding remarks, discuss the many questions that arise in connection with a planned economy—such as the problem of securing an adequate decentralisation of authority and the possibility of creating a 'quasi-market'. Here we are concerned only with the fundamental fact that by deliberately planning the future development of the economy it would be possible to solve the problems that follow as a natural consequence of automation. And in a few years the theory and practice of automation would itself give untold aid in the process of planning the future of the economy. Hitherto the introduction of economic planning—except in wartime—has been checked because those responsible for taking decisions at the highest level have never had at their disposal, at the right time, all the information that they need. If the drawing up and carrying out

[1]H. C. Sonne, *Technological Advance and National Policy* (National Planning Association, Special Report No. 34, Washington, D.C., Dec. 1954), p. 7.

[2]K. K. Doberer in the introduction to John Diebold, *Die automatische Fabrik* (1954), p. 7 (German translation of *Automation*).

of an 'economic plan' involved taking into serious account the wishes of consumers the problem appeared to be virtually insoluble for lack of facts upon which the planners could work. But today efficient electronic computers can solve this problem. Already big business concerns have installed 'giant brains' which solve problems of planning production and marketing.

The work of Arnold Tustin, Director of the Department of Electronics in the University of Birmingham, has opened up new vistas concerning the application of the mathematical theory of communication to the working of the economic system. Tustin has based his studies on Keynes's theory and he has suggested that the whole economy could be kept stable by the methods of the closed circuit. As in the closed circuit in a machine so in Tustin's 'closed circuit' the problem is to correct oscillations while they are still so small as to be relatively insignificant and this problem can be solved by formulae provided by new mathematical techniques.[1] Of course *this* sort of automation can be effective only if a particular society is fully prepared to act according to its dictates. And this would mean that the self-regulating adjustments of a free market economy would, to a great extent, no longer be allowed to operate.

The present situation has been summarised in the statement: 'Machines can do practically everything in the economy except buy the goods that are produced'. One might add that—in certain phases of technical progress—there is actually a tendency for new machines to deprive people of their power to consume goods. Hastily-improvised remedies can, as we can see, do little to alleviate the evils of such a situation. What must be done is to take a long-term view and to plan for the future with the aid of new machines and new techniques. And the object of economic planning must be to integrate automation with a free and democratic society. Success in such planning would mean that the second industrial revolution could help to establish a social system based upon reason.

[1]A. Tustin, 'L'économie dirigée à l'aide de systémes de contrôle automatique' in *Science et Société* (Paris, summer number of 1953, p. 144 *et seq.*) and A. Tustin, *The Mechanism of Economic Systems. An Approach to the Problem of Economic Stabilisation from the Point of View of Control-System Engineering* (London, 1953).

ABBREVIATIONS USED IN THE FOOTNOTES

A.C.	*Automatic Control*, The Application Magazine of Systems Engineering, New York (N.Y.).
A.M.A.	American Management Association, New York (N.Y.).
A.F.L.	American Federation of Labor, Washington (D.C.).
A.S.M.E.	American Society of Mechanical Engineers, New York (N.Y.).
A.H.	*Special Automation Handbook*, Production Handbook, published for distribution at the *A.M.A.* Special Manufacturing Conference, October 10-12, 1955, New York (N.Y.); Enlarged edition, *A.M.A.*, Special Report No. 7, *Keeping Pace with Automation*, New York 1956.
B.W.	*Business Week*, New York (N.Y.).
C.E.	Control Engineering, Instrumentation and Automatic Control Systems, New York (N.Y.).
C.I.O.	Congress of Industrial Organisations, Washington (D.C.).
D.Z.	*Deutsche Zeitung*, Stuttgart.
Ec. Report	Economic Report of the President, transmitted to the Congress, Washington (D.C.), 1955 and 1956.
F.A.Z.	*Frankfurter Allgemeine Zeitung*, Frankfurt.
F.R.B.	*Federal Reserve Bulletin*, Washington (D.C.).
G.M.S.	General Management Series of *A.M.A.*, New York (N.Y.).
H.B.R.	*Harvard Business Review*, Cambridge (Mass)..
Hearings	*Hearings before the Subcommittee on Economic Stabilization of the Joint Committee on the Economic Report*, Congress of the United States, Eighty-Fourth Congress, First Session, Washington 1955.
I.A.	*Instruments and Automation*, Pittsburgh (Penna.).
I.B.M.	International Business Machines Corporation, New York (N.Y.).
Margate Conference	*The Automatic Factory. What Does it Mean?* Report of the Conference of the Institution of Production Engineers held at Margate 16th to 19th June, London 1955.
M.I.T.	Massachusetts Institute of Technology, Cambridge (Mass.).
M.L.R.	*Monthly Labor Review*, Washington (D.C.).
N.A.M.	National Association of Manufacturers, New York (N.Y.).
N.H.T.	*New York Herald Tribune*, European Edition, Paris.
N.W.	*News Week*, International Edition, Paris.
N.Y.T.	*New York Times*, New York (N.Y.).

N.Z.Z.	*Neue Zürcher Zeitung*, Zurich.
Report	*Report of the Subcommittee on Economic Stabilization to the Joint Committee on the Economic Report*, Congress of the United States, Washington 1955.
S.A.	*Scientific American*, New York (N.Y.).
S.F. Symp.	*Proceedings Symposium on Electronics and Automatic Production*, Jointly sponsored by National Industrial Conference Board, Inc., New York (N.Y.). and Stanford Research Institute, Menlo Park, (California), San Francisco, August 22-23, 1955.
Stat. Abstr.	*Statistical Abstract of the United States*, Washington (D.C.) 1954-1955.
Syracuse Conf.	*Automation and Industrial Development*, Minutes of a conference sponsored by the State of New York, New Albany (N.Y.) 1954.
W.J.	*Wall Street Journal*, New York (N.Y.).

SELECT BIBLIOGRAPHY

THIS bibliography lists only a small number of the many books and articles on automation which have been appearing every month since 1952. Anything approaching a comprehensive bibliography, including articles in periodicals and printed speeches on automation, would run into many hundreds of items even if (as in the case of our list) the purely technical publications were, for the most part, omitted.[1]

Our list includes some of the more important books and articles which will enable the reader to extend his knowledge of the problems raised by the advent of automation. Limitations of space have sometimes made it necessary to take purely arbitrary decisions concerning what to include and what to omit.

Further publications on automation will be found in the bibliographies listed in the first section of our select bibliography and also in the footnotes to our text which mention all the sources which we have used. Several publications which appeared after this book went to press—or which came to our notice at that time—have been included in our select bibliography.

[1]Professor T. J. Higgins of the University of Wisconsin states that he has compiled a catalogue of books, etc., published on automation between 1945 and 1955. This comprises 3,612 titles, including the most important technical publications (in English, German, French and Russian) on the automation control of industrial processes. See *C.E.*, March 1955, p. 67. The number of technical works on automation is increasing rapidly.

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[1]We include under this heading some publications which are not, strictly speaking, bibliographies but which include much bibliographical material.