Technology and Livelihood

An Inquiry into the Changing Technological Basis for Production as Affecting Employment and Living Standards

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Documented with materials quoted from scientific, governmental reports and arranged to describe new technological developments and their effects on productivity and labor requirements

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I plead for recognition of the fact that progress in science does not only consist in accumulating information which may be put to practical use, but in developing a spirit of prevision, in taking thought for the morrow; in attempting to forecast the future, not by vague surmise but by orderly marshalling of facts, and by deducing from them their logical outcome; and chiefly in endeavouring to control conditions which may be utilised for the lasting good of our people.—Sir William Ramsay, in his presidential address to the British Association for the Advancement of Science, 1911.

Note to Reader

This study, initiated in the period between excessive unemployment involving many nations and a world war requiring utmost production, is offered as an indication of the progress of present-day productivity and its consequences in the prevailing social economic environment. While limited to the United States, it may likewise serve as a frame of reference for other nations, whatever the stage of their industrial development.

The industrial depression which began in 1929 brought to the people of the United States not only unusual distress through unprecedented unemployment—new in extent and duration—but also new knowledge of ever-increasing resources for production through science and invention. Scientific journals and reports by governmental agencies spread information concerning new productivity in industry and agriculture which seemed to afford substantial basis for hope of greater security and higher living standards. Paradoxically, however, enhancement of productive capacity for satisfaction of material and cultural needs was accompanied by continuing deficiencies even in the primary necessities of life for a large proportion of the population, and by the enforced idleness of many workers. Nor was the difficulty in finding employment limited to industry. All occupations, including the professions, were affected.

Even when revival in business began in 1933 and continued, with minor setbacks, up to the high point of the decade in 1937, employment, while increasing, lagged behind production. Stated differently, in many industries fewer workers were needed to produce the same output. Many began to wonder whether new science and invention were actually depriving men and women of a chance to earn a living. The phrase "technological unemployment" was heard more and more frequently. Recession in employment in 1938 increased the sense of insecurity which pervaded many homes, whether dependent for support upon work in industry for wages or salaries, or upon employment in business, farming, or a profession.

If technological change was causing unemployment on so wide a scale, certainly its influence was much more far-reaching than the displacement of a group of workers by some new invention in one workshop or industry. In unemployment that occurs at the very moment when capacity to produce is increasing, society is confronted not with the ancient problem of scarcity, nor with the familiar question of machines displacing workers, but with the new task of learning how to utilize new productivity for higher levels of living.

While study and experiment were in progress in the United States, directed hopefully toward achieving "full employment," war in Europe suddenly confronted the American people. Following the decade of unemployment and depression, which, though lessened by 1939, were not eliminated, production was suddenly to be expanded at an unprecedented rate for our own national defense and for other nations needing ships, airplanes, and munitions. For making instruments of war, the same metals and machinery were needed as for producing civilian goods. Surpluses, actual or potential, which had found no purchasers able to buy in years of unemployment, now gave place to actual shortages.

Unemployment diminished. In the military forces young men found opportunity for the employment of which they had despaired. War industries enlarged their labor force. As workers' purchasing power increased, their buying stimulated production for civilian use. At the same time, however, the requirements of civilian production for materials and machinery had to yield to the prior claims of munitions and the household economy of the military establishment, so that a new form of idleness, "priorities unemployment," emerged in communities not fully occupied through war contracts. Moreover, a new source of insecurity appeared, in anxiety lest in the post-war period unemployment should again confront the nation when war orders should be withdrawn and when public debts must be paid.

War itself had become new, with its instruments and its methods of warfare shaped by the new technology, by new engines, new metals, new chemicals. The problem of organizing material resources and mobilizing workers called for exact knowledge of new productive capacity. A production plan was required in which new materials, machinery, and methods would be co-ordinated and synchronized without break in continuity from design to finished product and its transportation to the battlefields. The plan, moreover, had to be susceptible of change at any point when military experience and strategy should call for a change in design. Precise co-ordination and timing toward a definite end, combined with ability to make swift changes, are the requirements which technology establishes for war economy. In peace the aim of production is different, but technology and the impact of change make the same demands for co-ordination and adjustment toward an agreed end.

Technology may be defined as the body of knowledge accumulated by science and invention and available for application in the processes of production. Every society, from the most primitive to the most developed, evolves tools and techniques which provide for the livelihood of its members. Livelihood is the living won by work. As man's knowledge of nature has increased through experience, and eventually through study in the laboratories of science, new tools have become available for production, and from these new means of production far-reaching social changes have followed.

The new science which has evolved during the past hundred years, with discoveries greatly accelerated in the last fifty years, would have made a period covering several centuries notable for scientific progress. The rapidity of the resulting rate of change explains in part the inability of society to adjust itself to the new basis for livelihood. Understanding of the process of adjustment requires not only analysis of social consequences of scientific discoveries, but recognition of technology itself as a prime mover in social change. No minor adjustment to a single invention will suffice. Technology must be analyzed in its entirety as setting new tasks of social organization for every community, for every nation, and for the whole world.

The present inquiry was undertaken for the purpose of assembling and co-ordinating available information on the exact nature of change which has made itself felt in prevailing insecurity. Since this change is in the realm of technology and production, its impact is not readily understood by the large number of persons who have no experience in production and no training in technology. Therefore our inquiry began as an exploration of the ever-increasing mass of information accumulated in reports by governmental agencies, in order to draw from those sources authoritative data so formulated as to be enlightening to the general reader.

Technological change is a composite picture. It moves with the dynamic emergence of new scientific discoveries and new inventions. No investigator working alone can adequately assemble all the needed facts nor weave the pattern of the future from the present tangled skein. A total analysis needs to be based upon contributions from specialists in all relevant fields.

Fortunately, reports were available which had been prepared for agencies of the federal government by just such a process of collaboration of many specialists. Most useful of these for our immediate purpose was a comprehensive, co-operative study prepared under the auspices of the National Resources Committee, subsequently known as the National Resources Planning Board. This substantial document, entitled Technological Trends and National Policy, Including the Social Implications of New Inventions, was issued in 1937. For the benefit of the reader who wishes to examine the sources of our information, this study and other reports are described in Appendix III. Preceding it is a synopsis of our study.

Because of the nature of these materials, involving the research of many different specialists, we decided to present a substantial part of our findings in the form of quoted matter. Rearranged in the order determined by the logic of our inquiry, the quoted material constitutes for us, and, we hope, for the reader, an orientation essential to realistic study of problems of employment and living standards, which are demonstrated to be inexorably shaped by the technology of production. Our purpose was to achieve that "orderly marshalling of facts" advocated by Sir William Ramsay when president of the British Association for the Advancement of Science, from which to deduce "their logical outcome" directed toward control of conditions "for the lasting good of our people."

It should be made clear that this study is an introductory exploration, designed to prepare the way for further investigation of the problems involved in full utilization of new productivity for living standards. Both the organization of employment, on which this inquiry should throw light, and the raising of standards of living, toward which further study must be directed, will be fundamental in post-war reconstruction.

As science knows no national boundaries, so the social need for organization of the new productivity for security of livelihood is world-wide. Even in the midst of war, this problem should be central in social economic research in the United States and in other nations. Everywhere a lasting peace demands that the peoples of the world learn how to eliminate waste and destruction, whether of war or of poverty, by conscious utilization of productive forces for human life.

PART ONE

THE NATURE OF TECHNOLOGICAL CHANGE IN BASIC INDUSTRIES

Chapter I

Change in Productive Forces Through Science and Invention

NEARLY a hundred years ago Thoreau, reporting on his adventure-in-living on the shore of Walden Pond in 1845, gave expression to the following conclusion:

> The necessaries of life for man in this climate may, accurately enough, be distributed under the several heads of Food, Shelter, Clothing, and Fuel; *for not till we have secured these* are we prepared to entertain the true problems of life with freedom and a prospect of success.[1]

Today, a hundred years later, it is strange to think that, after a century of technological progress, this primary security, of which Thoreau was able to write so simply, should have become, for many, not more attainable, but more remote. Likewise does it appear questionable whether we are today better prepared to "entertain the true problems of life with freedom and a prospect of success." In fact, the opposite seems true.

The reason, or reasons, why such a state of affairs has come about are not only being investigated by social scientists and other experts. Individuals in all walks of life are stirred today to give attention to the problem—perplexing to most people—of poverty and need in the midst of potential abundance. How, they ask, are we to understand what has befallen us? How can it be that a total situation approaching disaster should result from what, evidently, may be viewed as continuous expansion in the technological basis of our physical existence? Why is it that food, shelter, clothing, and fuel should be less rather than more accessible for many, when the potentialities for these since the days of Thoreau—even taking into account our increased population—have expanded several hundred times?

In those earlier days the availability for the individual of these necessaries of life appeared to most people to be dependent simply on a genuine and steady will to work. Why, then, in peacetime has

[1]Thoreau, Henry David, Walden and Other Writings; edited, with an introduction, by Brooks Atkinson. Modern Library, Random House, New York, 1937, p. 11. Emphasis ours.

work been unobtainable for millions of willing workers, so that the question arises as to whether unemployment is a lasting phenomenon? And, worse still, why do we prepare for death and destruction in war, instead of for life in peace and plenty?

These are the pressing questions of our day. They would, likewise, be most discouraging, were it not that hope for their solution lies exactly in this evidence of an ever-growing desire to understand. For widespread understanding is becoming increasingly a prerequisite to such responsible attitude and well-directed action as ought to prevail in the processes which shape our human destinies.

During the past century of technological development we have grown so far away from our original and immediate relationship to the earth's resources and the tools of men, that most of us fail to realize that, even so, the productive process governs our life on this planet. Therefore, production should be to us, at all times, a matter of primary concern. Failure to be aware of this all-pervading process as it affects our ways of life, both in the physical and in the cultural sense, may well account for what appears to be an absence of conscious and constructive motive power on the part both of governments and of peoples as a whole.

The Impact of Change

For an understanding of the configuration of productive forces which make up our present environment, it is not necessary to review in detail the hundred years and more to the beginnings of the so-called "industrial revolution." We all know about James Watt and the coming of the steam engine—perfected for use in 1781—which heralded the great advance in industrial equipment and ushered in the machine age and the factory system. Developments in transportation greatly accelerated the new machine technology. In 1829 Stephenson built the first workable steam locomotive, leading to the opening of the first railroad, in Great Britain.

What is important, however, is to realize afresh that the immense industrial and social economic developments of the nineteenth century came about through the availability of a new source of driving power, steam, which superseded man power and the natural forces of wind and of water. Handicrafts gave place to mechanical production, and an unending stream and variety of new and hitherto unobtainable goods began to flow. Simultaneously the new transportation facilities were able to distribute these goods at an increasing pace. The new communication created new human relationships, new cultural forms, and new needs. The new needs, in turn, stimulated the production of new goods and articles.

The new production tended to centralization, since steam power has to be used close to the point of generation. Hence people flocked to work in these new production centers. Industrialization and urbanization increasingly took the place of life in the country and on the farm. Far-reaching were the influences on education, science, and invention.

Such, in short, were the consequences following the discovery of steam as a motive power. Thus the new technology of steam and its attributes may be considered basic to the enormous changes and developments of the nineteenth century.

Already, however, at the beginning of the nineteenth century the discoveries which were to remake the twentieth were in process. While Thoreau, the social philosopher, was living at Walden Pond, Michael Faraday, the scientist and no less a social philosopher, was working in his laboratory at the Royal Institution in London—incidentally for a salary of £100 per annum, "with house, coals, and candles,"[1]—and laying the basis, through observations of electricity and magnetism, for the telegraph, the radio, and the increasing use of the new force, electric power.

1. Electricity—The New Driving Force of Modern Production

The new period, with the change from steam to electricity[2] as a basic driving power, was entered upon around the opening of the twentieth century. Steam was not discarded, but became the stepping-stone to this newly discovered force of a very much higher order. The steam turbine was developed for the specific purpose of generating electricity.

Electricity is "a fundamental quantity in nature"; it is potential energy. Energy is capacity for work. The nature of electricity may,

[1]Thomson, J. Arthur, "Michael Faraday," Introduction to The Chemical History of a Candle, by Michael Faraday; edited by W. R. Fielding, E. P. Dutton and Co., New York; J. M. Dent and Sons, Ltd., London and Toronto, 1920; reprint, 1933, p. 10.

[2]For explanation of certain technical terms pertaining to electricity, see p. 19, footnote 4.

perhaps, be described as unshackled energy. With the proper installation, electricity can be continuously generated; it can be stored; through a network of transmission and distribution, electric energy can be diffused; with a simple mechanism, it can be tapped at any point. Thus electricity is an unlimited fluid force, in contrast to steam power, which, as already indicated, is energy tied directly to the location of its source.

"The production of electricity on a commercial scale . . . dates from about 1880, and only after 1910 did electric power begin to penetrate the general economic structure of the world. . . . From 1923 to 1930 an extremely rapid upward movement took place. . . ."[1] Resulting productivity became immensely accelerated. In fact, there are hardly any limits to its possible acceleration. Important social consequences followed. Paramount among these, as already indicated, is the possibility of using the energy at a long distance from its source.

Experts of the National Resources Committee have described the nature of this new driving force of modern production.[2]

ELECTRIC POWER GENERATION AND ITS ENERGY RESOURCES

> Fuels and waterfalls are the major energy resources for mechanical power production. Fuels which play no part in the civilization of the past, [like oil and gas] are the major mechanical-power producers of today.[3]
>
> Three requirements are essential for the production and utilization of power: First, a source from which energy may be derived; second, a prime mover capable of transforming this energy into work; and third, a means for making the power easily available for use.

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[1]Encyclopaedia of the Social Sciences, "Electric Power," by Hugh Quigley [chief statistical officer, Central Electricity Board, Great Britain]. Macmillan Co., New York, 1931, vol. 5, pp. 456, 458.

[2]From this point on, the plan will be followed, as explained in the Note to Reader, of presenting the data of our study in the form of quotations or readings from the reports of the National Resources Committee and other authorities. These quotations are indicated by indention, with a wider left margin, and by footnote references. The headings of paragraphs are ours, as are the order and focus of presentation, following the line of our inquiry into "the changing technological basis for production as affecting employment and living standards."

[3]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 5, "Power," by A. A. Potter, dean of engineering, Purdue University; president, American Engineering Council; and M. M. Samuels, electrical engineer, Federal Power Commission. Government Printing Office, Washington, 1937, p. 253.

The term "prime mover" is applied to the main power-generating unit of a power plant. Thus the steam engine or the steam turbine is the prime mover of the steam power plant; the gas or oil engine is the prime mover in the internal-combustion-engine power plant; and the water wheel or water turbine is the prime mover in the hydraulic power plant.[1]

Only those prime movers which utilize the heat energy of a fuel or of waterfalls are significant for power production. Such prime movers do work by virtue of motion given to a piston, or to blades on a wheel, by steam, gas, or water which must be under pressure. This pressure in the case of the steam, gas, or oil engine is obtained by utilizing the heat of a fuel; while in the water wheel, work is obtained by utilizing the potential energy of water empounded behind a dam.[2]

In the . . . Diesel engines only air is compressed by the piston and the compression pressure is about 500 pounds per square inch; oil fuel, mixed or unmixed with air, is injected at the end of the compression process and the high temperature of the highly compressed air ignites the fuel, an electric spark or other auxiliary ignition device not being necessary to burn the mixture.

Water power is a function of the amount of stream flow and of the hydraulic head available. The water wheel or water turbine converts the energy possessed by moving or falling water into work. The wheel is made to revolve either by the weight of the water falling from a higher to a lower level, or by dynamic pressure which is produced by changes in the direction and velocity of flowing water. The total power available in water when in motion depends on the weight of water discharged in a given time and on the head or distance through which the water is allowed to fall.[3]

For the generation of electricity in large amounts electric dynamos are used. They are built in capacities which range from one kilowatt[4] (1⅓ horsepower) to 160,000 kilowatts and even larger, and are driven

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[1]Ibid., pp. 252-253. [2]Ibid., p. 253. [3]Ibid., p. 254.

[4]With the new discoveries of electricity and its use, the necessity arose for special terminology defining qualities and units of measurement. It is significant that the unit of power was called a *watt,* after James Watt, Scottish inventor of the steam engine. The *volt,* which is the unit of electromotive force, took its name from Alessandro Volta, Italian physicist. The elementary particles which compose electricity are named *electrons* (the negative charge) and *protons* (the positive charge). The force of electric current results from a difference of potential between two points, exactly as a current of water results from a difference in level. The *direct current* flows only in one direction, while the *alternating current* periodically reverses its direction.

The force, or voltage, is measured by resistance, with the *ohm* as the unit, defined as the resistance in which "a potential difference of one volt produces a current of one ampere";

by steam prime movers, internal-combustion engines or hydraulic turbines. Dynamos generate either direct or alternating current. Direct current is advantageous for certain industrial uses, such as for some motors in factories, street railway operation and elevator service. About 95 percent of all the electricity generated in the electric central stations of the United States of America is alternating current. Alternating current electricity can be generated at high voltages and its voltage can be easily increased or decreased by means of transformers, so that it is more practical than direct current for the economical transmission and distribution of electrical power.[1]

The steam turbine is the most important prime mover for the generation of electricity, as it operates at practically uniform speed, occupies very much less space than a reciprocating steam engine, can be built in very large sizes at low cost, and is very economical in steam consumption. The development of power from fuels by means of steam has been continually in the direction of more powerful prime movers, as operating costs decrease with the size of steam units. With the steam engine there is a limit to the size of a unit beyond which it is impractical to go. The maximum practical size of a reciprocating steam engine for stationary power plants is less than 10,000 kilowatts, while steam turbines of capacities of 160,000 to 212,000 kilowatts are now in operation in central electric stations. The modern steam turbine is highly economical and is used exclusively in large steam-electric plants. Besides the advantages mentioned, its high speed of rotation makes it more economical for driving electrical dynamos, the size and cost of dynamo-electric machinery decreasing as the speed increases. The steam turbine, because of the above-mentioned advantages, has made possible the modern large electric generating station and has also stimulated long-distance electric transmission of electricity.[2]

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while the *ampere,* in turn, is the unit of measurement of intensity of an electric current in which one volt acts through a resistance of one ohm. The ampere is also defined as the unit of electric current required to deposit a standard quantity of silver, copper, or gold in one hour. In terms of the ampere, the watt corresponds to the rate of work represented by a current of one ampere under a pressure of one volt. The work done or the amount of heat generated in one second is called a *joule.*

In common parlance it is significant that the new energy for work represented in the steam engine was referred back to animal power and measured in so-called horsepower, or the energy which a horse exerts in pulling. Similarly, the term "foot pound" refers to the energy required to lift one pound one foot.

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 5, "Power," p. 254.

[2]Ibid., p. 257.

THE NEW SCIENCE REQUIRED IN POWER-PLANT OPERATION

Plant efficiency has improved greatly owing to the recognition of the importance of well-trained and experienced power-plant personnel. The fireman of 40 years ago has been replaced by a combustion engineer well versed in the fundamentals of science, and able to apply chemistry and physics to actual operating problems. In addition to improved personnel, power-plant operating technique has greatly benefited by automatic and semiautomatic control, by the development of heat-saving equipment in connection with the modern steam generator, and by the perfection of accurate meters and instruments.[1]

ELECTRIC POWER TRANSMISSION AND DIFFUSION

Power without machines to be driven is useless. Thus the power producing equipment must be considered in association with some means of transmitting the power from the place where it is generated to the machine where it is used. For more than 100 years after the perfection of the steam prime mover by Watt transmission of power from the engine to the power-driven machines was entirely by mechanical means such as belts, chains, ropes, discs, cams, levers, gearing, and shafting. As late as 1880 no less an authority than the great English scientist Osborne Reynolds advocated the use of rope drives in preference to electric-power transmission, which he considered to be impractical. A new impetus to the use of mechanical power was given when electricity proved to be a practical link for transmitting power over great distances.[2]

"LIVING FORCE OF PRESENT CIVILIZATION"

Electricity, distributing and utilizing mechanical power most effectively, is the living force of our present civilization; the electric motor, made in sizes from a fraction of a horsepower to 40,000 horsepower, has provided a most practical means for driving the tools of industry and for relieving humanity from drudgery in the home and on the farm; electric traction, electric illumination, electric communication, the cinema, and numerous appliances and devices of the present age which save time, reduce labor, and provide amusement were made possible by electricity, the most important link between the prime mover and the user of mechanical power.[2]

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[1]Ibid., p. 258. [2]Ibid., p. 254.

CONCEALED AND UNIVERSAL DISTRIBUTION

The social implications of inventions in the field of electric transmission and distribution are more difficult to crystallize than those of inventions in many other fields. First, because these inventions are of a highly specialized, technical nature that cannot and really need not be understood by the layman; second, because the social unit does not come into direct contact with them. The telephone instrument, the radio set, the washing machine, the automobile, and similar invented devices are used by the public directly. But inventions in the field of electric transmission and distribution can only be brought home to the public indirectly in the form of more dependable service, lower rates or the possibility of making electric service available where otherwise it could not or would not exist.[1]

Electric energy can be generated anywhere and be made instantaneously available anywhere else by means of transmission and distribution. This, no doubt, is the most important social implication of transmission and distribution.[2]

Electrical Equipment—the Changing Tools of Production

In the industrial revolution initiated by the steam engine, the primary cause of change was the substitution of the machine moved by steam for the tool manipulated by hand. To this day the idea persists that the machine is of the essence of technological change. What has been said of electricity, however, should dispel this notion. The new industrial revolution arises out of the new energy, represented by electricity. The change is not merely the substitution of a mechanism for a hand. This fact is clearly demonstrated when it is realized that the machine itself is revolutionized by electricity. The electrical equipment industries abandon even the forms of the old tools. They tap and utilize directly the energy of electric power instead of merely enhancing the strength of the human hand. For the same reason, the term "manufacturing," still generally used, in reality belongs to a past period and might well be definitely replaced by the more appropriate use of the term "fabrication," or "transformation," which is more akin to the new technology.

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 5, "Power," p. 269.

[2]Ibid., p. 270.

Probably no other line of human endeavor has produced as many technological developments, both for its own use and for the use of others, as have been produced by the electrical goods industry. The reason is simple. It is because this industry has at its command a servant far more accomplished than Aladdin's Genii, but equally mysterious. While many of the accomplishments of electricity appear miraculous, it is because of our own human limitations that its work has not been utilized to an even greater extent. We do not know what to ask that electricity do next.[1]

THE ELECTRIC MOTOR—INCREASING CONVEYOR OF CHEAP POWER

Probably no other electrical tool so symbolizes the idea of technological development . . . as the electric motor. Yet one of the many things which the people of 50 years ago did not know and which has been in a large measure responsible for amazing industrial advance in all fields was the fact that the electric motor would bring cheap and efficient power to factories, revolutionize industrial processes, and perform virtually all the mechanical operations of whole industries. Today, 35,000,000 horsepower in electric motors turn the wheels of industry.[2]

RAPID INCREASE IN ELECTRIFIED TOOLS AND MACHINES

The rapid electrification of industry is indicated by the increase in the total horsepower of electric motors used in factories from 492,936 in 1899, to 4,817,140 in 1909, to 16,253,702 in 1919 and to 30,361,106 in 1927. The percent of electrified tools and machines of American industry has increased from 4 in 1899, to 23 in 1909, to 53 in 1919, and to 75 percent in 1927.[3]

INFINITE MULTIPLIERS OF HUMAN STRENGTH AND PROVIDERS OF PLENTY

Of all the tools that ever came into the hand of man, electric motors and control have been among the greatest. Touching a button, the modern American workman sees electricity, through a motor, multiply his own strength a thousandfold and increase his producing ability in countless ways. By the improvement of this industrial efficiency it is possible to produce more things for more people at less cost, both

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[1] Ibid., Part 3, sec. 7, "The Electrical Goods Industries," by Andrew W. Cruse, formerly chief, Electrical Division, Bureau of Foreign and Domestic Commerce, Department of Commerce; now assistant chief engineer, Federal Communications Commission, p. 315.

[2] Ibid., p. 321. The figures refer to the United States only.

[3] Ibid., Part 3, sec. 5, "Power," p. 251.

the things which make for a more abundant life and things which assist us in the performance of our daily work.[1]

THE MOTOR'S ACCESSIBILITY

In 1900, one manufacturer made five types of motors, and every one was custom built. Today, this same manufacturer with stocks in 29 warehouses, can supply immediately a motor for practically any application.

In 1900, a 5-horsepower polyphase motor weighed 716 pounds. Today, it weighs only 191 pounds, a reduction of 73 percent.

In 1900, that 5-horsepower motor occupied 19,700 cubic inches. Today, it takes up only 4,380, a reduction of 77 percent.

Today, the user without discount can buy three and one-half 3-horsepower motors for the same number of dollars that he would have had to pay for one 3-horsepower motor in 1900.[1]

The installed or available power in the United States in 1935 was 1,231 million horsepower. This, divided by an estimated population of 127½ million for 1935, gives about 10 horsepower per capita of our population, the equivalent of more than 100 slaves. In 1899, R. H. Thurston estimated the use of power in this country at 25 million horsepower, or the equivalent of about two man-power per capita of the population. Thus man's productive capacity has increased 50 times during the past 35 years.[2]

Two other electrical tools of considerable importance are the electric eye and X-ray controls.

THE ELECTRIC EYE—DISPLACER AND IMPROVER OF HUMAN SENSES

Silently into our lives is creeping a new technological brain-child whose ultimate social import cannot now be estimated. It is the photoelectric cell or electric eye as it is popularly known.[1]

A very good summary of some of the important functions of the photoelectric cell is furnished by C. C. Furnas in his book, The Next Hundred Years.[3]

The photo-electric cell, or electric-eye as the popularizers like to call it, can be made as sensitive as the human eye. It cannot be imbued with

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 7, "The Electrical Goods Industries," p. 321.

[2]Ibid., Part 3, sec. 5, "Power," p. 252.

[3]Reynal and Hitchcock, New York, 1936, pp. 207-208.

brains, but it can be adjusted (trained if you like) to perform routine tasks, reliably, consistently, cheaply. Suppose you are wrapping candy bars by machine. . . . The wrapping machine probably moves so rapidly that you cannot follow its motion with the unaided human eye; so, as might be expected, it missteps occasionally and omits a wrapper. Girl inspectors might be counted upon to catch such omissions but a photo-electric cell is better. It never fails to see the missing wrapper. Photo-cells never get sleepy, no matter how late they may have been up the night before. By keeping the bars moving down a belt conveyor, and keeping them separated one from the other, the photo-cell equipment will accurately and mercilessly throw off every uncovered specimen.

Similar equipment sorts beans or cigars on the basis of color. Photo-cells can judge the colors of textiles more accurately than can the human eye. They are being used to maintain lubricating oil at a given color and coffee at a uniform strength. Temperature is very important in the heat treatment of steel bars and electric eyes are being used to remove bars from reheating furnaces as soon as they reach the desired degree of redness. They are being used to guard prison walls and safes. By causing a bell to ring they warn a fireman when he is creating a smoke nuisance. They are used to regulate the thickness of paper in its manufacture and to stop the machinery and give warning if the paper breaks. They automatically level elevators at floor stops. They sort cards for tabulating machines and a practical device is available for apprehending speeders on the highways. They are certain, accurate and not susceptible to arguments or feminine beauty. At bridle-path crossings they operate traffic lights for horses but not for humans. The most common and simplest task of the cell is that of counting. They are used in factories to count almost every conceivable thing. The vehicles crossing the Ambassador Bridge at Detroit are so counted.

These examples are more or less random and do not cover the full range of possibilities. If you have never happened to notice these devices in operation, remember that they are very inconspicuous midgets and also they are as yet being used only in a very small fraction of the possible places. As a first guess I would say that there are at least a million workers in this country doing routine tasks of sorting, inspecting or controlling, who could be cheaply and successfully replaced by devices actuated by photo-cells.[1]

X-RAY CONTROL—IMPROVER OF MATERIALS AND CONSTRUCTION

There is a growing conviction that X-ray research and control methods can now and in the future be of invaluable service in the solution of problems of constitution and practical behavior of metals and alloys of every kind, of catalysts, textile fibers (cotton, flax, jute, ramie, sisal, hemp, silk, wool, rayon), rubber, balata, gutta percha,

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[1]Quoted in National Resources Committee, Technological Trends and National Policy, Part 3, sec. 7, "The Electrical Goods Industries," pp. 322-323.

resins, varnishes, lacquers, paints, pigments, dyes, enamels, carbon black, inorganic and organic chemicals, waxes, greases, soaps, oils, liquids of all kinds, dielectrics, storage battery oxides, colloidal metals and gels, patent leather, glass and its substitutes, gelatine, adhesives, abrasives, lime, plaster of paris, cement, ceramics, sugars, starches, biological systems, coal, gems, and numerous other substances.

Already X-rays are applied to detect flaws in our castings and welds which might so easily cause loss of life or serious injury—and certainly would prove a loss of time and money if the defective material was permitted to be made into a finished product.[1]

THE IMPACT OF ELECTRICAL EQUIPMENT ON FABRICATION

Four characteristic trends of modern manufacturing, (1) toward continuous processes, (2) automatic operation, (3) use of registering devices, and (4) of controlling devices are conspicuous. The last two may embody the new electric eye or ear or only the older mechanical "senses." Or they may automatically make chemical tests, such as sampling furnace gas every few minutes for its proportion of carbon dioxide, to enable efficient and smokeless combustion, or measuring acidity, or chemical content by an automatic spectrophotometer. Such controls serve to improve the product as much as to save labor.[2]

An entire industry specializes in the manufacture of measuring and controlling devices for scientific analysis of production methods.[3]

Measurement of one kind or another has always been an integral feature of technology, but it is only since about 1900 that instruments have been installed as auxiliary production equipment. A half century ago the use of measuring devices was limited to a few simple indicators and recorders, whereas at the present time a wide variety of types is to be found in virtually all industries. Modern manufacturing plants may employ several hundred instruments for both research and actual production, and many of the large concerns use thousands.[4]

Unaided by instruments, human observation is not sufficiently rapid or accurate to measure the large number of variables which enter into

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 7, "The Electrical Goods Industries," p. 323.

[2]Ibid., Part 1, sec. 3, "Social Effects of Inventions," by S. C. Gilfillan, formerly curator of transportation and social sciences, Museum of Science and Industry, Chicago, and author of The Sociology of Invention; pp. 24-25.

[3]Works Progress Administration, National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques. Industrial Instruments and Changing Technology, by George Perazich, Herbert Schimmel, and Benjamin Rosenberg. Philadelphia, 1938, p. 1.

[4]Ibid., p. 2.

production, particularly in the many recently developed processes—such as those employed in the manufacture of synthetics or alloy steels—for which operating conditions must be maintained with a high degree of precision. *Just as the development of the machine made possible the extensive application of mechanical power by removing the restrictions imposed upon production by the limitations of human or animal energy, so instruments have played an analogous role in regard to human perception and judgment.* They have, in short, removed the restrictions imposed upon many production processes by man's limited ability to observe and control physical phenomena.[1]

After the desired operating conditions have been determined, they must be maintained consistently in actual practice. Most commonly this end is achieved through the installation, in connection with major production equipment, of instruments whose measures act as constant guides to production workers. Frequently a number of such instruments are brought together on a single central instrument panel, enabling the operator to coordinate several stages of production.

Perhaps the most significant function of instruments, when these are integrated into actual production and are employed for direct control of process conditions, is to further the development of new forms of mechanization. The use of automatic control and of central instrument panels makes it possible for one operator to supervise many machines and equipment units which would otherwise have required a much larger labor force.[2]

It appears that no limit can be set to the work which might be taken over by machinery, although the rule holds that it is the most simple and most monotonous tasks, whether physical or mental, that are the most readily replaceable through invention. While such tasks are being mechanized, new monotonous tasks are being created, through subdivision of old jobs whose product has become available for larger scale production.[3]

Unlike inventions in some other fields, devices in the electrical goods industries tend to be particularistic in their application rather than cumulative in their effect. Thus, these industries seem to be subject to the factor of rapid change. Likewise, the future of these industries is so linked up with developments in rural electricity, the extension of transmission lines, and the cheapening of electricity that the extraor-

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[1]Ibid., pp. 2-3. Emphasis ours.

[2]Ibid., p. 5.

[3]National Resources Committee, Technological Trends and National Policy, Part 1, sec. 3, "Social Effects of Inventions," p. 25.

dinary and extensive results which may ensue cannot be readily anticipated.[1]

2. Chemistry—the Creator of New Materials and Equipment

Present developments, however, are by no means due to electrified mechanization alone, nor to allied discoveries in physics. They are likewise to be attributed to the new chemistry. Chemistry may be defined as the science of the elements[2] and their combinations and interactions. While physics, with electricity as its central phenomenon, has to do with the movement and force of energy, chemistry is concerned with substances and their changes. The chemical industries, applying the new chemistry, have become the auxiliary of raw materials and fabrication.

Today raw materials have acquired, so to speak, a productivity of their own. Through chemistry, their function in industry has been lifted to a new order of magnitude, precisely as the energy of electricity was of a higher order than the force of steam. At present the productive contribution of the chemical industries to living standards is as basic as are the electrical and mechanical processes which run the wheels of industry. The potency of the materials of industry ranks increasingly with its prime movers—power and machinery.

> Just as the science, chemistry, is one ministrant to sciences, so the chemical industry is one which serves all other industries. Fully to grasp the truth of this statement one needs only remember that few of the raw materials provided naturally are ready for use and that in most cases a chemical change takes place before they are suitable. Even where a change in physical state is involved—as for example, sawing a tree into useful lumber—the operations are likely to be carried on with tools which would be inefficient and unsatisfactory except for the contributions of chemistry. Thus the chemistry of metals, otherwise known as metallurgy, is involved in the manufacture of a suitable circular or band saw, [and] the chemistry of the lubrication necessary for the operating mechanism . . . [is similarly involved].[3]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 7, "The Electrical Goods Industries," p. 328.

[2]An element is a primary substance which cannot be further subdivided or simplified.

[3]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 6, "The Chemical Industries," by Harrison E. Howe, editor, Industrial and Engineering Chemistry, p. 290.

The products of the chemical industry are rarely recognized by the ultimate consumer as such, because they do not reach him as individual products. They constitute one of the best examples of how the finished products of one industry may be the semifinished or even raw materials for some other industry. In a certain sense that is a weakness, because any industry needs a sympathetic understanding on the part of the public and particularly the official public. One may see a modern structure in the course of erection and be very conscious of the importance of the steel industry. He may go anywhere in these United States and have reason to marvel at progress in automotive engineering. These and many other industrial products are self-evident and are easily identified with a special industry. But those who see such evidences cannot be expected to have any appreciation of the chemical control which lies back of the production of satisfactory steel, nor of the unnumbered contributions from the various special fields of chemistry to the perfection of the modern motorcar.[1]

THE CHEMICAL INDUSTRY REQUIRES CONSTANT RESEARCH

The chemical industry does not frown upon its ever-changing nature. It recognizes that just so long as products lack perfection and people demand more and newer things, and scientists have the urge to know the why and wherefore as well as the behavior of matter, research will continue. It encourages this research. It supports it indeed with a generous hand, for from it have come the processes and the products which are the industry.[2]

[A] mode in which technology has been of tremendous benefit to pure scientific research is in the development of novel apparatus and materials for performing tasks which previously could be done inefficiently, or not at all. Precision balances, compound microscopes, reagent grade chemicals, micrometer calipers, thermionic tubes, and scientific glassware are so commonplace that we are apt to forget that we owe them, at least in their present form, to technological developments to meet industrial demands.[3]

PRODUCTS IMPROVE THROUGH CONTINUOUS PROCESSES AND AUTOMATIC CONTROL

One of the important tendencies or trends in the chemical industry has been that from batch to continuous processes. This is one of

[1]Ibid., pp. 289-290. [2]Ibid., p. 292.
[3]Ibid., Part 2, sec. 2, "The Interdependence of Science and Technology," by Edward C. Elliott, president, Purdue University, p. 94.

America's signal contributions to the chemical industry. The continuous process requires a more complicated set of equipment and perhaps more careful supervision, but there is a saving in time, a more uniform product, and smaller losses in production. By a careful choice of units, the production rate can be made very elastic.

Another more recent trend in common with certain other industries is that toward automatic control. Automatic control is not installed primarily to reduce the number of jobs. What it accomplishes principally is accuracy in operation, improved uniformity of product, and hence lower over-all cost. It achieves a higher quality and tends to increase the skill of the operator. It is vital to a continuous process and it rests for the most part on the ability to detect, by chemical or physical means, very small differences in such physical attributes as pressure, temperature, volume, density, weight, vapor pressure, magnetism, electrical resistance or conductivity, light intensity, color, thermal properties, relative humidity, and the like. Electrical and mechanical engineers working with chemists and chemical engineers have developed devices which after detecting these differences actuate mechanisms which in turn are able to correct for these variations. Thus there are devices which will proportion fluids or solids. There are those which will add or remove heat or will regulate the rate of flow; will automatically maintain a desired pressure or vacuum. They will adjust the composition. They will detect errors in wrapping and labeling or packaging. Indeed it is not generally realized how essential automatic control is to many operations nor what the trends are toward broader automatic control. In one chemical plant $500,000 is invested in control instruments. Extensive automatic control is found in plants distilling solvents, in refining petroleum products, in heat treating metals, and in power plants.[1]

INCREASED PRODUCTIVITY THROUGH CONTROL OF CHEMICAL COMPOSITION

[A clear instance of this may be seen in] the lowered cost of glass articles . . . due in large part to mechanical improvements, as in blowing machines which manufacture an incredibly large number of electric-lamp bulbs, drinking glasses, glass tubes or bottles, in 24 hours. *But these mechanical devices in turn depend upon physical characteristics in the modern glass which are attained only by a careful control of the chemical composition.* Trends here may be toward greater output

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 6, "The Chemical Industries," pp. 293-294.

per unit with still lower cost of product, though at the moment it is difficult to see why still greater speeds should be necessary.[1]

AUTOMATIC DEVICES CENTRALIZE INSPECTION AND CONTROL

Formerly when the operator of, say, a distillation plant, was required to go from unit to unit to read pressure gages, thermometers, and flow-meters and then adjust valves, it was customary to house the whole equipment. Nowadays the control panel with its actuating devices is all that need be put into one small air-conditioned, comfortable room and the remainder of the equipment . . . can be left to the elements, protected only by the resistant materials of which it is constructed and its insulation. This has given rise to a new type of architecture, upon many a landscape, and has served literally and figuratively to reduce the overhead that once appeared in brick and mortar, steel, and galvanized iron. One fair sized alcohol distillation plant operates with one man per shift.[2]

AGRICULTURE BENEFITS BY THE CHEMICAL INDUSTRY

The food value of the crop as influenced by its fertilization has not been neglected by the chemist who in collaboration with the animal nutritionist has traced the dietary benefits from the well-fed crop, linking therewith the health and performance of the animal organisms fed thereon, even to their progeny.[3]

The optimum placement of fertilizers with respect to the root system of the crop which they are to nourish has been determined as a factor of major importance and has resulted, through collaboration with the engineer, in mechanical fertilizer drills whose use greatly increases the effectiveness of the fertilizer applied.[4]

SOIL CULTURE MAY BE SUPERSEDED BY CHEMICAL PROCESSES

Research chemists have been successful in devising rubberlike materials synthesized to perform work which rubber cannot do. The outstanding examples in America are Neoprene and Thiokol. . . . The Thiokols, like Neoprene, are highly resistant to solvents, and as they increase in number and variety will offer increasing competition to crude rubber. . . . Indeed, the threat of synthetic rubbers and rubberlike materials grows in various parts of the world and leads to the inquiry, Will they some day be another indigo[5] causing acres and

[1]Ibid., p. 310. Emphasis ours. [2]Ibid., p. 294. [3]Ibid., p. 301. [4]Ibid., p. 300.
[5]"In the . . . period from 1900 to 1915, a dramatic end was brought to the centuries old indigo trade. The area planted in India decreased from roughly 1,600,000 acres in

acres to go out of production of this national product, as did synthetic indigo not so many years ago?

It is difficult to predict the ultimate in the synthesis of rubberlike materials, but if carried to its logical conclusion in time we may see produced chemically in the area of an acre within a chemical plant, more material to give the service of crude rubber than would come from a great tropical plantation. Even now an acre of plant for Thiokol manufacture will produce in 2 hours, 200 tons of a synthetic rubberlike plastic, as compared to the 500 pounds of rubber which an acre of rubber trees will produce in 5 years.[1]

In the last little while it has been demonstrated by Gericke in California and others, that many foods, such as potatoes and tomatoes, can be grown with enormous yields without soil. Tanks of liquid plant food containing calcium nitrate, potassium nitrate, magnesium sulfate, potassium bisulfate, aluminum phosphate, titanium oxide, manganous chloride, boric acid, zinc sulfate, copper sulfate, nickel sulfate, and cobalt sulfate seem to be all that is required in addition to water and light. As used in the greenhouse, the tank also contains an electric heating cable to maintain a temperature at which the plants make the most rapid growth. One tank of exactly one one-hundredth acre of water surface produced 25.6 bushels of potatoes, and yields of other crops are equally impressive.[2]

NON-FOOD USES FOR AGRICULTURAL PRODUCTS

The story of the service of science in the utilization of agricultural byproducts is well known, with cottonseed perhaps an outstanding example and with the utilization of packing-house byproducts a close second. Recently, however, the plight of agriculture[3] has focused attention anew on work that has been in progress for some time. This is the effort to find non-food uses for agricultural crops, whether these be low-grade, surplus, or raised for the purpose. A new group, known as the Farm Chemurgic Council, seeks to be of service through effecting a new alliance between agriculture, industry, and science. It is too early to predict results, but there has been reason to believe that with the increased number of interested and capable

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1896 to 300,000 in 1912. Meanwhile German exports of synthetic indigo increased from 1364 tons in 1899 to 24,827 tons in 1912." (Encyclopaedia of the Social Sciences, "Modern Dyestuffs Industry," by Theodore J. Kreps, vol. 5, p. 302.)

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 6, "The Chemical Industries," pp. 305-306.

[2]Ibid., p. 307.

[3]See Chapter III, "Agriculture."

investigators concentrating on this phase of our national problem, something will be achieved.[1]

THE NEW COMPETITION

Characteristic of the chemical industry is the new competition which it has introduced. The new competition is that which exists between products devised to perform the same services. While their availability gives the user a great latitude of choice and in many cases a better opportunity to express his individual tastes and satisfy his personal judgment, it nevertheless means that to compete in the new competition an industry finds it necessary to lean heavily and constantly on the support science can give.[2]

NEW PLASTICS COMPETE WITH ORIGINAL MATERIALS

Highly competitive with metals and wood, the plastics . . . have made possible low-cost production of many molded articles with or without metal parts that would not have been otherwise attempted. The tribe is certain to increase.[3]

CELLULOSE—BASIC RAW MATERIAL FOR MANY NEW INDUSTRIES

Cellulose and the industries dependent upon it as a raw material afford one of the most interesting fields in the modern chemical industry. This compound, the molecular structure of which is still not definitely determined, has long been the basis of such important industries as textiles, paper, and lumber, and has supplied the raw material for pyroxylin, still the cheapest of plastics, gun cotton, and perhaps one or two other industries. In the last little while there have been added to this list artificial leather, film for photographic and other purposes, toilet articles, Cellophane, Sylphrap, Kodopak, and similar wrapping materials, lacquers of cotton or other cellulose base, and the amazing chemical fiber or rayon industry.[4]

"Things Which May Come to Pass"[5]

From a field so vast [as synthetic organic chemistry], touching the public at so many vital points, it must be that an ever-increasing num-

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 6, "The Chemical Industries," p. 307.

[2]Ibid., p. 313. [3]Ibid., p. 306. [4]Ibid., p. 302.

[5]Science was defined by Leonardo da Vinci as "knowledge of the things that are possible present and past." To this he added "prescience," which he described as "knowledge of the things which may come to pass." (MacCurdy, Edward [arranger], The Notebooks of Leonardo Da Vinci. Reynal and Hitchcock, New York, 1938, vol. 1, p. 73.)

ber of useful products will come. We do not know what they will be nor just how they will be used, but that they will have profound effects may be taken for certain. They will disturb industry by superseding old products and offering new employment. They will affect social problems by helping decrease, if they do not eliminate, certain ailments only to leave the race subject to still others. Vitamins, hormones, and the glandular products have been or will be synthesized and in time their use may have a profound influence on the human race. Improved colors and perfumes will have their effect upon esthetic senses. New products will offer new structural materials, just as the plastics and chemical fibers have done. They will aid in combating rust and corrosion, expand the opportunities for culture, and contribute to safety and "better living through chemistry."[1]

During the present century chemistry and the chemical industry have been most potent in creating a fourth kingdom and a fifth estate. There has been added to the animal, vegetable, and mineral kingdoms, the new one of synthesis; while to the lords spiritual, the lords temporal, the commons, and the press, there must now be added the fifth estate of the scientists, who more than all the others, guide the destinies of modern civilization.

This is not likely to happen unless the plans for the future include adequate provision for support in continuity of fundamental or basic research undertaken primarily to advance the frontiers of knowledge rather than for immediate monetary gain. The progress so notable in the present century is based primarily on accumulation throughout two centuries of knowledge to which unnumbered scientists have contributed. While there is a more widespread interest among Government agencies, academic institutions, and industrial concerns in research in pure science than at any other time, this must not be allowed to decline and should be increased rather than diminished. What has been done and what has been established to be fact, however impressive and extensive, indicates more than anything else the real paucity of our information, the need for further and more difficult investigation, and emphasizes the possibilities in terms of various social implications that could result if we but knew more of the ways of matter.[2]

What has been done thus far through applied science in lifting burdens from the backs of men seems in some instances to have gone to the point where there were too few burdens for men to bear. That

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 6, "The Chemical Industries," p. 312.
[2]Ibid., pp. 313-314.

> is a challenge to the utilization of the fruits of science and should not suggest curtailment of its work. Famines have become questions of transportation, purchasing power, and the weather, rather than technology or plant food. Facilities for housing and clothing have been enormously extended, and while many human ills remain to be understood and mitigated, the record of science in protecting health and prolonging the period of productive life is commendable.[1]
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> It is most difficult to forecast what the social implications may be as we go forward with chemical research and the applications of its results. Sir James Irvine once said that by the modesty of their predictions do scientists justify faith in their work. Notwithstanding carefully planned investigation, unexpected by-products of such activity may be the very ones that will have the most far-reaching effect. When Maxwell, Hertz, and others began their investigation of short wavelengths, no one could have imagined the variety of almost vital applications to which X-rays are now put. There are many such examples which make the scientist hesitate to put on the robes of the prophet.[1]
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> Doubtless the inventions through science in future will continue to change industry to the point of causing periods of difficult adjustment for employees, unless planning provides some way to lessen this difficulty. Old industries and certainly old products will disappear in favor of new ones. A wise use of what is provided will create greater leisure and more desirable products to be possessed at low prices. *The problem would seem to be how to use what can be produced in a way to be equitable, while at the same time planning to employ suitably for cultural and other activities the increasing leisure which may be prophesied for the race.*[1] [Emphasis ours.]

What lies ahead cannot be predicted in detail. What can be foreseen, however, is the ever widening scope of knowledge concerning the forces of nature. Even as the potentialities of electricity, chemistry, and the new metallurgy are still in process of examination and experiment, scientists already announce that a new source of power has become available.[2] Experiments in the physics department of Columbia University have finally disclosed a method for separating for the first time in pure form a new substance known as U-235, a

[1]Ibid., p. 314.

[2]New York Times, May 5, 1940, "Vast Power Source in Atomic Energy Opened by Science—Relative of Uranium Found to Yield Force 5,000,000 Times as Potent as Coal." Article by William L. Laurence.

close relative of uranium. So great is its energy that one pound of U-235 is said to be capable of power equal to five million pounds of coal or three million pounds of gasoline.

> A chunk of five to ten pounds . . . would drive an ocean liner or an ocean-going submarine for an indefinite period around the oceans of the world without refueling, it was said. For such a chunk would possess the power output of 25 to 50 million pounds of coal or of 15 million to 30 million pounds of gasoline.[1]

While much remains to be done before the new substance can be used in industry, the new discoveries reveal an exceedingly simple method of liberating its energy.

> All that is needed to put it to work running motors and steamships is to place it in a tank of water and keep it supplied with a constant flow of cold water. Left by itself, the substance would be inactive. As soon as it touched water of ordinary temperature, it would immediately start to liberate its energy. The water would be turned into steam and the steam would drive powerful turbines. The new water supply would keep the process going indefinitely. To stop it, all that would be necessary would be to cut off the water supply. Thus the process would be the nearest practical approach to a form of perpetual motion.[1]

We have come a long way since the days of Thoreau and of Faraday. The processes of scientific discovery in the laboratory move forward with ever-increasing success in revealing to man the hitherto unknown potentialities of nature. What is overdue is the study of methods of progressive social adjustment which technological change requires.

The rapidity of recent scientific progress is amusingly illustrated by the fact that part of Michael Faraday's salary was the provision of the very candles which his discoveries in electricity eventually made obsolete. Moreover, the subject of his favorite course of lectures, given repeatedly for young people, was "The Chemical History of a Candle." In these popular talks he revealed himself not only as one who had made discoveries, but as a teacher who was able to show how a discovery is made and thus to give acceleration to mankind's accumulation of knowledge.

> If a boy reads The Chemical History of a Candle carefully, and, unless he is very clever, three times over, and if he puts to a candle of his own the

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[1]New York Times, May 5, 1940. Article by William L. Laurence.

> questions Faraday asked of his, he is likely to get an idea of the method by which discoveries are made, and he may be prompted to go on to be a discoverer himself.[1]

Such was the appraisal of Faraday by another scientist, closer to our day, J. Arthur Thomson of Aberdeen.

The candle of the boy of a hundred years later, thanks to the discoveries of Faraday and others, has become an electric light bulb. Yet if an illuminating engineer is called on by the board of education to measure the light on the schoolboy's desk, he describes it as so many "candle power." Or if an automotive engineer measures the strength of the engine in the school bus, he calls it "horse power." For language, like all social sciences, clings to the familiar and accepted, thereby reflecting inertia which delays social adjustment to scientific discovery.

The environment betokened by candles as part of a professor's salary was to be profoundly changed in a hundred years by the discoveries of this same professor and others. The task thereby bequeathed to our generation may well be to write "The Social History of Light and Power" with the same scientific detachment and clear insight that Faraday demonstrated in describing the candle's chemical history.

New social research must clarify the basis for social adjustment to technological change. In such research true evaluation of the impact of increasing productivity upon requirements for human labor, due to electric power production and the new science of chemistry, is bound to occupy a primary place.

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[1]Thomson, J. Arthur, "Michael Faraday," Introduction to The Chemical History of a Candle, by Michael Faraday, p. 7.

Chapter II

Mineral Industries: Increasing Productivity and Changing Labor Requirements

THE adaptation of electrical and chemical processes to our basic mineral industries has resulted in great and continuing increases in the availability and usefulness of mineral raw materials. Literally thousands of new metals have been created by chemistry and electricity, through combining elementary materials in alloys.

While these developments create great potential increases for the standard of living, they likewise considerably influence the labor requirements and employment opportunities pertaining to mineral extraction and its related processes.

THE TASK OF MINERAL TECHNOLOGY

The task of mineral technology is to supply the fuels and the raw materials for which modern life has come to depend on the resources of the under-earth. Ours is the age of the power machine and the minerals furnish both the power and the metal for the machine. The minerals now supply 90 percent of the national requirements for energy—water power furnishing 10 percent. Aside from the manufacture of food products and textiles, the minerals have become the greatest of the raw materials of industry, the chief bases of chemical manufacture, the chief materials of construction. It is hard to imagine any activity of modern life which does not utilize either energy derived from mineral fuel or articles fabricated from mineral raw materials, and in large part the progress of invention has been an increasing ingenuity in devising means to use the energy or the exceptional materials made available by the mines.[1]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," by F. G. Tryon, U. S. Bureau of Mines; Thomas T. Read, professor of mining engineering, Columbia University; K. C. Heald, staff geologist, Gulf Oil Corporation; George S. Rice, chief mining engineer, U. S. Bureau of Mines; and Oliver Bowles, chief engineer, Building Material Section, U. S. Bureau of Mines. Government Printing Office, Washington, 1937, p. 145.

While a century ago the metallurgical materials, exclusive of the noble metals, were wrought iron, cast iron, steel, copper, brass, zinc, bronze, lead, tin, and not much else, there are now at least 5,000 alloys in industrial use.[1]

THE FUNCTION OF NEW ALLOYS

Although alloys (e.g. bronze) have been used for many centuries, recent technical improvements have greatly augmented their number; there are now thousands of alloys, which are important chiefly because they improve upon the basic metal either generally or for some specific purpose. Alloying may harden a metal, increase its ductility, raise its resistance to external influences and produce other desirable changes. The multitude of alloys may be divided into three great groups: iron and steel alloys, copper alloys and aluminum alloys.[2]

MAJOR FUNCTIONAL GROUPS OF METALS

In their modern technological uses metals may be classified into three major groups: structural metals, power transmission metals and chemical metals.[3]

The growth of metal consumption has been especially great in the past fifty years; thus the value of metal production in the United States rose from an annual average of $191,000,000 in the years 1881 to 1885 to $1,476,000,000 in 1929. Machinery and other types of industrial equipment, railroads, steamships and bridges, new forms of construction, all absorbed continuously greater supplies of metals; and the demand was strengthened by an increasing and varied production of metal consumption goods. Electricity augmented immensely the use of copper, while the development of industrial chemistry called for large supplies of "chemical metals." These changes were accompanied by progress in extractive and refining methods; the advent of new processes, such as electrometallurgy; improvements in the quality of metals, particularly in the form of alloys; and the discovery and technological utilization of many new or rare metals, such as vanadium, tungsten, manganese, nickel, chromium and aluminum. Industrialism may aptly be called a metal economy.[4]

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[1]Ibid., Part 3, sec. 8, "Metallurgy," by C. C. Furnas, associate professor of chemical engineering, Yale University, p. 330.

[2]Encyclopaedia of the Social Sciences, "Metals, Modern," by Alfred Marcus. Macmillan Co., New York, 1933, vol. 10, p. 384.

[3]Ibid., p. 369.

[4]Ibid., pp. 368-369.

NEW ALLOYS FOR LIGHT-WEIGHT CONSTRUCTION

The most abundant metal in the earth's surface (if silicon is considered a nonmetal) is aluminum. It is estimated that over 8 percent of the outer 10-mile shell of the earth is aluminum, whereas iron can only account for 5 percent. Another light metal which is beginning to enter industry in ever-increasing quantities is magnesium. It is distinctly lighter than aluminum (specific gravity 1.74, compared to aluminum specific gravity 2.7), and can be made into alloys which are almost as strong as those of aluminum. Because of this advantage of light weight, the high magnesium alloys are beginning to appear in aircraft construction. In that field, where light weight is paramount in stratosphere balloons, the gondolas are made of Dow metal, which is a trade name for certain magnesium alloys. Within the past 2 years great advances have been made in improving the corrosion resistance of these alloys so that now magnesium at 28 to 30 cents a pound is beginning to be a competitor of aluminum at approximately 20 cents a pound. As magnesium alloys improve, there will certainly be an interesting commercial conflict between these two materials.[1]

ELECTROCHEMICAL PROCESSES CREATE NEW DEVELOPMENTS

Many of the outstanding developments of the past have been due to the adaptation of electrical processes to metallurgy. For instance, in the electrorefining of copper, America leads the way with her rather stubborn and low-grade western copper ores. Not only was a better grade of copper produced more cheaply than was possible with the old complex pyrometallurgical process, but the residual gold and silver were turned into profits. At the present time a multitude of metals, notably copper, silver, gold, nickel, lead, bismuth, iron, antimony, and zinc are electrolytically refined. Others are reduced from their ores by electrolysis in a bath of fused electrolytes. The principal materials produced electrolytically or subjected to electrolytic refining are aluminum, beryllium, calcium, cerium, lithium, magnesium, and sodium. A great deal of electric energy is also used simply as a source of heat in the metallurgical industry. Practically 95 percent of the brass is now produced in electric furnaces of various types and an ever-increasing percentage of the alloy steels is being produced in electric equipment, not to mention the fact that a great

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," p. 352.

deal of the ferro-alloys which are used in making up finished alloy steels are produced in electric furnaces.[1]

The history of aluminum production in this country is the history of the Aluminum Co. of America. . . . They have been so outstanding in the field that they have been practically the sole producers in this country. . . .

With the price wavering in the vicinity of 20 cents per pound, aluminum is still, when compared to steel, an expensive metal. It will forever remain more expensive than steel because, while it is abundant, it is very difficult to persuade the metal to leave the chemical combination with oxygen. It requires approximately 10 kilowatt-hours per pound of aluminum to effect this separation. Hence power cost alone makes it inherently more expensive than steel. Aluminum Co. equipment represents an investment of approximately 1 dollar per pound per year installed capacity for metal production. Hence carrying charges, or investment, amount to about 6 cents per pound of aluminum—a heavy burden.

It is difficult to separate aluminum from the other metal constituents. Hence the material used for making the metal must be practically free from iron, silicon, and titanium. With the Hall process, as it is now used, it is necessary to have relatively pure bauxite to begin with and it is necessary to refine it by expensive leaching processes.

Dozens of inventors have worked more or less successfully upon processes which will permit the use of lower grade ores than are now necessary, and for cheaper methods of extraction. . . .

The electrolytic production of magnesium requires almost as great a power consumption as does aluminum.[2]

Electrochemistry[3] is beginning to enter into the electrolytic production of another valuable metal, namely, manganese. Manganese is a metal which is essential as an alloying material as well as a deoxidizer in the steel industry. . . .

Another material which is essential in the production of alloy steels, as well as for a coating metal, is chromium. It . . . is largely produced from foreign ores.[4]

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[1]Ibid., pp. 351-352. [2]Ibid., pp. 356-357.

[3]"Another interesting possible development in electrometallurgy may be forthcoming in the field of those metals such as aluminum and magnesium which are now produced by deposition from molten salt baths. It has been demonstrated in research laboratories that any metal can be deposited electrolytically from water solutions. It is possible to produce aluminum in this way though no process has yet proven commercially feasible." (Ibid., p. 357.)

[4]Ibid., p. 357.

NEW METALS CREATE NEW WAYS OF LIFE

The most obvious result of the use of new metals has been the production of mechanisms which it would have been impossible to produce even at unlimited cost in the early days. The best known example, of course, is the automobile. It would be impossible to construct a machine of cast iron which would withstand the wear and tear of even the most carefully handled motor car. . . . The various makes of the average-priced automobiles of 1935 contained 83 different alloy steels.

Though airplanes were first made without any appreciable quantity of metals outside the engine, the modern, efficient, speedy plane is becoming almost completely a metal mechanism. This is a direct result of the development of the light aluminum alloys of the duralumin type of which aluminum is the chief constituent.[1]

The last 20 years have seen a tremendous increase in the temperatures and pressures used in chemical industries. The chemical engineer has designed equipment which called for steel that would retain its strength and resist corrosion at a bright red heat. After a great deal of research the metallurgist has supplied such materials and has thus revolutionized the petroleum industry as well as many a process of chemical manufacture.

These three examples [automobile, airplane, and equipment for chemical industries] show how new materials make new equipment possible. Hundreds of technological developments can be attributed to the metallurgist's improvements in his materials.[1]

Mineral Extraction and Its Auxiliary Industries

Except as chance or patient exploration finds other new deposits, equal in richness or in accessibility to those exhausted, mineral extraction always faces the prospect of increasing physical obstacles. In manufacturing every advance in technology assures a net gain in efficiency; in mining it may be offset by the increasing handicaps of nature. . . .

Mineral economics, therefore, is the record of struggle between opposing forces. On the one hand is the factor of exhaustion, with its burden of accumulating handicaps. On the other is mineral technology, aided by its allies, exploration and transport.[2]

Ultimate exhaustion of many minerals is inevitable, but in no

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," p. 330.
[2]Ibid., Part 3, sec. 2, "The Mineral Industries," p. 145.

case will exhaustion be catastrophic. Many important minerals maintain their commanding position, even today, only because they are slightly cheaper or have slightly superior qualities to those of other substances that are available in abundance and that are clamoring for a market.[1]

DECREASING NEED FOR LABOR FORCE IN MINERAL EXTRACTION

Prior to 1923, the labor force engaged in mineral extraction increased both absolutely and in relation to the working population as a whole. Thereafter, the combined effects of the acceleration of technique and the retardation of demand produced a sudden change and the number of workers engaged in the mineral industries declined from 1923 to 1929. Of the major branches of mineral extraction, only oil and gas continue to provide more jobs. With the onset of the great depression, of course, both output and employment have decreased in substantially all branches except gold.[2]

MODERNIZATION OF AUXILIARY INDUSTRIES

A metal passes through many stages before it reaches its final form. The mining and preparation of the ores are followed by smelting, which in the case of many metals is divided into a number of phases, and then by refining, which is being increasingly accomplished by electrochemical and electrothermic methods. The metal is then worked into semifinished and finished products. Compared to the processing of other industrial materials, such as wood, the treatment of metals is relatively complicated and protracted. The length of processing also affects the economic importance of metals, which is considerable even before the metal is worked at all. The many auxiliary industries involved require apparatus and machinery on a large scale: ore mining equipment, smelting and refining furnaces, huge electrolytic plants, rolling mills and foundries and the frequently enormous machinery used in the manufacture of finished metal products.[3]

Mechanization and Employment in the Iron and Steel Industries

Here in relation to the earth's resources and their new forms and uses, great changes are occurring which directly affect the tasks of the workers and their opportunity for employment.

[1]Ibid., p. 151.
[2]Ibid., p. 148.
[3]Encyclopaedia of the Social Sciences, "Metals, Modern," by Alfred Marcus, vol. 10, p. 369.

As in every other line of industrial activity, the most noticeable trend in the metallurgical industries since the beginning of the present era has been the increased efficiency of production, brought about largely by the substitution of machines for hand labor. In the early days, the blast furnaces for the production of pig iron from ore were small affairs which would turn out perhaps 5 to 10 tons of molten metal per day. There are now several blast furnaces in operation which, *using no more men than formerly,* can turn out as much as 1,000 tons of iron every day. . . . The bulk of the product of the blast furnaces, pig iron, is further refined to make the stronger and more useful product, steel.[1]

GREAT REDUCTION IN NEEDED MAN-HOURS

If there is to be any significant further decrease in the number of man-hours required for the production of steel, it will probably come in that part of the operations which is concerned with the making of the steel from pig iron and its later fabrication into shapes; for on the average about 12 man-hours are required to produce a ton of pig iron, while it takes about 35 man-hours per ton of steel after the pig iron has been delivered. This figure is for average production and does not include pipes and tubing or special shapes.[2]

There is every reason to believe that in the future the average figure of 35 man-hours per ton of finished steel produced from pig iron will be materially reduced. In 1929 there were 1⅛ billion man-hours consumed in the production of steel. Any item which makes a very large percentage change in this figure will undoubtedly have a distinct effect, at least of a temporary character, on technological unemployment.

SOME MAJOR INSTANCES OF MECHANIZATION

In the early days of the making of steel shapes it was customary to roll into billets and slabs, then take these materials and reheat them at a later time and roll them down into the particular shapes desired. There is a certain tendency to perform more of the operations without these cessations of processing which necessitate intermediate reheating. In former years it was necessary not only to reheat the material one or more times during the production of thin steel sheet but it was also necessary to use a great deal of hand labor in

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," pp. 330-331. Emphasis ours.
[2]Ibid., pp. 331-332.

feeding the sheet which was being rolled from one mill to another. These hand operations and the reheating are being rapidly eliminated by the process of continuous rolling from the steel ingot to the finished sheet.[1]

A development has taken place in the field of making castings which is roughly parallel to the continuous rolling of sheet steel. The Crane Co. and the Westinghouse Air Brake Co. years ago made use of a continuous process for making iron castings. The Ford Motor Co. has instituted a system of continuous pouring of castings. Molten iron is taken directly from the blast furnace and after passing through an intermediate mixer and electric furnace is poured into cylinder block molds on a production line. Several thousand cylinder blocks, as well as over a thousand tons of other castings, are made in this way every day. There is a large saving in labor as well as in fuel. It is another instance of what may be accomplished by a simple synchronization of industrial processes.[2]

INCREASE IN QUANTITY PRODUCTION THROUGH HIGH-SPEED TOOL STEELS

One of the most significant changes in the fabrication of articles in the present century came with the introduction of the high-speed tool steels. The ordinary carbon steel can be made into excellent cutting tools, but it does not retain its properties of hardness and strength at high temperatures. When a tool is used to cut metal, as in a lathe, no matter how sharp the tool may be and how perfect the cut, there is a large amount of local heating. Hence, with the old type of tool steel, a metal object had to be cut or shaped very slowly.

With the introduction of the high-speed tool steel (discovered by White and Taylor of the Bethlehem Steel Co. in 1900 as the result of a fortunate accident which successfully terminated a long series of expensive experiments), the usable cutting speeds were increased four or fivefold. Within a few years there was a revolution in those industries which depend upon cutting tools for the fabrication of articles. All the old machines became obsolete and quantity of production was enormously increased. This introduction of one simple improvement so changed the industrial picture in this country that the efficiency of all industries underwent an estimated increase of some 15 percent. In other words, the increased productivity of all industries, due to the introduction of high-speed tool steel amounted to about 8 billion dollars per year. All this was accomplished by the utilization of about 20 million dollars worth of these special steels

[1]Ibid., pp. 332-333. [2]Ibid., p. 333.

per year plus, of course, the required additional investments in new machines. This is one of the most phenomenal examples of the immense effect of one small development. This development has been further accelerated by the use of Haynes Stellite as a hard tool material.[1]

A new material is now available which consists of a mixture of tungsten and titanium carbides cemented with cobalt. This is perfectly satisfactory for cutting steel and it has been found to have 60 times the life in operation that the original cemented tungsten carbide had.

The introduction of this new material is enabling the cutting speeds to go up and up. The limiting factor in cutting speed in this material with this type of tool is no longer the property of the material itself, but the rather peculiar and unexpected difficulty of getting rid of the chips. The study of chips is now a basic problem in metallurgy. The significance of this new development [increasing cutting speed by using still another new material] can only be estimated when it is realized that it has only invaded a very small proportion of the field at the present time. *There is no question but that it will make many machines now in use obsolete and the productivity throughout the industries as a whole will eventually again be markedly increased, certainly in the order of millions, perhaps of billions of dollars per year.*[2]

INCREASING AND LASTING TECHNOLOGICAL UNEMPLOYMENT

There seems to be little doubt that one of the results of future metallurgical developments will be an increasing amount of technological unemployment among the workers directly concerned in the production of metal and fabrication of its products. It seems doubtful if this can be remedied by increased production and consumption. This will be particularly true in the nonferrous fields where the raw materials used are relatively expensive, for there is not a single plant in the world engaged in the fabrication of articles of copper, brass, lead, zinc, etc., which is completely up to date in the utilization of labor-saving devices. As plants become completely modernized, and eventually they will, there will be more men and women thrown into the lists of the unemployed. Organized labor will oppose such advances. This will delay, but not stop them. This item of future

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," p. 354.

[2]Ibid., p. 355. Emphasis ours.

technological unemployment is mentioned here merely to point out again that *we as an industrial society have found no fundamental solutions for the problems raised by the replacement of men by machines. This statement is made with full knowledge of the fact that increased consumption of goods and increased use of personal services do tend to furnish employment for those displaced by machines. It must be considered that the ideal society would be one in which as much of the drudgery as possible would be performed by machines but in which no man or woman would be denied a means of livelihood. It is useless to evade the issue by postponing the use of labor-saving methods and devices. Metallurgical industries, and all others, must look ahead to the day when machines and not men will be the principal organs of production and they must answer the question: How is the average man to make a living?*[1]

OTHER NEW EQUIPMENT MAKING FOR PRODUCTIVITY, OBSOLESCENCE, AND UNEMPLOYMENT

There are several developments in the making now which, though still unproven, stand a chance of having a great deal of influence in future metallurgy.[2]

The Hazelett process (Hazelett Metals, Inc.) for the direct rolling of metals has been in the developmental stage in the brass and copper industry for several years. At least a million pounds of brass sheet have been rolled directly from the molten metal by this method. It is not only a labor saver; it also produces metal with some distinctly improved qualities. It has been utilized for the rolling of copper. The use of this method is spreading to other countries and is probably more advanced in Germany than it is here. Recently a 20-inch mill for direct rolling of brass and copper was shipped from this country to Japan. It has the capacity of 1 ton in 4 minutes. Similar mills are in operation in this country. . . .

This direct-rolling process is not yet a major item in the production picture but there is little doubt that it will rapidly become so in the nonferrous field and if the troublesome difficulties are overcome will undoubtedly have a decided effect upon the labor required in the production of finished products. This tendency toward increased efficiency of production will unquestionably enter even further into the problem of technological unemployment in the future than it has in the past. Moreover, there is some good evidence that metal

[1]Ibid., p. 333. Emphasis ours. [2]Ibid., p. 355.

sheet produced by this process is inherently better than that rolled from ingots.[1]

CONSUMER DEMAND STIMULATES TECHNICAL PROGRESS

In the iron and steel industry there have been a great many strides due primarily to economic pressure since the relatively carefree days which ended rather abruptly with the 1920's. Now they actually read and record temperatures of heats of molten steel. That was nothing but a piece of academic foolishness a few years ago. In a word, the steel industry is being modernized. It is estimated that in 1935, 140 million dollars were spent on what might roughly be called modernization, and in 1936 some 200 millions will probably be spent for the same purpose. Stress is being placed upon efficiency of operation and quality and adaptability of the product. Steel is being produced in small lots to exact specifications to fit individual needs. The steel industry can now supply some 500 different products in as many as 100,000 different grades, shapes, and sizes. Part of this is due to what might be called "customer pressure," rather than from any desire from the inside to improve. This is particularly true in the field of sheet metal. In 1929 less than 25 percent of the production was in the form of steel sheets. That figure rose to 43 percent in 1935. Single-piece automobile tops, and pressed-steel bathtubs are partially responsible. This increased production of sheet metal has resulted in the construction of the automatic continuous strip mills. . . . There are now 21 such mills. In 1926, sheet steel cost $83 per ton, $30 of which were for labor. In 1935, it cost $53 per ton, $21 of which were for labor.[2]

Another very important step forward, initiated by American steel manufacturers in the last half decade, has been through the control of grain size of finished steel, by proper temperature and work control and the addition of certain metals, such as aluminum. This has permitted much closer control of all steel properties. It has been found that ordinary plain carbon steels can now have strengths only found in the better alloy steels a few years ago. In other words, one of the functions of alloying elements in previous years was to cover up sloppy steel-making practice. The carefully controlled plain carbon steels and the new "low alloy" steels[3] are now so satisfactory and

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," pp. 355-356.

[2]Ibid., p. 350.

[3]By 1941 the alloy steels, other than tool and stainless steels, numbered several thousand. Under the pressure of national defense needs the American Iron and Steel Institute, on April

uniform in properties that they are displacing many of the more expensive high-alloy steels, particularly in the automobile business. These new steels average so much stronger than the old carbon steels that structures, freight cars, and truck bodies can be made 25 to 40 percent lighter than formerly. Some of the new lightweight streamlined trains are made of these alloys. With competition and consumer pressure behind them, the more forward-looking steel makers have been very much on the job.[1]

NEW METHODS OF METAL CONSTRUCTION

Another item of ever-increasing importance in the field of fabrication of metals is that of welding, particularly electric welding. . . . In the construction of buildings, in those areas not crippled by too many building restrictions, the buzz of the electric arc has now pretty well displaced the din of the riveting hammer, and welding is even entering the tradition-ridden field of shipbuilding.[2]

The more skilled trade of welder replaces that of riveter. The fearful noise of riveting is eliminated. Metal is economized, and capital is further saved through assembly savings and the greater durability of welded products. . . . Welding, more than riveting, but less than casting, fosters neatness of form, curves, streamlining, and the new art style of metal architecture. It helps especially in the manufacture of airplanes, automobiles, high-speed trains and many other devices, mostly in transportation that especially need lightness, trimness, or permanently tight joints.[3]

At the present time, welding is only being used in a small proportion of the places where its use is justified. When the various forms of industrial and human inertia are overcome, it will unquestionably continue to decrease the cost of fabrication of all types of articles and structures and probably make possible many types of operation not now being used.[4]

28, 1941, announced a new list of 76 standard alloy steels. This was the result of two years' study by the Institute's general technical committee, for the purpose of standardizing steel-mill products, thus increasing efficiency in production by reducing the consumers' specifications. The committee had found that in 1940 about 96 per cent of the total output of tonnage alloy steels was covered by only 55 varieties. The consuming manufacturers were told that the reduced list would provide standard steels to replace non-standard grades, without the necessity for changing manufacturing methods or impairing quality. (New York Times, April 21, 1941, news item headed "Steel Technicians Cut Alloys to 76.")

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," pp. 350-351.

[2]Ibid., p. 352. [3]Ibid., Part 1, sec. 3, "Social Effects of Inventions," p. 25.

[4]Ibid., Part 3, sec. 8, "Metallurgy," p. 353.

CHANGE IN TYPE OF PERSONNEL REQUIRED

There is one item which seems to stand out very clearly, namely, that the production of the various metals is becoming more and more of a complicated business. One of the major effects of this tendency has been, and will continue to be, a distinct change in the type of personnel required. The old type rule-of-thumb man, who hadn't the slightest idea (scientifically speaking) of what he was doing, and only followed a certain technique because his predecessor had done so, is passing out of the picture. The college-trained men have, in spite of an immense amount of opposition, been making great improvements in the steel, as well as in almost every other metallurgical industry. Although all the operations are carried out for the most part by men who, though they may be skilled, have not had fundamental scientific training, it is becoming practically necessary to have the supervision of the industry under the hand of a man who has some understanding of fundamental physical chemistry and engineering principles. There has also been an increasing tendency for the technically trained college graduate to rise rapidly to the executive positions in corporations because of the fact that it is necessary for the people in charge to have a fundamental conception of what it is all about. There is a distinct shortage at the present time of the type of technically trained men who can keep production up to its present standards of quality and who can contribute something to the research in production and processes. As our metallurgical picture becomes more and more complex, and it undoubtedly will continue to do so, it will be increasingly important to have a larger supply of competently trained technical men and that is one commodity in which there now is certainly a shortage.[1]

TECHNICAL DEVELOPMENTS FOSTERING LARGE-SCALE ENTERPRISE

One tendency, which probably is unfortunate, is found in the fact that as processes become more and more complex, they progressively require more expensive equipment and personnel and hence tend to be a barrier in the way of small producers. One striking example is found in the foundry business. Customers are progressively demanding more and more that castings which come from a foundry shall be carefully and competently inspected for faults by means of X-ray or gamma-ray apparatus. Such apparatus is expensive and requires carefully trained men for its operation. The small foundry tends to object

[1] National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," pp. 359-360.

strenuously to such "foolishness" but it is a perfectly valid demand on the part of the customer and is something which probably must become routine in all future production. It is quite evident that this will be the straw that will break the camel's back for many a small producer. There is also an ever-increasing tendency to use alloy cast irons made by the introduction of nickel or molybdenum or other metals. Making this type of casting requires careful work and a knowledge of what one is trying to accomplish. It means that the old-time foundryman who operated mainly on tradition will probably have to pass out.[1]

Other New Developments

To the picture of the many significant developments already outlined, the following may be added, since they reveal further the enrichment of our metal resources and their attainable products.

CORROSION CONTROL AND METAL SAVING

It is Nature's intention to keep the metals, with a few exceptions, in the corroded state. Man, with his infinite stubborness, intends to keep this from happening. The item of corrosion plays an extremely significant role in modern metallurgy.[2]

It is quite evident that even in the "stainless" material there is still much to be done in the development of corrosion resistance.[3]

The one time-honored method of resisting corrosion is to coat an inexpensive material with a very thin layer of something which will resist corrosion, at least for a time.[3]

Another method of putting on protective metal coatings is that of electroplating.[3]

[A] successful attempt at resisting corrosion has been found in the so-called "anodic coatings."[3]

It is quite certain that these newer items in the coating of metal are not only going to make many things possible which were not possible, heretofore, but are also going to make many corrosion-resisting metals much less expensive and thus open up new markets for metals. These more or less successful attempts to bring corrosion under control are going to have a decided effect upon the picture of metal production in the future, for the more metal that is saved from the destructive forces of the elements, the less new metal will have

[1]Ibid., p. 360. [2]Ibid., p. 346. [3]Ibid., p. 348.

to be produced. Paradoxically, the metal producers who have done most of the research upon corrosion resistance will probably eventually suffer a contraction of their market simply because of the efficiency of their research. On the other hand, competition among producers is very keen, and if one is to stay in business, he must advance in order to give better and better products to consumers. It would seem, then, that the metal producer will eventually be caught upon both horns of his dilemma; and while this possible contracting market, because of improving corrosion resistance, is not yet a major consideration, it is something which must be thought about in the future.[1]

RECOVERY AND RECIRCULATION OF METALS

Since this country was saved from the Stone Age of the Indian to be plunged into the iron age of the white man, we have produced over 1 billion tons of metallic iron in one form or another. Approximately 15 to 20 percent of this primary production has been irrecoverably lost by rusting, according to the best authorities. On the average, about 35 percent of the total primary production is irrecoverably lost either by rusting, burying in the ground, or putting into objects from which it is not profitable to recover the metal. This leads to the estimate that there are at the present time in this country about 700 million tons of iron and steel which will eventually find its way back to the scrap pile to be remelted and used again. This is an immense mine of material which must be reckoned with if we are to consider metal production in future years. At the present time about 65 percent of all the iron and steel which is produced eventually finds its way back to the steel mills as the material for refabrication. About 25 percent comes back to the steel mill in a short time and most of the remaining 40 percent has returned within 30 years.[2]

TIME LAG BETWEEN LABORATORY DISCOVERIES AND ACTUAL TECHNOLOGICAL PROGRESS

Ordinarily the consumer does not see the result of scientific or technical advances until many years after the original discovery or invention, for it always takes a great deal of time and effort to con-

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 8, "Metallurgy," pp. 348-349. The change in the situation, brought about by war, will be noted in the Postscript. War's artificial demand changes the balance, but does not end the dilemma.

[2]Ibid., p. 349.

vert an idea into a laboratory success and then into a technical advance. Moreover, there are always various types of inertia to be overcome all along the line; sometimes financial inertia because of new investments required, then perhaps the inertia of the executives' prejudices, and finally, the very slow moving mass of the operator's and then the consumer's mind must be changed. A great many of the advances in an industry are due, not so much to a new discovery or an invention, as to the greater adaptation of facts or equipment already long in existence. The bulk of research in recent years as well as the dispensation of scientific information has come from the metal consumers rather than the producers. American metal producers, until recently have been particularly narrow in their policies of research and development.[1]

ADVANTAGES TO LIVING STANDARDS

There seems to be little doubt that metals are going to be one of the most important instruments in the gradual raising of the average standard of living for some time to come. Until our resources and ingenuity begin to decline there will be more and better metal objects in our lives than ever before. There will also be many more objects of many other kinds of materials. They all go together. The physical existence of the human race is certainly going to be greatly improved. This will all be an unhampered benefit to the consumer.[2]

If this were an ideal world it would make but little difference where the discoveries and inventions came from, but that unfortunately is not a situation which is approached in any sense of the word. If we, as a nation, are to stay ahead of the game it is absolutely essential that within the forthcoming years we must expend more and more effort upon obtaining the fundamental information which is necessary for an advancing civilization. Moreover, viewing the picture a little more minutely, there is going to be an era of ever-increasing competition not only between individual producers of one material, but between producers of different materials, and it is quite certain that only those who have a firm scientific background will be able to survive.[3]

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[1]Ibid., p. 350. [2]Ibid., p. 361.
[3]Ibid., p. 364. During the present war period, when all available metals are readily absorbed, such competition may be less in evidence. The truth of this statement nevertheless holds good.

Coal Mining and the New Technology

Coal, in its earliest uses, dating from the thirteenth century in England,[1] was a fuel for heating, not yet a factor in industry. In the Steam Age, it became the agent for converting water into vapor, and thus shared with the steam engine its manifold uses. In the Iron Age made possible by metallurgy, coal again was the indispensable original source of the excessive heat required for making steel and numerous other metals. For the new primary resources of the Power Age, coal holds its place as the principal means of starting the process of tapping the energies of electricity, though now its supremacy is challenged by other fuels, especially petroleum and natural gas, and by water power.

While coal continues to be used for heating homes, where it enters directly into the standard of living, its principal uses are in the system of production.[2] From its role in relation to production, it follows that the coal industry is affected more profoundly by the new technology as a whole than by changes in its own processes. The new resources for energy are its consumers, and therefore its market changes with the technical developments arising out of electricity as the chief new energy.[3] Its future will be conditioned partly by fuels, but largely by the capacity of the community to use the output of the new production; that is, to raise the general standard of living.

Likewise, for the coal miner, a lifting of the general level, both in working and living conditions, might be expected as a consequence of the new technology. Actually, a curiously belated mechanization, greatly accelerated in the past five or six years, added to the long-standing condition of insecurity from short-time em-

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[1]See Wieck, Edward A., The American Miners' Association. Russell Sage Foundation, New York, 1940, p. 32.

[2]This is true of both of the principal kinds of coal in the United States, anthracite and bituminous, though the latter is far more important in present quantity and in reserves for future use. This section will deal with bituminous coal, unless otherwise noted.

[3]It should be noted that science affects coal also when new methods of burning produce more heat per unit burned. Thus the supply needed becomes relatively less. Cf. National Resources Committee, Technological Trends and National Policy, p. 256: "The best steam-electric plants are generating, at present, a kilowatt-hour on less than 1 pound of coal as compared with an average of 3⅓ pounds in 1918, 5 pounds in 1900 and about 10 pounds of coal in 1880."

ployment,[1] exposes the miner and the mining community to an excessive burden of displacement. The burden is the greater in the degree that similar lack of opportunity is occurring in other industries, especially agriculture, to which the miner has turned in years past to make up his annual deficiency in employment. This background needs to be kept in mind in reviewing the progress toward greater productivity in the bituminous coal industry.

INCREASING MECHANIZATION IN UNDERGROUND MINING

> In coal mining present technologic development centers around machines to reduce hand labor.[2]
>
> At present the most active field of mechanization [in underground mining] relates to the work of the men at the face who constitute, under the system of hand loading, from 50 to 70 percent of the entire working force.[3]
>
> Animal power has given place to mechanical traction on main-line haulage in all but the smallest mines. Even in the gathering of cars from individual working places to be made up into trains, the mule is rapidly giving way to the faster and more powerful electric locomotive, and low-built machines have been developed for use in thin seams. In some areas electrification of haulage is now approaching the saturation point. . . . Another line of expected development is increased use of belt or trough conveyors for transporting coal from the face to central loading points, or even to the surface.[3]
>
> The tonnage of bituminous coal loaded by use of machines of all . . . types has increased from 1,500,000 in 1923, the year of the first statistical record, to 47,000,000 in 1935, and now amounts to 13.6 percent of the underground production.[4] (The tonnage of Pennsylvania

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[1]See van Kleeck, Mary, Miners and Management, Russell Sage Foundation, New York, 1934, p. 179: "From 1890 to 1932 the bituminous coal mines were open for operation an average of 205 days in a year; and the maximum year's employment in those four decades was 249 days in 1918, during the World War."

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 151.

[3]Ibid., p. 152.

[4]A very rapid increase occurred in the following two years. The National Research Project of the Work Projects Administration reported in August, 1939, that "between 1935 and 1937 the machine-loaded tonnage increased from 47 to 83 million tons, or to 20.3 percent of all underground production," as compared with 7.3 percent in 1929 and 0.3 percent in 1923. In West Virginia 21 percent of the output was mechanically loaded in 1938, as compared with 2 percent in 1935. (National Research Project of Work Projects Administration and Bureau of Mines, Department of the Interior, Mechanization, Employment, and Output per Man in Bituminous-Coal Mining. Philadelphia, 1939, vol. 1, letter of transmittal.)

anthracite similarly loaded has increased to 9,300,000 or 21 percent of the underground output.) For the industry as a whole, the new machinery, therefore, is just getting under way. That it is destined to spread very widely is shown by the fact that in some districts the great bulk of the output is already mechanized. In 1935, 90 percent of the Wyoming production was mechanically loaded, 62 percent of the Indiana production, and 56 percent of the Illinois production.[1]

Some light on the possible rate of increase [in mechanical loading] is thrown by the past record of the introduction of the cutting machine. . . . The first 10 years of the loading machine have followed a course much like that of its predecessor. It is well to remember, however, that the cutting machine had to make its way in an industry which was just beginning to use electric power. The loading machine enters at a time when primary haulage is already electrified in all but the smaller mines, making the task of bringing power to the face comparatively easy. The loader may therefore spread more rapidly than did the cutter.[2]

PREVAILING WAGE RATES INFLUENCE MECHANIZATION

The rate at which the mechanization of loading can go on within a given area depends partly on the wage rate. The districts of the West where mechanical loading has now become general were marked by relatively high wage rates, and conversely the districts where wage rates were low, found little incentive to mechanize. With the recovery in wage rates which began in October 1933, sales of equipment have multiplied and numerous companies in the East and South that formerly saw no advantage in mechanical loading are now installing machinery. In 1936 more machines [were] sold in West Virginia than in any other State.[3]

PREPARATION OF COAL FOR MARKET

Until recently, the miner was expected to separate impurities at the time of loading his car, so that only clean coal was sent to the surface. In fact, it has been the custom to impose penalties or at least to reprimand the miner whose car of coal contained impurities

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 153.

[2]Ibid., p. 154. Introduced in the late 1880's, not until about 1915 was more than half of the coal mechanically cut, and only in recent years has the use of the undercutting machine become general.

[3]Ibid., p. 154.

when it reached the surface. Machine loading, however, prevents this sorting of coal at the workplace, and leaves the task to be done when the coal has been taken out of the mine. The effect has been a further refinement of the whole process of preparing the coal for market, a development which has undoubtedly been stimulated also by the new competition of coal with other fuels.

> Mechanical loading underground has also stimulated changes in the work of preparation on the surface. . . . The tonnage of bituminous mechanically cleaned has increased from 3.8 percent of the total output in 1906 to 12.3 percent in 1935, and further extension is assured. . . .
>
> The mechanical changes under way in the bituminous coal mines constitute a major technical development. Mechanical cleaning yields a better and more uniform product, mechanical loading reduces the cost.[1]

INCREASING MECHANIZATION IN STRIP AND OPEN-CUT MINING

Bituminous coal in the United States often lies near the surface. Under such conditions, it is possible to take out the coal without sinking a shaft. The development of electrification has made it possible to use this method, known as strip mining or open-cut mining, for somewhat deeper seams. Limited as are the areas in which strip mining is possible, it offers for the moment an opportunity to reduce costs, and under conditions of intensified competition it was to be expected that mechanization in this type of mining should have been accelerated.

> The substitution of power for human muscle reaches its maximum in strip or open-cut mining. In limited areas where the coal seam lies close to the surface, the overlying dirt or rock may be removed with power shovels and the coal loaded into cars or trucks, usually with smaller shovels of the same type. The use of open-cut methods is expanding, both in coal and in certain branches of metal mining. The lines of technical advance have included the application of caterpillar mounts, replacement of steam by electric power, development of machine methods of shifting the tracks on which the coal or ore cars enter and leave the pit, or even elimination of the tracks by use of motor trucks. But the most important change has been the simple

[1] Ibid., p. 154.

evolution in the size, power, and range of the shovel. Capacity of the dipper of the largest shovels has increased from a maximum of about 4 cubic yards in 1914 to 32 cubic yards, and the physical limits have not yet been reached. These enormous machines can handle not only dirt but sometimes beds of limestone and shale and permit the removal of 50 feet of overburden to recover a 5-foot seam of coal.

The immediate outlook points to further expansion of stripping as opposed to underground mining, though the long-run outlook is for exhaustion of the areas which can be worked by stripping. As the thickness of the overburden to be handled increases, the costs of stripping mount, and ultimately expansion of stripping will be checkmated by the competition of underground methods. . . . The rise of open-cut mining poses an obvious problem of technologic unemployment. Only a half or a third as much labor as in underground mining may be required, and where conditions are especially favorable the method provides the cheapest fuel and metal thus far attained.[1]

PROSPECT OF LABOR DISPLACEMENT

Overshadowing other social effects is the possible influence upon the mine workers. The short-run effect is to inject an element of technologic unemployment in an industry where other factors have already reduced the number of jobs. The decline of 247,000 in the number of men employed at bituminous coal mines since 1923 is due chiefly to other causes—to the liquidation of surplus capacity created by the war[2] and to changes in demand associated with fuel efficiency, oil and gas competition, and the depression of general business. These other causes have thus far overshadowed the factor of technologic displacement, yet it is clear that the introduction of mechanical loading does work to curtail jobs. Any attempt to estimate the extent of such displacement requires much more accurate data than are yet available. A few mines which passed from 100 percent hand loading to 100 percent loading with mobile machines show a reduction in the man-hours required per ton of coal amounting to about 35 percent in the course of 10 years. How far these are typical it is not yet possible to say. Displacement with pit-car loaders and conveyors appears to

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 151.

[2]The implication of this phrase should be accepted with caution. As a matter of fact, surplus capacity characterized the development of the coal industry in the United States for many years before the World War. See van Kleeck, Mary, Miners and Management, op. cit., Chapter 9, Insecurity and Waste, pp. 179 ff.

be much less, while mechanical cleaning usually works to increase the number of jobs.

No forecast can be attempted here of the amount of future labor displacement or of the rate at which it can proceed. The answer depends on many imponderables, such as the future of demand, improvements in the machines, the bargaining power of the mine workers, the wage rate, and the hours of labor. The history of the cutting machine indicates that it may be many years before the introduction of the loading machine is complete. Yet it would indicate, also, that except as other factors operate to spread the available work, the new machines may locally create a definite problem of unemployment. Obviously, this will be most apparent in districts where hand loading is still entrenched.

COMPETITION FORCES MECHANIZATION

At the same time, it is clear that to attempt to block the advance of mechanization would offer no solution for the difficulties of the industry. Unless it is proposed to throw the entire burden on the mine workers by cutting wage rates, mechanization is the chief hope of meeting the competition of other fuels or other coal fields paying lower rates. It is a striking fact that in Wyoming, Montana, Illinois, and Indiana the only mines which seemed clearly able to survive the intensely competitive conditions of the last decade—aside from strip pits and little truck mines—were the mines that managed to mechanize. They have maintained employment far better than the mines which were unable to adopt the new technique. In any district where costs can be reduced by mechanization, failure to mechanize in the face of competition may actually reduce employment more than mechanization itself.[1]

CHANGING LABOR REQUIREMENTS AND LASTING TECHNOLOGICAL UNEMPLOYMENT

The loading machinery likewise affects the kind of worker needed. Certain of the old skills are no longer required though familiarity with the customs and the dangers of life underground remains essential. The machines put a premium on quick reaction time, adaptability, intelligence, mechanical knowledge, and ability to work under supervision. They favor younger men and the prospect of working up

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 155.

to machine jobs tends to attract youths with better education who formerly had no interest in the mines. Older men without machine experience are handicapped and it is possible that the young men now recruited for service with the machines may be superannuated at an earlier age than prevailed under hand loading.[1]

"Completely mechanized" mining still requires much human supervision and control.[2]

Trends in Metallurgy as a Whole

Our review of the technologic trends in production of the major metals has disclosed some tendencies observed [also] in the analysis of coal mining—a tendency toward fewer and larger enterprises and a tendency to substitute mechanical power for human labor. The latter is stimulated by the long-run upward trend of wage rates and results in a gradual change in the kind of skills required. The possibility of actual job displacement depends also upon the uncertain factor of demand, and the outlook for recovery of demand is perhaps more favorable in the case of the metal group than it is in coal.[3]

CONCENTRATION IN LARGER UNITS AND THEIR EFFECTS ON COMMUNITY TRENDS

Over the mineral industry as a whole technology is forcing concentration into larger units. The increase in size of unit, in turn, affects the location and the size of mining towns. Fewer company towns will be built in the future. A slow drift from isolated camps to central communities is already under way. More and more of the mine workers will live in permanent towns and ride to work in the surrounding area. The change is due chiefly to the external factors of hard roads and cheap automobiles, but it is facilitated by the centralized operation which the trend of mineral technology is favoring.[4]

NEW INTER-INDUSTRY COMPETITION BETWEEN FUELS AND MAJOR METALS

Technology is also working to increase competition between one branch of mining and another. More and more, one metal substitutes for another, while competition between the several sources of fuel becomes more fluid and more interchangeable. The change is, of course, largely due to developments in the consuming industries . . . , but it is also stimulated by the advances in refining, preparation, and

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 155.
[2]Ibid., p. 165. [3]Ibid., pp. 168-169. [4]Ibid., p. 175.

pipe-line transport. . . .[1] This inter-industry competition—so striking as to elicit the name of "the new competition"—has become a major factor in the economic environment of coal, oil, and gas, and the major metals. It aggravates the problem of economic stability. To balance supply and demand becomes more difficult for any one of the fuel industries acting alone or for any State government acting alone. The drift plainly observable toward collective action to control the more destructive forms of competition is stimulated by the changes of technology.[2]

Petroleum and Natural Gas

The most formidable competitor of coal among the energy resources required by our industrial civilization is the comparatively new industry of petroleum and natural gas. These two resources fill today the requirements of more than a third of the country's total fuel supplies for industry and transportation. Their fuel efficiency is superior to that of coal.[3] Like coal, this industry is indirectly affected by science and invention in all the industries which it serves. In addition, scientific discoveries and mechanization progressively change the processes and organization of the oil and gas industry itself.

With the coming of motor transportation the production of petroleum began a rapid advance to supply the great new need for gasoline and lubricating oil. This advance apparently is still in progress, partly at the expense of coal through the substitution of oil for coal as a fuel for heating and partly through displacement of railroad transportation by motor transportation. Natural gas has followed the growth of oil, owing in some degree to their association in production but accelerated greatly by the remarkable development of long distance pipe lines.[4]

[1]See Chapter V, "Transportation and Communication," p. 137.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 175.

[3]"The energy furnished by oil and gas is obtainable with only about half the expenditure of labor per B. t. u. that is required for an equivalent amount of energy obtained from coal. In so far as the former is being substituted for coal, the increase in its importance is one of the factors responsible for the failure of total employment in mineral-fuel production to keep pace with the Nation's rising utilization of energy." (National Research Project of Work Projects Administration and Bureau of Mines, Department of the Interior, Technology, Employment, and Output per Man in Petroleum and Natural-Gas Production. Philadelphia, 1939, p. xix.)

[4]National Resources Committee, Energy Resources and National Policy. Government Printing Office, Washington, 1939, p. 9.

PIPE LINES—NEW METHOD OF TRANSPORTATION AND INCIDENTAL STORAGE[1]

The fluid nature of oil and gas early led to the development of a specialized form of transportation to carry the product from field to refinery or place of use. The pipe line systems form an essential part of the petroleum and natural gas industries and in most instances are closely integrated either with the stages of production or with refining and distribution, or with both. The evolution of pipe-line transportation is one of the chief technologic contributions of oil and gas engineering. Technical improvement has developed step by step from small beginnings, . . . as indicated for example by the increasing radius of transmission of natural gas. Among the specific advances are the introduction of welded joints, higher operating pressures, labor-saving machinery in trenching and in laying pipe, and the appearance of thin-walled, seamless pipe of high-carbon steel in diameters up to 24 inches.[2]

REDISCOVERY AND CONSERVATION OF OIL WELLS THROUGH MORE SCIENTIFIC OPERATION

The simple technique for drilling oil and gas wells and for recovering those minerals, that was practiced during the early days of the petroleum industry, is changing rapidly. . . .

Improvement in understanding of the difficulties to be overcome and in design and application of methods and instruments to combat those difficulties have kept pace with improvement in equipment. . . .

The improvement in methods of increasing the flow of wells, when once drilled, has been equally remarkable. The percentage of wells that, a few years ago, would have been abandoned as dry or, at best, would have been very small wells has been sharply decreased. In some areas that were practically abandoned a few years ago because profitable production could not be secured, excellent wells are now being completed in pay sands once considered worthless. In other areas wells which apparently were approaching the end of their productive life have been rejuvenated.[3]

There is an encouraging increase in the number of operations designed to recover oil from semi-depleted fields and in the research under way in company laboratories and educational centers.[4]

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[1]The growth and present extent of pipe-line systems are described in Chapter V, "Transportation and Communication," p. 135.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 157.

[3]Ibid., p. 156.

[4]Ibid., p. 157.

Improvements in discovery methods promise to be even more important than improvements in completion technique.[1]

Scientific analysis of the conditions that control the occurrence of oil and gas has indicated many desirable modifications of traditional practice.[1]

NEED FOR TECHNICALLY TRAINED PERSONNEL

The trend is toward more scientific operation. We may say that the possibilities of applied science in the field of oil and gas production are just beginning to be appreciated, and may predict that the scientific attack will be intensified. It should lead to the employment of more technically trained men, both in the field and in the laboratory, and also should demand an increase in unskilled labor due to the development of new practices. In short, the petroleum and natural gas industries will benefit from technologic employment.[2]

REFINING PROCESSES CREATING NEW USES, NEW PRODUCTS, AND NEW ENGINES

The scientific attack on refining problems has steadily intensified and it is stated that today "in the United States chemical work in petroleum and related fields equals in quality, as well as in volume, the chemical work in all other fields combined."[3]

The record of the response of the refining industry to the creation of new needs augurs well for its future productivity. For years the products needed from petroleum were kerosene and lubricants. These needs were met and products that could not be utilized were wasted. However, knowledge of the nature and availability of gasoline permitted the invention and development of the internal-combustion engine. The great and persistent increase in demand for gasoline was met in part by discovery of additional crude oil, and in part by invention of the cracking process.[4] Were it not for cracking, refiners would, today, have to process almost twice as much crude oil in order to supply the demand for gasoline. The possibilities of additional benefits from this process are far from fully explored.

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[1]Ibid., p. 156. [2]Ibid., p. 157.

[3]Ibid., p. 157. (Quotation from Hopkins, M. B., "Chemical Trends in the Petroleum Industry," in World Petroleum, July, 1936.)

[4]"A process in which the complex hydrocarbons composing petroleum, or other similar oils, are broken up by heat and, usually, pressure, into lighter hydrocarbons of simpler molecular formulae. Cracking is used in producing commercial gasoline, and in enriching illuminating gas." (Webster's New International Dictionary of the English Language, second edition.)

Characteristics of gasoline obtained by cracking permitted modification of engine design resulting in economies of construction and performance, lowering both the initial cost and the cost of operation of automobiles. Additional progress in this same direction is promised by polymerization,[1] a newcomer. Products supplied by this process have permitted important changes in design of aeronautic engines—changes that could not be considered practicable before both the quality and quantity of the fuel supply for these improved engines were assured. It is believed that improvement in automotive engines will follow the road opened by the aeronautic engineer.[2]

The development of lubricants has been equally important. In fact, technology does not at present know of processes that could supply our needs for lubricants from raw materials other than petroleum. The present trend is to refine petroleum so that the yield of gasoline will be as great as possible, at the expense of all other possible petroleum products. When shortage of crude petroleum is definitely in sight it is to be expected that this tendency will be reversed and that the effort will be concentrated on high yields of lubricants.

The basic qualities that control lubricating value are not well understood. It may be said that development in the production and skilled use of lubricants is in its infancy in spite of the hundreds of lubricating compounds, each for a specialized purpose, now available. Solvent refining, a development of recent years, has added greatly to the flexibility with which a desired lubricant can be produced. Increased development and application of this process to a wider range of uses is anticipated.[3]

There have been a multitude of other developments, unimportant to the petroleum industry because of the comparatively small volume of material involved, but highly important in their contribution to the effectiveness and comfort of life. New chemicals are being found, almost from day to day. Some have already found places in industry and promise to become indispensable. Others will displace materials now in use. The hardship on the present purveyors of the displaced materials will be compensated, from a national viewpoint, by the increase of available resources for a given purpose. Others may result in the development of new industries. Some are filling needs not previ-

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[1]The process of "change (by union of two or more molecules of the same kind) into another compound having the same elements in the same proportions, but a higher molecular weight and different physical properties." (Ibid.)

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," pp. 157-158.

[3]Ibid., p. 158.

ously met, as, for example, the effective insecticides and fungicides that recently have appeared.

It is encouraging that the most important developments are in the direction of conservation. Thus the polymerization process utilizes raw materials that previously were either wasted or burned under boilers. Cracking makes gasoline out of raw materials that earlier were considered suitable only for fuel. Solvent refining promises to permit the manufacture of valuable lubricants from raw materials previously considered unsuitable.[1]

There is no apparent prospect of interruption of the trend toward intensive technologic attack on refinery problems with resultant improvement of products now in demand, development of new products, and conversion to higher use of more and more of the available raw material.[2]

POSSIBLE USE OF SUBSTITUTE RAW MATERIALS (COAL AND OIL SHALE)

Much has been written about the possibility of securing motor fuel and lubricants from substitute raw materials such as coal and oil shale. The development of methods of utilizing these alternative sources is among the most important achievements in the field of mineral technology and has gone far enough to effectively dispel the bogey of a break-down of civilization through failure of the petroleum supply. It is essential to realize, however, that the alternative sources are inherently high-cost, and available—by any techniques now known—only at prices several times what American consumers are accustomed to pay. At present oil shale and coal contribute only an insignificant part of the world's supply of motor fuel and nothing of its lubricants.[2]

The United States possesses huge reserves of coal and of oil shale, the two most promising substitute raw materials. It also has a supply of petroleum adequate to meet its needs for many years to come. Other nations, lacking petroleum resources and driven by nationalistic zeal, are intensively at work on processes to develop petroleum substitutes from coal and shale. If they succeed in so reducing costs as to compete successfully with oil from natural reservoirs, the processes developed will doubtless become generally available. In any event, if and when the need arises to replace petroleum products with liquid hydrocarbons from coal and oil shale, the United States will have the benefits of this pioneer work which will, by so much, shorten the task of our own technologists.[3]

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[1]Ibid., p. 158. [2]Ibid., p. 159. [3]Ibid., p. 160.

Looking ahead, we may anticipate no great industrial development of petroleum substitutes[1] in this country during the next 10 years, but may expect a steady increase of experimental and semi-commercial work looking toward the utilization of substitute materials when economic conditions warrant. The increase in cost which the substitutes imply reinforces the case for conserving our supplies of petroleum by avoidance of preventable waste.[2]

PROSPECT OF DECLINING EMPLOYMENT OPPORTUNITIES IN MINERAL INDUSTRIES AS A WHOLE

In coal mining the forces making for labor displacement are strong enough to be a cause of some concern. In metal mining also the chances of expansion beyond the level of the 1920's seem unfavorable. In oil and gas, on the other hand, the trends point to an increase in labor requirements. The relations of the different branches are in part complementary. Thus if metal proves more difficult to win, fuel will be required in greater volume in the mining, concentrating, and smelting of low-grade ores, and if supplies of oil and gas fail to meet expectations, there will be an increase in demand for coal. Under these conditions, a shrinkage in the anticipated demand for labor in the oil-and-gas industry would be offset—probably more than offset—by an increase in the labor needed in coal. Taking the mineral industries as a group, there seems little chance that the total demand for labor will rise greatly above the levels of the 1920's. During that decade technology was able to supply an increase in the national requirements with a diminishing percentage of the national labor force and there is small prospect that the next decade will greatly change this tendency.[3]

Conclusion

Prior to the present century, the development of the mineral industries constituted a laborious task in the national economy, with relatively meager results. Today, comparative profusion prevails, owing to the development of new primary resources in electromechanical techniques and electrochemical processes, which have created entirely new methods of production. At the same time it is

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[1]During the war the lack of sufficient petroleum, which was felt most drastically in the East, was due apparently to lack of shipping and transport facilities rather than to actual shortage which might have stimulated development of substitutes.

[2]Natural Resources Committee, Technological Trends and National Policy, Part 3, sec. 2, "The Mineral Industries," p. 160.

[3]Ibid., p. 174.

easy to perceive how all-pervading are these processes of production and how profoundly they affect human life, both through the needs which they supply or create and through the employment which they offer or withhold.

From the foregoing manifold and illuminating data it is not difficult to conclude that, owing to science and invention in the realm of primary production of raw materials, the world in which we live today is increasingly different from the one into which most of us were born. In fact, *we have reached a new stage in our material existence.*

Equally clear are the changes in labor requirements which condition employment opportunities. In the basic mineral industries the need for human labor is constantly decreasing, as regards the numerical need for hands. These changed and changing labor requirements increasingly make, in themselves, for smaller numbers of workers in proportion to production, while the work itself is becoming ever more dependent on qualities of mind and temperament, rather than on muscle and force.

This trend in the mineral industries, of course, runs counter to a naturally growing working population. As our next chapter, on agriculture, will make clear, this changing relationship between employment and population is furthermore considerably affected by a constantly increasing agricultural productivity, as a result of which the requirements in agriculture—once the greatest employer of human hands—likewise have made and continue to make for a steadily decreasing labor force.

Chapter III

Agriculture: The Battleground of New Productive Forces

Of agriculture it may be said that it is the world's oldest industry, immediately related to the first of our primary necessities, food. "The great domestic grains of the world are wheat, rye, barley, oats, maize, rice and millet. Of these wheat, maize and rice stand in the foreground. History and archaeology have so far brought to light no great civilization not largely dependent upon one of these three grains."[1]

1. The Land—Our Greatest Natural Resource

Agriculture, even more than the mineral industries, is directly concerned with our greatest natural resource, the land. While mineral technology exploits the underearth, agriculture makes use of the topsoil and the earth sources of moisture and chemical composition.

> Contributions making possible the increase in productivity [in agriculture] have come from many sources and not alone, as is often supposed, from the invention, improvement, and use of machinery and power. Major contributions have come through the introduction, adaptation, and improvements of plants and livestock; the increased ability to meet the challenges of insects, pests, and diseases; increase in knowledge relating to the use and replenishment of soils; and improvement in managerial and marketing techniques.[2]

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[1]Encyclopaedia of the Social Sciences, "Primitive Agriculture," by Clark Wissler, curator, American Museum of Natural History. Macmillan Co., New York, 1933, vol. 1, p. 572.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," prepared under the direction of S. H. McCrory, chief, Bureau of Agricultural Engineering, U.S. Department of Agriculture, and Roy F. Hendrickson, Bureau of Agricultural Economics, U.S. Department of Agriculture, who acted as chairman and secretary, respectively, of the Committee on Technology of the Department of Agriculture composed of expert staff members from the Bureaus of Chemistry and Soils, Agricultural Economics, Plant Industry, Dairy Industry, and Animal Industry, and the Agricultural Adjustment Administration. Government Printing Office, Washington, 1937, p. 97.

The Evolving Modern Science of Soil Productivity

The soils of western Europe and eastern United States have common characteristics, in that they are relatively low in inherent productivity, are acid, are low in organic matter, their structure is easily destroyed, and they did not lend themselves readily to agriculture in their native forested state.

The efforts to increase their productivity were made by men who looked on the soil as a static and unchanging medium deficient in one or more components, as compared to an ill-defined standard of perfection. In certain ways these efforts may be looked on as a study in soil pathology. Thus, much research was given to the study of the chemical and textural compositions of soils without a consideration of their genesis or evolution, other than as geological material containing certain and lacking other specific elements of nutrition which could be corrected. . . .

Relative to the influences of the present techniques on the future developments in agriculture, it is essential to note the rise of [the science of] pedology, . . . [which] considers the soil as a natural body, dynamically responsive to the environment of which the active factors for soil development are the climate, the vegetation, the relief, the age or length of time the environment as such has been active, and the parent material. Although it is recognized that the marked characteristic of the soil is its productivity for plants, the soil is not looked on exclusively as a medium for plant growth, but rather as a distinct entity whose physical and chemical characteristics have been shaped by an accord with the environment. Hence the soil of a specific area is not lacking, according to some standardized concept, but is the accompaniment of a certain environment with a characteristic inherent productivity for certain plants.

Accordingly soils are studied as objects in themselves, and differences in the structure, color, depth, and texture of the various horizons[1] are noted. This has led to the establishment of soil types, defined by certain physical and chemical characteristics which have been developed by the environment. It follows necessarily that soil types are limited in geographical extent, according as one or more factors of the environment may change. This newer concept carries the thought that all techniques of crop and livestock production are ultimately concerned with specific soil types as units of the landscape, having a

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[1]The strata all over the earth, which were formed at the same time, are said to belong to the same geological "horizon."

distinct profile, native vegetation, range of relief, drainage, response to fertilizer, inherent productivity, adaptations for crop plants, and other features.

One of the technological trends of the future appears to be the more exact mapping and study of these land units, or soil types. Research will be conducted on their chemical, physical, and biological characteristics as they pertain to crop plant growth and production. This means further intensive study in the laboratory, experimental plot, and the farmer's field, along such lines as colloidal characteristics, soil-moisture movement and availability, soil structure, chemical constituents, and response to certain treatments and managements. The inherent productivity and the response to amendments of the individual soil types for specified crops will become current knowledge among agricultural workers. The extension of fundamental data and experience depend on classification of the soil on the basis of land units which may be given geographic extension.[1]

Necessity for Soil Conservation

The problem of soil conservation is inevitably involved in any agricultural development. Breeding or introduction of a new crop may alter the balance of agriculture in wide areas. Its production may require new and, to the soil, hazardous methods of cultivation. It may open new regions to the plow. Thus the introduction and breeding of new drought-resistant varieties of wheat made profitable the cultivation of thousands of acres of western prairie land, with a resultant tremendous increase in the hazards of wind erosion during times of drought. New implements, new systems of cultivation, and new methods of processing, storing, and transporting crops may similarly alter the nature of agricultural production and its effect on the soil.

Except on the relatively small areas of perfectly flat land any form of agricultural development, however primitive, speeds up the process of erosion. There is ample evidence that erosion was an important factor in the destruction of primitive civilizations whose agriculture never progressed beyond the stage of the ox-drawn plow. But technological developments affecting the soil have not been all on the debit side. The same large tractors that turned the virgin sod have been used to build terraces to conserve the rainfall and the soil. Plant exploration and scientific plant breeding have discovered and developed plants that

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 121-122. "Geographic extension" refers to land suitable for extensive, in contrast with intensive, cultivation.

protect the soil as well as those that expose it. The same engineering skill that was used to drain the prairies of the upper Mississippi Valley now is used to build terraces, check-dams, and farm reservoirs.[1]

The application of scientific methods to the study of soil erosion and its control is a recent development. Prior to 1929, when the first erosion experiment stations were established, a few pioneering State colleges and experiment stations had investigated the subject but most knowledge of it has been gained incidentally. The first understanding of the widespread incidence of erosion was gained by soil scientists engaged primarily in the survey and classification of soils. Foresters were investigating the importance of forest cover as a protection to the soil and the occurrence of disastrous soil washing as an aftermath of destructive lumbering practices and forest fire. A few exceptional farmers had taken adequate steps to prevent soil washing.[1]

Since 1933, when the Soil Erosion Service (now the Soil Conservation Service of the U. S. Department of Agriculture) was established, there has been a tremendous expansion of work in soil conservation. New techniques have been developed and old ones tested and applied on a scale never before attempted. During the last 3 years great strides have been taken toward a synthesis of new points and plans. A coordinated attack on the problem of erosion has been developed and applied under a wide variety of conditions. It is bringing the resources of agronomy, forestry, engineering, and soil science together in a unified, integrated program of erosion control.

It is not too early to say that the concept, if not the final methods, of scientific soil conservation has been established, tested, and proved. This development of an integrated approach to the study and control of erosion is the most important technological advance in the field of soil conservation.[2]

The significance of technologies which will provide economical and adequate conservation of soil cannot be easily overstated in terms of social advantage. The wastage of soil is wastage of the basic asset on which society depends.[2]

Contribution of Irrigation and Drainage Engineering to Agricultural Development

Technology has developed the equipment and methods for building the drains which have converted more than 50 million acres of swampland into farms. Studies of run-off and of hydraulics have determined the drainage requirements of such areas and the fundamentals of de-

[1] Ibid., p. 122. [2] Ibid., p. 123.

signing the drainage works. The 1930 Census reported more than 84 million acres in organized drainage enterprises. The States of Ohio, Indiana, Illinois, and Iowa rank high both in extent of drainage improvements constructed and in agricultural development. Where community drainage enterprises are operating, farm lands as a rule are highly developed.

The drainage work thus far undertaken has reclaimed those lands most easily occupied. There are yet in the United States some 60 million acres of varying degrees of fertility that when needed can be made available for agriculture by drainage. But the cost of doing this will be much higher than that for the land already drained because of unfavorable location, heavy timber cover, or other disability. In their present condition these lands are valuable for grazing livestock, sheltering wild life, or growing timber. When increasing markets, deterioration of hill lands, or other conditions make it desirable, these areas can be drained and brought into cultivation.

Underdrainage has been profitable to farmers, but in the past decade little of such work has been done because of low farm incomes and the extended period of scanty precipitation. There are indications that with return of normal conditions use of underdrains will greatly increase, and that they will become common in many sections where now comparatively unknown.

. . . Only through application of developments in construction machinery and materials has it been possible to bring water to a large part of the 19,500,000 acres irrigated in the United States in 1930, upon which is so largely based the agriculture of a great portion of the West. The huge dams, canals, tunnels, flumes, and siphons could have been neither built nor designed without engineering technique, and expansion of the productive acreage sufficiently to pay the cost has required further technology.[1]

While irrigation is as old as the Pyramids, only recently have devices been perfected for accurate measurement of flowing water. This achievement has made possible detailed studies of the use of water by crops, losses of water in transit, and waste of water from fields and from canals.[2]

Areas that can be irrigated cheaply by direct diversion of water from streams have been almost completely occupied. Any large areas yet to be brought under irrigation must be supplied with pumped or stored

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 108-109.
[2]Ibid., p. 109.

water. Creation of storages for this usually must be coupled with development of power if the cost of obtaining water is not to be greater than the value of the crops that can be grown with it. Nevertheless, indications are that for several decades the area irrigated will continue to increase, until the practically available water supply is wholly utilized.[1]

Pumping from wells to supplement other water supplies will increase in importance in many of the older, highly developed sections. Expansion of the area so irrigated is encouraged by improvements in pumping equipment, extension of electric power lines, and cheapening of fuel costs. In many areas the drafts upon the underground waters are seriously depleting that supply. Studies of means to increase natural recharge by spreading floodwaters upon porous tracts have met with sufficient success in southern California to encourage ambitious attempts of the same kind in other sections of the West.

Irrigation agriculture, within the available water supply, escapes the greatest hazard of farming in a large part of the United States. Federal irrigation promotion was undertaken primarily to make public lands usable and to foster development of sparsely settled western States. The excessive drought of 1934 stimulated migration from the semiarid region to localities where irrigation is the regular practice. Settlement upon unoccupied fertile lands in irrigation enterprises seems to offer aid in the relocation of people from drought-stricken and wind-eroded areas, and would promote the prosperity of communities that lack farmers to utilize the irrigation facilities available.

In the humid States there probably will be some extension of irrigation for truck crops, fruit crops, and citrus, and probably for other high-priced crops such as hybrid seed corn and nursery stocks.[1]

The Role of Forestry in the Balance of Nature

Nature created forests, spacing them strategically on watersheds throughout the country, where they served in part as huge sponges for absorbing rainfall and maintaining the soil and water supply. Similarly, nature clothed mountain slopes and hillsides, valleys, and plains with grass and other herbaceous vegetation which helped percolate precipitation into the soil. But man has disturbed nature's balance.

Without trees, shrubs, grass, and allied cover as deterrents, precipitation forms ever-growing little waters;[2] rivers rush to the sea from

[1]Ibid., p. 109.

[2]For an illuminating study, see Person, H. S., acting director, Water Resources Section, and acting chairman, Water Planning Committee, National Resources Committee, and

their sources on exploited watersheds. This action, plus that of winds, leaves soil erosion and calamity behind. Specialists tell us that the dust storm of May 1934 swept 300 million tons of fertile topsoil off the great wheat plains; that 400 million tons of remaining material are washed annually into the Gulf of Mexico by the Mississippi; that generally water and wind erosion together each year remove beyond use 3 billion tons of soil.[1]

Numerous measurements and tests are being made throughout the United States. Immense amounts of data have been collected and analyzed. Values of forest, range, and other vegetative cover in flood prevention and soil absorptivity have been established.[2]

Technologies are as yet in the preliminary stages. They must be further developed and refined, and applied Nation-wide. For social significances of preventing floods and erosion and regulating streamflow by means of vegetative control are broad and far reaching. They impinge upon agriculture and industry alike. The present and future of communities such as those of southern California are directly linked with proper water conservation and use.[2]

FOREST EXPLOITATION AND THE NEED FOR PROTECTION

Four-fifths of our commercial forest land is in private ownership. It still furnishes 98 per cent of all our forest products. With but minor exceptions, timber on it has been mined rather than cropped. For decades, fire protection was nonexistent or utterly inadequate. Immediate economic necessity, rather than scientific knowledge, still rules in the selection of species and trees cut. Through ignorance and economic pressures, little attempt has been made to leave the land productive. Forest operations have been transitory. Cut out, burn out, and get out has been the order of the day. Ghost towns, depressed agriculture, distressed social structures, have resulted. Now, when physical frontiers are gone, natural resources are limited, and many other conditions over the country have changed, these sores are difficult to heal. New ones

member, Mississippi Valley Committee, Public Works Administration, and associates, Little Waters: A Study of Headwater Streams and Other Little Waters, Their Use and Relations to the Land. For Soil Conservation Service, Resettlement Administration, and Rural Electrification Administration. Government Printing Office, Washington, 1936.

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 133. "It takes about 400 years to lay down an inch of new soil on land which is not being disturbed by man." (Cooke, Morris L., Chairman of Great Plains Committee and Mississippi Valley Committee, "A Challenge to Save," in New York Times Magazine, March 21, 1937.)

[2]Ibid., p. 133.

cannot be tolerated, for the cumulative effect is very definitely felt on the social and economic structure of the Nation.

Technologies developed, refined, and applied by the Forest Service in connection with growing, harvesting, and managing the Federal forest crop, promise relief from the consequences of past practices on other wild lands. Included are technologies having to do with forest protection; silvicultural, nursery, and planting methods necessary to insure forest reproduction; selection and breeding of individual trees and tree species to increase future forest values; methods and machinery for harvesting rather than exploiting the forest crop; current forest inventories, and sustained-yield forest management.[1]

Within the continental United States more than 334,000,000 acres of forest land are grazed by domestic livestock. In southern pine forests, forest forage is of distinct value to the rural population. In the humid East, grazing is usually detrimental to hardwood forests. In the West, where wildland forage largely involves the national forests and the public domain, economic and social welfare is frequently dependent upon forest-land forage.

The American tendency to abuse and ruin grazing lands is historic. Overgrazing has been followed, all too often, by capture of soil by relatively worthless weeds, and erosion. This process has adversely affected enormous farm values, thus contributing to collapse of economic and social structures.

Technologies developed through research and applied administratively on the national forests, and other technologies now in process of development, promise to show the way to halting overgrazing and its inevitable consequences. Among these techniques are: Improved systems of grazing to bring about natural revegetation, obtain more stable forage production, and minimize livestock damage to timber production; development of methods and species for artificial reseeding of wild-land ranges and abandoned dry farms. Soil science, botany, range ecology, and the behavior of soils and plant and animal life under different methods of treatment are involved.

Combined into a socio-technical system of control, such techniques promise to bring huge benefits if they are extended to our seven hundred-odd million acres of range lands. For this resource might then contribute far more than it ever has done to the support of successful homes and prosperous communities.[2]

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[1]Ibid., p. 134.

[2]Ibid., p. 135.

WOOD AS INDUSTRIAL RAW MATERIAL

Technologies with respect to wood utilization, evolved and adapted by the Forest Service point the way for wood and its products and byproducts to regain and broaden many old markets and capture new ones. Techniques in the pulp and paper industry include those having to do with utilization of new woods, modifications of mechanical and chemical pulping and bleaching processes, and application of them to woods that are cheaper and more plentiful than those heretofore used. In the construction industry are techniques having to do with usable strength data and grading rules for lumber and timber; use of chemicals to preserve wood and make it fire resistant; construction of large wooden members from small dimension stock; development of new structural units and systems adapted to large-scale production and rapid field assembly with low first cost, depreciation, and maintenance. In the chemical conversion field, technological developments include those to make wood plastic, bacterial fermentation of cellulose to acetic acid and isopropyl alcohol, and the production of wood gas and alcohols.

Application in industry and commerce of such technological developments presages things of wide social import such as diversification of raw material for pulp, low-cost housing, and motor fuels that may successfully be used when gasoline becomes scarce or too high in price. They point to more complete utilization of wood waste (which has in the past reached 50-60 percent of the actual material grown or available on the stump), and added employment by the forest industries. They lead to conservation of our remaining forest resources.[1]

WILD LIFE AND OTHER FOREST POTENTIALITIES

A substantial part of the remaining wildlife in the United States, valuable for food, fur, and hunting, or for aesthetic purposes, finds its home on forest, range, and other wild lands. Wildlife directly interests more than 13,000,000 people who hunt and fish each year. It helps support many more and adds to the happiness of millions who are eager to catch a glimpse of wildlife in its home environments.[2]

Wildlife management is a field of knowledge and activity which promises to advance far in the next two generations. Instances of restoration, reversing the trend of wildlife depletion, have been accomplished by development and application of techniques having to

[1] National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 134-135.
[2] Ibid., p. 135.

do with production and use of forage, as well as bio-ecological methods involving technical determination of food, feeding, and other wildlife habits.[1]

The potentialities of forests and their products have been only partially and vaguely determined. Their latent values as sources of both mechanical and human energy largely remain to be developed. Under skilled technical direction of the scientist they may be employed to supply a wide array of human needs in ways superior to those by which such needs now are met, and thereby develop a new outlet for labor. Wood as a source of mechanical energy has now passed beyond the field of experimentation. It is our greatest source of cellulose. Its pre-eminence as a source of numerous elements or substances basic to a wide array of useful commodities already is established.

Restoration of the United States to a condition of natural equilibrium is vital to its security and permanence. That requires the restoration of forests to much of the land from which they unwisely have been removed. To that end, ways must be devised whereby the products of forests may replace our nonrenewable natural resources. That is the field which lies ahead for the scientist and the technician.[2]

The Growing Science of Chemical Fertilization

The fallowing of one-third of the land was a long established feudal practice because of the low productivity of the soils for grain. Owing to the insistence of Jethro Tull, inventor of the drill and horse hoe, that cultivation of the soil was imperative for plant growth, a change in methods preceded a change in crops. His teachings were accepted to the extent that turnips were introduced to facilitate cultivation of the soil given to grain production. As turnips were best utilized as feed for livestock, increased numbers of livestock furnished an increased manure supply. Yields increased and more livestock were kept. Grasses and legumes were introduced, and a succession of crops known as the Norfolk system supplanted the fallow system.

This change from a system of grain following grain with every third year in fallow to one of a rotation of crops doubled wheat yields, from 10 to 20 bushels. It was an important revolution in agriculture. Commercial fertilizers were as yet unknown. They are not to be confused with the liming and marling practiced under the Norfolk system.

Fertilization, by other than animal manures, owes its development largely to Liebig who in 1840 in a report upon "Chemistry in Its Application to Agriculture and Physiology" denounced and eventually

[1] Ibid., p. 136. [2] Ibid., p. 135.

killed the humus theory which stated that plants obtained carbon only from the soil. Believing that plants obtained a sufficient supply of carbonic acid from the air, Liebig introduced the mineral theory which stated that plant growth was related directly to the quantity of mineral elements in the soil.[1]

With the understanding of these principles came the birth of the fertilizer industry which at first dealt in naturally occurring materials and various animal and plant wastes, later supplemented by the byproducts of other industries. The modern chemical fertilizer industry began with the discovery in 1840 that the fertilizing value of bones was increased by their treatment with sulfuric acid and with the commercial application thereof for the production of dissolved bone and superphosphate.

Commercial mixed fertilizers are mixtures primarily of materials that contain the three fertilizing elements, nitrogen, phosphorus, and potassium. Until comparatively recent years, the United States was largely dependent upon foreign sources for its nitrogen and potassium and was self-sufficient only as regards phosphorus. Our enormous deposits of phosphate rock, which for years not only met our own demands for phosphorus for fertilizer purposes but also supplied those of many European nations, still suffice for all our anticipated needs in the near future. As a result of technological progress, a synthetic nitrogen industry, based on the utilization of the inexhaustible supply of the nitrogen of the air, has been developed, the capacity of which, together with our byproduct nitrogen capacity, is capable of expansion to supply all future needs, whether for fertilizers or explosives. The dearth of potassium during the period of the World War, resulting in a thousandfold rise in price, stimulated a successful search for native deposits of potassium salts. The discovery of large natural beds of these salts, coupled with the development of procedures to exploit them, and other sources of potassium in this country, has freed us from dependence on foreign monopoly for this element also.[2]

With increasing consumption of commercial fertilizers and the resultant growth of the fertilizer industry, the more serious question of supply arose. A number of materials extensively used, such as cottonseed meal and tankage, were more and more diverted to use as feed for stock. In addition, the output of the industrial byproducts that found use in the fertilizer industry was dependent on the sale

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 120.

[2]Ibid., pp. 123-124.

of the principal products and could not be increased independently to meet increased demands for the byproducts. The increased demands for fertilizer materials have therefore been supplied more and more by high-grade chemical products.[1]

A method of calculation has been developed for determining the potential acidic or basic reaction of fertilizer materials. By use of the values thus obtained, fertilizer manufacturers can know in advance the potential reactions of their various fertilizer mixtures.[1]

Proper placing of fertilizers with respect to the seed both as regards closeness and relative location has been found to considerably enhance the increased yields.[2]

Developments and improvements of fertilizers in the future have many important possibilities. Nationally, we have become self-contained as regards the elements on which we are dependent for the production of our future crops. As a result of new and cheaper methods of manufacture, the cost of these elements in fertilizer materials has been considerably reduced.[2]

The increased yields per acre obtained will encourage the withdrawal of lands now unsuited to cultivation and their sowing to grasses or their reforestation, and an intensification of the cultivation of the better suited lands with greater consideration given to the conservation of their fertility. In many farming sections the development and maintenance of pastures on the poorer land, with the aid of fertilizers, and cultivation of only a small portion of the land, will necessitate the expenditure of less labor on the part of the farmers in proportion to the financial returns.[2]

Chemical and Engineering Contributions to Control of Insect Pests

Insect pests affect man's every activity. They destroy his food plants, his livestock, his clothing, his buildings, and indirectly through insect-born disease, affect man himself. In the United States alone the annual tax paid to insect pests attacking agricultural crops and livestock often amounts to over 2 billion dollars. The cotton boll weevil, for example, destroys an average of nearly 2 million bales of cotton every year; the hessian fly takes an average annual toll of 48 million bushels of wheat.[3]

In the use of insecticides alone developments in economic entomology have brought the control of insect pests from hand-picking

[1]Ibid., p. 124. [2]Ibid., p. 125. [3]Ibid., p. 115.

> and the sprinkling of a simple insecticide with a whiskbroom to the high-powered sprayers that reach the highest shade trees and the permanently installed spraying equipment by which several hundred acres of orchards can be treated from a central spray plant, and the airplane duster that can cover several cotton plantations in one day.[1]
>
> The control of insect pests is increasing in complexity. The achievements of the past give assurance of future developments to meet ever-changing conditions. The constant development and change in agriculture and improvement of public health accompanied by the ever-increasing insect consciousness contribute to the complexity of the problem of insect control. The placing of large areas under cultivation and erecting cities and towns have contributed to making favorable environments for insects which in earlier times were of little importance. The rapid development of methods of transportation materially increased the opportunities for dangerous pests being transported to new areas.[2]

From the information gathered in this chapter it becomes evident that the new technology is potentially able to contribute immeasurably to the development and enhancement of our greatest natural resource, the land, as a means of livelihood. At the same time, many workers would be constantly needed for employment in an adequate program of conservation of land and all its resources.

2. Cultivation and Farming—Their Increasing Productivity and Changing Labor Requirements

In the United States agriculture remains the leading single industry, so far as geographical extent and numbers employed are concerned. Yet, unlike other industries, agriculture continues to be a small-scale industry, made up of many small units.[3] Little more than a century ago, its implements were still limited to those of very ancient times, namely, the plow, the hoe, and the digging stick. Production was intended for self-sufficiency. It was only as a parallel

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 115.

[2]Ibid., p. 116.

[3]According to the 1935 Census of Agriculture the numbers of farm units by size of farm are: Under 20 acres, 1,254,000; 20 to 49 acres, 1,440,000; 50 to 99 acres, 1,444,000; 100 to 174 acres, 1,404,000; 175 to 259 acres, 540,000; 260 to 499 acres, 473,000; 500 acres and over, 256,000. (Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, by John A. Hopkins. Government Printing Office, Washington, 1941, p. 56.)

to the industrial revolution, with its resultant transportation and urbanization, that a transformation of agriculture took place which diverted its products from home consumption and limited exchange to far-flung commercial ends.

To the cultivation of grains, such as wheat, oats, rye, and corn, and of hay for food and fodder must be added the growing of cotton for clothing and for the new industrial uses to which today cotton can be put. In the United States tobacco, sugar cane and sugar beets, rice, and, recently, soybeans are also grown, while most important farm products are cattle, milk, hogs, poultry, eggs, fruits, and vegetables, including potatoes.

The Advance of Mechanical Implementation

Twenty-five years after the signing of the Declaration of Independence farmers here and abroad were still employing largely the techniques of 3,000 years before. Plows were wooden, crude. In many areas hand tools were favored over plows in preparing soils for seeding. Cotton and corn were planted by dropping seed and covering it with a hoe—much as suburban gardeners of today plant radishes, endive, or sweet corn. Small grains were sown by hand. Cultivation and harvest were performed largely with hand methods.[1]

The cotton gin,[2] invented soon after the Revolutionary War, was one of the earliest of a long series of inventions that changed greatly the character of American farm production. Authorities are not in agreement as to the exact date the grain cradle[3] was introduced. However, there is sufficient available information to fix the date sometime between 1760 and 1800. The iron plow came into general use about 1820 to 1830. The hay rake and the first crude threshing machine came into use soon after. An abundance of land was available for crops and livestock. Export markets opened, especially for grain.[4]

The three decades, 1830 to 1860, constituted an outstanding period in the development of farm machinery. During the Civil War, with manpower on farms reduced and the demand for food increased,

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 97.

[2]Probably no reader needs to be reminded that the work of the cotton gin is to separate seeds from the cotton—a task which once used the hands of many slaves in the southern cotton fields.

[3]The grain cradle is a scythe with attached rods or fingers which gather the grain into bundles after it has been cut.

[4]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 97-98.

there were developed or greatly improved the mowing machine, the steam tractor, the grain separator, and the reaper. The war removed a million men from northern farms alone, while needs for farm products increased. . . .

The stream of mechanical improvements continued to flow. The invention of the internal-combustion engine opened the way to development of the modern tractor. This in turn opened the way to development of more implements. Today farmers can obtain from merchants in nearly every community, or by mail order, a large and growing variety of mechanical aids.[1]

Since 1909 improvement of tractors has been almost continuous and has had four principal objectives: (1) increased adaptability to farm work, (2) increased operating speeds, (3) greater mechanical dependability, and (4) reduced cost of operation. The improvement achieved rested on a large number of changes rather than on a few outstanding and dramatic ones. . . . Thus, the modern tractor is a far better piece of machinery than tractors of the decade before 1920.[2]

Development of the row-crop or general purpose type meant that the tractor could be used in cultivation. As a result, the number of hours of use per year was augmented by 50 percent to 100 percent.[3]

Areas of land that resisted profitable cultivation before have been utilized since the arrival of the tractor. The introduction and adaptation of plants have helped to make this possible. The Corn Belt was moved northward and westward by the corn breeder.[4] The introduction of Russian strains of wheat pushed production westward into dry-farming areas. The development of rust-resistant grains contributed to increasing yields in many wheat-producing areas.[5]

On farms with the larger acreages, it is economically feasible to buy both larger and more specialized machinery, such as multi-row planters or cultivators, small-grain combines, or mechanical corn pickers. Such equipment can seldom be used where acreages are small. There may, however, be an opportunity on such farms for saving labor by the use

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 98. These aids may be classified as (1) tillage implements, (2) planting and seeding equipment, (3) cultivating equipment, (4) harvesting machinery. See Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, pp. 70-71.

[2]Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 56.

[3]Ibid., p. 58.

[4]The word "breeder" applied to corn refers, as in stockbreeding, to controlled propagation directed toward improvement of the species.

[5]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 98.

of bigger implements, like plows, disks, and harrows, adapted to several crops. This depends on the total crop acreage rather than on acreage of the individual crop.[1]

Plowing is one of the most time-consuming operations on a majority of farms. Consequently the shift to more power and larger plows has resulted in a relatively large saving of the labor.[2]

Adoption of larger and more effective cultivating equipment has been one of the more important means of saving labor in crop production in nearly all areas except the eastern cotton area, where there has been but little change.[2]

The combined harvester-thresher has been the outstanding case of the introduction of an existing machine into new areas, but it is by no means a new machine. A machine of this type was used in Michigan in 1837 and in California in 1854. It was well established in California in the 1880's. Introduction in the small-grain area began during the World War, stimulated by high wheat prices and a shortage of farm labor. After 1920, wider adoption of the combine occurred in conjunction with adoption of the tractor in the small-grain area. Recently the development of smaller and lighter combines, with cutting widths down to 3.5 feet, has led to adoption of these machines in many parts of the corn area and, to a small extent, in eastern areas also. The machine has been applied to the harvesting of other small grains as well as wheat, and to soybeans, which lend themselves particularly well to combine harvesting. Adoption of the combine is almost invariably accompanied by a decline in farm employment. The most spectacular reduction occurred in the small-grain area, where a large army of migratory harvest hands disappeared almost entirely within a decade.[3]

Many mechanizations, such as for producing grade A whole milk and for washing spray residue from fruit, have been introduced to perform higher quality, more satisfactory services than are practicable, or perhaps possible, by hand methods. The effective control of many insect pests, weeds, and plant diseases depends in large measure upon use of mechanical devices.[4]

The application of refrigeration to farm products has done much to insure that perishable farm products such as meat, milk, fruit, and vegetables reach the consumer in good condition, and has made pos-

[1]Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 114.

[2]Ibid., p. 72. [3]Ibid., p. 73.

[4]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 107.

sible many improvements in diets. Refrigerator cars and refrigerated trucks provide even the smallest and most remote towns with dependable supplies of fresh meats. Fruits and vegetables can be shipped across the continent and reach the consumer in perfect condition. Refrigeration in transportation has permitted shift of the production of perishables away from the localities of consumption to the regions best suited for growing them.[1]

Motortruck transportation of farm products has increased rapidly. It is likely this trend will continue. It has resulted in many changes in the comparative advantages of various producing areas.[2]

The rise in technology has stimulated commercialization in agriculture. Numerous functions have left the farms and are now carried on in population centers, functions which once were an integral part of the farm enterprise. In only a few counties, found in the southern Appalachian Mountains, are self-sufficing farms more common than any other type. In 1929 on most of the Nation's farms more than 80 percent of all farm products were "sold or traded," according to the census.[3]

Unrealized Productivity Due to Delayed Use of Electric Power

Agriculture, although a large user of mechanical power, has thus far made relatively little use of electrical power as compared with other industries.[4]

On certain types of farms electricity can be used in many ways to lower the cost of production or improve the quality of products. On dairy farms it can be used for milking, separating, cooling, pasteurizing, sterilization of utensils, and refrigeration of products. On poultry farms it is used for heating incubators and brooders, for illuminating laying houses to increase egg production, and for mixing feed. In market gardening this power is used in pumping water for irrigation and for washing vegetables, in heating hotbeds, and refrigeration for temporary storage of perishables. On grain and livestock farms fewer jobs have been found for electric power, but it can be used for pumping water and for storing grain and hay.[5] Where water is pumped from wells for irrigation of field crops, electric power is used extensively. More than 200 different uses of electricity on farms have been noted.[4]

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 108.

[2] Ibid., p, 103. [3]Ibid., p. 104. [4]Ibid., p. 107.

[5]Electric power is useful in the storage of grain and hay because, through refrigeration, it makes possible the maintenance of a desirable temperature.

Experience in other industries indicates that only a beginning has been made in adapting farm operations to economical use of electricity. Further research will make it practicable to increase greatly the farm electric load so that this power will be very profitable to the user. Ultimately, there will be a considerable increase in the use of automatic and semi-automatic machinery for such purposes as pumping water and operating processing machinery; an extensive use of heating devices for hotbeds and stock-watering tanks; perhaps, air conditioning; and, possibly, substitution of electric for other power in field operations. Rapid extension of power lines to serve farms, which has been started under public auspices, will do much to stimulate progress and will make possible introduction of many labor-saving devices in farm homes. The wise use of electricity in agriculture should lower cost of production, improve quality of produce, lighten the labor of farm people, and make possible more comfortable living on the farm.[1]

Increasing Farm Productivity and Decreasing Need for Farm Labor

The development in farm machinery during the past century has greatly increased the efficiency of farm workers. While the total population of the United States increased from 17,000,000 in 1840 to almost 123,000,000 in 1930, the persons engaged in agriculture increased only from 3,720,000 to 10,480,000. *In 1840, agricultural workers comprised 77.5 percent of all persons gainfully employed in the United States; since then, the proportion has dropped steadily until in 1930 it was only 21.5 percent.*[2]

In some types of agriculture per capita productivity has increased much more slowly than in others. The increase in efficiency has been most striking in the production of grain and hay crops.[3]

In the four years 1878-1882 the production of 100 bushels of wheat required 129 hours of a man's labor, as compared with 86 hours in the four years 1898-1902, and 49 hours in 1928-1932. For corn the hours required were 180 in the first period and 104 in the last. In cotton 304 hours were needed in the 1880's and 235 in the 1930's.[4] In another, more recent report issued by the Government

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[1] Ibid., pp. 107-108.
[2] Ibid., p. 107. Emphasis ours.
[3] Ibid., p. 100.
[4] Ibid., p. 101; our summary of Table 10.

it is stated that "the labor required on an acre of wheat in 1934-36 was half the amount needed in 1909-1913."[1]

> In 1787, the year the Constitution was framed, the surplus food produced by 19 farmers went to feed one city person. *In recent average years 19 people on farms have produced enough food for 56 nonfarm people, plus 10 living abroad.*[2]
>
> Productivity per farm worker increased steadily, and at very nearly the same rate in agriculture as in industry during the 75 years after 1850. Between 1910 and 1930, output per worker increased 39 percent in manufacturing and 41 percent in agriculture.[3]
>
> The decade of the twenties witnessed a striking increase in farm efficiency in terms of productivity. From 1922 to 1926, production increased 27 percent while crop acreage remained little changed and the number of workers in agriculture decreased.[3]
>
> An important factor in increasing per worker productivity, especially during the twenties, was that as mechanical power increased, land formerly required for producing feed for horses and mules was released for the production of commodities offered for sale. The loss of about 9,000,000 horses and mules on farms between 1918 and 1932—and probably a million more in cities—is credited with releasing more than 30,000,000 acres each of crop land and pastures.[4]

PROGRESS IN DAIRY FARMING DOES NOT INCREASE FARM LABOR FORCE

> Our domestic farm animals represent millions of highly adaptable factories for the conversion of raw materials into food, fiber, or power. Both as factories and as storehouses they tend to stabilize the land's production through the seasons and through years of highly fluctuating production.[5]
>
> In 1920 the production of butterfat per cow in herds owned by members of 452 dairy-herd-improvement associations averaged 247

[1]An Interbureau Committee and Bureau of Agricultural Economics of U.S. Department of Agriculture, Technology on the Farm: A Special Report. Government Printing Office, Washington, 1940, p. 61.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 99. Emphasis ours.

[3]Ibid., p. 99.

[4]Ibid., p. 100. "[These] acres of cropland [are] enough, if planted in crops suitable for human consumption, to support about 16 million persons. This shifting of land and feed undoubtedly had a strong influence in preventing the nation's food costs from rising as much as they would have done otherwise with the increasing population." (Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 68.)

[5]Ibid., p. 112.

pounds annually. By 1928 the average had increased to 284 pounds; by 1930 to 302 pounds and by 1932 to 310 pounds. In the 5 years preceding the depression the number of dairy cows in the Nation was about 5 percent greater than 10 years before. The production of milk was 25 percent greater while it is estimated the consumption of feed did not increase over 15 percent.[1]

The purpose of Federal, State, and nongovernmental forces engaged in animal technology efforts is to aid, through research, professional advice or law enforcement, in the fulfillment of livestock's greatest usefulness. It is a constantly changing field in which man's increasing fund of knowledge widens the possibilities, presents new theories and problems for solution, and renders the future difficult of prediction.[2]

The trend is toward greater adaptability of livestock to trying environmental conditions and to man's needs, better utilization of feeds, increased vigilance and skill in prevention of parasite and disease losses, and marked progress toward eradication of the most serious infections from our herds and flocks. The result should be to open new areas to livestock production, to increase the chances of success with livestock in all areas, and to contribute directly and indirectly to human health.[2]

It is a striking fact that dairying provided more hours of employment than the corn crop in the corn area, and more than wheat and oats combined in the small-grain area. As milk cows require more time in winter than in the crop-growing season, *the increase in dairying makes for more complete year-round utilization of available labor rather than for the employment of a greater number of persons.*[3]

With increasing commercialization of dairy farming and the demand for a more sanitary product, a notable shift of functions from the dairy farm to the processor and distributor of dairy products took place. The manufacture of butter and cheese, once an important function of many dairy farms, is now done largely in town factories. An increase in the practice of pasteurizing and bottling market milk has added further to the nonfarm labor. *Thus, a larger proportion of the total [labor] used on dairy products is now employed in urban centers.*[4]

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[1] Ibid., p. 100. [2] Ibid., p. 112.

[3] Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 138. Emphasis ours.

[4] Ibid., p. 139. Emphasis ours.

LASTING UNEMPLOYMENT OF FARM LABOR

Between 1930 and 1935, agricultural production declined more than 10 percent, owing principally to unfavorable weather.[1] Meanwhile, because of urban unemployment conditions, nearly 2,000,000 people were living on farms on January 1, 1935, who were not living on farms 5 years before, and perhaps 2,000,000 farm youth remained on farms who would have migrated to cities if jobs had been available.[2]

In manufacturing industries unneeded workers are laid off during a depression, while in agriculture unneeded workers tend to stay on the farm until other opportunities open up.[3]

There are many individual estimates that application of maximum use of present available technologies in agriculture might mean an increase from 25 to 50 percent in output, somewhat irregularly distributed among commodities. They cannot be proved, but they have a sufficient basis of fact to deserve consideration. Assuming that the present area devoted to agriculture were not reduced, this would mean, over a period of years with average weather, vast unsalable surpluses. For *agriculture continues to stand face to face with the problem of an increasing potential capacity to produce out of proportion to its capacity to gain outlets for its products.*[4]

Anticipated Productivity of the Cotton Industry

Cotton is the largest employer of agricultural labor, owing to the fact that the processes of cotton growing and harvesting are much more numerous than those involved in the production of corn, hay, or wheat, even though the latter far exceed cotton in the acreage covered. Comparatively little change has occurred in the methods used in cotton planting and reaping, though there has been a gradual increase in the use of tractors.

The gainful production of cotton has thus far been dependent upon a large and cheap labor supply, including a considerable proportion of woman and child labor. As long as this remains

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[1]It is to be questioned whether mention should not be made here of the industrial depression between 1930 and 1935 as having played a role in the decline of agricultural production, possibly of equal importance with "unfavorable weather."

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 100.

[3]Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 150.

[4]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 102-103. Emphasis ours.

available in the South, there may be little inducement to mechanize any of the major processes in the raising of cotton, unless unusual pressure, for instance through war, should change the situation. Nevertheless,

> Although cotton from planting to harvest has largely defied mechanization, cotton as a raw material in the fabrication of textiles played a dominant role a few generations ago in the series of convulsive changes—technological, economic, and social—known as the industrial revolution.[1]
>
> It is more than idle fancy to suppose that cotton may again play a significant part in fundamental economic and social rearrangement.[1]

ITS POSSIBLE MECHANIZATION—THE COTTON PICKER

> Exhibitions and tests in 1936 of cotton pickers in Texas and Mississippi have led many people to believe that the key to complete mechanization of the cotton industry is closer to a reality today than ever before. It will require several years thoroughly to test the machines on different soils, topography and varieties of cotton. But if the confidence of the inventors is justified, the picker will inevitably create new social and economic problems.[2]
>
> There are 8 to 9 million individuals in nearly 2 million tenant families in the 10 Cotton States. If mechanization proceeded rapidly without substantial change in the present cotton acreage, it has been estimated that at least one-fourth . . . to three-fourths of these would no longer be needed. But any such estimate is likely to be unrealistic until the rate at which mechanization would proceed can be forecast—and this in turn awaits proof that the picker is practical and that it can be produced at low cost.[2]
>
> If, on the other hand, lower cost of production leads to increased consumption of cotton both at home and abroad, acreage will be expanded and many who would otherwise be unemployed will find work not only in the cotton fields but throughout the agencies engaging in handling and processing cotton. Moreover, further reduction in the cost of textiles will tend to expand consumer demands in other directions and, in turn, provide more jobs. Lower production costs offer some, but limited, assurance that we shall recapture the foreign markets once dominated by American cotton, because the same machinery would be available to other cotton-growing coun-

[1]Ibid., p. 140. [2]Ibid., p. 142.

tries. India, Brazil, China, Argentina, and Russia are also important cotton-producing countries.[1]

The good and the bad effects of [the cotton picker] are not clearly and distinctly set apart. The cotton picker would cut down sharply the greatest single source of employment for woman and child labor in America. They could not compete with a successful mechanical cotton picker, especially in the river bottom areas of Mississippi and Arkansas and in the Gulf coast prairie and the Texas black prairie, where high acre yields and large plantations would probably encourage the adoption of new mechanical equipment. Their backs and their hands would be spared the labor. But how else, it may be asked, are these people to make a living? Would a larger percentage of them be driven into domestic service? Or might the mechanical picker result in employment of fewer members of a family, but these at better wages, thus releasing women and children for other tasks which might contribute to higher educational and living standards? This latter course is not improbable in view of the experience with advances in machinery in other agricultural pursuits.[2]

THE FUTURE OF THE SHARECROPPERS

If we assume that cotton acreage will remain about the same, and that a successful machine will be produced in large quantities and sold to all who can afford to buy, tenant farming as it now exists in the South would undergo change. Some tenants and share-croppers would still be needed as laborers in the cotton fields, but many would have to turn elsewhere for a livelihood.

Would they pour into the North and seek employment in industry? If so, what would be the effect on organized labor, wages, and standards of living among both skilled and unskilled workers? Many of the people from the rural South have had almost no experience with industrial discipline and complicated machinery; could they be trained to useful and self-supporting employment?[2]

THE NEED FOR SOCIAL ADJUSTMENTS

These effects are based upon the supposition that the cotton picker will be rapidly introduced, privately purchased, and employed just as any other piece of capital equipment is purchased and employed. Perhaps arrangements can be invented which will help to distribute widely the profits derived from conserving human labor. Many ques-

[1] National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 142. [2] Ibid., p. 143.

tions which arise may never have to be answered if, as in the case of many improvements, the cotton picker requires decades rather than just a few years to get into common use. Given a long period of introduction the period for readjustment would be longer and individuals actually displaced by this labor-saving device might be absorbed elsewhere with only limited shock. The key to the degree of disturbance which the cotton picker will create, therefore, to a large extent lies in the length of the period of introduction.[1]

If the United States became engaged in another great war, adoption of a mechanical cotton harvester might be expected. The mechanical picker has reached a stage at which, in the face of labor scarcity, it would prove a very important help in harvesting cotton in the volume necessary for major war needs.[2]

Does the solution lie in whole or in part in the development of farm cooperatives, or more diversified farming? Will northern industry move into the South and take up the slack in the labor supply? Perhaps new industries will grow out of the small beginnings that have been made in air conditioning, large-scale production of prefabricated houses, and rural electrification—to the benefit of all parts of the country. *A cotton picker would prove advantageous if, as millions were released from the cotton fields, new industries surged forward to employ idle hands.*[3]

Size of Farm Unit Conditions Technological Progress

Farmers do not and cannot apply at equal rates the products of science and invention. . . . [This dilemma is] one of the most significant impacts of technological change in agriculture.[4]

For topographical reasons many farms are not suited to effective use of tractors. They may be hilly or poorly drained. A barrier to their use which is far more general is the size of the farming unit or the character of the farming enterprise. Tractors and machines mean a considerable investment. The investment cannot be justified in terms of lower production costs and higher net income if equipment is idle beyond certain time limits. A four-row corn planter is not economically justified on a farm that has only 10 to 20 acres of corn. Thus there has been added to "man-sized farm" and "family-sized farm" the term "tractor-sized farm."[5]

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[1]Ibid., pp. 143-144.
[2]Ibid., p. 107. Written before the outbreak of "another great war." Four years of its demands on production have not yet brought about this great change in the cotton fields.
[3]Ibid., p. 144. Emphasis ours. [4]Ibid., p. 100. [5]Ibid., p. 101.

Generally, technological trends in agriculture have been in the direction of larger and larger farm units.[1]

Larger units in many types of farming, particularly those which lend themselves to mechanization, tend to reduce production costs and increase net income. They make possible a greater division of labor with more specialization; they justify larger investments in machinery; they make possible purchases of supplies in larger quantities and reduce overhead costs much in the way larger factory units achieve certain economies that are impossible for smaller competitors. But, except for very rare cases incident to the production of specialties, *the farm unit, no matter how large, cannot harvest the monopoly gains that in many cases grow out of consolidation of industrial units.*[2]

AGRICULTURE SUBJECT TO RELATIVELY LARGE INVESTMENT, SLOW TURNOVER, AND HIGH PROPORTION OF FIXED COSTS

Large units do not escape the fact that the proportion of fixed costs is relatively much higher in agriculture than in industry.[3] Production and prices of farm products are much less certain than production and prices of many, if not most, industrial products. The large farming enterprise is therefore subject to many risks—the vagaries of weather, pests, and diseases, even though technology has erected some effective defenses against these. The farming enterprise built around a family has shown an extraordinary capacity to weather these risks. The family will sacrifice living standards and will continue producing even when returns on its labor are reduced to very low levels.[1]

Thus potential production cannot be dealt with realistically in terms of achieving maximum efficiency quickly. The readjustment, involving as it would widespread reorganization in terms of larger units, could not be accomplished speedily even if that were desirable. The risks involved are of limited attractiveness to capital at the present time. With the existing limitation on alternative opportunities of employment for persons not engaged in agriculture, operating farm owners would not readily part with their holdings.[1]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 101.

[2]Ibid., p. 101. Emphasis ours.

[3]Emphasis ours. See also the following statement in another governmental report: "Agriculture involves relatively large investments of capital per worker, and a relatively slow turnover on the investment. With an average of 11,200,000 workers in agriculture in 1930, the average total investment per worker . . . amounted to $4,489. Roughly two-thirds of this . . . was in land. . . ." (Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 37.)

Contributions of science and invention to agriculture are most quickly employed by farmers who are possessed of more than average capital. They are better prepared to buy a new machine or buy better livestock or improved seed than their poorer neighbors. Thus, they gain competitive advantages. In turn these farmers already face sterner competition from larger units adequately financed and employing corporate forms of organization. The larger unit, capable of supporting skilled management and specialists may, in some future time, provide farmers now considered wealthy with competition of equal or greater intensity than that now provided by the latter for farmers on undersized farms, on poor land, or handicapped by heavy debts and other burdens. It remains to be seen whether this will become a trend; the extremely large farm unit so far has not proved its capacity to weather the economic shocks to which agriculture has been subjected.[1]

But larger farms and a smaller proportion of the Nation's population engaged in agriculture do not necessitate abandonment of the principle of family-sized farms, a traditional objective in American agriculture. Reorganization of family farms in terms of size and adjustments in practices has been going on steadily in response to technological and other factors for generations. This will continue. Many farms have decreased in size with gains in efficiency when the type of agriculture has changed reflecting some factor such as a new road to a city market or establishment of a canning factory that has made truck growing profitable where more extensive farming was practiced before.[2]

Where the opportunity for an increased income arises only out of commercial farm production the chief trend will be toward that size unit which promises lower costs—and this promise generally is identified with more land.[2]

There are many commodities which are not produced in excess in terms of consumer needs, particularly of low-income consumers including many farmers. But farmers cannot produce irrespective of price in terms of exchange value without going bankrupt. *Dependent as they are on incomes of consumers, they cannot produce without respect for consumer demand. Thus their interest in consumers of farm products is a reflection of their own place as consumers of industrial and other products.*[3]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 104. [2]Ibid., p. 102. [3]Ibid., p. 103. Emphasis ours.

Farmers' Co-operative Action

Cooperative marketing and cooperative buying are gaining a place of increasing significance in agriculture. This reflects, to a considerable degree, advances in technology which have made them possible or necessary. It is probable that this trend will continue. It is probable that it will be extremely important in assisting the system of family farms to meet the challenge of new technologies.

Cooperative ownership of farm equipment such as threshers, wood-sawing rigs, sorghum sirup plants, creameries, cheese factories, grain elevators, and terracing machinery may be expanded. Investment in a machine may not be justified for a single farm but the machine may pay its way when used on several farms.[1]

There has been a steady rise in the volume of business done by farmer consumer cooperatives, particularly in the purchase and distribution of production goods such as fertilizers, feeds, twine, gasoline, and oil. This trend is certain to continue.[1]

There has been another relatively new development—cooperative farm-management associations. In these, farmers jointly employ one or more experts to check their operations and to maintain cost and production records. Measures of labor, feed, machinery, and other factors are developed and from these measures are developed programs for changing farm production plans. Individuals and firms are also offering similar services for a fee and many nonresident farm owners have placed their properties in the custody of these specialists.[1]

An important factor in assisting agriculture to narrow the gap between the rise and use of a new technique has been the erection of institutions. The public, through the land grant colleges, the United States and State departments of agriculture, supports scientific research and also the carrying of research results to farmers. There are one or more extension workers in nearly every agricultural county. The task of bringing their research results to farmers and their families has resulted in the development of a vast field of interpretive techniques. Similarly the field of cooperative management has stimulated the rise of principles and techniques which promise to increase the efficiency of cooperatives as operating entities.[1]

The advance of technology in agriculture has tended to widen the gap in general well-being between farmers who are able to embrace it and those who are unable to utilize many of the fruits of science

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 104.

and invention. This gap is certain to widen. The hoe has not been relegated to the museum. The man with the hoe and the man with a tractor are not competitive equals where they are engaged in the same type of farming.[1]

There is likely to be growth rather than relief in the tension created by the uneven impact of technology affecting large numbers of agricultural people.[1]

New Distribution Techniques for Agricultural Produce

Within virtually the space of a lifetime we have changed from an agricultural to an urban-industrial Nation. This transformation has necessarily revolutionized the methods of marketing farm products in the United States. No longer face to face on market days the farmers and consumers see most products pass through many channels and processes between the farm and the home.[2]

Development of different kinds of market places is one of the outstanding advances. The kinds of markets have changed with changing years, but many of the earliest American markets still exist. Our present market places range from small uncovered local curb markets, through the large city or municipal markets of earlier days, to the newer great terminal markets and outlying regional markets for receiving and redistributing motortruck receipts. Ownership may be public or private. Methods, technical equipment, regulations, and authority vary with the markets—from the antiquated to the most modern. Then there are the exchanges and the auctions. Branch and chain stores with their accompanying problems are among the newer developments.[3]

Methods of marketing or shipping from the farm vary correspondingly. A relatively few farmers still market direct by wagon, motorcar, or motortruck. Others still act as their own salesmen on the local market. Others sell from roadside stands or by parcel post. The old personal relationships between the consumers and those who supply their wants die hard.[4]

A large and increasing number sell through intermediaries of many kinds. Some find the methods involved in such selling satisfactory and some do not. Most farmers feel that the complicated systems are necessitated by modern conditions and demands. They may deplore the mechanized and commercialized methods but they expect an increasing proportion of the farm commodities to be marketed through these channels. They want the channels kept clear

[1]Ibid., p. 105. [2]Ibid., p. 125. [3]Ibid., pp. 125-126. [4]Ibid., p. 126.

and open, they want them improved, and to a certain extent they want them regulated.

Federal and State agencies have been working to those ends actively since 1914, when a wave of interest in costs of living and costs of distribution reached a crest. Subsequent improvements in the marketing mechanism include the Nation-wide system of standards for practically all farm products, formulated by the Bureau of Agricultural Economics and now widely used, the shipping point and market inspection service, the Nation-wide market news service on farm products, the agricultural outlook service, and educational regulatory services, both State and National, that tend to improve the ethics and the technique of marketing.

Techniques involved in these services are many, varied, and ingenious. Each service could tell a technological story in itself. In each case the service, soon after being inaugurated, has become virtually an indispensable part of our vast marketing machinery.

Transportation and refrigeration, among the chief technological advances that have aided this revolution, [have already been mentioned]. The importance of their part in past, present, and future could scarcely be overemphasized. Among recent notable transportation developments in marketing is the use of the motortruck.[1]

Besides the farmers who sell direct and the farmers who sell through middlemen, we have the cooperative marketing of farm products by groups of farmers. Cooperative marketing in this country has reached huge proportions. These cooperative organizations vary from simple associations to large and complicated bodies employing most of the techniques of the usual commercial marketing but employing them for the benefit of the farmer members.

The cooperative marketing idea now seeks primarily to eliminate certain so-called wastes in the marketing process. The principal difference between the chain-store idea and the farmers' cooperative today is the direction of integration. The chain-store integration proceeds from the consumer back to the producer while the cooperative-marketing scheme integrates from the producer forward to the consumer.[1]

Technological improvements in marketing have aided farmers in disposing of their products and consumers in obtaining food and fibers that more nearly fit their wishes and pocketbooks. Most of them probably were designed to more nearly satisfy the consumers' require-

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 126.

ments. Many have lowered or will lower the costs of both food and clothing. Some have added to living costs. Many, but not all, are socially desirable. Nearly all have arisen out of or are related to the growing complexities of our American life.[1]

The marketing mechanism—which is so closely related to the economics of production that the technological phases of the two cannot be separated—can undoubtedly be improved a great deal more in the years to come.[2]

As our marketing program deals with the materials for the food and clothing of this and other nations, *perhaps in no other line of work is it more necessary that the technician and the social inventor work hand in hand.*[3]

Inability to Absorb Available Farm Labor and to Sell Potential Produce

With an increase of 38 percent in the population of the United States from 1910 to 1935 something like a proportionate increase in agricultural employment might have been expected. Actually, only 1 person was employed in agriculture for each 11.5 persons in the total population in 1935, as compared to 1 person for each 7.6 persons in 1910. Had it been necessary to employ as large a proportion of workers in agriculture in 1935 as in 1910, the total number in the latter year would have been 16.7 millions, or 5.7 millions more than were actually employed.[4]

More persons now are engaged in agriculture than can be supported if a steady rise in rural living standards is to be achieved. Unless there is an increase in the rate at which rural people are absorbed in industry, the number of persons to be supported by agriculture will continue to increase. Rural birth rates are characteristically higher than are the rates for any other major population group. Rural areas are now responsible for most of the Nation's net increase in population. Some decline in rural birth rates has been indicated in recent years and a trend toward a further decrease is probable, because the gradual spread of birth control is to be expected.[5]

Domestic requirements for farm products remain relatively in-

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[1]Ibid., p. 127. [2]Ibid., p. 128. [3]Ibid., p. 130. Emphasis ours.

[4]Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture, p. 21.

[5]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 101-102.

elastic. There is doubt whether consumption at present levels of consumers' incomes would increase more than 10 percent even if it were possible to reduce prices of farm products 25 to 50 percent. Domestic consumption of farm products remained relatively stable during the years 1930 to 1933 while farm prices were extremely low. Since food habits are relatively inflexible, it is doubtful that any but the very poor would consume much more as a result of a substantial increase in consumer income. New industrial uses, while promising, do not at present offer definite outlets for large quantities of products beyond present utilization.[1]

Foreign markets for farm products are not being reopened rapidly. Yet the Nation's farm plant continues to be on a scale capable of sending 12 to 25 percent of its output abroad in years of average crop yields.[1]

FARMERS' MIGRATION

Unrestrained competition will lead toward greater concentration of commercial production on fewer farms with an increase in the average size of these farms and fewer commercial farmers. This would mean an increase in the number of farmers with relatively small commercial production, swelling the ranks of self-sufficing farmers. This group will have increasing incentives for migrating to industrial centers and competing there for existing employment opportunities. These opportunities, unless increased as a result of greatly expanded industrial production, are likely to be so limited that migration would be possible for only a relatively small number of those ready and willing to leave rural areas.[2]

Displaced people, who have been compelled to abandon farm homes of all types for life in transient farm labor camps, trailers, and tents, participate but little in the conveniences and higher material standards of living which have come to those on the top rungs of the agricultural ladder. These transient folk have suffered all of the liabilities of social and economic change without being able to participate in any of the assets. They have lost security. Their loss of security in many cases is a direct result of the mechanization of agriculture.[3]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 103.

[2]Ibid., p. 105.

[3]An Interbureau Committee and Bureau of Agricultural Economics of U.S. Department of Agriculture, Technology on the Farm, p. 71.

AGRICULTURAL DISPLACEMENT AND INDUSTRIAL UNEMPLOYMENT

The highest economic efficiency and the greatest productivity would be achieved if all persons were employed in the lines where they contribute the most. But the accomplishment of this goal assumes that we can have full employment (restricted of course by a reasonable length of working day); that anyone displaced in one occupation can readily find another job, and that a worker in a new job contributes more to the national output than he would in any other job available to him. Yet under conditions of chronic unemployment in other industries, the workers displaced from agriculture may find no other work, or, if they do, they will displace industrial workers.[1]

Industrial Utilization of Farm Products

There is a possibility of using either agricultural or non-agricultural raw materials interchangeably for producing the same or similarly derived products. Any prognostications are subject to the prevailing economic situation, to the relative obtaining prices of raw and finished materials, and to the existence of other competing raw materials.[2]

In expanding the use of agricultural surpluses in nonfood industries, certain trends are under way which may result in greatly increased consumption.

Cellulose Products. We live in a cellulose age. Heretofore cellulose has been used mainly in the form of lumber (wood), paper, cotton and linen. Tremendous quantities of cellulosic wastes are destroyed annually as crop byproducts, which are suitable for producing synthetic lumber, insulating board, paper, absorbent paper products, and cellulose derivatives, such as rayon, lacquer, etc.

The enormous consumption of cellulose by the *paper industry* continues to increase.

The young industries of *synthetic lumber* and *construction insulation board* have established places for themselves in our economic life. Delayed somewhat by our general economic conditions they are again demanding increasing amounts of cellulose.

The world *rayon* output during the last 10 years has increased fivefold, and although today the production exceeds 1 billion pounds annually the increase continues. For example, the increase in the rayon production in 1935 nearly equaled the total world production 10 years ago. The rayon staple fiber production today only equals the rayon yarn production of 12 years ago, but this production increased almost threefold in 1935.

Staple fiber is made into a distinctive separate *textile* which is becoming

[1]Ibid., p. 76.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 133.

very popular. Rayon staple fiber, cellulose *plastics,* and some of the *lacquers* are yearly demanding increasingly large amounts of industrial alpha-cellulose.

The *shoe* industry through new innovations in its processes is demanding large amounts in special grades of industrial cellulose.

In producing 1 ton of cane sugar, about 1 ton of sugarcane bagasse is also produced. This waste has until recent years been used as a fuel in the sugar factories. Now the *fiber board* industry uses large amounts of this waste, as well as some cornstalks and straw. It is easily possible to go far beyond the present styles of boards produced and enter other fields of building material not at present competitively attacked. The use of wood waste for producing fiberboard can be supplanted by the use of cornstalks or straw, should competitive prices permit. A large variety of pressed products can be produced from such materials as straw, cornstalks, and sorghum cane waste, and several plants are already in operation.

By further refining, many grades of *paper* can also be produced from these materials, and by still further chemical treatment it is possible to make cellulose derivatives from which *textiles, plastics, lacquers, films, cements,* and *explosives* may be produced. More than a hundred million tons of cellulosic material are produced and wasted annually as byproducts of our grain crops. Seed flax straw, for instance, a byproduct of the linseed-oil industry now largely wasted, can be processed to yield paper or fiber for textiles.[1]

By hydrolyzing cellulose wastes with acid and fermenting with special micro-organisms, alcohols, organic acids, and useful gases are obtainable which may find application in industry. By destructive distillation of certain crop byproducts, acetic acid, methanol, tars, and activated carbons can be produced. Such activated carbons may be used for decolorizing oils, deodorizing, purifying of municipal water supplies, recovery of vaporized organic solvents, etc. From the tars, creosols and oils having marked insecticidal properties can be recovered. From pecan shells a tanning extract might be recovered, and ground corn cobs might possibly be used to replace spent tan bark in the manufacture of white lead. Cobs, hulls, and other crop wastes, as well as the charcoal resulting from their destructive distillation, may be pressed to form fuel briquettes for farm use. Cellulose pulp might be pressed into shapes such as window frames and chair seats, replacing other industrial materials, or used in conjunction with other materials to secure lightness and porosity. Vegetable oils may be treated to increase their lubricating value for special purposes, especially in internal combustion engines.[2]

By processing certain vegetable oils, such as linseed, soybean, and tung oils, many new industrial products having special properties might be evolved. The new synthetic casein wool fiber ("lanital") made in Italy is based on the casein obtainable from that Nation's supply of skim milk. Soybean protein might possibly be substituted for the skim milk casein. A pound of coagulated skim milk is needed for a pound of this yarn.

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 131. Paragraphing and emphasis ours.
[2]Ibid., p. 132.

Present production capacity is stated to be 11,000 pounds a day. Comparable production in this country would consume substantial amounts of soybean and skim milk casein. New oils can be recovered from grape and tomato seeds, nut shells, and fruit pits. By hydrolyzing cellulose certain adhesives are theoretically possible. The present production of furfural[1] from oat hulls might be greatly expanded and other crop wastes might be used as a source of supply. At present, furfural has been used for decolorizing wood rosin, for producing plastics, and for treating lubricating oils used in internal combustion engines. Furfural, however, forms the basis for a number of synthetic chemical reactions whereby dyes, perfumes, and other compounds are evolved.[2]

Until recently the industrial outlet for soybeans was limited. But in the last few years new uses have been found, as in the manufacture of paints, enamels, varnishes, lard and butter substitutes, linoleum, oilcloth, insecticides, lecithin, disinfectants, core oil, soap, printer's ink, medicinal oil, and waterproof goods. Production of soybeans is now a stable and important industry.[3]

There are a number of possibilities for the extension of present uses of agricultural products in industry, but before these can be properly evaluated consideration must be given to present industrial trends which might have a limiting effect on such expansion.[4]

Conclusion

Today, as in the past, the land, our most accessible and greatest natural resource, and agriculture, our oldest and largest industry, continue to provide the first two of our indispensable necessaries of life—food and clothing. Yet, with each decade, land and agriculture are increasingly becoming the battleground of new productive forces and a source of human distress. Even at present low levels of usage, electric power and the sciences of metallurgy, chemistry, and biology have endowed agriculture with a new productivity not only completely surpassing actual employment opportunities for the land's inhabitants, but likewise exceeding by far the existing consuming power of the nation.

While in normal times the products of the mineral industries, responsible today as never before for our necessaries of life in shelter and fuel, can be transmuted and transformed, shaped and reshaped into an unending flow of consumers' goods and a variety of public

[1]Furfural is a chemical compound, an oily liquid, obtained by distillation of various vegetable growths, wool, and other agricultural products.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," pp. 131-132.

[3]Ibid., p. 112.

[4]Ibid., p. 130.

structures, the use of agricultural products, though greatly extended during the past century, remains much more limited. Consumption of food and, to a lesser degree, demand for clothing are comparatively inelastic. Food is already the largest single item in the minimum subsistence budget. Improvements in diet or in dress do not increase production nor add to expansion of living in the same way as do the thousand and one objects, from automobiles to small household articles, for which minerals increasingly provide the raw materials, not to mention, as outlined in the following chapters, their fundamental role in the fields of construction and transportation.

In times of war, with the enormous additional demands for mineral supplies, this functional disparity between agriculture and the mineral industries becomes increasingly apparent. At the same time, however, the needs of military forces considerably enlarge consumption of agricultural products. At present they more than offset the loss of markets in enemy and occupied countries. Under prevailing conditions, shortage of food may even arise, owing to such factors as shifts in the kinds of agricultural produce as between normal consumer needs and military purposes; drafting of farm labor; and the low level of stabilized farm wages, which encourages farm workers to seek industrial employment.

Chapter IV

The Construction Industries and Changing Living Conditions

THE influence of technological developments on construction has been both immediate and far-reaching. Their effect on living conditions is basic, since, in addition to domestic shelter, commercial, farm, and other buildings, the construction industries are responsible for carrying out most public works.

> In recent years, mechanical devices and scientific understanding of the forces of nature and the properties of materials have, with some exceptions, enlarged and are continuing to expand greatly man's capacity to create works and structures for his use and convenience.[1]
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> Technical progress in construction for many centuries was determined by fortuitous circumstances, and the slow handiwork of skilled artisans. During the past 70 years, however, it has increasingly responded to scientific analysis. Today such analysis by trained engineers and architects dominates the design of works and structures other than houses; plays an important part in the improvement of materials and equipment, and within the past 15 years has more and more determined the methods used by contractors and others in actual field operations. This situation has greatly advanced the rate of technical progress and is likely to continue to do so in the future. . . . Nearly all of these recent advances are the results of research in the fields of chemistry, physics, and mathematics. From a technical point of view, the opportunities for the future extension of many of these methods appear very great.[2]
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> As an industry construction is not always sharply defined but is generally understood to include the design and production of domestic

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," by Lowell J. Chawner, chief, Construction Economics Section, U.S. Bureau of Foreign and Domestic Commerce; Carlton S. Proctor, consulting engineer, New York; O. H. Ammann, chief engineer, Port of New York Authority; H. W. Richardson, associate editor, Engineering News-Record; John C. Page, commissioner, U.S. Bureau of Reclamation; Malcolm Pirnie, consulting engineer, New York; and J. L. Harrison, senior highway engineer, U.S. Bureau of Public Roads. Government Printing Office, Washington, 1937, p. 367.

[2]Ibid., p. 387.

shelter; enclosed space for commercial, manufacturing, public, and other purposes; substantial changes in the earth's topography; and fixed works for transportation and for the transmission of commodities such as water, gas, and electrical energy. The products of this industry ranging from single-family houses to bridges, dams, water purification and distributing systems, and streets and roads, are conspicuous in the differences in their technical development and in the physical conditions and geographic areas in which they are created.[1]

In terms of its finished products, construction is . . . principally a nonduplicating industry.[1]

Contracting as a business is, furthermore, essentially mobile. Administration and technical personnel, equipment, and to an important although lesser extent skilled mechanics often move over wide areas. Productive plant is not permanently situated as in most manufacturing industries but must be set up at each particular project. Increasing shop fabrication of materials and the use of mechanical equipment are, however, tending somewhat to fix the situs of employment of a larger portion of the total number of workers directly or indirectly dependent upon construction for their livelihood.[1]

Architects, engineers, and manufacturers are giving a great deal of attention at the present time to possible methods of fabrication of walls and other structural members, particularly for commercial office buildings. The increasing development of such methods of prefabrication has a tendency to reduce the number of workers required on the site at the time of construction, but to increase employment in the manufacture of these materials, in many cases under conditions more favorable to safety and sustained employment than would be possible on the construction site.[2]

Mutuality of Technical and Social Change

Technical improvements in construction are related, in important respects, to costs and to the size of the works and structures which are technically feasible. These two primary effects appear to be associated in many cases with secondary changes such as the enlargement of the volume of activity and employment, the stimulation of other industries, improved community health, and variations in the rate of urban growth. Single cause and effect in economic and social actions

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 367.
[2]Ibid., p. 375.

is, of course, exceedingly rare and the social effects of technological changes in construction are no exception to this general observation.[1]

Technical trends in other industries, in many cases, also influence construction. For example, improvements in farming have lessened the proportion of our population required for the production of basic agricultural commodities [as fully explained in our previous chapter]. A century ago, more than three-fourths of the working population of this country was required to provide food and other necessaries from a reluctant soil and only a very few could be spared for the production of other conveniences of life. This condition has given way gradually to an age in which, according to the census of 1930, less than one-fourth of all gainfully employed persons in the United States were required on farms to provide basic agricultural commodities even in abundance. This change has resulted for many years in a shift of population from farm to city areas, particularly to the satellite communities of large metropolitan districts. This shift has been met by a movement away from the centers of these metropolitan areas because of unsanitary and congested housing conditions. These migrations, which the automobile and rapid-transit lines have largely made possible, have resulted in periods of marked building activity on the outskirts of urban areas, such as occurred from 1922 to 1928. The volume of residential building has been tremendously influenced by this process of urbanization and other types of construction have also been directly affected.[2]

The phenomenal technical developments in the automobile industry during the past 25 years have also influenced construction in many ways. Indeed, the construction of highways and the manufacture of trucks and motorcars are particularly dependent one upon the other for their development. The introduction of new processes in chemical, steel, electrical machinery, and other industries is also frequently reflected in factory building activity.[2]

Domestic Shelter as Influenced by Technical and Social Change

One of the most far-reaching possible changes associated with housing facilities is not technical but social. Modes of living are likely to reflect the tremendous increase in the comforts and conveniences available under controlled conditions of temperature, humidity, and air cleanliness. It is noteworthy that the ultra-modern or twentieth century houses are dominated by the arrangement of interiors for comfortable living and by outlook rather than by external orna-

[1] Ibid., p. 368. [2] Ibid., p. 370.

mentation. This development is likely to continue at an accelerated pace in the immediate future but will depend for its fullest exploitation and widest enjoyment upon the reduction in the costs of facilities attainable through improved industrial methods and large-scale production.[1]

Electricity has multiplied the uses of mechanical power. It appears, however, that neither the home nor industry is making full use of electricity. Apparently less than two-thirds of the urban population live in homes wired for electricity and less than one-half of those wired use electric current only for lights, doorbells, and flatiron. As time goes on and development expenses have been met, one can predict much lower prices for electric appliances, and the consequent greater use of electricity in the home for cooking, baking, water heating, laundry service, and many other uses; it is doubtful as to whether it is reasonable to expect electricity to be cheap enough in the near future to make possible its use for household heating, except during certain seasons of the year and in special localities. The devices which consume large amounts of energy are those which produce heat. Thus a large use of electricity for heating water in homes would greatly increase the load in central-electric stations, and would result in lower costs to the user of electricity.[2]

The technical availability as well as the extensive use of . . . facilities should not obscure the extent to which they are still economically unavailable to large groups of our people. For a surprising number of families, housing is still little more than shelter. Recent statistical inquiries into the condition of urban residential property have provided detailed measures of housing conditions not heretofore available. The most extensive of these inquiries, conducted during the early months of 1934 in 64 cities throughout the United States disclosed a wide range of data on the crowding, facilities provided, the age and condition of structures, and other housing information. "Crowded" conditions (from one to two persons per room) were disclosed in 15.6 percent of the dwelling units surveyed. About one-fourth of the units in the 64 cities were without installed bathing facilities and almost one-fifth without private indoor water closets. In several of the cities the units which were without installed baths or water closets ran as high as half of the standing dwelling units. A number of these urban areas also showed more than one-fourth

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 372.

[2]Ibid., Part 3, sec. 5, "Power," p. 265.

of the units to be without running water. These proportions, which may be accepted as roughly representative of all urban areas, although many of the oldest cities and poorest housing were not included, indicate that approximately 4 million urban American families are still without the barest essentials of "modern improvements" such as running water, private indoor water closets, and bathing facilities, in addition to possibly twice that number in rural areas. The wide technical advance in production methods which has brought the price of adequate clothing, books, a wholesome variety of foodstuffs, even of radios and automobiles in normal times within the range of nearly all persons still finds "modern" houses (not necessarily new ones) beyond the means of one-third to one-half of the families of the United States.[1]

NEW AND CHANGING MATERIALS AND METHODS OF HOUSE CONSTRUCTION

The technical developments in facilities have been accompanied by some, but, until quite recently, hardly comparable changes in the materials and methods of building the housing structure itself. Certain materials such as steel, copper, brass, aluminum, concrete, gypsum, and asbestos have extended their uses in the housing field. The forms in which basic materials are fabricated are also changing; for example, wood is finding new uses as plyboard and as processed wood shavings for insulation. Synthetic plastics are frequently mentioned as having striking possibilities in house construction (as in many other industries) but thus far have been little used, largely because of their present prohibitive cost. These developments in materials have frequently improved the quality of houses but thus far have not conspicuously changed the costs or the prevailing methods of house construction. Some changes in technical methods to be sure have been made. For example, power tools such as electric and gasoline saws (both hand and stationary), concrete mixers, and pneumatic paint applicators have been increasingly used. In addition to these there have been developed a number of changes in methods of fabrication and assembly such as ready-cut houses using wood and more recently steel as the principal structural material. The members of these houses, studding, beams, wall plates, roof beams, rafters and trusses, floor slabs, and wall coverings are accurately cut and fabricated to designed dimensions in a mill or shop and then shipped to the site ready for installation. In some cases these methods appear to have effected sub-

[1] Ibid., Part 3, sec. 9, "The Construction Industries," p. 371.

stantial economies and in others to have provided houses superior in strength and durability to those built by other methods. . . .

Shop fabrication of structural members using various materials is likely to be further extended during the next few years with some important effects upon costs, quality of construction, and architectural design. It may not, however, be the ultimate technical development in the fabrication and construction of houses. The most alluring as well as bewildering aspect of modern housing from the structural point of view is the shop fabrication of complete panels. Comparisons with the automobile and other highly mechanized industries suggest many attractive possibilities to the end of substantial reductions in costs and far reaching improvements in quality.[1]

Problems of manufacturing organization and the perfection of line assembly for the extensive shop fabrication of houses are neither simple nor have they to any appreciable extent been solved. It is hardly likely, however, that such considerations will determine the success or failure of the completely prefabricated house to expand into a major industry in this country. On the other hand, it is almost certain that such considerations as those mentioned above as well as the highly fluctuating character of the housing demand will determine the trends in this new industry.[2]

THE GREAT VALUE OF INTEGRATED NEIGHBORHOODS

A housing trend . . . which has become increasingly important during the past few years is the design and construction of substantial neighborhoods as integral units with suitable amenities for comfortable living such as space and outlook, parks, and community centers as well as adequate schools and utility services. The economic advantages of such planned and regulated neighborhoods are also important. They permit some control of obsolescence, lower cost of construction, lower capital outlays for utility distribution systems in areas which are not already supplied, and lower costs for providing such municipal services as fire and police protection.

Integrated neighborhoods of this character are believed to be most satisfactory in units providing for 3,000 to 6,000 persons, determined in part by the economical size of a primary school.

Such neighborhoods have been designed and built by Government agencies and cooperative groups, as well as by strictly private devel-

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 372.

[2]Ibid., p. 373.

opers. They have also been built both in large cities and in the outskirts of urban areas although the problems of land acquisition in the centers of many cities have proven particularly difficult. The salutary effects of integrated neighborhoods upon health, morals, and community solidarity are undoubtedly very large and such units are believed to offer much promise for the economic and well ordered social development of housing in the United States in the future.[1]

TREND OF APARTMENT-HOUSE CONSTRUCTION AND FAMILY DWELLINGS

Increasing urbanization in the United States was accompanied from 1925 to 1929 by a very active period of apartment-house construction. During this period the total number of multi-family dwellings in cities of 25,000 or more in the United States was substantially greater than the number of single family houses. During the depression years such residential construction as took place was predominantly one- and two-family dwellings. Improved transportation by subways, express highways, extensive vehicular tunnels, and bridges, together with the readily available mechanical devices for heating and for housekeeping may somewhat offset the trend toward apartment-house living, which would normally be expected with returning urbanization.[2]

DEPENDENCE OF SLUM CLEARANCE ON LAND VALUES

Physical depreciation and obsolescence of dwellings, although in most cases gradual, are becoming increasingly important in their social and economic effects. They have already created major public problems in many American cities. The common practice by which the occupants of older dwellings have vacated such units (frequently in perfectly sound structures) for the use of families of lower income has proceeded to the point where many old units, wholly inadequate, unsafe and unsanitary, according to any acceptable modern standard, are sparsely occupied or completely abandoned. Many of these properties are actual liabilities both to their owners and to the govern-

[1]Ibid., pp. 373-374. The idea of an integrated neighborhood as a unit in community planning was first suggested and made concrete by the studies of Clarence A. Perry, then associate director of the Department of Recreation, Russell Sage Foundation, in his work for the Committee on Regional Plan of New York and Its Environs. (Perry, Clarence Arthur, "The Neighborhood Unit," in Neighborhood and Community Planning. Regional Survey, vol. 7, monograph 1. Regional Plan of New York and Its Environs, New York, 1929.) Mr. Perry subsequently formulated the idea in its relation to housing, with definite suggestions for legal procedure to make possible the planning of a neighborhood. (Perry, Clarence Arthur, Housing for the Machine Age. Russell Sage Foundation, New York, 1939.)

[2]Ibid., p. 374.

mental jurisdiction in which they are situated. The land in such areas is, nevertheless, frequently held at high speculative values. This is due in part to an absence of adequate zoning restrictions. Moreover, under present laws relating to the ownership of real property, which for the most part is held in comparatively small lots, the replacement of those submarginal structures by improved residential buildings is quite unprofitable. Consequently, in nearly all States there is needed adequate legislation permitting the consolidation of urban land, either by collective action of the present owners, by granting the right of eminent domain to public utility housing corporations or by the exercise of existing legal powers by municipal and State governments. In brief, one of the major economic and social problems of American cities is the rebuilding of areas on which submarginal structures predominate, or the removal of such structures and the dedication of the land to parks and playgrounds in order that it may serve a useful public purpose.[1]

Commercial Building—Its Trend Toward Unified Commercial Districts

In commercial building the tendency today is away from the construction of very tall structures which often are expensive at great heights both from the point of view of construction costs as well as from the point of view of the elevator space required to service such buildings. The trend is toward the development of unified commercial districts and single structures covering several city blocks such as Rockefeller Center in New York and the Merchandise Mart in Chicago. From the economic point of view, such developments appear very promising but are nevertheless greatly retarded by the difficulties encountered in the consolidation of land ownership which frequently in large urban areas is in the hands of many small property owners. The development of Rockefeller Center in New York City was greatly facilitated by the fact that the land on which it is built was obtained for the most part as a leasehold from Columbia University.

The construction of tall buildings has in the past in the United States introduced a highly speculative element into land values. This problem is most acute in New York City.[2] The zoning for use and height developed there about 20 years ago has been in large measure the basis for similar restrictions in other cities.

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 374.

[2]In turn, the tall buildings in New York are due in large part to the restricted area on Manhattan Island, and consequent high values of land.

Improvements in the restrictions upon various land uses and the height and mass of buildings which may be erected in given areas are likely to be made in the future and are actually under consideration by civic organizations of the New York metropolitan area. Contemplated changes in zoning restrictions in the light of recent experience will have a tendency to stabilize land values and to result in other salutary effects.

In the design and construction of manufacturing buildings much more attention is now being given than formerly to the comfort, safety, and convenience of the workers as well as to the careful arrangement of production stages in order to develop a high efficiency in the whole manufacturing process. Mechanical conveyors and other transportation equipment are increasingly used. Improvements of the last 15 years in trucks and highways have, to an important degree, been responsible for the establishment of many new factories on the outskirts of metropolitan areas. This has resulted in a substantial amount of new factory building in which a great deal of attention has been given to planning and design of the manufacturing plant as an operating unit rather than as a group of industrial shops.

Both improved transportation and communication have tended to reduce the concentration of manufacturing and commercial activity in restricted areas. Also the prevailing tendency is toward the concentration of such activity not in one or two cities in the United States but in a number of such areas throughout the country. The structures themselves may also in the future be less massive and more flexible particularly with regard to exterior walls and partitions. The use of shop-fabricated interlocking units, for example, would provide greater opportunity for growth and greater elasticity of plan arrangements for changing process of manufacture or commercial office use than are readily possible under prevailing methods of construction. Furthermore, instead of isolated tall buildings, we may expect to see the development of an increasing number of unified commercial and manufacturing areas.[1]

Farm Buildings—The Need for Their Planned Modernization and Improvement

Changes in building types [on farms] take place slowly because of the long life of well-built structures. In New England, for instance, the majority of farm dwellings were built more than 50 years ago

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," pp. 375-376.

and a great many more than 100 years ago. In recent years farm buildings have depreciated greatly in value both through deterioration in physical value, partly the result of depressed farm incomes, and through obsolescence. The farm housing survey of 1934 showed about half of the farmhouses needed major repairs or replacement, with the other buildings in about the same condition. Changes in farming methods and in farm production have modified the requirements for buildings, and adoption of automotive machinery in place of animal power, on the farm and in the city, has reduced the shelter and feed storage needed for work stock.

A program of readjustment is needed that will take advantage of new or improved methods in farm-building design and construction and of researches in farmstead planning. Studies have developed arrangements more economical of labor in caring for livestock, and including accommodations for such equipment as feed grinders and litter carriers. The balloon type of barn framing has been developed as more economical than the heavy frames of early days. Concrete foundations and floors instead of the old log foundations and the pole and plank floors, and concrete walks, feeding floors, dipping vats, and other structures have permitted better sanitary conditions and thus contributed largely to more healthful milk supplies for city as well as for country people. Construction methods providing greater safety against fire and storm, and better protection against weather, have been developed. Use of insulating material on farms is comparatively new but is rapidly being accepted. A better understanding of ventilation, moisture control, air conditioning, and lighting requirements may be expected to bring about changes in building design that will provide greater comfort for man and beast and improved quality in stored products.

Much progress has been made since the day of the pioneer whose large family was housed in a log cabin lighted by candles, heated by open fireplaces which also served for cooking, and supplied with water from the old oaken bucket. Yet the farm housing survey showed that only about 15 percent of the farms have the safety and convenience of electricity[1]; 27 percent have kitchen sinks and drains;

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[1] "Since the inauguration of the rural electrification program in 1935, the proportion of farm homes supplied with electric light service has increased . . . to approximately 29 percent and the prospect is for further steady development in this field. This development has been brought about chiefly by the redesign of transmission lines and electrical equipment in such a way as to cheapen very materially the cost of rural electricity, and by the development of a means of organizing and financing rural electrification cooperatives at a very reasonable cost." (An Interbureau Committee and the Bureau of Agricultural Eco-

17 percent have cold water piped into the house, 8 percent have piped hot water; 9 percent have flush toilets; 8 percent have furnace heat; and 4 percent have gas or electricity for cooking.[1]

Public Works—The Consummation of Technological Advance for Improved Living Conditions

New technical developments or improvements frequently make possible works and structures of a type or extent which otherwise would be impossible. Long span suspension bridges, such as the George Washington Bridge across the Hudson River at New York City, were made possible by the development of cold-drawn steel wire of high strength. Treatment plants for the purification of large quantities of turbid, bacteria-laden water for domestic use have been made possible only as chemistry and biology have developed the required processes. Modern reinforced concrete buildings and bridges have depended heavily upon new methods for the stress analysis of rigid structures, power equipment for mixing the concrete, and recent developments in the chemistry of cement. Subaqueous tunnels in soft materials required compressed air and the air lock before they could become a reality. For many years work under high pressures was retarded by inadequate knowledge of the physiological effects of compressed air.[2]

Foundation engineering has experienced one of its greatest periods of advancement during the past decade. In this period the science of soil mechanics has come into being, and its rapid development has marked the transition of foundation engineering for clay soils from an art to a science. No longer is it necessary or considered good practice to base a soft-ground foundation design entirely on experienced judgment and precedented action of similar soils. In dealing with clays and other cohesive soils it is now the foundation engineer's duty to subject undisturbed samples of such soils which affect his design to careful laboratory analyses and tests. Through soil analyses he determines the effect and soil action under various intensities of load, the shearing strength, rate of consolidation, and water content of the soil, and predicates his design on determined soil factors and on the anticipation of definite soil reactions. Notable progress has

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nomics of U.S. Department of Agriculture, Technology on the Farm, U.S. Government Printing Office, 1940, p. 97.)

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 1, "Agriculture," p. 108.

[2]Ibid., Part 3, sec. 9, "The Construction Industries," pp. 368-369.

also been made in caisson design and construction. These developments have greatly enlarged the conditions under which many works and structures may be technically and economically feasible.[1]

HIGHWAYS

Through their effects upon costs, technical improvements have also enlarged the physical volume of works possible with a given allocation of funds particularly by public agencies. According to the estimates of the Bureau of Public Roads, the expenditure which in 1922 built 100 miles of highway, would have built 124 miles of that same type of highway in 1930 and 170 miles in 1932. This was possible, not at the expense of wage rates, which were substantially higher in 1930 than in 1922 and approximately the same in 1932 as they were 10 years earlier, but almost wholly through technical improvements in the various processes of highway construction.[2]

Historically, highway construction is one of the oldest construction fields. From the technical standpoint, however, it is one of the newest, for it is only within comparatively recent times that technical knowledge has been intensively applied to the solution of the various problems which it presents.[3]

Technical changes in highway-construction operations hinge around the steady progress toward mass production which has taken place during the past 15 years. Larger and larger machines have so completely replaced the shovels, the wheelbarrows, and the carts of only a few years ago, that few industries can today boast of a more completely "machine made" product than modern highways.[4]

From the social standpoint, the changes which have taken place in the highway field have produced several important results. Mass production has meant less manpower used per unit of work performed with a steady reduction of unit cost to the public. During the 10 years prior to 1933 the drop in the unit cost at which highway work was being done was pretty steady and quite uninterrupted. It was somewhat accentuated by the depression and from the depression lows there has been some recovery. However, the over-all effect of the trend toward mass production has been definitely to reduce cost and definitely to reduce the demand for human labor per unit of work performed in the highway-construction field.[4]

On the other hand, the trend in design has been toward the use

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 376.

[2]Ibid., p. 369. [3]Ibid., p. 385. [4]Ibid., p. 386.

of higher standards which with equal uniformity have resulted in the use of more and more units of work per mile of pavement laid down. Thus, in the modern highway more and more dirt is moved per mile, and more pavement laid. Bridges and culverts are wider. There are more miscellaneous structures. Advantages in unit costs and reductions in the amount of human labor required per unit of work done have thus been offset by the additional amount of work required. The net result has been that the cost per mile of highway and the demand for human labor per average mile constructed have not changed very greatly. [However], there has been a vast change in what the public receives for the money it expends. The technical advancements which have been made in the use of materials, in design, and notably in construction methods are, in effect, constantly placing smoother, safer, more durable, more dependable, and more beautiful highways at the disposal of the public without additional cost.[1]

AIRPORTS AND AIRWAYS

Air transportation has grown tremendously in the last decade, changing the traveling and mailing habits of many persons. Airplanes in operation have increased from 2,740 in 1927, the earliest year for which complete statistics are available, to 9,167 in 1936, and the daily average of miles flown by the air lines from 16,083 to 212,851 over the same period. Adequate airports are as necessary to the development of this mode of transportation as are roads to automobiles and roadways and terminals to railroads.[2]

The increase in size of air transport planes with the resulting increase in gross weights, has rendered obsolete the old-fashioned landing field covered with sod, due to its inability to serve for all-weather operation, which is one of the basic requirements for every landing facility designed for transport purposes. Major airports serving interstate, transport, and mail planes, now require at least a three-directional runway layout with each runway not less than 3,500 feet in length at sea level and 150 feet in width. These runways must have clear approaches within gliding angle of not less than 15 to 1. The surfacing of runways is of major importance. In their construction, machinery such as tractors and scrapers is utilized, as well as conventional paving materials such as cement aggregates, various types of tars, asphalts, and road oils in addition to steel for reinforcement purposes. Drainage, in most cases, is accomplished by

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[1]Ibid., p. 386.

[2]Ibid., p. 384.

the installation of drain tiles of clay, concrete, or metal as well as broken stone or gravel.[1]

Modern air terminal facilities must include also proper housing, servicing, shop facilities, adequate lighting including boundary and runway lighting, provisions for flood lighting of landing area, and buildings on the airport proper, obstruction lights, and telegraphic and radio communication facilities.[2]

A special effort has been made to further the use of seaplane and open water flying by the development of a new seaplane ramp of the marine railway type. Landing floats and passenger facilities, together with service facilities for seaplanes have also been developed. Many of the larger cities along the Atlantic seaboard, the Pacific coast, and the Great Lakes region are today taking advantage of this plan.[2]

The Bureau of Air Commerce and the Works Progress Administration now are cooperating in a program in which many new fields are being established and existing airports improved and modernized. Another development of the future will be radio and other assistance for landings in adverse weather. All indications are that air transportation will continue to grow rapidly and will continue to require further technical improvements in airport construction and a wider provision of such facilities.[2]

BRIDGE CONSTRUCTION

Recent years have witnessed a great advance in the science of bridge construction. This has been due to a number of factors; namely, the development of materials, especially alloys and lightweight metals, refinements in design arising from a better understanding of the theory of structures aided by research and experimental work, and improvements in fabrication and construction methods and equipment. Certainly our modern bridge structures owe their existence to the technical developments which have taken place.

When viewed for the period of the last 100 years, the modern period of bridge construction, progress has been truly phenomenal. Although adhering to the same fundamental types of earlier times, spans have been increased over sevenfold and span weights, capacity of erection equipment, and speed of construction have been increased a hundredfold.[3]

Perhaps the most important factor which has contributed to prog-

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 384.

[2]Ibid., p. 385.

[3]Ibid., p. 377.

ress in bridge construction in recent years has been the development to a marvelous degree of the strength and excellence and the economical mass production of the two artificial materials which now predominate in the field of bridge construction, steel and portland cement concrete.[1]

Alloy and other high-grade steels, by their greater strength and corresponding saving in weight of metal, are essentials in important modern bridge structures. Wire for the cables of suspension bridges has also been increased in strength to a marked degree—from a wrought-iron wire having an ultimate strength of 60,000 pounds per square inch to the present cold-drawn steel wire of 235,000 pounds. The last-named material makes possible great suspension bridges, such as the 3,500-foot span of the George Washington Bridge and the 4,200-foot span of the Golden Gate Bridge.

The possibilities inherent in lightweight metals are becoming continually more apparent. For example, aluminum has been proposed in a number of cases where it is desired to replace an existing floor system with one of greater capacity without adding to the total weight of the structure, as in the case of the Brooklyn Bridge.

Portland cement concrete has been growing in importance as a bridge construction material since metal reinforcement embedded in concrete was introduced in France in the 1880's and a few years later in this country. A marked improvement in this material has been made in the last few years due to a better understanding of the methods of mixing and placing. The compressive strength of concrete ordinarily incorporated in present-day structures exceeds that of 25 years ago by at least 50 percent.[2]

The theory of structures is also now better understood than formerly because of a greater knowledge of the properties of the materials, brought about by extensive research and experiments, calculations of stresses having been repeatedly checked by measurements on actual models or on members of structures as actually built.[3]

An important factor in bridge construction has been the development of high-power fabricating machinery, equipment, and methods. Today the fabricating shops, equipped with power-operated punches, drills, shears, planers, and riveters, turn out completely assembled members weighing as much as 150 tons. A comparatively short time ago practically all fabricating was done at the bridge site.

Of equal importance has been the development of erection equip-

[1]Ibid., p. 377. [2]Ibid., pp. 377-378. [3]Ibid., p. 378.

ment of increased capacity. Tractor cranes now have capacities up to 40 tons and certain sections of the Triborough Bridge viaducts were erected entirely by such cranes. In many cases the design of the structure takes into account the type of equipment to be used in erection, as was the case on the San Francisco-Oakland Bay Bridge and the Golden Gate Bridge, where a hammerhead crane, mounted inside the column sections, was used for tower erection.

Welding has played an increasingly important part in steel construction both in the fabricating shops and in the field. This important technique has made most of its development within the last 15 years. Savings in properly designed welded trusses are said to run as much as 30 percent under the cost of riveted structures. Cable spinning, stepped up to unprecedented speeds on both the San Francisco-Oakland Bay and the Golden Gate Bridges by the use of multiple spinning equipment, is another example of the possibilities of modern equipment.

Other important improvements in construction equipment have had to do with the handling and placing of concrete. Belt conveyors for aggregates expedited construction of the anchorages of the George Washington Bridge. Trucks equipped to mix concrete in transit, pumps for placing concrete at points difficult of access, vibrators for securing dense concrete, and mechanical screeds for securing a high degree of perfection in the finished surface, have all played an important part in the construction of the Triborough Bridge, as, in fact, they have in many modern structures. Pumping concrete, in particular, is a distinctly modern innovation. First introduced on a commercial basis in 1932, this method of placing now accounts for over 1,000,000 cubic yards per year.[1]

A large bridge structure depends for its construction upon justification from a self-liquidating standpoint. The time necessary for construction therefore becomes a very essential feature.[1]

The improvements in construction equipment which make possible the reduction of construction time to a minimum are therefore exceedingly important, and remarkable progress has been made along these lines. For example, the Eads Bridge at St. Louis, completed in 1874, was erected at the rate of about 90 tons of steel per month, but the Bayonne arch, completed in 1931, was erected at the rate of 1,800 tons per month. In order to be able to compete at all, the present-day

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 378.

contractor is obliged to make the maximum use of the most modern material-handling equipment available.[1]

Improvements in materials and design methods have contributed materially to modern bridge construction. But most important of all, the development of highly mechanized equipment by greatly increasing the speed of construction, has made more projects economically feasible and thus has been the principal factor resulting in the employment of labor in this branch of the construction industry. At the same time the manufacture of essential equipment has also offered new opportunities for the employment of labor.[2]

The construction of large bridges, especially those over wide streams traversing great metropolitan centers, such as New York, Philadelphia, Pittsburgh and San Francisco, has a pronounced influence upon the economic life of the communities they serve. Not only do they effect enormous savings in cost and time to the traveling public, but they are also of vast indirect benefit to the public in permitting the spreading of the population to comparatively undeveloped areas, in improving the accessibility of the countryside for recreation to those who live in the congested centers, and in bringing the commercial and educational institutions of the city closer to the people living in the surrounding country.[2]

TUNNELS AND SUBWAYS

For many years the construction of tunnels in the United States was principally identified with railroad work in mountainous areas. More recently, tunnels have been widely used in providing for the flow of large quantities of water for hydroelectric-power development, for irrigation, and for urban water supply upon a greatly extended scale. Tunnels are also in wide use today for sewer lines and for the carrying of gas, power, light, and other utilities. They have also been extensively used in rapid transit systems and more recently for vehicular traffic in New York, Detroit, Oakland, Boston, Liverpool, Antwerp, and other cities. The social effects of these structures, particularly in facilitating the growth of metropolitan areas, are very large.[2]

In the last decade or so, the art of tunneling has advanced amazingly, due primarily to the rapid development of equipment and materials. While the fundamental changes have been few, they have had a tremendous influence in the development of tunnel driving, which in turn has had important social and economic effects.[2]

It is the introduction of scores of mechanical devices and pieces

[1]Ibid., pp. 378-379. [2]Ibid., p. 379.

of equipment that makes tunneling the highly mechanized, scientific procedure that it is today: Drill carriages for the mounting of the rock drills as a time-saver in setting up and dismantling of drilling equipment; the electric locomotive, offering fast haulage for muck and materials; the collapsible steel form, which, with the development of the concrete placing machine or "gun," has revolutionized concrete-lining procedure; the pressed-steel liner plates that have made soft-ground tunneling so much safer, easier, and less expensive; the improvements in explosives, now available in safe form for any type of ground encountered; the use of electric detonators, which has made blasting safe and certain; and mechanical ventilation for safeguarding the health and comfort of underground workers. Modern tunneling, being largely mechanized, requires skilled workmen and technical organization. It thus not only provides needed and useful engineering work, but offers considerable employment to a highly specialized class of workmen.[1]

Subway building is a specialized form of construction and its problems are different from any other class of work. As is the case in tunnel work, it has developed and improved along mechanical lines. Except where subways lie in tunnels, their construction is of the cut-and-cover type of work wherein a trench is excavated, the line structure built, and the trench backfilled to its original state. As this usually takes place in busy city streets, the difficulties involved are many and serious. Subway building requires skilled workers, experienced in that class of work. This type of construction is of tremendous social importance in the three American cities in which such structures have been built, but because of the very limited local application, they do not have the wide interest and importance attached to other types of structures.[1]

Tunnels during the past few years have had an increasingly important place in the rate of growth and type of development of metropolitan areas. They have been essential parts of systems for conducting pure water from remote watersheds to such areas as Boston, New York, and Los Angeles. They have also made possible many hydroelectric developments which otherwise would not have been practicable. Underground rapid transit has substantially determined the character of commercial activity especially in New York City.[1]

Tunnels and bridges in urban areas frequently serve much the

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," p. 380.

same purpose and it is at times difficult to determine which type of structure will serve most satisfactorily and economically. Developments within the past 5 to 10 years have tended to make both types possible at lower cost and under a much wider range of conditions. This fact, combined with the trend toward a widening range of social and commercial activity within metropolitan areas, may very likely sustain both bridge and tunnel construction at present levels for a number of years.[1]

DAMS

The adaptation of machines to particular purposes by increasing their size, portability, and strength, as well as the devising of new appliances, is strikingly evident in the present construction of large dams [such as Boulder Dam].[1]

There is found a tremendous advance in the last several years in the details of investigational procedure, the theoretical considerations in design, the adequacy of preparatory features, the excellence and strength of materials, and the efficient methods of actual construction; all directly concerned with the expanding use of the machine.[2]

Materials have kept in step with advanced methods in other activities. Metals have increased in strength, special alloys are provided for particular purposes, and low-heat, slow-setting, and quick-setting cements are all available. Motive equipment has gained in strength, power, and portability.[2]

It would have been impracticable from an economical standpoint, and almost impossible from a physical standpoint to have erected these structures without the aid of modern machinery, due primarily to the inaccessibility of site and the large volume of water flow. Presenting a concrete example, Boulder Dam and the Great Pyramid have practically identical volumes. According to historians, 100,000 men labored 20 years in the construction of the pyramid, while 1,200 men in less than 2 years built Boulder Dam. The pyramid thus required 2,000,000 man-years of direct labor and the dam, 2,400.[2]

From a sociological point of view, the benefits accruing from the building of these dams are far reaching. Water and power resources have been conserved, effective barriers have been raised against flood and drought, homes and a means of livelihood have been provided, communities have been stabilized, and electrical energy has created industrial pay rolls and brought conveniences and comfort to millions of homes. In addition there are the immediate beneficial effects

[1]Ibid., p. 380. [2]Ibid., p. 381.

through aid in the solution of the unemployment problem. Thousands of men assisted in their creation, and it is estimated in the building of these large structures that for every dollar spent in direct labor an additional 2 or 3 dollars were paid for the labor involved in manufacturing, marketing, and transporting materials and machinery.[1]

WATER SUPPLY

Construction for the procurement, extension, and betterment of water supplies and distribution works in the United States has a normal annual dollar volume at present prices of about $150,000,000 or a little more than $1.15 per capita per year. It is obviously a large field which is increasing in importance with the trend in consolidation of farm operations and the continued long-time growth of urban centers of industrial activity. There were only 17 waterworks in the United States 136 years ago, all but one of which were privately initiated, constructed, and owned. Twelve years ago there were 9,850 waterworks, only 30 percent of which remained in private ownership. The established trend in public ownership of waterworks has continued at an accelerated rate in recent years. Today there are probably no less than 50,000 employees engaged in operating waterworks and possibly three times this number on the average are employed in the manufacture and transportation of waterworks materials, equipment, and supplies, and in building new works and extensions and betterments of existing works.[2]

Waterworks constructions involve buildings of the smaller type, foundations, bridges, tunnels, dredging and excavation, dams, and relocation of railroads and highways. They are job site operations to the extent of from one-third to two-thirds of their cost. About one-third of the total number develop surface water within the natural drains of the adjacent or contiguous lands, the other two-thirds tap the underground waters for relatively small supplies. In arid sections and in thickly populated areas supplies must be obtained from distances of as much as 100 miles or more, sometimes involving controversies and negotiations between two or more States.[2]

Almost universally water is still regarded as a necessity which must be used sparingly. It is truly a commodity like grain, being an annual crop related to the rainfall and depending for its utilization upon storage provided in connection with the area which catches

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," pp. 381-382.

[2]Ibid., p. 382.

SEWAGE TREATMENT AND DISPOSAL

There is no cheaper nor better way of disposing of sewage than by dilution if the proper amount of dilution can be obtained at all times. Storage reservoirs constructed on drainage areas to regulate stream flow for power purposes or to retard flood flows by holding back storm run-off to be released gradually during a subsequent period of weeks or months are of almost equal value in raising the dilution factor for the almost universal present method of disposal of urban sewage. Flood-retarding and stream-flow regulation works therefore command first place in regard to benefits per dollar of expenditure. Loss of fish life in the main river valleys is in this way largely compensated for by ease of maintenance of fish life in the large lakes artificially created. There is obviously a vast field of construction open to employ large numbers of future generations in works to regulate stream flow which will be a substantial contribution to a steady rise in our standard of living.[1]

The effective solution of the multitude of problems involved in sewage and sewage disposal requires that such works be classified in the order of greatest benefits per dollar of expenditure and proved best technological procedure at the time of undertaking each remedial measure. There is here room for extended and continuous research and for the employment of great numbers of future generations in the planning, construction, and operation of the needed public works. Long term programs of improvement of main drainage basins are essential to economies and sustained progress in execution. For example, the proper Federal agencies could cooperate with similar agencies of industry and the States and their political subdivisions to define the scope of the problem of pollution and to formulate a definite plan and schedule of construction equitably apportioned. With such cooperation progressive improvement in the quality of the waters of the United States may be accomplished.[2]

Future Outlook Dependent on Social and Economic Factors

The extent to which new developments [in construction] are likely to be introduced will undoubtedly be determined . . . in an important degree by nontechnical factors. Some of these factors which logically are closely related to the trends in construction technology are:

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," pp. 383-384.

[2]Ibid., p. 384.

1. The extent to which facilities for research are provided for investigations in the design and methods of fabrication of works and structures.
2. The quality and availability of scientific training to qualified students in colleges and universities.
3. The freedom afforded by the form of organization of private industry and by governmental agencies for the introduction and development of new processes.
4. The extent to which financial and other economic conditions may be favorable to long-time expenditures.[1]

The physical resources and productive energy of American governmental and private business organizations have enabled us to excel in the magnitude and number of works and structures actually built, but for many years we leaned heavily upon the methods of analysis developed in Europe. Refined methods, however, and the scientific character of professional engineering instruction have advanced considerably during the past 15 years in the United States. Unfortunately, the low levels of activity and employment in construction since 1930 have greatly discouraged the study of professional engineering although the proportion of students continuing with advanced studies has increased.[1]

The violent fluctuations in activity which have characterized many types of construction in the past, particularly private residential and commercial building, are unfavorable to technical progress. Technical methods, such as the shop fabrication of houses, requiring a substantial capital outlay are confronted by serious difficulties in an industry the demand for the product of which fluctuates as violently as has that for new dwelling units. Furthermore, the unsound financing of the types of structures mentioned above, commercial and residential building, in which the financial instruments resting upon many properties were quite unrelated to the long-time rate of income and to the depreciation and obsolescence of such properties, was to a large extent involved in the complete break-down of the new capital market in 1932 for these types of buildings. Notable changes over the past 20 years have been made in the financing of farms and farm improvements by such agencies as the Federal land banks. Marked improvements in the financing of urban homes and of some large dwelling structures have also been made in recent years by the Federal Home Loan Bank System and the Federal Housing Administration. The practices in the financing of other types of real prop-

[1]Ibid., p. 387.

erty ownership which are likely to prevail during the next decade are, however, not as yet well defined.[1]

Some interesting conclusions might be drawn from the data heretofore outlined. The most significant of these, however, is undoubtedly this question: Does not experience show that *technological advance is likely to find its greatest liberation and unhampered triumph in public works construction, that is, in works initiated by government for the common weal?* Great bridges, dams, highways, and tunnels, precisely the structures made possible by new scientific discoveries, can be undertaken most effectively in a long-time plan to serve an entire region or nation and its total economy. The products of many industries must be brought together, often from widely separated places. Frequently new problems arise, requiring solution by science as the work proceeds. Sometimes the work necessitates comprehensive control of living conditions in an entire region, which only government can achieve; witness the extensive program for health protection and elimination of the source of yellow fever which made possible the building of the Panama Canal. Finally, full utilization after completion depends on many factors in community organization beyond the control of any one group of entrepreneurs.

Such undertakings, made possible on an increasingly magnificent scale by the new technology, are too far-reaching, involving too great risks and too remote returns, to constitute a feasible investment for private capital. At the same time, the many new inventions and discoveries make possible ever new types of construction for a nation's development and for the cultural life of its people. The imagination is stirred by thought of the works which a nation can undertake, giving to technology its foremost opportunity to serve the common interest.

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 9, "The Construction Industries," pp. 387-388.

Chapter V

Transportation and Communication: Their New Social Implications

IN THE nineteenth century it was the steam engine and the steam locomotive which gave the great impetus to industrial development and resulting commercial, social, and cultural interchange. In the present century the immense progress in transportation and communication is once more due to technological change. New power developments, combined with newly discovered qualities in mineral resources, and scientific research making possible the radio and the airplane, have created completely new means of communication and interchange of such a nature that the span of time is thereby forever shortening, whilst distance is being annihilated.

Naturally it follows that such changed momentum is bound greatly to accelerate and intensify our modes of living.

Transportation Establishes Communication

Whether or not we agree with Kipling's assertion that "transportation is civilization," it is plain that most of our present civilization is dependent on transportation for its existence and that the transportation industry itself is one of the most important factors in the economic and social life of the United States.[1]

A major social significance of all inventions for travel and fast transport is that they serve also for communication. The people who

[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," by Harold A. Osgood, vice-president, Fulton Iron Works Co., St. Louis, assisted by a committee under leadership of Frederic A. Delano, chairman, Advisory Committee, National Resources Committee, formerly official in several railroad companies. The committee assisting in this study included the following: Advisory on air transportation, Eugene L. Vidal, former director, J. S. Wynne, former assistant director, and F. R. Neely, chief of information service, Bureau of Aeronautics, U.S. Department of Commerce; advisory on highway transportation, Thomas H. MacDonald, director, H. S. Fairbank, chief of information division, and F. W. Lovejoy, highway transport specialist, Bureau of Public Roads, U.S. Department of Agriculture; advisory on rail transportation, Joseph B. Eastman, Federal Coordinator of Transportation, and J. L. White, director, section of carload freight service; advisory on water transportation, Maj. Gen. E. M. Markham, Chief of Engineers, U.S. Army, and Brig. Gen. G. P. Pillsbury, Acting Chief of Engineers. Government Printing Office, Washington, 1937, p. 177.

travel, as tourists, businessmen, and immigrants, carry the ideas of one region to another. Swift movement of goods is commonly of letters, printed ideas, examples of art, or highly manufactured goods which serve often as samples or suggestions. National business and political organization, as against local and State, with the accompaniment of national ways of thinking, are built up by every improvement of long-distance transport and communication.[1]

NATURAL AND HUMAN RESOURCES CONDITION TRANSPORTATION

The volume and character of transportation, both freight and passenger, depend largely on factors, social and otherwise, quite outside of the transportation industry. . . . Let us realize that the exhaustion of mineral resources, or the destruction of timber in a region may leave no freight traffic in that area. A failure of the California citrus fruit crop, a drought in the Kansas wheat belt, a strike closing the Illinois coal mines, the completion of a great new hydroelectric power plant in Tennessee—all such things have a profound temporary and frequently a permanent effect upon the transportation industry which itself cannot take any counteraction. Similarly, shorter hours, higher wages, greater old-age security, and better education will favor increased passenger travel just as the long hours and poverty attendant upon farming submarginal land virtually root people to the soil.[2]

Passenger Transportation

In the past 15 years we have seen an almost incredible increase in passenger transportation, due to the convenience and low cost of private automobiles. . . . Today, lightweight, high-speed, streamlined trains and low passenger fares are increasing railroad travel. It is notable that transportation, as it becomes more speedy, regular, frequent, economic, or efficient, creates, like other public services or utilities, an increased demand.[3]

The history of transportation has shown that as a whole it grows at a rate higher than the increase in population.[3]

The urge to travel is undoubtedly a deep-seated human characteristic. Not only has it been evident from the earliest times down to date but a yearning for "fresh fields and pastures new" is apparent through the widest ranges of social classes. No more striking exam-

[1]National Resources Committee, Technological Trends and National Policy, Part 1, sec. 3, "Social Effects of Inventions," by S. C. Gilfillan, formerly curator of social sciences, Museum of Science and Industry, Chicago, and author of The Sociology of Invention, p. 29.
[2]Ibid., Part 3, sec. 3, "Transportation," p. 206.
[3]Ibid., p. 208.

ple of this general thesis can be found than in the United States. Here the average travel per inhabitant was about 500 miles per annum in 1920, and over 2,000 miles per annum in 1929.

In the words of the Federal Coordinator (from whose Passenger Traffic Report these figures are taken), "within less than a decade, American travel desires and habit were quadrupled, and at the end of 4 years of depression, were still more than three times as great as they were prior to the automotive era."[1]

All increases in leisure or in speed of travel and all decreases in transportation costs promote passenger travel,[2] and the more people travel the stronger is their desire to do so.[1]

Unlike freight, where all the railroad or other common-carrier advertising, education, and solicitation in the world will not make tonnage move beyond the economic needs of the time, the passenger-transportation market is even today capable of large expansion.[3]

Freight Transportation

The United States still seems to use a disproportionate amount of freight service as compared with older and more settled and stabilized countries.[4]

Everywhere the industrial world is trying to eliminate useless transportation, and the cumulative effect is already noticeable. A good instance in the not distant past has been the production of steel, using hot metal direct from the blast furnace and eliminating the transportation of pig iron and of the fuel formerly used to melt it. Other examples are the shift of the textile industry from New England to the Southern States, and of the shoe industry from the East to the Middle West. Location of industries where freight costs can be saved is a conspicuous factor. Manufacturing plants are being built out of savings in freight rates. In lighter manufacturing particularly an undoubted tendency toward relocation and dispersion of industry is evident, although this tendency does not arise from transportation considerations alone.[4]

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[1]Ibid., p. 180.

[2]Cf. Verdoorn, P. J., "The Influence of Railway and Postal Rates on the Demand for Railway and Postal Services," paper submitted at Conference on Methods of Research Concerning Productivity and Standards of Living, under auspices of Research Group of International Industrial Relations Institute, The Hague, 1939. By the methods of multiple correlation an analysis was made of passenger traffic in Holland during the years 1921-1937. The conclusion drawn was that "the level of wages is one of the determining factors in the demand for railway services." (Unpublished proceedings.)

[3]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3. "Transportation," p. 180. [4]Ibid., p. 178.

Freight traffic is peculiarly a product of factors beyond its control, and in a survey of such factors must be read the future of the transportation of freight—both as to its volume and its character. We have better and longer-lived materials. We ride on tires advertised to run 20,000 miles, and coming much nearer to meeting this standard than the guaranteed 3,000-mile tires of 20 years ago came to the claims of their manufacturers. The American Iron and Steel Institute calculates that the 34,000,000 tons of steel produced in 1935 may be expected to last an average of 32 years, or approximately twice as long as steel did 40 or 50 years ago. The development of alloy steels, minimizing rusting and ·making the steel itself stronger and more durable, improved manufacturing eliminating impurities, improved processes for coating steel products with tin and zinc to resist corrosion, and the refinements in manufacturing processes and rigid tests assuring higher quality and insuring fewer replacements once the steel is in use, are pointed out by the Iron Age[1] as factors in lengthening the life of steel.

As in material, so in designs—particularly designs permitting the use of higher speed, lighter machinery.[2]

A . . . factor, not merely limiting freight transportation but making constant, direct inroads into the volume of freight service required, is the competition of electric transmission lines and natural-gas pipe lines.[2]

While freight traffic, measured by ton-miles, will probably increase but slowly above the normal levels of the past, lighter and bulkier freight will in some measure serve as an offset from a revenue and even from a carload or truckload standpoint. Such items as electric refrigerators and radios have reached a surprising volume in recent years. A large traffic in fruits and vegetables, from such distant territories as the Rio Grande and Imperial Valleys, has grown up, and the near future will probably see increasing movements of air-conditioning and insulating equipment and materials, portable houses, trailer bodies, and the like. These increases in volume will partly compensate for reductions in weight.[3]

While no great, new heavy industry has appeared on the horizon, many new lighter industrial and manufacturing activities are in plain

[1]Iron Age is the well-known technical and trade journal of the iron and steel industry and related branches of production.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 179.

[3]Ibid., pp. 179-180.

view. This trend will call primarily for flexibility and speed in transportation.[1]

Railway Transportation—Motive Power

Looking to the future three types of railway motive power will probably be used—electric, Diesel, and steam.

The recent electrification of the Pennsylvania-New York-Washington lines, including particularly the great terminals in New York and Philadelphia, less recently the electrification of the Illinois Central suburban zone out of Chicago and the N. Y. C. electrification of the Cleveland terminals, together with the older electric lines of the New York Central and the New Haven out of New York, has given millions of people personal experience with this form of transportation. Invariably they are impressed with the electrified road's rapid acceleration, smooth operation at high speeds, cleanliness, and ability to handle anything from the smallest switch locomotive or single unit passenger car to the longest, heaviest, and fastest freight and passenger trains.[2]

Electrification involves a heavy additional investment, probably creating little additional traffic. Only with a large volume of business can enough operating expenses be saved to justify the increased capital charges. Broadly speaking, a railroad line will have to double its capitalization in order to electrify.[3] It is true that the electrified road will cut its coal bill in two and effect other less striking operating economies, but obviously the new capital costs must be spread over a tremendous volume of freight and passenger business.[4]

The Diesel Engine—"Mobile Electric Power Plant"

Quite recently the Diesel engine, as the motive power of lightweight high-speed streamlined trains of novel designs and colors, has received wide attention. . . . The present Diesel locomotive is, roughly speaking, a mobile electric power plant.[4]

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[1]Ibid., p. 180. [2]Ibid., pp. 190-191.

[3]The Chicago, Milwaukee and St. Paul Railroad offers material for a case study of electrification in its relation to the financial structure of the company. (See Lowenthal, Max, The Investor Pays. Alfred A. Knopf, New York, 1933.) Extensive data on this railroad, its receivership and reorganization, have been published in reports of committees of the United States Senate. (This material is listed in Senate Committee on Interstate Commerce, 76th Congress, 2d Session, Additional Report, Pursuant to Senate Resolution 71, 74th Congress, Report no. 25, Part 21, p. 1.)

[4]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 191.

While the Diesel engine in passenger service will attain a high degree of reliability and simplicity; while it will require little time in the shops; while little operating time will be spent in fueling, taking water, etc.; and the engine will generally be economical to operate, these advantages are today largely nullified by high investment costs and fixed charges. Such costs will no doubt be reduced, and if safety and other considerations will permit the crew of a Diesel road locomotive to consist of a smaller number of men, or be paid less than a steam-locomotive crew, material reductions in operating costs may be effected.[1]

Based on about 10 years' actual operation in Europe and extensive experiments and tests in the United States, supercharging of Diesel engines is just getting under way in this country. The engine builders are seeking to recover power from the exhaust gases in sufficient amounts to drive the supercharger and hope thus to obtain a material increase in power without a corresponding increase in the dimensions of the Diesel engine itself. Where space and weight limitations are desirable, as in railroad service, developments along this line are logical. Increases from 30 to 80 percent in power are talked about and one manufacturer is actually guaranteeing 900 horsepower from an engine customarily rated at 600 horsepower.[1]

Even today the Diesel electric has many advantages in terminal service, and in that field probably lies the Diesel's best chance in the near future. Particularly will this be true when electric transmissions cost less or if less costly hydraulic or mechanical devices are developed. The average switch engine spends the majority of its time doing nothing except burning coal; the Diesel engine can be shut off and started about as easily as the ordinary automobile. Public outcry against the noise and smoke of steam switch-engine operation can be satisfied by Diesel operation. Cold weather, to which so many of our greatest railroad gateways and terminals are exposed, cuts about a third of the power of steam locomotives and does not affect the Diesel.

The Diesel electric switch engine generally has a higher starting power and better acceleration than corresponding steam engines, does not have to haul a 50- or 60-ton tender wherever it goes, can operate more than 48 hours continuously without taking fuel or

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 191.

water, and naturally does not require fire cleaning and boiler washing.[1]

The principal limit on Diesel switching today is probably the railroads' unwillingness in the face of decreased business to retire existing steam power, much of which has nearly been written down to a scrap basis, and incur the relatively heavy capital charges involved in new Dieselized equipment.[2]

IMPROVED STEAM LOCOMOTIVES RETARD DIESEL OPERATION

Looking forward to a freight traffic increasing only slowly at best beyond the 1926-28 levels, the bulk of railroad freight will be hauled by steam locomotives. Indeed no serious effort has been made to apply Diesel power to freight service other than switching or transfer service, and little or no doubt is expressed as to the steam locomotive's ability to meet any ordinary demands of freight or passenger service. Considering the many years of research and practical experience back of steam engineering, and the cumulative and accelerating progress in this art, this is to be expected. Nor does this imply any lack of progress. Few types of machinery have been so greatly improved in the past 20 years as steam locomotives. Weight per horsepower has been cut in half and the thermal efficiency doubled. Progress in the future will undoubtedly continue. Higher boiler pressures, higher steam temperatures, greater fuel economy, greater steam capacity, better steam distribution, ability to make longer daily runs and greater mileage between shoppings[3]—in all these and many other ways the steam locomotive is being . . . radically improved . . . Comparatively few people realize the superiority of today's locomotive over engines built 15 or 20 years ago.[4]

Lighter weight, lower maintenance, greater efficiency and economy, construction with more steel castings and more welding, and, of course, greater durability and higher speeds, are constant trends in the steam locomotive's construction.[4]

The [improved] steam locomotive will likely prove adequate to the general demands of the railroads in the next 20 years, and in the field of passenger traffic will help to bring to the rails a good share of the business now handled by other agencies.[4]

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[1]Ibid., pp. 191-192. [2]Ibid., p. 192.
[3]"Shopping" is the railroad industry's term for sending a car or locomotive to the repair shop.
[4]Ibid., p. 192.

Water Transportation

From 1920 to 1929 water-borne commerce in the United States increased steadily, and since 1929 has probably fallen off less rapidly than rail traffic.

Studies made by the United States Board of Engineers for Rivers and Harbors tend to show, based on tonnage alone, that freight transportation by water was about 17 percent of rail tonnage in 1920, gradually rose to 30 percent of rail tonnage in 1933, and only slightly receded in 1934. Both agencies lost traffic to highways and pipe lines during the period.[1]

Looking to the future in waterway transportation, no radical changes are in sight.[2] Use of the Diesel engine on inland waterways and smaller coastwise vessels is progressing. On inland waters the tunnel type propeller boat is supplanting the old-time stern paddle wheel Mississippi River steamer.[1]

A good deal of attention has been given to the development of inland waterway propelling craft suitable for low-bridge clearances. The use of welded construction for steel hulls is gaining, reducing cost and dead weight, eliminating rivet points and lap edges of plates and materially reducing skin friction. This applies particularly to smaller vessels, including river craft.[3]

On the large coastwise boats and in overseas trade, both Diesel engines and high-pressure-steam turbines are increasingly important factors. The Director of the United States Shipping Board states that the principal advance in technical shipping developments in recent years has been in fuel economy. This has resulted from the adoption of air preheaters and economizers, a steady increase in boiler pressures and temperatures which now run about double standards which prevailed at the close of the World War, and more modest improvements in the steam turbines.[3]

We cannot yet be sure whether marine power plants will be Diesel or steam—the steam plant having a marked advantage in the price of boiler fuel, in weight, simplicity, and generally in initial cost, the Diesel having a somewhat lower oil consumption per horsepower.[3]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 190.

[2]It is interesting to note that the steam engine in transport was first tried out on a river—Robert Fulton's Clermont on the Hudson River in 1809. It is in the development of the engine that river traffic confronts changing technology, while simultaneously the same inventions of new prime movers create competitors for the waterways on land and in the air.

[3]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 190.

Improvements other than those to propulsive machinery include specially designed propellers and rudders, and stream-lined after hulls to improve the flow of water to the propellers.[1]

Water transport is almost the oldest of all forms of transport. As such, it can hardly look forward to the rapid developments of newer agencies such as airplanes. Nor is any spectacular development in sight for a form of transport so largely devoted to handling bulk commodities. While Florida fruits and vegetables may move by water to eastern markets, deckloads of automobiles be shipped on the Great Lakes and the Mississippi River, merchandise move freely from the Atlantic seaboard to Texas, and many other kinds of traffic obtain sufficient service as well as low rates by water, the general characteristics of water transportation are not speed and flexibility. Where port-to-port business in sufficient quantities is available, commerce will take to the water like the proverbial duck. When, however, it is necessary to gather freight at interior points, move it by rail or highway to a waterway, transfer it to a vessel and repeat the process at the other end, speed, flexibility, and even costs are unfavorable, although a certain amount of such business moves on lower than all-rail rates.[1]

Probably inland waterway traffic, both from its nature and the competition of other transportation agencies, will increase much slower than coastwise traffic. Business on the Great Lakes is almost as specialized as that of the pipe lines and has long been so well developed and so efficiently handled that no great fluctuations are probable.[1]

Pipe-line Transportation

The least conspicuous, the most efficient (within its limits), and the most successful economically of all present forms of freight transportation is the pipe line.

Operations of pipe lines in 1932, as reported to the Interstate Commerce Commission, show 93,000 miles of line, 83 million tons of oil originated, and a gross investment of 764 million dollars. The total of all petroleum pipe-line mileage is probably in excess of 115,000 miles, and these lines even through recent years have, as a whole, yielded a fair return on the investment—something that can be said of no other transportation agency.[2]

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[1] Ibid., p. 190.

[2] Ibid., p. 197. In July, 1941, under conditions of war in Europe, the Petroleum Coordinator, Harold L. Ickes, recommended extension of the pipe-line system from the West

California, Oklahoma, and Texas produce over 80 percent of our crude oil; east of the Mississippi River, where 70 percent of the population and the gasoline consumption is found, only 5 percent of our oil is produced. The solution of this has been forcing oil through 8-inch or 10-inch diameter lines of pipe, and this has been done with such efficiency that even waterways offer small competition save for such long hauls as from Texas Gulf ports to New York and Philadelphia. Less than 3 percent of the production of crude petroleum is handled by railroads, about 25 percent is moved coastwise, and the remaining seventy-odd percent travels by pipe line.[1]

The oil is pumped by Diesel engines taking their own fuel from the line, or by electric power. Steam equipment, which formerly predominated, is pretty well confined to the territory east of the Mississippi River and is a relatively minor factor. Oil moves through the lines at about 3 miles an hour, and at 325 barrels per mile of 8-inch pipe and about 500 barrels per mile of 10-inch pipe some 40 million barrels are stored underground and are practically as permanent an investment as the pipes themselves.[1]

It may be noted that in addition to this quasi-storage in the lines the pipe-line companies and their owners, the oil companies, have about 400 million barrels storage capacity. Most of this storage is incidental to the purchasing, marketing, blending, and refining of oil rather than to its transportation. No revolutionary developments in pipe lines are anticipated in the next 20 years, but the mileage of these lines is steadily and profitably increasing.

Exhaustion of oil supplies would, of course, upset the present pipe-line industry.[1]

Of petroleum products, however, only 3 percent or 4 percent moves

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to the East Coast because coastwise tankers were affected by shortage of ships and by disadvantages of ocean transportation. The recommendation seemed to forecast a development for increase of pipe-line transportation of crude petroleum and corresponding decrease of water transportation. The recommendation was not carried out at the time, because of prior claims upon the necessary steel and other materials for munitions. Subsequently approval was granted for a 24-inch pipe line from Texas to Norris City, Ill., and work was begun in August, 1942. In October the War Production Board announced approval of an extension across Indiana and Ohio to Phoenixville, Pa., with branch lines to Philadelphia and New York areas, and allocated 224,000 tons of steel. Plans called for a line 1,388 miles long, with 25 pumping stations. Capacity would be 300,000 barrels daily. The entire extension would be financed by the federal government through the Defense Plant Corporation, and supervised by the War Emergency Pipe Line, Inc., a company organized by the oil industry. The new line, known as "Big Inch," was completed in July, 1943.

[1]Ibid., p. 197.

by pipe line, the balance being fairly well divided between the railroads and the waterways.[1]

In the main, . . . the petroleum and gasoline pipe lines are plant facilities of the oil companies, and their development in the next 20 years will depend upon the development of the petroleum industry itself. Within their own relatively narrow field of transportation, pipe lines have a virtual monopoly of the crude oil business and will obtain an increasing share of the gasoline traffic. Their seemingly impregnable competitive position, however, arises from their ability to render a specialized transportation service more cheaply and efficiently than any other agency.[2]

Air Transportation

In the year 1926, 5,800 passengers were carried in the course of regularly scheduled air transport operations in the United States; our airlines are now [prior to June, 1937] handling over 100,000 passengers per month.[3]

Unlike railroads, which have to own and maintain their lines and terminals, the transport airplane to a large degree depends upon Federal aids to air navigation and, of course, on the aid of cities for terminals.[4]

As to the future[5] the aircraft manufacturers and operators, who in the past have experienced extreme difficulty in looking ahead as much as 3 years, are naturally hesitant.

To date the factor of obsolescence has been disproportionately large from a commercial standpoint; ships have been changed about every 3 years in response to increasing demands for higher speeds, better accommodations, and larger carrying capacity. From this standpoint too rapid a development of planes would probably be unfortunate—no transportation agency can long stand a 2½ percent per month depreciation on its fixed capital.

It should be borne in mind that from the standpoint of physical depreciation alone the modern transport plane probably has a life of 8 or 10 years, subject to ordinary maintenance and the replacement of its engines generally after every 3,000 or 4,000 hours of flying.[6]

The social implications of air transport of the future differ in degree

[1]Ibid., p. 197. [2]Ibid., pp. 197-198. [3]Ibid., p. 198. [4]Ibid., p. 199.

[5]The report cited here was written before the war in Europe began, with its heavy demands upon the aviation industry in the United States. The "future" of this industry will apparently be profoundly affected by production for war.

[6]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 200.

rather than in kind from what we have today. High-speed trains and automobiles have long ago rendered county and state lines meaningless, have widened trade territories, and brought once distant regions close together. Air transport does not change, but intensifies these effects.[1]

The effect of aviation on employment will be beneficial. The construction, operation and maintenance of aircraft, their high obsolescence and comparatively short physical life, are favorable employment factors by any railroad standards. More important is the fact that passenger traffic, unlike freight, can be created. The probability is that far more traffic will be created by aviation than is diverted from other transportation agencies.[2]

Urban Transportation

City transportation of passengers, at one time almost altogether handled by electric street railways, has more and more drifted to the motorbus and the private automobile.[2]

The future of urban transportation seems unusually obscure. Probably this is because the trends of all urban development—particularly in the larger metropolitan areas—are uncertain.[2]

The National Resources Committee in their "Studies of Urbanism" are making an exhaustive analysis of mass transit facilities and their effects on the internal development of urban communities and regions. They are considering not only the different forms of urban transportation, the effects which the internal organization of urban communities has on the use of city transit, but also the possible modifications in transit and traffic practices and policies advisable in furthering healthy urban and regional growth. This work when completed should shed a good deal of light on a decidedly dark subject.[2]

The construction of subways depends on concentration and density of population—that is to say, the geography of each individual city. Manhattan, a long, relatively narrow island, where millions of people must be transported in and out of a comparatively small area daily, could not function without subways. Cities where the population is spread over wide areas, as in Detroit or St. Louis, present a totally different problem, making subway construction unlikely.[2]

Because it does not have to provide its own right-of-way, the bus is well adapted to operate with the utmost economy in light-traffic

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," p. 203.

[2]Ibid., p. 204.

areas. Busses also can be economically built in a wider range of sizes than streetcars, providing a desirable flexibility of services; the small bus to some degree makes up in speed and frequency of service what it loses in passenger capacity. . . . In periods of temporary traffic interruption occasioned by accidents, fires, broken water mains, and other hazards of metropolitan life, busses may readily be detoured. From the standpoint of the individual passenger, bus stops at the curb are far more convenient than streetcar stops in the middle of wide boulevards full of rapidly driven automobiles. Not only from the disabilities of the street railway but from these definite superiorities of busses, the latter should gradually gain on the "trolleys."[1]

Summary and Outlook for Transportation

We have a great and highly efficient transportation system today, the social effects of which are plain to all of us. This system is constantly being improved in speed, comfort, flexibility, and in lowered cost, but this progress is in degree rather than in kind. We are improving a wonderful machine. We are readjusting the machine to handle a freight traffic consisting more largely of consumer goods and relatively less of capital goods than in the past, and to serve the rapidly increasing passenger traffic of a surprisingly nomadic society.[2]

Within the transportation industry itself the social prospects for the future are good. The internal shifts will probably be toward types of service employing relatively more operating personnel per traffic unit than the business of the past has required.[2]

Probably three-quarters of our million railway employees are engaged in a freight service handling 236 billion ton-miles annually; motortrucks, according to the Automobile Manufacturers' Association, employ 2½ million drivers alone to handle 10 or 15 percent as much business. This indicates that motortrucks furnish 20 or 30 times as much employment per ton-mile as do railroads. While the figures are not completely accurate . . . nor the statement of the case entirely fair owing to the somewhat different nature of the traffic, so wide a difference may be liberally discounted without impairing the validity of what it implies.[2]

Similarly, air traffic, which will increase at a higher rate than other forms of transportation, is a liberal employer of high-class personnel.[2]

One transportation agency . . . is part and parcel of our daily life—

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[1]Ibid., p. 205. [2]Ibid., p. 206.

the highway and the motor vehicles that use it.[1] It is unnecessary to attempt to catalog the obvious influences of motor transportation ranging from its evil effects upon the hammock business through the many conveniences, the different kinds of usefulness, the broadening recreational opportunities, the recasting of the pattern of farm life, and so on to the vision (or nightmare) of half our population living in trailers. Even the slightest reflection as to how elimination of all motor vehicles would affect us would produce a picture quite as appalling as those drawn of a world without electric power. That the world managed to get along without the "high line" and the motorcar until quite recently (in 1895 four automobiles were registered in the United States) is perhaps beside the point. From the fact that the ordinary automobile owner will surrender almost any of his possessions and make material sacrifices in his way of living, if only he can hang on to his car, we may infer how largely highway transportation bulks directly in our lives.[2]

Whether trailers come under the head of housing or transportation may be debatable. That this is a rapidly growing industry of large possibilities and wide social implications, however, is beyond argument. Probably 50,000 tourist-type trailers were manufactured in 1936 and production is notoriously far below the demand.[3]

Whether, as Mr. Babson is credited with saying, half of the population of the United States will be living in trailers within the next 15 or 20 years, or whether the trailer is mostly a substitute for a cabin at a tourist camp, an auxiliary service for our motoring population, the tourist trailer undoubtedly answers a great many demands both for mobile residences not affixed to real estate, and for cheaper and more comfortable travel.[3]

As to the part transportation plays in our civilization, . . . two quite modern and still rapidly developing influences should . . . be noted. First is the improved quality of freight and passenger service, particularly in speed and reliability. The producer, the manufacturer, the merchant, the public utility, or the individual is getting a freight service measured in hours instead of days, and in days instead of

[1]Experience in occupied countries of Europe, and later in the United States, during wartime is demonstrating the way in which this "part and parcel of our daily life" may suddenly be withdrawn, with consequences calling for a contraction in exchange and communication. The experience makes all the more evident the change which the introduction of the motor has made in increased facilities for trade and travel.

[2]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," pp. 206-207.

[3]Ibid., p. 183.

weeks, even as compared with 15 or 20 years ago. With this increased speed has come greatly increased reliability, and the influences of both have been profound.

Inventories need only be sufficient for a few weeks, where months were formerly necessary; goods are in transit a few days instead of a matter of weeks; a tremendous amount of capital formerly locked up in these items is now released. Investment of capital in storage facilities may be diminished; the cumulative processes of converting raw materials into finished goods are steadily being speeded up. Carrying less stock, stores become decreasingly vulnerable to changes in styles and to whims of public fancy; with less money tied up in their inventories, manufacturers are more ready to modify their products to suit changing demands.

Improved service affects the transportation industry itself by requiring less equipment. . . . Increased speeds in passenger transportation permit much broader and more intensive solicitation and servicing in a business way, and a greatly increased range of recreational and semi-recreational travel.

The second great development in transportation in recent years has been the increasing ability of the individual to supply his own freight and passenger service, and to some degree render himself independent of common carriers.

The overwhelming bulk of passenger transportation is already an individual matter—the private automobile dominates the field both in business and pleasure travel.[1]

Probably about 85 percent of the motortrucks are privately owned and operated, and the total volume of freight handled by trucks is increasing more rapidly than the business handled by railroads or waterways.[1]

The present freight rate structure will be materially modified through the trucks' influences on pickup and delivery service, packing requirements, more liberal classification of freight, and the level of the charges themselves being based, to an increasing degree, on cost of service. Ordinarily lower freight rates widen trade territories and intensify competition rather than increase the volume of business. More ton-miles may be produced, but with a narrower margin of profit.[1]

Whether or not lower freight rates mean much on any specific commodity is immaterial; transportation costs in the aggregate are a large element in the costs of our material civilization. Anything

[1]Ibid., p. 207.

reducing this element, provided it allows a fair living to the transportation agencies themselves, is plainly beneficial.[1]

We have a transportation system made up of widely diverse agencies. Some of them are closely related and furnish comparable competitive service—for instance, railroad and highway transportation. Others in the nature of things can be neither competitive nor cooperative—the transport plane and the pipe line are the best examples.

Mississippi River vessels compete with railroads on freight, but not on passenger business. The pipe line has virtually driven the railroad out of hauling crude petroleum, but today offers no competition on other commodities save gasoline. The bulk of freight transportation is performed by common carriers. The privately owned motorcar dominates the passenger field.[2]

The difficulties and the magnitude of transportation problems do not preclude the possibility of beneficial and effective coordination and regulation.[2]

Probably regulation of transportation in the future will be needed more for coordination and the prevention of unfair competition than to bring about reductions in rates.[2]

Nor are the problems of transportation static—the movement of freight and passengers is in a constant state of flux, shifting with changes in agriculture, industry, trends of population, and all the multifarious factors of our modern civilization.[2]

One of these factors might, in conclusion, receive some special emphasis. It is the factor of migration.[3] The purposes of travel which give rise to transportation are not only to serve the needs of business nor to express a mere urge to roam. Deeper than these is the immediate quest for livelihood, greatly accentuated today by our increasing insecurity. The truck and trailer may be the shelter of those unable to pay either rent or carfare, providing both home and transportation for the family obliged to move about as "migrant labor." This forced migration of labor is an accusing

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 3, "Transportation," pp. 207-208.

[2]Ibid., p. 208.

[3]For full information on migration and its consequences, see the public hearings, 1940-1941, and final report, April, 1941, of the House of Representatives Committee Investigating the Interstate Migration of Destitute Citizens. This material has been used as the basis for Collins, Henry Hill, Jr., America's Own Refugees: Our 4,000,000 Homeless Migrants. Princeton University Press, Princeton. New Jersey, 1941.

symptom of our times. Its existence confirms our present lack of social adjustment to an ever-increasing technical ability to produce both for human security and for creative living.

COMMUNICATION

One of the most important reasons for the progressive widening of the individual human being's perception of the world around him has been the tremendous growth in communications during the last half century.[1]

The most important communication developments of modern times are the telephone, telegraph, and radio. Important adjuncts to these developments are the vacuum tube, facsimile, television, devices which permit multiplex communication over single carriers, and modern methods of printing and photography.[2]

When one adds to aural broadcasting the ability to see and to record permanently what one has seen and heard, there will have been attained a perfection in communications which will certainly have the most profound effect upon our social and economic life.[2]

Adjustments will have to be made to accommodate the rapid changes in the panorama of the future as compared with that of today. With the ability to see and hear from persons at a distance when one is traveling by airplane, automobile, or steamship, as well as when one remains at home, or as one conducts business in an office or works in a factory, it appears inevitable that the mental processes of the future must be such as to produce an entirely different outlook than exists under circumstances when one's vision, horizon, and social contact are limited.[3]

It also may be expected that these new developments will speed up ordinary life and business, and will affect certain existing industries, such as the motion picture, the newspaper, advertising, and the existing telegraph, telephone, and radio systems of the country. The effect of these developments upon the industry and their consequent effect upon commercial activities in every walk of business life, requires modifications of economic views which exist today.[3]

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[1]National Resources Committee, Technological Trends and National Policy, Part 3, sec. 4, "Communications," by T. A. M. Craven, chief engineer, Federal Communications Commission, and a committee of the Commission's Engineering Department, composed of E. K. Jett, A. D. Ring, John J. Hassler, and Gerald C. Cross, who wrote the section on "Communication by Wire and Wireless"; and A. E. Giegengack, Public Printer, who wrote the section on "Printing and Photography," p. 211.

[2]Ibid., p. 210.

[3]Ibid., p. 211.

Whether or not these new developments will permit more leisure and greater profits will depend entirely upon the control which the public places upon such new developments, particularly as to the organization and methods of making these wonderful facilities available for use by the public at the cheapest cost. In consideration of this factor alone, one must take into account the economic limitations which will be involved in the rapid obsolescence of present-day communication facilities.[1]

It is considered by many that the application of these modern communication facilities will not result in a decrease in employment, but rather in an increase in employment. However, such employment will tend toward those who are qualified scientifically rather than those who are qualified manually.[1]

An accurate estimate of the effect of the growth of broadcasting on related industries is difficult as it has affected many industries. It has provided a new field for many already established electrical manufacturers and for the establishment of other manufacturing industries for the production of radio transmitters, receivers, tubes, and associated equipment. Broadcasting has produced a new group of retail organizations which employ salesmen and technicians for the purpose of selling and servicing receivers. There are, in addition, many independent technicians who gain a livelihood through the servicing of receivers. Broadcasting has provided a new field of employment in the operation of the physical equipment and the preparation and presentation of programs for broadcast stations.[2]

It is believed that the greatest service which communications can do in the future will be to provide extensions into the hitherto remote and inaccessible places whereby people who formerly had no means of communication can be connected with the communication arteries of the world.[3]

Looking back to Kipling's statement, quoted at the opening of this chapter, that transportation—and hence communication—"is civilization," at no time, certainly, has it been more difficult to affirm this thought. For it is exactly modern transportation, particularly air navigation and up-to-date communication, which enable the peoples of the earth to fight a global war. Such development is a demonstration that science and invention do not necessarily and of themselves ameliorate man's condition or add to life's hap-

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[1]Ibid., p. 211. [2]Ibid., p. 226. [3]Ibid., p. 233.

piness. Nevertheless, since the same technology increasingly produces the powers both of world-wide construction and of global destruction, man's opportunity to build a progressively evolving civilization remains at all times a practical reality.

PART TWO

LABOR REQUIREMENTS AND EMPLOYMENT OPPORTUNITIES UNDER THE IMPACT OF TECHNOLOGICAL CHANGE

Chapter VI

Changing Labor Requirements and Increasing Productivity in Manufacturing

THE vast and complicated apparatus of the new technology in the basic industries, as described in preceding chapters, is merely preparatory to the making and marketing of goods for the use of the nation's population. Practically all the output of agriculture, mining, and metallurgy undergoes a process of preparation or transformation for the consumer. This preparation or transformation constitutes manufacturing. Manufactures represent a stage in the process of production, not an independent branch of industry. Within manufacturing itself, moreover, after a stage is completed, the resulting output may in turn become materials for another stage, also included in manufactures, as when yarn manufactured from cotton is used in weaving cloth, and in turn the cloth is used in the branch of manufacturing included in the making of clothing. It is in manufacturing that the output of the production system is made ready, stage by stage, for ultimate use by the consumer.

MANUFACTURING—BRIDGE BETWEEN PRODUCTION AND CONSUMPTION

Thus manufacturing fulfils a distinctive role in the system of production. It is the connecting link between the basic industries and the consumer. Manufacturing industries are directly responsive to expansion or contraction in consumption. Their demands upon raw materials, machinery, sources of power, and transportation are necessarily proportionate to the requirements of the people who buy the goods and use them in their daily lives. Manufactures and their rate of expansion or contraction may be described as barometers of consumption. They are also regulators of production in the basic industries, through the demands they make upon raw materials and sources of power. In turn, they serve the basic industries because they make all needed machinery and mechanical equipment, as well as the machine tools which make other machines.

Within manufacturing industry itself, processes have been changed by the same technological developments which have created new resources in primary production. No longer to be defined as "making by hand," "manufacturing," or, more appropriately, "fabrication," now uses modern techniques made possible by electricity and chemical processes which science has developed also in the basic industries. New processes create new products for the consumer. These new products, in turn, draw on a wide range of primary industries for their making. Steel, tin, aluminum, chromium, many new alloys, rubber, cotton and other agricultural products, and plastics have become so customary as to be almost indispensable in the making of such familiar necessaries of life as shelter, clothing, and household furnishings and equipment.

Manufactures may be analyzed according to the raw materials of which they are made, or the goods they fabricate. The census of manufactures taken biennially by the United States Bureau of the Census affords the basis for this analysis.[1] The "industry groups" are based primarily upon the materials used. Included in them, but also separately tabulated, are the much larger number of individual "industries," which take their names from their principal products. The industry groups in 1937 and the number of wage-earners employed, i.e., their labor requirements, are shown in Table 1.

The principal raw materials and related basic industries which determine the classification of these industry groups are readily discernible from their titles. For manufacturing or processing of textiles, food, forest products, and leather, the basic industries of agriculture and forestry provide the materials. To forestry also

[1]The census of manufactures differs from the census of occupations, which will be cited in Chapter VII, "Occupational Change and Employment Opportunities." The census of occupations, which is part of the census of population, is based on a house-to-house canvass in which either the individual or a member of his household is asked to give information concerning his occupation. The census of manufactures is based on visits to manufacturing establishments and on data drawn from payrolls and other records. Naturally there are some differences, due to differences in sources and the different naming of occupational groups. Moreover, certain mechanical industries which are classified with manufactures in the census of population are excluded from the census of manufactures. In the census of manufactures the count of numbers employed is the average on payrolls during the year, whereas the census of population records the occupation at the time of enumeration; this also gives rise to some difference between the two counts.

belong rubber products, though from countries other than our own. From plant life, soil, and air are derived the elements for manufacture of chemicals. Under the soil are petroleum and coal, and likewise the minerals and metals which are used for iron and steel and their products and for machinery and transportation equipment. Printing, publishing, and allied industries derive raw materials from another industry group, paper and allied products, which in turn depend primarily upon forestry, while stone, clay,

TABLE 1. INDUSTRY GROUPS IN MANUFACTURING, BY AVERAGE NUMBER OF WAGE-EARNERS DURING YEAR, 1937[a]

Rank in number of wage-earners	Industry group	Average number of wage-earners during year
1	Textiles and their products	1,814,387
2	Iron and steel and their products, not including machinery	1,166,287
3	Machinery, not including transportation equipment	955,975
4	Food and kindred products	888,298
5	Forest products	694,341
6	Transportation equipment, air, land, and water	623,845
7	Printing, publishing, and allied industries	353,108
8	Leather and its manufactures	331,955
9	Chemicals and allied products	314,520
10	Stone, clay, and glass products	300,278
11	Nonferrous metals and their products	270,327
12	Paper and allied products	264,455
13	Rubber products	129,818
14	Products of petroleum and coal	106,473
	Miscellaneous industries	355,164
	Total	8,569,231

[a]Bureau of the Census, U.S. Department of Commerce, Biennial Census of Manufactures: 1937. Government Printing Office, Washington, 1939, Part 1, p. 22.

and glass products use materials of the earth, applying processes associated with the contemporary technology. All use machinery, which is itself a product of manufacturing. Moreover, all require some form of energy or motive power, whether electricity or steam, while in varying degrees handwork appears, at least as auxiliary.

Thus manufacturing is intimately related to the basic industries of minerals and agriculture and to the primary productive forces. Finally, every manufacturing establishment is dependent in some degree on the basic industries for its equipment or services, relying upon the construction industry for its buildings, for the homes of its employes, and for its highways and roads; upon the transportation system to fetch its raw materials and to carry its products to market; and upon the communication system to connect it with producers and with buyers.

After thus viewing these industry groups in their relation to the basic industries, it is clarifying to change the point of view and to consider their role in service to the consumer. This role is clearly to transform the products of basic industries, which give the manufacturing groups their names, into the familiar necessaries of life, namely, food, shelter, clothing, and fuel. In such a consideration of the consumer it is important to note that the home and its heating and lighting are served not only by manufacturing, but directly also by the industries of construction and electrification, and more or less directly by mines and farms. Again directly related to the individual consumer are the services of transportation and communication which have become elements of ever-increasing importance in standards of living.

Labor Requirements in Manufacturing

Thus manufacturing represents the area within which new industries or new products are developed in whole or in part as a consequence of technological change and in response to consumer demand. An answer to the question as to how new technological developments affect employment may well be sought first in the changing labor requirements of manufactures. Statistically the question resolves itself into an inquiry regarding trends in numbers employed in all manufacturing industries, with special attention to those which make new products.

At first glance it would appear that old industry groups rank high, as for instance textiles and their products, including clothing; machinery; food and kindred products; and forest products, such as lumber, wooden furniture, and paper. Though iron and steel have great technological significance, they are not new. Their initial development was due to the revolution of steam in the nineteenth century, though they are profoundly affected by the new energy resources of the present. It may be clarifying to compare past and present and to note the industry groups of 1899 and the number of wage-earners they employed. While not strictly comparable as between the two censuses, the classifications are similar enough to indicate the general direction of change. Table 2 shows the rank of industry groups, according to number of wage-earners in 1899.

TABLE 2. INDUSTRY GROUPS IN MANUFACTURING, BY AVERAGE NUMBER OF WAGE-EARNERS DURING YEAR, 1899[a]

Rank in number of wage-earners	Industry group	Average number of wage-earners during year
1	Textiles	1,029,910
2	Iron and steel and their products	733,968
3	Hand trades	559,130
4	Lumber and its manufactures	546,953
5	Vehicles for land transportation	316,214
6	Food and kindred products	313,809
7	Paper and printing	297,551
8	Clay, glass, and stone products	244,987
9	Leather and its finished products	238,202
10	Metal and metal products, other than iron and steel	190,757
11	Tobacco	142,277
12	Chemicals and allied products	101,522
13	Liquors and beverages	63,072
14	Shipbuilding	46,781
	Miscellaneous industries	483,273
	Total	5,308,406

[a]U.S. Census Office, Twelfth Census of the United States: 1900, vol. 7, Manufactures, Part 1, United States by Industries, 1899, p. cxliv.

The industry groups of textiles and iron and steel have held their own as first and second, respectively, in 1937 as compared with 1899. It is an interesting coincidence that the third group in 1899 was hand trades,[1] while in 1937 the third place was held by machinery. Notable is the advance in the group of manufactures of food and kindred products from sixth place, employing somewhat over 300 thousand, to fourth place, employing 888 thousand in 1937. The inclusion in 1937 of those employed in the trade of liquors and beverages, while this constituted a separate group in 1899,

[1]"Hand trades" as a separate category appeared for the last time in the census of 1899, which covered "manufacturing and mechanical establishments." Thus, also, the earlier censuses up to and including 1899 grouped the building trades or construction with manufacturing. When the Bureau of the Census makes comparison of 1899 with subsequent years, as in the data to be quoted in Table 3, p. 154, hand trades are omitted. This accounts in part for the difference in totals for 1899 in Tables 2 and 3.

accounts only in part for the recent increase. The more important factor is the growth of food preparation and processing as a manufacturing industry removed both from agriculture and from the home. For the rest, it must be said that the mere naming of the groups of industries does not indicate the degree to which new products or new processes have created new labor requirements or displaced old skills. For this information it is necessary to examine the data for separate industries which are named for their products rather than predominantly for their raw materials, as are the industry groups.

CHANGE IN NUMBERS EMPLOYED IN PRINCIPAL MANUFACTURING INDUSTRIES

Eight industries employing 200,000 or more wage-earners in 1937 are compared in Table 3 with numbers employed in making the

TABLE 3. NUMBER OF WAGE-EARNERS IN MANUFACTURING INDUSTRIES EMPLOYING 200,000 OR MORE IN 1937, IN COMPARISON WITH NUMBERS EMPLOYED IN 1899[a]

Industry	Average number of wage-earners during year (in thousands)	
	1937	1899
Total manufacturing	8,584.1	4,495.9
Automobiles, including bodies and parts	479.3	2.2
Steel works and rolling-mill products	479.3	183.2
Cotton goods	422.3	297.9
Lumber and timber products	323.9	413.3
Printing and publishing—book and job, music, and periodical	276.6	163.8
Electrical machinery, apparatus, and supplies	260.2	42.1
Bread and other bakery products	239.4	60.2
Boots and shoes, other than rubber	215.4	141.8

[a]Source: Bureau of the Census, U.S. Department of Commerce, Biennial Census of Manufactures: 1937, Table 4, pp. 22–33, for list of largest industries in 1937; Fabricant, Solomon, Employment in Manufacturing, 1899–1939, National Bureau of Economic Research, New York, 1942, Table B-1, Average Number of Wage-Earners in Manufacturing Industries, pp. 182 ff., for adjusted comparable figures for 1937 and 1899.

same products in 1899. It must be realized that the change in classification of industries from census to census creates difficulties in such a comparison. Sometimes a minor product may be transferred from one group to another, or a product of considerable importance today may not have been separately listed in earlier censuses. The data suffice, however, to indicate main trends in growth in employment; differences in naming the same industries in the different censuses are ignored in the table.

Thus, as the table shows, employment in manufacturing as a whole in the years of development of the new technology increased from approximately 4½ to 8½ million. Practically all of this increase, however, had already occurred by 1919, when the average number of wage-earners employed during the year was a little over 8,400,000.[1] Apparently the total labor requirements in manufacturing by 1937[2] had not increased substantially since 1919. Yet this was exactly the period of the newly emerging productive forces as described in preceding chapters.[3]

Five of the eight major industries of 1937 were also major in number of wage-earners employed in 1899. Among the eight major industries ranking highest in number of wage-earners in 1937, the two with the greatest expansion in employment since 1899 were automobiles and electrical machinery, apparatus, and supplies. Both were products of the new technology. Extraordinary was the growth of employment in automobiles, from 2,200 in 1899 to 479,300 in 1937. In that year automobile workers exactly equaled the number of steel workers. Electrical machinery, apparatus, and supplies—characteristic products and instruments of advancing technology—increased employment more than sixfold, from 42,100 in 1899 to 260,200 in 1937.

[1]Bureau of the Census, U.S. Department of Commerce, Sixteenth Census of the United States: 1940, Manufactures, vol. 1, p. 20.

[2]The year 1937 as a base for comparison has the advantage of coinciding with the publication of the report of the National Resources Committee which has been the principal source of descriptions used in Part One, "The Nature of Technological Change in the Basic Industries." Moreover, studies of the business cycle have established the fact that 1937 and the decennial years from 1899 to 1929 were all comparatively prosperous, so that data may be assumed to measure normal change. (See, for example, for earlier years, Thorp, Willard Long, Business Annals (National Bureau of Economic Research, New York, 1926); and for 1929 and 1937, as well as for earlier periods, see indexes of industrial production and other business indicators published in Federal Reserve Bulletins and employment statistics currently issued by the Federal Bureau of Labor Statistics.) In the intervening years considerable fluctuations took place, but these are not the present subject of analysis, since they are related to recurrent depressions in business, rather than to expansion of new industries through changing technology.

[3]To what extent increases prior to 1919 corresponded with increases in number of workers available for employment, due to growth in population, will be analyzed in Chapter VII, "Occupational Change and Employment Opportunities." In that chapter it will be found that the occupational group entitled "manufacturing and mechanical pursuits," which is more inclusive than manufacturing alone, increased in both periods more than any of the basic industries, but less since 1899 than before.

The next largest increase within these four decades was in the manufacture of bread and other bakery products, which gave employment to 60,200 in 1899 and to 239,400 in 1937. Doubtless a considerable part of this increase was due to removal of baking from homes to factories, rather than a proportionate expansion in production of that very old necessity of life—bread. Comparison with another old industry—cotton textiles—is interesting, in that employment had increased much less than in manufacturing as a whole in 1937 as compared with 1899, owing perhaps to the fact that removal of cotton-textile making from home to factory had occurred more than a century earlier. Table 1 has already shown that textiles and related products, among which cotton goods are of principal importance, ranked first among the industry groups in employment in 1937, with more than the number of workers required by the two industry groups of machinery and transportation equipment, including automobiles. Certainly the old industry of textiles cannot be overlooked in an examination of present labor requirements.

The automobile is not the only new product of manufacturing. The National Resources Committee has pointed out that

> six industries based on the telephone, the automobile, the airplane, the motion picture, rayon, and the radio represent great accumulations of capital and give employment to millions, besides having had social influences so vast in number and extent as to be impossible to calculate.[1]

By 1937 these industries, which, with the exception of automobiles, were not even mentioned in 1899, had their established place in the United States census of manufactures, with motor vehicles, including bodies and parts, employing 479,341 and the other new products mentioned trailing behind in numbers employed: the airplane, designated as "aircraft and parts," ranking seventy-ninth and employing 24,003; rayon broadwoven goods, thirty-sixth, with 57,949 wage-earners, and rayon and allied products, thirty-ninth, with 55,098 employed; and radio manufacture ranking forty-fourth, employing 48,343; the telephone was not listed as a separate indus-

[1] National Resources Committee, Technological Trends and National Policy, Part 1, sec. 1, "National Policy and Technology," by William F. Ogburn, professor of sociology, University of Chicago. Government Printing Office, Washington, 1937, p. 5.

try, but was included in "electrical machinery, apparatus, and supplies."[1] Omitting for the moment consideration of automobiles, the figures suffice to show the comparative unimportance of the newest products as measured by numbers required in making them, however important may be their total influence on employment through the ramifications of their requirements for raw materials and their potentialities for changing habits and conditions of life.

The war has had the twofold influence of restricting the use of the automobile and of giving new prominence and extraordinary expansion to manufacture of airplanes.[2] In the last war it was the motor vehicle and its uses in battle which claimed first attention of those responsible for war industries. The airplane was only in its beginnings. In 1914, makers of airplanes employed 168 wage-earners. (It is, incidentally, not without humor to note that 588 were employed in making horseshoes, not counting their manufacture in steel works.)[3] The air force in our military establishment was not yet created. In the present war airplanes have come to rank with ships and tanks as primary in equipment. To what extent the expanded aviation industry will be used in times of peace is a question of first-rate importance in postwar economic development.

AUTOMOBILE—TYPICAL NEW PRODUCT

In the postwar period of the 1920's it was the automobile which profoundly influenced the production system. Its influence is much greater than the figures of numbers employed in its manufacture, already cited, would indicate.

The automobile was made possible by metallurgy, with its new ability to transform metals and create new materials; by new types of engines; by the petroleum industry and its products—thus by technology centering in electric power. In turn, the manufacture of automobiles utilizes practically all the basic industries. Ore must

[1] Bureau of the Census, U.S. Department of Commerce, Biennial Census of Manufactures: 1937, Part 1. pp. 34 ff.

[2] The recent growth of airplane manufacture, even before the war, is indicated by the industry's rise to thirty-sixth place in 1939, employing 48,637. (Bureau of the Census, U.S. Department of Commerce, Biennial Census of Manufactures: 1939, Relative Importance of Leading Industries, for the United States. Preliminary report, February 5, 1941.)

[3] Bureau of the Census, U.S. Department of Commerce, Abstract of the Census of Manufactures, 1914, Table 210, pp. 466, 470 (for airplanes and horseshoes, respectively).

be brought from the mines, and cotton raised on farms. Iron and steel, zinc, aluminum, nickel, nickel-steel, copper, tin, tungsten, and magnesium are all required. Rubber must be grown in other countries for American industry, or made synthetically at home. Highways and bridges have to be built. All materials and completed products must be transported. The workers congregated in centers of automobile manufacture need to be supplied with consumers' goods and services.

Thus the half million wage-earners employed in making automobiles and their parts do not represent the total requirements for labor to be credited to this new product. One of the industry's statisticians has estimated that automotive transportation, including direct manufacture as well as contributory materials and services, employed perhaps

> close to 8,000,000 or about one-sixth of the gainfully employed. Probably not more than 3,000,000 of these have been taken from the ranks of the railroad employees, the carriage makers and the harness makers. That leaves about 5,000,000 extra jobs created by the advent of the automobile.[1]

This conclusion was based upon consideration of the wide ramifications of automotive transportation. Connected with motor transportation are not only makers of automobiles, but workers in rubber-tire factories and in garages, automobile dealers, and oil and gas-well operatives. In addition, to keep a car running requires repairs, gasoline, oil, tires, license fee, batteries, and the like, thus giving employment to workmen on highways, filling-station attendants, and workers in oil fields. Finally, truck and bus drivers are needed. Altogether, it appears that the automobile and all the services connected with it, together with its manufacture, employ millions.

Because of such considerations, the automobile industry has become the classic example to refute the widespread impression that technological change displaces workers and causes unemployment without compensating expansion. The truth, however, seems to lie deeper. For, as Table 3 plainly shows, if for the moment manufacturing alone be considered, total figures for employment in all

[1] Scoville, John, Statistician, Chrysler Corporation, "Behavior of the Automobile Industry in Depression." Address delivered before Econometric Society, New York, December 30, 1935, p. 25.

manufacturing trades combined do not indicate such great expansion in labor requirements to the level concerning which these large estimates for the automobile alone are given. Yet the period covered, from 1899 to 1937, was precisely the time of growth of the automobile industry. Moreover, within the automobile industry labor requirements have changed year by year in response to changes in processes and methods of work, and these changing labor requirements slacken the rate of growth in employment which might otherwise accompany expansion of the market. The assembly line, for instance, with its specialization of tasks and accelerated output, is but one illustration of an increase in productivity whereby actual volume of production increases faster than total employment. This alteration in the relation between volume of production and labor requirements, which results from increasing labor productivity, is the deeper truth concerning the influence of technology on employment. Change in labor productivity has a more lasting influence on livelihood than mere displacement from old jobs or expansion of new industries.

Increasing Labor Productivity in Manufacturing

As labor productivity, that is, average output per worker, increases, expanding production outstrips requirements for labor. *The need for workers may even decline while volume of production expands.* This is the real significance of so-called technological unemployment, as distinct from unemployment caused by depression in business.

Concerning expansion of the automobile industry and increase in labor productivity, with resultant decline in labor required per unit of product, an impressive statement was given in an advance summary of a report by the National Bureau of Economic Research, issued in December, 1941. In 1937, as compared with 1899, requirements for labor per unit of product had declined 88 per cent,[1] that is, for 100 wage-earners employed for a given output of automobiles in 1899, 12 did the work in 1937. The enormous change was indicated by an index of 180,000 for physical output in 1937, as compared

[1]Fabricant, Solomon, The Relation Between Factory Employment and Output Since 1899. Occasional Paper 4. National Bureau of Economic Research, New York, December, 1941, p. 9.

with 100 in 1899; and an index of 21,300 for number of wage-earners employed. It was in the automobile industry that "jobs per unit of product fell most precipitately," while "this industry is to be credited also with the largest expansion in both total employment and output."[1]

For the total of all manufacturing industries included in the study, "labor per unit of product was cut in half. The processed goods turned out in 1899 required 5 million factory workers; in 1937 four times the goods were produced by only twice as many factory workers."[2] Physical output for manufacturing as a whole had increased more than fourfold by 1940 (with an index of 429 as compared with 100 in 1899, and with 376 in 1937);[3] while the total number of wage-earners had increased not quite twofold, with an index of only 190 in 1940, as compared with 100 in 1899. The report points out that in appraising these changes improvement in quality must also be considered, together with far-reaching changes in manufacturing techniques and materials, all of which are factors in changing labor requirements.

In a series showing the changing relation of production to labor requirements in manufacturing in the decennial years from 1899 to 1929, as compared with 1937, the census takes over the data on production of the National Bureau of Economic Research. (See Table 4.)

Most significant is the fact that *increase in production outruns the rate of increase both of population and of workers employed.* While population increased in proportion to an index of 100 in 1899, rising to 172 in 1937; the 1937 index for number of wage-earners was 194, as compared with an increase in production represented by an index of 376. In other words, between 1899 and 1937 the output of manufacturing industries was multiplied by three and three quarters, while wage-earners increased about twofold, and population by 72 per cent. In 1939, wage-earners and pro-

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[1]Ibid., p. 20. For the basic figures on physical output used in this study, see Fabricant, Solomon, The Output of Manufacturing Industries, 1899-1937. National Bureau of Economic Research, New York, 1940. Since the completion of this manuscript, the final study forecast in Occasional Paper 4 has been published: Fabricant, Solomon, Employment in Manufacturing, 1899-1939: An Analysis of Its Relation to the Volume of Production, National Bureau of Economic Research, New York, 1942.

[2]Ibid., p. 6. [3]Ibid., p. 37.

TABLE 4. INDEXES FOR POPULATION, WAGE-EARNERS, AND PRODUCTION, 1899-1939[a]

Census year	Population	Wage-earners	Production (quantity)[b]	Production per wage-earner
1899	100	100	100	100
1904	110	115	124	108
1909	121	139	158	114
1914	131	147	186	127
1919	140	191	222	116
1921	145	147	194	132
1923	149	186	280	151
1925	154	178	298	167
1927	158	178	317	178
1929	162	190	364	192
1931	166	140	262	187
1933	168	131	228	174
1935	170	163	301	185
1937	172[c]	194	376	194
1939	175	187	373	199

[a]Bureau of the Census, U.S. Department of Commerce, Sixteenth Census of the United States: 1940, Manufactures, 1939, vol. 1, Statistics by Subject, p. 20.
[b]The index of physical output is that computed by Dr. Solomon Fabricant for the National Bureau of Economic Research.
[c]Revised.

duction declined slightly, in comparison with 1937, but production per wage-earner increased.

Notable, in the light of earlier references to the change around 1923 in the basic industries,[1] is the indication that a new high level of production was attained in that year, with a very much smaller increase in number of wage-earners in relation to increase in production as compared with 1921. Moreover, the volume of pro-

[1]Indications that this fundamental change was due to the spread of electrification and of its consequences are contained in statistics of increase in electric motors as compared with decrease in prime movers using steam in the years 1919, 1923, 1925, and 1927. Both in number of motors and in horsepower, electricity was progressively substituted for steam in that period. In round numbers the horsepower of electric motors used in manufacturing establishments increased from 16 million horsepower in 1919 to 22 million in 1923, and to 30 million in 1927, while horsepower from steam engines decreased from 14 million in 1919 to 10 million in 1927, with an increase, however, in horsepower from steam turbines, from 3 million in 1919 to 7 million in 1927. (Bureau of the Census, U.S. Department of Commerce, Biennial Census of Manufactures: 1927. Government Printing Office, Washington, p. 1270.) How great was the change by 1927, as compared with 1899, is indicated by the fact that in that year, of the total power used in manufactures, steam engines furnished 8,742,416 horsepower, or 77.4 per cent, while electric motors furnished 311,016 horsepower, or 2.7 per cent, with the remainder coming from such prime movers as water wheels, gas and gasoline engines, and other mechanical power. (U.S. Census Office, Twelfth Census of the United States: 1900, vol. 7, Manufactures, Part 1, p. cccxv.)

duction reached in 1919 was achieved with a labor force actually larger than that employed four years later with a considerably increased output.

This significant change has been amplified and interpreted in several other studies by the National Bureau of Economic Research. Concerning relations between employment and production in the important period of 1919-1929, Frederick C. Mills wrote as follows:

> Advancing productivity was, of course, a conspicuous feature of the last decade. From 1919 to 1929 output per worker employed increased . . . among the industries in the present sample . . . at an average annual rate . . . substantially greater than the corresponding figure . . . for the fifteen-year period from 1899 to 1914, which itself represents a notable advance in productive efficiency.[1]
>
> If we carry this story back thirty years by census periods we note the highly suggestive fact that not once has there been a check to the increase in per capita productivity. The rate of advance has varied greatly, but the tendency toward increasing productive efficiency has persisted, in good years and bad. *In general, however, the chief factor in expanding production prior to 1923 was an enlarged body of wage-earners.* This was true during the great advances from 1904 to 1909, from 1914 to 1919, from 1921 to 1923. *Since 1923, however, better technical equipment, improved organization and enhanced skill on the part of the working force seem definitely to have supplanted numbers as instruments of expanding production.* The persistence of this tendency must compel men to consider its implications for the future.[2]

These trends in the years around 1923 had already been mentioned in the census of 1927. While the figures to be quoted are not identical with those of Table 4, they are used as given in the census of 1927 because of the introduction in that census of data

[1]Mills, Frederick C., Economic Tendencies in the United States: Aspects of Pre-War and Post-War Changes. National Bureau of Economic Research, in co-operation with Committee on Recent Economic Changes, New York, 1932, pp. 290-291. Not all industries covered in the census were included in this study. The sample of 35 industries actually represented 40.9 per cent of the total value of all manufactures in 1899, and 39.2 per cent in 1914. (Ibid., p. 26. For list of the 35 industries, see p. 30.) The actual figures are not quoted here, because they give place to the longer indexes subsequently developed by the National Bureau of Economic Research and quoted from the Bureau of the Census in our Table 4, p. 161. While Professor Mills' earlier data understated the situation, as compared with the longer series, his contemporary interpretation remains true in the light of subsequent analyses.

[2]Ibid., p. 291. Emphasis ours.

for comparison on number of establishments and total annual payrolls. In general, the change in relationships as shown in the earlier computations is simply confirmed, with considerable amplification, in the more recent analyses. According to the census of 1927, between 1921 and 1923, during two years of revival from depression, volume of output in manufacturing rose 53.7 per cent. In the two preceding years, between 1919 and 1921, the decrease had been 20.6 per cent, thus showing in 1923 a remarkable capacity for recovery toward a higher level than had preceded the depression of 1921. By 1925, as compared with 1923, physical output had increased by 3.4 per cent, while number of establishments decreased 4.6 per cent, number of wage-earners declined 4.5 per cent, and total annual payrolls diminished by 2.5 per cent. These figures need to be read against the background of the whole period from 1914 to 1927, when physical output in manufacturing industries expanded to the extraordinary degree represented by a percentage of 60.5. To the facts concerning the decreases in employment and total payrolls between 1923 and 1925 should be added the information that during those two years value of products increased 3.5 per cent; value added by manufacture, 3.6 per cent; and cost of materials, supplies, fuel, and power, 3.5 per cent.[1]

During four decades, as shown in Table 4, productivity per worker has steadily increased, but at no time have wage-earners been free from the fear of unemployment accompanying the so-called business cycle. These depressions have recurred at more or less regular intervals throughout the whole history of the United States.

Recurrent Fluctuations in Manufacturing

While 1932 was the most depressed year in the period of unusually severe depression beginning in October, 1929, it was only one of the many recessions in business and employment which have recurred at shorter or longer intervals in the whole period of modern

[1]Bureau of the Census, U.S. Department of Commerce, Biennial Census of Manufactures: 1927, pp. 13-15. The statistics are quoted exactly from the source indicated, but do not check precisely with Table 4, because, as indicated there, a different index of production, quoted from the National Bureau of Economic Research, was presented in the manufacturing census of 1939 as compared with earlier censuses. The new index was designed to give full weight to the newer products of recent years.

industry. In the course of recovery from 1933 to 1937 output increased faster than employment (as shown in Table 4), thus demonstrating again the increase, already noted, in labor productivity. In 1938 another recession began, from which revival was accelerated in 1939 by demands for war production. An indication of repeated fluctuations in employment is shown in Table 5, which combines

TABLE 5. INDEXES OF VOLUME OF PRODUCTION AND OF FACTORY EMPLOYMENT AND PAYROLLS IN MANUFACTURING, 1919-1939[a]

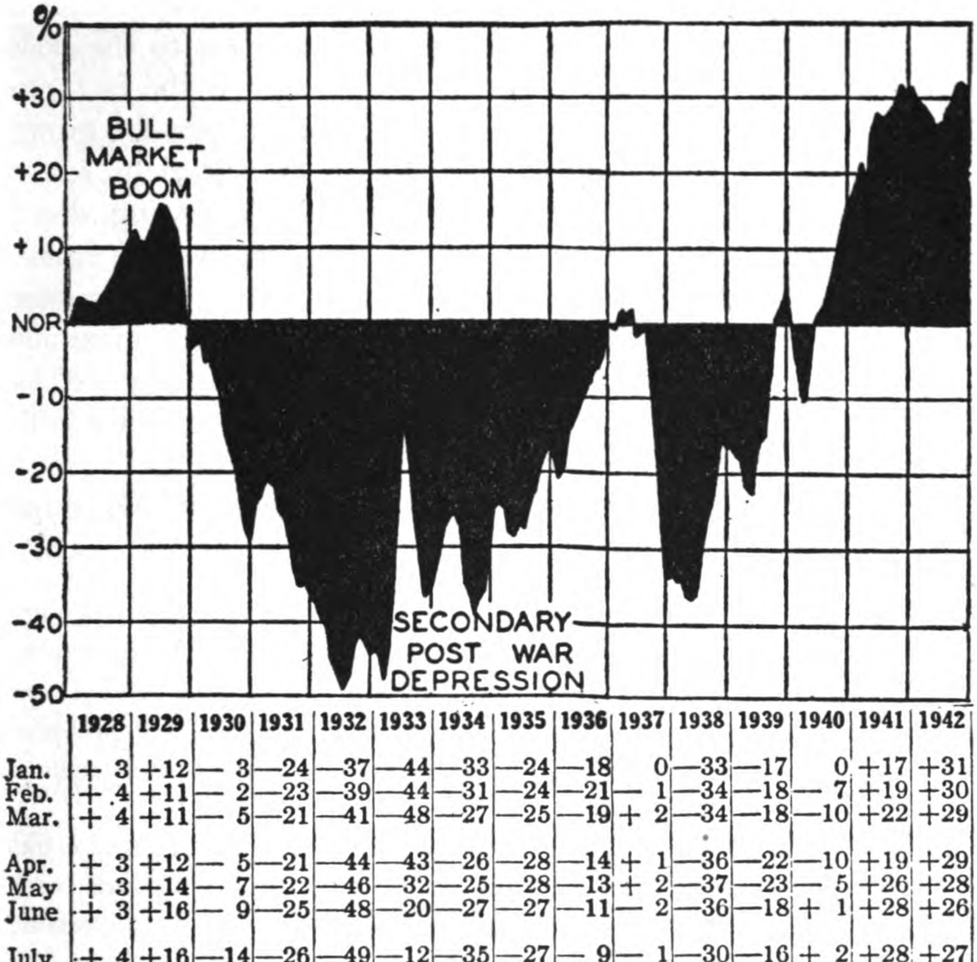
Year	Index[b]		
	Volume of production[c]	Factory employment	Factory payrolls
1919	84	107	98
1920	87	107	117
1921	67	82	76
1922	86	91	81
1923	101	104	103
1924	94	96	96
1925	105	100	101
1926	108	102	104
1927	106	100	102
1928	112	100	104
1929	119	106	110
1930	95	92	89
1931	80	78	68
1932	63	66	47
1933	75	73	50
1934	78	86	65
1935	90	91	74
1936	105	99	86
1937	109	109	103
1938	84	90	78
1939	105	97	91

[a]Federal Reserve Bulletin, July, 1940, p. 707.
[b]Index numbers are based on the average for 1923–1925 as 100.
[c]Includes manufacturing industries only. In the summer of 1940 the index was revised to give more weight to newly developing industries, and thus to make it more truly representative of changed conditions since it was formulated in 1927. The earlier index is used in this table. It errs on the side of belittling the effects of the new technology on production, but is probably satisfactory as indicating date and direction of change, though not its intensity.

the production index of the Federal Reserve Board with corresponding data on trends in employment and in factory payrolls gathered by the Bureau of Labor Statistics.

Though production, as shown in Table 4, had expanded from 222 in 1919 to the maximum volume of 376 in 1937, the high level once reached has never been continuously sustained. In the twenty-

FLUCTUATIONS IN INDUSTRIAL PRODUCTION 1928-1942



	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
Jan.	+ 3	+12	— 3	—24	—37	—44	—33	—24	—18	0	—33	—17	0	+17	+31
Feb.	+ 4	+11	— 2	—23	—39	—44	—31	—24	—21	— 1	—34	—18	— 7	+19	+30
Mar.	+ 4	+11	— 5	—21	—41	—48	—27	—25	—19	+ 2	—34	—18	—10	+22	+29
Apr.	+ 3	+12	— 5	—21	—44	—43	—26	—28	—14	+ 1	—36	—22	—10	+19	+29
May	+ 3	+14	— 7	—22	—46	—32	—25	—28	—13	+ 2	—37	—23	— 5	+26	+28
June	+ 3	+16	— 9	—25	—48	—20	—27	—27	—11	— 2	—36	—18	+ 1	+28	+26
July	+ 4	+16	—14	—26	—49	—12	—35	—27	— 9	— 1	—30	—16	+ 2	+28	+27
Aug.	+ 5	+14	—17	—29	—47	—19	—36	—24	— 8	— 1	—26	—15	+ 3	+28	+28
Sept.	+ 7	+12	—19	—33	—42	—25	—39	—22	— 8	— 7	—24	— 7	+ 6	+29	+30
Oct.	+ 9	+ 9	—21	—35	—41	—31	—37	—19	— 7	—15	—21	+ 1	+ 9	+29	+32
Nov.	+10	+ 1	—27	—35	—42	—36	—36	—18	— 3	—27	—16	+ 2	+12	+32	+32
Dec.	+12	— 4	—29	—36	—44	—36	—30	—16	+ 1	—34	—17	+ 4	+16	+31	+32

Reproduced, by permission, from a section of Cleveland Trust Company's diagram (omitting wholesale price line), "American Business Activity Since 1790," edition of March, 1943 one years from 1919 through 1939, as Table 5 indicates, important decline in production, employment, and payrolls was registered in six years, in comparison with the level of the preceding year; that is, in 1921, 1924, 1930, 1931, 1932, and 1938. The index numbers for these declines, though they accurately measure trends in factory employment, do not give sufficient emphasis to the widespread unemployment of those years. Disquieting is the fact, confirmed in numerous governmental studies, that, despite the growth in capacity to produce, which reached so high a level in 1929, a disastrous decline in actual production in the following decade was not prevented. The accompanying chart, reproduced from a long diagram of "American Business Activity Since 1790," pictures the extent of the failure to produce in the decade of maximum productive capacity following 1928, in contrast with the extraordinarily rapid increase in the period of utilization, beginning in the first two years of the new war.

As a consequence of the depression in production following 1929 came the most severe unemployment in the history of the nation.

> The decade [preceding 1940] is unique in American economic history. It has been marked by the worst depression the country has ever known—a depression unparalleled both in severity and in persistence. At the end of the decade recovery is still far from providing normally full employment of the country's human and material resources.
>
> Perhaps the best indication of how much worse the economic difficulties of the past 10 years have been than those of any previous period is afforded by a comparison with the so-called "great" depressions of the seventies and nineties. . . .
>
> [Comparison is made of] industrial production for the three decades, 1872-1882, 1892-1902, and 1929-1939. The peak year of the preceding prosperity is in each case taken as the base. The unique character of the decade that has just passed is immediately evident. The differences in severity and length between the depressions of the 1930's and the two earlier depressions are so great as to suggest a difference in kind. From 1929 to 1932 industrial production declined by almost 50 percent, as compared with a maximum decline in the nineties of 13 percent, and in the seventies of 7 percent. The contrast in the three recovery periods is quite as striking. In 1939 production averaged somewhat below 1929. In each of the earlier periods it had far

surpassed the previous prosperity peak. Eighteen eighty-two was 70 percent above 1872, and 1902 was 55 percent above 1892.[1]

In every important respect the depression of the 1930's has been far more severe and far more persistent than any previous depression the country has seen. In 1939 we had 2 or 3 million fewer persons employed than in 1929 despite the fact that the volume of goods and services produced was almost the same. This unemployment was in addition to the 2 million persons who were unemployed in 1929 and was aggravated by the natural increase in population which resulted in over 6 million net new additions to the labor market. Consequently, . . . there were 10 to 11 million unemployed in 1939. The major problem is thus one of fuller utilization of the productive forces of the Nation—natural resources, plant capacity, and labor.[2]

Thus the European war declared in September, 1939, came at a moment when, ten years after the onset of the depression in 1929, neither government nor business in the United States, despite the growing potentialities in new productivity, had been able to sustain production at a level once attained, or to restore employment to a labor force equal to that required in 1929.

The changed ratio between production and employment, and its possible effect in causing unemployment, had already become evident before 1929. Although 1928 was commonly regarded as prosperous, partly because of its increasing volume of production, nevertheless unemployment was extensive enough to cause the United States Senate to request the Secretary of Labor to report on it. In response to this request, the Secretary transmitted, on March 24, 1928, a report prepared by the Commissioner of Labor Statistics, who made the following comment:

It is not unreasonable to believe that a considerable percentage of the employment shrinkage shown in this report is due to new machines and new mechanical devices. Waiting for industrial developments is of no avail. Their jobs are gone.[3]

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[1]Work Projects Administration, National Research Project, Unemployment and Technological Change, by Corrington Gill. Based on testimony by Corrington Gill and David Weintraub, given before the Temporary National Economic Committee in Washington, D.C., April 26, 1940. Philadelphia, p. 2.

[2]Ibid., p. 4.

[3]United States, 70th Congress, 1st Session, Senate, Document no. 77, Unemployment in the United States. Letter from Secretary of Labor, March 24, 1928.

The Secretary continued:

> Inventive genius must devise new industries, commercial agencies must create new wants in order to create new occupations for these people, in so far as age permits them to learn new occupations or adapt themselves to new industries.[1]

This proposal to create new products and new industries, currently accepted as effective at that time, was shown by experience in the following years to be merely a projection of the trend toward increased productive capacity, which, in itself, has not resulted in sustained production or in maintenance of full employment. Every depression in business, with its accompanying unemployment, demonstrates that the problem of maintaining full employment is not solved, but rather complicated, by new inventions.

In these periods of restriction or failure to produce, the greatest waste of the labor force through involuntary unemployment takes its course, paralleled by lowering of standards of living and by decline in the national income. Technological change enters into the whole problem at the point where consideration needs to be given to ways and means of restoring idle workers to employment. In periods of expansion after depression, the tendency has been to introduce improvements in mechanical equipment, which in turn result in increasing production without a proportionate increase in the number employed. Under such circumstances, the places of many who worked under the old conditions and at former levels of production are shown to have been eliminated through the new automatic processes and the greater productivity of the labor force. Among them are those whose old skills have become obsolescent.

Fluctuations do not merely retard technology. They also accelerate it in an unplanned way which brings in its train another depression. Here is an area calling for investigation not of single aspects of separate industries, but an analysis of the total economy within which all industries are becoming ever more closely interrelated through the nature of the new technology. The problem has gone beyond the control of any one enterprise, however powerful, or of any one industry or even any one nation; thus it calls also for international investigation. The involvement of business

[1]United States, 70th Congress, 1st Session, Senate, Document no. 77, Unemployment in the United States. Letter from Secretary of Labor, March 24, 1928.

cycles with war and its aftermath makes all the more vital and immediate this international point of view.

Analysis of conditions of business which have resulted in failure to produce, whether by old or new technological methods, is not within the scope of this inquiry. However, on the basis of many studies, including those quoted in preceding pages, the conclusion may nevertheless be drawn that while the trend in technology is toward greatly increased productivity, the trend in business, recurrently, is toward restricted and retarded production.

While the data quoted in this chapter apply to manufacturing only, similar trends toward larger output and fewer wage-earners have ~~already~~ been noted in the basic industries. The broad statistics seem to confirm the social consequences forecast in descriptions of technological change as outlined in previous chapters.

In modern production man is no longer the primary producer. Man is being used in order that production may take place. At the same time, man thus used has become highly productive. This productivity, moreover, is constantly on the increase. Of the relation of technology to livelihood it may thus be said that the technological basis for employment and living standards has been profoundly altered. With the new technology, livelihood depends not merely upon a man's individual labor, but upon his opportunity to use, in association with others, the new instruments and materials of the highly organized system of production.

A matter for special consideration is involved in the speeds to which labor is required to conform. Today automatic processes control speed of machinery and its output. With technological advance these speeds have constantly increased, nor need there be any limit to this development. Slower speeds, as well as shorter hours, would reduce the excessive demands made on workers and enlarge employment opportunity. But where is the line of demarcation between such moderation of work tempo as would spread employment and reduce excessive and unjustifiable fatigue, and those speeds which commercial competition seems to compel?

Does this raise the question as to whether increasing productivity, due to science and invention, is, of its own momentum, and therefore, in its turn, automatically, transcending the capacity of business today to spread the benefits of technological advance for higher living standards?

Chapter VII

Occupational Change and Employment Opportunities

THE assumption that increasing productivity would always be paralleled by increasing employment was supported by the classical economists and has persisted widely until today. Recent experience, however, indicates that a profound change has occurred in the relation between production and employment, not only in manufacturing, as indicated in the preceding chapter, but in practically all branches of production. Increase in capacity to produce may be coupled with actual decrease in opportunities for employment in the production industries. Instead of taking for granted that increasing production creates employment, the truth of the matter must be recognized, that productivity, under the impact of technological change, is putting forth different labor requirements. These different labor requirements, in the setting of prevailing social economic conditions, have resulted in far-reaching changes both in the nature and in the relative importance of the various occupations of the people.

Changing Rank of Occupational Groups in the Population

Over a long period the rank of occupational groups in the population has been shifting. The occupational distribution of the total population may be viewed as reflecting opportunities for employment under the impact of technological change. A significant measure is the number serving each 1,000 persons.[1] Table 6 shows these changing proportions for the principal occupational groups and for all occupations combined at thirty-year intervals since 1870.[2]

[1]This measure eliminates growth of population as a factor in the growth of an occupation, and makes it possible to compare changes in number of workers required in each industry or service, in proportion to population.

[2]These dates are chosen because in 1870 occupational data were presented for the first time in a form comparable with subsequent censuses. Moreover, the thirty-year interval, which gives a clearer perspective than a single decade, is convenient because 1900 seems to have been a great divide between two centuries, while 1930 as the terminal date has the added advantage that special circumstances since 1930, namely, unprecedented depression

TABLE 6. NUMBER IN EACH MAIN OCCUPATIONAL GROUP PER 1,000 OF POPULATION IN 1870, 1900, AND 1930[a]

Occupational group	Number per 1,000 of population		
	1870	1900	1930
1. Agriculture	172	144	85
2. Forestry and fishing	2	3	2
3. Extraction of minerals	5	9	8
4. Manufacturing and mechanical industries	66	95	115
5. Transportation and communication	14	26	31
6. Trade	22	40	50
7. Public service (not elsewhere classified)	2	4	7
8. Professional service	8	16	27
9. Domestic and personal service	31	37	40
10. Clerical occupations	2	9	33
Production, transportation, and communication (1–5 above)	259	277	241
Trade and services (6–10 above)	65	106	157
Proportion of gainful workers in population	324	383	398
Total population	38,558,371	75,994,575	122,775,046
Total in all occupations	12,505,923	29,073,233	48,829,920

[a]See Bureau of the Census, U.S. Department of Commerce, Fifteenth Census: 1930, Population, vol. 5, General Report on Occupations (Government Printing Office, Washington, 1933), Table 1, p. 37, for population, total labor force, and percentage of population gainfully employed, 1870, 1900, and 1930; and Table 2, p. 39, for percentage distribution in occupational groups in 1930, used in figuring column 3. In figuring columns 1 and 2 we have used data on occupational groups for 1870 and 1900, reclassified to correspond with 1930, in Bureau of the Census, U.S. Department of Commerce, Industrial Distribution of the Nation's Labor Force: 1870 to 1930. Released October 23, 1938, Table 1, p. 1.

The years 1870, 1900, and 1930 roughly correspond to significant dates in technological development. In the decade 1860-1870 the industrial revolution of steam was fully inaugurated. By 1900 the expansion of industrialized America had pushed its frontier to the Pacific. The technology of electricity, described as characteristic of the present moment, may be said to have matured in the period following the World War, i.e., from about 1919.

As Table 6 indicates, the proportion of the gainfully employed in the population in the sixty years from 1870 to 1930 increased from 324 to 398 per 1,000. Significantly, in the industries concerned with primary production, fabrication, and transportation, namely, agriculture, forestry and fishing, extraction of minerals, manufac-

in the early years of the decade and the beginning of production for war at the end, are excluded. Nevertheless, for purposes of comparison, the data for 1940 would have been added to the total, were they available in comparable form at the time of completing this manuscript.

turing and mechanical industries,[1] and transportation and communication, the number at work per 1,000 of population increased from 259 in 1870 to 277 in 1900, and then declined to 241 in 1930. In these industries of production and transportation it would appear that the number of workers needed to provide the output used by each 1,000 of the population had decreased. At the same time the service groups, namely, trade, public service, professional service, domestic and personal service, and clerical occupations, increased from 65 per 1,000 of population in 1870 to 157 in 1930.

In the production industries the most significant change is the decline of the number in agriculture, once "the largest employer of human hands,"[2] from 172 per 1,000 in 1870 to 85 in 1930, while the proportion engaged in trade and transportation and communication increased from 36 per 1,000 in 1870 to 81 in 1930, or to a number almost equal to the proportion employed in agriculture in that year.

The rate of growth in manufacturing and mechanical industries was most rapid between 1870 and 1900, with the number employed increasing from 66 per 1,000 to 95. This expansion might be expected, since it was during the period up to 1900 that industrialization spread to the West and increased in the areas previously developed. The rate of growth in employment in manufacturing between 1900 and 1930, however, failed to keep pace with the rate of increase in production in that period, as has been shown in Chapter VI, clearly indicating that *technological change since 1900 has been different in kind and has altered the relation between numbers employed and output.* Increase in labor productivity was probably considerably greater after 1900 than before, though data on this point are lacking for the period before 1899.

In selecting only three census years in the period of six decades between 1870 and 1930 it should not be overlooked that in certain

[1] As already pointed out, the census of occupations is taken when the population is enumerated. The group reporting occupations in manufacturing and mechanical industries is not identical with the number counted in the census of manufactures. Aside from the inevitable difference due to difference in source of information, the census of occupations groups the building trades and independent hand trades with manufactures, so that manufacturing and mechanical industries constitute a more inclusive group than has been described in Chapter VI, "Changing Labor Requirements and Increasing Productivity in Manufacturing."

[2] See Chapter III, "Agriculture."

of the main occupational groups the high point in employment was reached not in 1900 nor in 1930, but in intervening censuses. Table 7 therefore gives the data for each decennial census from 1900 to 1930 for the production groups in which numbers employed decreased in 1930, and these decreasing groups are compared with manufacturing and mechanical industries, which showed an increase in each census year, though at a lesser rate from 1920 to 1930.

TABLE 7. NUMBERS IN SPECIFIED OCCUPATIONAL GROUPS, SHOWING YEAR OF MAXIMUM NUMBERS IN DECENNIAL CENSUS YEARS FROM 1900 TO 1930 AND INCREASE OR DECREASE IN 1930[a]

Census year	Agriculture	Forestry and fishing	Extraction of minerals	Manufacturing and mechanical industries
1900	10,911,998	209,539	694,352	7,199,208
1910	11,591,767[b]	241,806	965,169	10,656,545
1920	11,448,770	270,214[b]	1,090,223[b]	12,860,914
1930	10,471,998	250,469	984,323	14,110,652[b]
Decrease in 1930 from maximum	1,119,769	19,745	105,900	
Increase from 1910 to 1930				3,454,107

[a]Bureau of the Census, U.S. Department of Commerce, Industrial Distribution of the Nation's Labor Force: 1870 to 1930. Released October 23, 1938, Table 1, p. 1.
[b]Indicates maximum in each group in the census years from 1900 to 1930.

In two basic industries, extraction of minerals and forestry and fishing, the maximum was reached in 1920 and a decline was shown in 1930. In agriculture the maximum was reached in 1910. Manufacturing and mechanical pursuits ranked first for the first time in 1920, and reached a still higher level in 1930. Thus it was the only one of the occupational groups concerned directly with production which did not decline in 1930, in comparison with its previous maximum. After 1910 agriculture as an occupation declined by more than 1,000,000, in comparison with the following increases decade by decade in manufacturing and mechanical industries:

1910 over 1900	3,457,337
1920 over 1910	2,204,369
1930 over 1920	1,249,738
Total increase from 1900 to 1930	6,911,444
Average increase per decade	2,303,815

Employment opportunities in manufacturing and mechanical industries expanded in the decade of 1900-1910 by nearly 3½ million. In 1920-1930 their growth as an occupational group was only a million and a quarter, in comparison with an average increase of a little over 2¼ million in the three decades from 1900 to 1930. Thus the top-ranking occupational group of 1920 showed in the census of 1930 a declining rate of growth in employment opportunities as compared with the decade preceding 1920 or 1910.

Since manufacturing has been described as the bridge between production and consumption, it is interesting to note that expansion in employment in manufacturing, plus the mechanical industries, which are chiefly the construction trades, has not resulted in proportionate expansion in numbers employed in agriculture or in mining of minerals, nor in the smaller industries of forestry and fishing; on the contrary, these have declined, both absolutely, and relatively in proportion to population. Decrease in number of workers required has evidently occurred also in these industries, even though their production must have increased in some relation to expansion in the processing or fabrication of their output in manufacturing and mechanical industries. Thus the statistics of occupations confirm descriptions in previous chapters of decreasing labor requirements per unit of product, with resulting loss of employment opportunities in basic industries as accompaniments of increasing labor productivity.

The greatest loss in employment opportunities has occurred in agriculture. Moreover, relative to total population, as shown in Table 6, agriculture has suffered the greatest decline, that is, from 172 farmers and agricultural workers per 1,000 of population in 1870 to 85 in 1930.

Apparently decreases in employment opportunities in these basic occupations, as Table 6 indicates, have been offset to a substantial degree by gains in manufacturing and mechanical industries, but to an even larger extent, proportionately, in trade, services, and clerical occupations.[1] As against 59 jobs lost in agriculture for each 1,000 of population between 1900 and 1930, 20 were gained in manufacturing and mechanical industries, 5 in transportation and com-

[1]While it is true that some of these clerical occupations may be in industry rather than in trade, they are not industrial in character, but rather to be classed as service occupations.

munication, 10 in trade, 24 in clerical occupations, and 17 in services, public, professional, and domestic—or 76 in all. Of these, 51 were in distribution and services. At the same time the proportion gainfully employed has increased from 324 to 398 in each 1,000 in the population.

The trend away from production toward trade and services was also observed by investigators for the National Resources Committee.

> The notable expansion in employment which took place between 1920 and 1929 was due almost entirely to the rapid growth of service activities.[1]

This occupational trend has several important implications. The old function of trade, earlier performed by the small producer himself, is now a highly organized process. The increasing interdependence of industries and multiplicity of their products, and their competition for the consumer's dollar, have turned distribution, or the business of marketing goods to prospective buyers, into a complicated and costly process, hardly to be recognized as similar to the old tasks of shopkeeping or trade. Distribution's role today is greatly enlarged. It weighs on the product for consumption in quite another degree than in the past, and its proportionate share in the price to the consumer is constantly increased. A United States Government official, reporting on cost of distribution, draws the following conclusion:

> Society has unconsciously placed a heavier and heavier burden upon the marketing structure resulting from such changes as the growth of urban centers, the widespread advances in communication and transportation, and the expansion of the national income, all culminating in greater demands for marketing services. All of these changes have had the net effect of magnifying the task of distributing the goods which we have learned to produce with growing ease and efficiency.

[1]National Resources Committee, Technological Trends and National Policy, Part 1, sec. 5, "Unemployment and Increasing Productivity," by David Weintraub, director of National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques, Works Progress Administration. Government Printing Office, Washington, 1937, p. 87. The statement continues with the following observation: "Their occupational requirements differed so widely from those of the basic industries which registered declines that it is extremely unlikely that all the workers displaced from basic industries obtained new jobs in the service industries."

> There is a fundamental difference between production and distribution which is often overlooked. Production, in many industries, lends itself easily to economies because of the wide latitudes offered for mechanization and the use of capital. Large-scale production, however, had to await the growth of mass markets and marketing facilities. Distribution on the other hand is very largely a matter of personal service. Labor looms large and machine methods have distinct limitations. For this reason it is much easier to reduce production costs, than marketing costs.[1]

The complex modern techniques, which transformed resources of nature and of science for use in daily living and gave rise to far-reaching changes in work processes, have affected not only those actually engaged in industrial production; they likewise influence the occupations of all who work for a living, be they shopkeepers, clerks, artists, teachers, physicians, or those engaged in other professions, together with their families and dependents. For all of these rely upon the basic industries and manufacturing for production of the goods which they need in their daily life and work; and for the surplus of wealth which sustains services and standards of living, over and above the minimum needs for subsistence. All are affected by increasing costs of distribution.[2] Both the availability and the degree of attainability—through earnings or otherwise—of the goods of the productive industries constitute the basis for standards of living of all individuals and groups in the population.

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[1]Engle, Nathaniel H., assistant director, Bureau of Foreign and Domestic Commerce, U.S. Department of Commerce, "Distribution Cost Analysis by Commodities." Address at Ninth Boston Conference on Distribution, Boston, Massachusetts, September 21, 1937. Mimeographed, Department of Commerce, Washington, p. 4.

[2]See Stewart, Paul W., and Dewhurst, J. Frederic, Does Distribution Cost Too Much? A Review of the Costs Involved in Current Marketing Methods and a Program for Improvement. Twentieth Century Fund, New York, 1939. "Production costs have been reduced steadily, and in some cases sensationally, over the past several decades, while there is good reason to believe that distribution costs have been rising. Since 1870, for example, the number of persons engaged in the production industries—farming, mining, manufacturing, etc.—in the United States has much less than trebled, while the number of persons engaged in distribution has increased nearly nine times. . . . We are now producing and consuming more than nine times as large a physical volume of goods as we were seventy years ago, with a population only three times as large. . . . It appears that there has been more than a threefold increase in the output of goods produced per worker, while the amount of goods distributed per worker in the distribution industries has increased only slightly. . . . Large-scale production, which is necessarily specialized production, has lengthened the path between producer and consumer." (pp. 336-337.)

EXTENSION OF WAGE-EARNING AND SALARIED STATUS

That the United States is a nation of workers, dependent upon their occupations for their livelihood, is indicated in Table 8, showing the proportion gainfully employed in each age group.

TABLE 8. PROPORTION GAINFULLY OCCUPIED, BY AGE GROUPS, IN TOTAL POPULATION AND BY SEX, 1930[a]

Age group	Number		Per cent gainfully occupied		
	Total population	Gainfully occupied	Male	Female	Total
10–13 years	9,622,492	235,328	3.3	1.5	2.4
14	2,382,385	157,660	9.2	4.0	6.6
15	2,295,699	274,130	16.3	7.6	11.9
16	2,367,315	587,817	32.7	17.0	24.8
17	2,295,822	891,024	49.9	27.5	38.8
18–19 years	4,593,279	2,542,213	70.7	40.5	55.3
20–24	10,870,378	7,147,053	89.9	42.4	65.7
25–29	9,833,608	6,255,677	97.0	31.0	63.6
30–34	9,120,421	5,567,327	97.6	24.4	61.0
35–39	9,208,645	5,619,242	97.7	23.1	61.0
40–44 years	7,990,195	4,881,298	97.6	21.9	61.1
45–49	7,042,279	4,276,070	97.2	21.0	60.7
50–54	5,975,804	3,555,091	95.7	19.7	59.5
55–59	4,645,677	2,640,064	93.0	17.3	56.8
60–64	3,751,221	1,950,528	86.8	14.7	52.0
65–69 years	2,770,605	1,227,042	75.7	11.4	44.3
70–74	1,950,004	642,902	57.5	7.6	33.0
75 and over	1,913,196	335,023	32.3	4.0	17.5
Age unknown	94,022	44,431	59.9	31.8	47.3
Total 10 years and over	98,723,047	48,829,920	76.2	22.0	49.5

[a]Bureau of the Census, U.S. Department of Commerce, Fifteenth Census of the United States: 1930, Population, vol. 5, General Report on Occupations, Table 2, p. 115.

Of the men in the population, 97 or more of each 100 between the ages of twenty-five and fifty were gainfully occupied. In the total population ten years of age and over, 76.2 per cent of the men and boys worked, and 22 per cent of the women and girls. For women and girls the percentage of workers was highest in the age group between twenty and twenty-five, i.e., 42.4 per cent. The smaller proportion of gainfully employed, as compared with men, merely reflects the fact that the work of women in the home, though contributing to the livelihood of the family, is not counted as a gainful occupation in the census, because it is not done for compensation.

The term "gainfully employed," as used in the census, refers to those who work for remuneration, whether self-employed or hired. The housewife or the man who has a garden for his own household is not included in such a definition, though a home kitchen or garden should be counted as contributing to the subsistence of the family. In its definition the census reveals that the simplicity of an earlier economy has given place to the highly developed interrelated industries in which for the great majority of workers it is now true that they participate only if they are hired for pay. Increasingly the form of remuneration is a wage or salary, rather than compensation paid directly by the consumer or client to a self-employed worker.

That the proportion of the gainfully employed has been augmented has already been noted in Table 6, showing that in 1870 the number working for remuneration was 324 per 1,000 of population, as compared with 398 in 1930. Superficially, these figures might have been interpreted as meaning that opportunities for employment have increased during the period of technological change, despite the decrease in labor required per unit of product in the basic industries. Closer analysis is therefore important.

The first point to note is that, according to Table 6, the greater increase in the proportion gainfully employed occurred in the three decades from 1870 to 1900. In that period the proportion rose by 59, as compared with a rise of only 15 between 1900 and 1930. Apparently, increasing industrialization in the period before 1900 drew more and more of the population into the system of gainful employment, with less and less supplementary and unpaid activity contributing to livelihood. For example, to a decreasing extent, proportionately, farmers raised food for their own families, and increasingly they sold their produce in the newly developing system of marketing and distribution. Moreover, women performed fewer tasks of production in their households, such as weaving, sewing, cooking, and other domestic work, and to an increasing extent became gainful workers, selling their labor in factories. The textile industry grew and employed many hands, and the industry of making bread outside the home expanded rapidly. Livelihood, which is the living won by work, thus became more and more dependent upon "gainful employment," which means, for the majority, being hired for wage or salary.

DECLINING OPPORTUNITIES FOR INDEPENDENT WORK

As might be expected from an analysis of the new technology, with its large-scale operations, the number of independent workers has declined. This trend was evident in the nineteenth century, especially in manufacturing, including hand trades, and it has become even more marked in the twentieth. Agricultural pursuits and shopkeeping have always been areas offering opportunity for self-employment. Naturally, as the proportion of workers in agriculture and in independent hand trades or crafts declined, opportunities for independent work were increasingly restricted. Expansion in distribution or trade, however, continued to provide some scope for individual enterprise. The very slight increase in the proportion of independent workers in non-agricultural pursuits in the decade from 1920 to 1930, from 11.9 to 12 per cent, which might be accounted for as an error in the figures, certainly indicates no significant increase in opportunities for independent work. Self-employed or independent farmers declined from 71 to 67.2 per cent.[1] But less than half of the self-employed farmers were independent in the sense of owning their own farms; only 47 per cent of farmers in the United States were "full owners" in 1935.[2]

The changing nature of technology has resulted in rendering natural resources and the machinery and apparatus of production largely inaccessible to the independent worker. Only an associated labor force can operate it. Correspondingly, enterprises have increased in size, while control has been increasingly concentrated. Opportunity to work for a living depends upon the chance of being hired for employment, rather than upon individual initiative.

[1]Woytinsky, W. S., Labor in the United States: Basic Statistics for Social Security. Report Prepared for Committee on Social Security. Social Science Research Council, New York, 1938, p. 129. Table 21 in this report indicates that in all occupational groups the percentage of independent workers in 1910 was 28.3; in 1920, 25.4; and in 1930, 22.6. The percentage of independent workers in agriculture in 1930 was 67.2; and in non-agricultural pursuits, 12. Except for the classification of "independent hand trades," in which 99.4 per cent were independent in 1930, the largest percentage of independence, next to agriculture, was in trade, 35.8 per cent. In professional service 22.2 per cent were independent, compared with 30.7 per cent in 1910.

[2]Bureau of Agricultural Economics, U.S. Department of Agriculture, Changing Technology and Employment in Agriculture. Government Printing Office, Washington, 1941, p. 30.

The important question arises, whether this livelihood, under the new form of being hired for pay, affords the same measure of security as the earlier *independent work with direct access to land, materials, and tools.* This question is especially pertinent, in view of the foregoing evidence that the proportion of the gainfully employed increased less rapidly after 1900, in the three decades which constitute the period of development of the present technology in the electric power age, with its enormous advance in productivity.

INCREASING EMPLOYMENT OF WOMEN

Increase in gainful employment as a whole does not mean that opportunities have increased for the male breadwinner. The fact is that the increasing employment of women in gainful occupations, as distinct from their contribution without pay to the family's livelihood, accounts largely for the increase in proportion of the population counted in the census as gainfully employed. The following statistics bring out these facts:

(1) Of each 1,000 females in the population in 1870, six were gainfully employed, and in 1900, 143, showing an increase of 137. Of each 1,000 males in the population in 1870, 547 were gainfully employed, and in 1900, 612, showing an increase of 65.

(2) Of each 1,000 females in the population in 1930, 177 were gainfully employed, as compared with 143 in 1900, showing an increase of 34. Of each 1,000 males in the population in 1930, 613 were gainfully employed, as compared with 612 in 1900, showing an increase of one.[1]

Advance figures for the census of 1940 seem to indicate that, although the proportion of women in the labor force continues to increase, the proportion of men has actually begun to decline. In 1940 of each 1,000 females in the population, 196 were counted in the labor force, as compared with 177 in 1930, showing a gain of 19. This compares with a decrease in male workers from 613 per 1,000 in 1930 to 605 in 1940.[2]

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[1]Bureau of the Census, U.S. Department of Commerce, Fifteenth Census: 1930, Population, vol. 5, General Report on Occupations, p. 37. The census explains the comparatively small increase in proportion of males gainfully employed as due, to a considerable extent, to decrease in child labor, especially boys ten to fifteen years of age; the decrease in that group "was particularly large in mining, manufacturing, and clerical pursuits." (Ibid., p. 38.)

[2]Figures for 1940 are from an advance release of April 16, 1942, for the Sixteenth Census of Population, Series P 10, no. 7. Final figures are not yet available.

Thus over the period of sixty years between 1870 and 1930, the increase in the proportion gainfully employed seems clearly to measure the spread of what may be called the gainful employment system as the prevailing means of livelihood, especially as it affects women's work. In the latter half of the period the declining rate of growth in employment is evidently a statistical measure of decline in labor requirements resulting from increased technological productivity in the basic industries. At the same time gainful employment increased in services, including trade and the professions.

EXPANSION OF EMPLOYMENT IN SERVICE GROUPS

Whether the increase in employment in distribution, professions, and other services compensates the labor force for declining employment in production, depends upon whether livelihood, i.e., the opportunity to obtain a living by work, is thereby made more secure. A complete picture of the effect of technology upon livelihood in our present environment calls for an analysis of living standards to determine whether they are adequate or inadequate, in terms of needs for healthful, creative living. This is a subject needing further research. On the basis of general knowledge, however, obtained from a large number of current investigations, it can be assumed that deficiencies in living standards have been widely prevalent in the United States, even in times of peace and comparative prosperity. Under such circumstances the shift from the basic industries required to provide the necessities of life, especially food and shelter, to trade, clerical services, and professions, cannot be viewed with complacency.

Moreover, the extensive lack of employment in the decade following 1929, which was the starting point of the present study, has to be regarded as in itself a symptom of lack of utilization of the new technology for the livelihood of the people. Unemployment bars workers from access to the new productivity, cuts off their means of livelihood, and starts the vicious circle of underconsumption and consequently declining production. Less and less has it been possible for the unemployed to find even a temporary refuge on the farms.

The Problem of Organizing Employment for Higher Living Standards

The problem of employment is not primarily to provide jobs, but to expand production needed for living standards. At the same time employment must be so organized as to meet the labor requirements of production, with adequate return to the workers in wages and in leisure time,[1] so that the living standards of workers in the basic industries may be established as basic in the development of the people's livelihood. With employment organized in the basic industries, cultural and professional services, with their added opportunities for employment, would normally develop as increasing wealth becomes available to support them. Unquestionably there is an optimum occupational distribution; it is optimum if, thereby, living standards have been progressively raised with expanding and improving productivity, while employment, which is the link between productivity and living standards, has been made both secure and congenial.

One adjustment contributing to the organization of employment which should be noted is the continuous shortening of hours of work which has occurred in all occupations and has been substantial since 1923. Today technology itself gives support to the long-time demands of trade unions to obtain the eight-hour day, as a result of their experience with increasing productivity in industry. The unions, before the present war, were asking for a five-day week, and in some industries for a six-hour day.

Summary of Data

A great change in the occupations of the people is clearly discernible in the data presented decade after decade in the United States census of population. Covering as it does the entire population, it forms the framework for analysis of long-time trends and thus makes clearer the changes in employment which have occurred during the period of technological change already described. Analyses of changes in employment in any one industry,

[1]In an earlier memorandum entitled "Optimum Productivity in the Workshop," by Mary L. Fleddérus (Appendix I, p. 205), the subject of organizing the workshop in relation to production as the source of living standards is explored, and a definition of optimum productivity is formulated as a guide for further research in this area.

or even the sum total of these analyses, do not suffice, since it is of the essence of the new technology that it influences all occupations in their interrelationships.

The salient facts brought out both in this and the preceding chapter may be summarized as follows:

1. In 1870 more than half of the working population earned their livelihood in agriculture. By 1930 less than one in four (approximately 22 per cent) worked on farms. In each 1,000 of the population the number employed in agriculture, once the most important occupation, declined from 172 to 85. Self-employed or independent farmers declined slightly, from 71 to 67.2 per cent, between 1920 and 1930. Farmers in full possession of their farms were actually a minority.

2. Manufacturing and mechanical pursuits, now based on iron and steel, machinery, and coal, outstripped agriculture about the year 1920. Their most rapid rate of increase was in the three decades before 1900, from 66 to 95 per 1,000 of the population, as compared with the thirty years after 1900. By 1930 the proportion was 115, as compared with 85 in agriculture.

3. Trade meanwhile increased from 22 per 1,000 in 1870 to 50 in 1930. If to those employed in trade we add the numbers in clerical occupations, in public service, domestic and personal service, and professions, the proportion per 1,000 in 1930 was 157 as compared with 65 in 1870.

4. In manufacturing, through which much of the output of the basic industries of agriculture, mining, and metallurgy passes on its way to the consumer, production increased faster than either population or numbers employed. Labor productivity, which is measured by output per employe, is thus shown to have increased substantially, since larger output is produced by fewer workers. Measured by index numbers, volume of production in manufacturing increased from 100 in 1899 to 376 in 1937, as compared with an increase from 100 to 194 in number of wage-earners, and from 100 to 172 in population.[1] A similar trend is observable in other industries, with the added difficulty that whereas employment in

[1]See Chapter VI, "Changing Labor Requirements and Increasing Productivity in Manufacturing," Table 4, p. 161.

manufacturing and mechanical industries has actually increased, it has declined in other important industries, notably agriculture, despite increase in labor productivity.

5. Meanwhile to an increasing extent workers in the United States have become employes in large-scale enterprises. Their relative loss of independence was hastened by the decline of opportunities for livelihood in agriculture, where self-employment had hitherto been more extensive than in any other occupation. To earn a livelihood today, the great majority of workers must find jobs in association with other workers; that is, be hired for wages or salaries.

6. With increasing frequency, opportunities to find jobs are curtailed by recurrent business depressions with their accompanying unemployment; these depressions have become so customary as to be designated by the term, "business cycles." To the sum total of unemployment at any given moment, technological change contributes through displacement of workers by changes in labor requirements.

7. Agriculture, primary resource of any nation, has been unable to make adequate use of the new technology and to raise standards of living of farmers and their families to the level made possible by the new productivity. As producers, the 10 million who earn their livelihood in agriculture could greatly expand their purchases for the output of the other basic industries. As consumers, farmers and their families, constituting as they do approximately a fourth of the nation, if their industry were more prosperous, could provide a market for greatly increased consumption of all products which technology could make available for higher living standards.

Viewed as a whole, technological change has resulted in new products and new industries, and has enormously increased both actual and potential productivity of labor through use of electric energy and its instruments, and through chemical processes, which create new raw materials and new facilities for use of the earth's elements and for improvement of the soil. Theoretically, technological progress should improve opportunities for livelihood and increase security of employment. During the period of most rapid technological advance in the United States, however, this security has not been conferred upon the people. Employment opportunities in the industries based on the new technology have lagged behind expanding production. No longer is man required to toil excessively; yet neither does his present environment enable him to obtain the increasingly abundant fruits of his labor. Recurrent unemployment as an accompaniment of increasingly severe business depression, and deficiencies in purchasing power, with consequent failure to raise living standards for the whole population in conformity with increasing productivity, all are evidence that the potential benefit of technology to standards of living has not been realized.

Chapter VIII

Summation: The New Technological Basis for Livelihood and Living Standards

FUNDAMENTAL change in the nature of man's work has occurred in the span of years since the discovery of America. The far-reaching changes arising out of technological developments in the last two decades can be better understood in the perspective of a longer historical period. Between 1492 and 1942, though, amusingly, the numerals are identical, man's discoveries had so enlarged his knowledge of this planet and its resources as almost literally to create for the human race a new earth. Yet how to share these resources among all peoples and how to insure to the individual an opportunity to earn a living are practical questions which in 1942 appeared to be as baffling as was the search for a new route to India and its riches for the Europeans of 1492.

"Make a figure to represent Labour in the act of dragging, pushing, carrying, restraining, supporting,"[1] wrote Leonardo Da Vinci in his Notebooks toward the close of the fifteenth century. He was writing during the decade of the discovery of America. His specifications accompanied a sketch of little figures making the motions indicated in the tasks of industry.

Perhaps the words may be regarded as the first recorded job analysis of the motions of the human hand in lifting or moving objects from place to place or from position to position. It is well to be reminded that these motions, whether performed by a worker or by a machine, are primary elements in the processes of industry. The same motions appear in the work of the craftsman, but with the element of design added when an object is not merely moved but transformed in size or shape or combined with others in a structure. Nevertheless the simple motions of labor are primary in carrying out the design of the artist, as clearly manifested in Leonardo Da Vinci's work as a sculptor.

[1]MacCurdy, Edward [arranger], The Notebooks of Leonardo da Vinci. Reynal and Hitchcock, New York, 1938, vol. 1, p. 140.

Again, the motions of the hand, when in primitive society the farmer sows seed or gathers a harvest, are seen to be auxiliary to changes wrought by nature or by the elements. When man has knowledge of nature's processes, these auxiliary motions of the human hand result in production. It has been inevitable that man should invent new methods of manipulation—again a word indicating the hand as the primary factor. From these inventions come the new processes of "pro-duction," which means "bringing forth" the resources of nature and shaping them for man's use.

In the long history of the laborer's task in the industrial arts, which Leonardo Da Vinci's sketch depicted in simplest form, without even the introduction of tools, the latest stage encompasses the highly intricate technology developed by the new science of the present century. This new science has given man access to (1) electric power, (2) chemical action, (3) mechanical movement; these three can be utilized for production only if a fourth element, organization, be provided. *The change which has taken place is the most complete in all history,* since in the new productive processes the energy provided in electricity and chemical action is nature's power, with mechanical motion substituted for the hand of man. Man today is needed to discover, to design, to direct, to co-ordinate, and to co-operate, rather than to push, to carry, to restrain, or to support. Yet if "hired hands" are not needed, if the energy of electricity makes human strength or skill unnecessary, how is a man to be assured of a living if livelihood is earned only through his being hired?

This profound transformation of man's relation to the apparatus of production is central in the nature of the new technology. The means of producing the necessaries of life have become so complex and elaborate as to be no longer immediately accessible to the individual. This inaccessibility gives rise to insecurity of livelihood in a century of potential abundance.

The New Significance of Standards of Living

New meaning is given to standards of living by the new technology. The phrase has often been used to describe levels of living. Studies have dealt with budgets of families and mere costs of the things they buy. If, however, the word "standards" be used in the engineering sense, as acceptable specifications, it becomes clear that standards can be established for the area of consumption and in the general field of living conditions with as great a degree of objectivity as research applied to determination of standards in the processes of production. The science of life and human association is in its early stages, but has already accumulated more knowledge as to what is good for man than is yet utilized in daily living.

The basic material elements in standards of living, the "necessaries of life," as Thoreau pointed out, continue to be food, shelter, clothing, and fuel. Cultural elements center in education, recreation, and creative living in its many aspects. Expressed in terms of buildings in the community, cultural elements are related to schools, churches, libraries, museums, and theaters. In Da Vinci's time they found expression primarily in cathedrals. Exceedingly important and new in our day are provisions for transportation and communication. The mere listing of these elements indicates that advancing knowledge concerning human life and social relations establishes constantly new standards in these areas; that here also scientific processes based on experience teach new ways of attaining the optimum.[1] Such standards are best measured in terms of the community as a whole, instead of studying merely the modes of living of separate families.

Closely related to elements in living conditions are working conditions, not merely as part of the industrial process, but as aspects of the environment of the individual in his daily life. To treat working conditions as elements in standards of living constitutes a break with the traditional separation of work from leisure time. It conceives, rather, of the life of the individual as a whole. The conditions of his work are elements in his standards of living, affecting his health and his opportunities for cultural development and social participation. If high standards prevail in working conditions as well as in home and community life, cultural development and social participation need not be regarded as separate from work, but as expressed alike in work and in leisure.

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[1]The optimum of a condition or a development (standards of living, for instance) is one which results from due recognition of all relevant values and their true relativity. See, also, definition of "optimum," Appendix I, p. 205.

A broad definition of optimum living standards would be expressed in terms not of static conditions, but of function, thus calling for *such standards to be achieved through man's control of his environment as shall constitute the most favorable conditions for the individual's participation in society.* The nature of this participation would, in turn, reflect the stage of evolution to which he, individually, and the community of which he is a part have progressed.

Clearly the prevailing levels of living of the community and the degree to which they conform to potential standards measure success or failure in utilization of science and invention. Utilization of invention is not the same as its mere use. "Utilization" is a more complex term, and may well include reference to selection and adaptation to socially desirable ends.

Reviewing the way by which we have come in this inquiry, noting the potentialities in the development of technology and the restriction which has retarded its utilization, it becomes clear that waste and frustration inhere in the failure to direct productivity toward the largest possible objective, namely, the progressive raising of standards of living in the community as a whole. The same scientific spirit which has created our immensely increased productivity is applicable to this new task.[1]

Research for Social Design

In the past, social research has been occupied almost exclusively with conditions as they are or as they have been. The present need is for a technique of designing the future. The science of economics must broaden its scope beyond its too exclusive concern with business as at present organized, to cover the larger subject of social administration of the new technology.

Economics, as a branch of the social sciences, had its origin in the necessity for explaining the new practices of business, arising from the industrial revolution which steam-driven machinery initiated. Under the impact of this change, old forms of feudalism

[1]That this is not a utopian dream seems to be indicated by the resolution which the League of Nations adopted in 1937, calling for study of standards of living as the new objective for all governmental measures and policies, both national and international. This resolution is quoted in Appendix III.

had to give way to new processes in factories, new conditions of life and work in towns and cities, new terms for business contracts, and new relationships between landlord and merchant, between employer and employe, between town and country, and between nation and nation. The new economics was defined as the science of wealth.

The new science demanded a policy and program for government. "The Wealth of Nations," not the wealth of merchants or of corporations, was its concern. It was in 1776, the year of the New World's Declaration of Independence, that Adam Smith's book under that title appeared. The new economics of that day was known as political economy, and, although it laid the basis for leaving business free of interference by government, it nevertheless recognized that wealth is the concern of the nation as a whole.

Thus economics as a social science had its origin in technological change. It is not surprising that the profound technological changes of the present should call for new formulations of economic problems as subjects for research. Such an enlargement of the science of economics has been authoritatively forecast in the Encyclopaedia of the Social Sciences, in the following definition by its editor-in-chief, the late Professor Edwin R. A. Seligman, a leading economist in the United States:

> Economics deals with social phenomena centering about the provision for the material needs of the individual and of organized groups. . . . The line of demarcation between the subject matter of economics and that of other social scientific disciplines is very shadowy. . . . Yet to make this definition more specific would be to enter at once into the realm of controversy, to engage in a battle of words, in which slightly different nuances of definition disguise radical differences in approach and emphasis in the study of the subject. Economics, which has long been and will perhaps ever continue to be the battle ground of rationalizations for group and class interests, has suffered more than any other discipline from the malaise of polemics about definition and method. Economics was defined as a science of wealth and as a science of welfare; it was spoken of as centering about the business enterprise and as including the entire range of economic behavior; it was declared to be essentially abstract and deductive or essentially empirical and descriptive; it was proclaimed by some as a science and by others as an art. The modern

> student regards these controversies not as dispassionate attempts to attain by logical means to eternal verities, but as the reflection in one field of changes in *Zeitgeist* and of shifts in the class structure of economic society. . . . For his purposes the broad definition of economics given above should be entirely adequate; it indicates that *economics is a social scientific discipline and that it is concerned with the relations of man to man arising out of processes directed to the satisfaction of material needs.*[1]

The consideration might be added that man does not live by bread alone, that more than his "material needs" remain to be satisfied. Nevertheless Thoreau's statement that "not until we shall have secured the essential material necessaries of life are we prepared to meet life successfully" remains supremely true.

Meanwhile, if the practice of the scientific discipline of economics is to achieve fulfilment of our material needs, it remains for the social sciences as a whole to develop to the extent where they can fruitfully guide and direct society toward realization of man's social and cultural aspirations.

Three basic considerations would appear to affect the scope of research which may guide society toward such higher standards of life.

1. Science is unified by the interrelations of its subject matter. The subject matter of specific studies may be predominantly technical or predominantly social, but the problem of widening the area of man's control of his environment calls for removal of the barriers which current concepts have erected between "natural" or "physical" science and "social" science. "Science is the organization of experience; what shall go into it is entirely a matter of experience."[2] Neither technology, understood as the science of productivity, nor sociology, conceived as the science of human association, can be completely scientific unless both are viewed as aspects of the reality which constitutes man's experience in the productive process.

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[1]Encyclopaedia of the Social Sciences, "The Discipline of Economics," by Edwin R. A. Seligman, editor-in-chief. Macmillan Co., New York, 1933, vol. 5, pp. 344-345. Emphasis ours.

[2]Jennings, Herbert Spencer, The Biological Basis of Human Nature. W. W. Norton and Co., New York, 1930, p. 372.

2. The totality of man's life in the community, whether local, regional, national, or world-wide, must be recognized as the framework within which specific problems for research are to be formulated. The community, which includes man and his environment, is more than the sum of its parts. No one part can be truly understood except in relation to the whole. The nature of the new technology has resulted in the necessity for integration of all branches of production through a unifying social objective which directs production toward such material and cultural standards in the community as will prove to be most favorable for the creative life of all its members. Social research must achieve a similar integration.

3. *Change is constant,* and a change in any part affects the whole and all other parts. As technology is dynamic, social science cannot be static.

Lacking orientation with technology in a total reality, social research has failed to create the necessary social design which would guide production for the general welfare. Such guidance clearly is its present task, if the potentialities of science itself are to be realized. Recognition of the unity of science, the totality of man's life in his community, and the constancy of change would make possible the needed new approach to social research.

Finally, it must be recognized that knowledge of human life and association, which is the fruit of social science, is in itself—when motivated by devotion to the general welfare—a force for evolutionary change. Without this knowledge and motivation, the inevitable change resulting from technological advance may turn to waste and human misery. The social cost of ignorance in the area of needed social invention is amply demonstrated in contemporary history.

Postscript

War and the New Technology

PRODUCTION for war in Europe, which began to make its demands upon American industry as early as 1939, illuminated like a sudden flash of lightning both technological development and its retardation. Airplanes, tanks, and ships constituted the apparatus for the new warfare which technology had made possible. The same inventions and discoveries which had transformed the apparatus of production for peacetime living changed both the equipment and the processes of war. Bombs and high explosives are products of the new chemistry. Engines and new materials for construction of transportation equipment on land, in the air, on the sea, and under the ocean, are products of the new age of electric power and of metallurgy.

Thus science and invention enhanced the soldier's efficiency for war and the productivity of his death-dealing tools in the same manner as it augmented labor's capacity to produce for civilian life. It has been said that eight machines on a British "Hurricane fighter" could deliver in a few seconds more lead "than all the machine guns in an infantry battalion in the world war."[1]

While methods of warfare were thus undergoing rapid change, private industry was obliged to adapt itself to quantity production of engines and airplanes. The making of airplanes, still virtually a handicraft, was to be turned into a genuine mass-production industry. In this attempt, existing obsolescence of machinery for metal work,[2] and especially the depressed state of the machine-tool-building industry, became quite evident and needed to be quickly overcome. Hence in the beginning of the war effort in 1940, prevailing conditions constituted retarding elements.

[1]New York Times, March 7, 1941, article by Charles Hurd, "Huge New Industry for Machine Guns—Colt Company Making Rapid Expansion at Hartford—Lends Experience to Others."

[2]In its periodic Inventory of Metal-Working Equipment in 1940 American Machinist, trade journal of the machine industry, found 70 per cent of such equipment "obsolescent," i.e., more than ten years old (American Machinist 1940 Inventory of Metal-Working Equipment: A Study of Obsolescence. New York, May 29, 1940).

Contrasts with 1918

Nevertheless in its Survey of Current Business in August, 1941, the United States Department of Commerce was already able to make the following statement, under the title, "Production Rate Now Double That in Last War":

> Whereas a year ago, military output in this country was only a small fraction of total production, it now is beginning to assume, after months of "tooling up," a substantial proportion of a much larger production volume. Some appreciation of the present level of aggregate industrial output is gained from noting that it is just double that in the middle of 1938.
>
> Moreover, the mid-1938 production level was approximately that which prevailed throughout the whole period of the first World War. . . . The present upswing is radically different from the experience of a quarter of a century ago, when after an initial advance in 1915, first the lack of plant, then a shortage of additional labor (caused partly by growth of the armed forces), and increasing frictions within the economy precluded any further advance.
>
> The availability of unemployed labor and plant has made it possible to bring about the great expansion of the past year with a minimum of friction. For the time being, labor shortages are still a problem of secondary importance. The chief difficulty now is an inadequate capacity, both of finished plant and required raw materials, for producing the type of commodities in sufficient volume needed by the country at this time.
>
> These capacity deficiencies are being rectified to some extent. But the raw material problem, particularly in the metals, has grown increasingly serious, and in July it became more evident that consumer goods industries competing for scarce metals must face an accentuated curtailment of output.[1]

Hence the American people, confronted for ten long years with abnormal unemployment, were faced, in the next decade, with the quite different problem of shortage of consumers' goods through competition of war, the new consumer, with governments paying the bills through taxation and loans. This development, in its turn, revealed the fact that lack of purchasing power, and not lack of ability to produce, had slowed down American industry in the

[1] Survey of Current Business, August, 1941, vol. 21, no. 8, p. 6.

1930's. For as soon as government became the preferred consumer, with ability to purchase on a large scale, production expanded rapidly. The chart showing "Fluctuations in Industrial Production, 1928-1942,"[1] has already indicated the great change between 1940 and 1942, in comparison with the pre-war period. Commenting on this increasing rate of production for war, especially in the early months of 1943, and comparing the new situation with indices of business activity extending back on a monthly basis to 1790, the Cleveland Trust Company Business Bulletin declares that

> the production records of 1941 and 1942, as well as those of the early months of 1943, are the highest ever recorded, even after they have been corrected to allow for long-term growth of population and production. The highest previous figure was 24 percent above normal during the War of 1812. The highest figure reached in the first World War was 16 percent above the computed normal level.[2]

Thus, in contrast with the depression of the 1930's, the 1940's opened with the new stimulus to industry offered by production for war. In a period in which consumption has lagged, as in 1914 and again in 1939 and all of the preceding decade, assurance of a great and privileged customer such as war, especially for the long-depressed primary industries of coal, steel, and machine-tool building, must obviously act as a powerful accelerator of business.

Increased labor productivity was an important factor in the resulting expansion. In 1937, two years before the war began, volume of production had attained a peak of 376, highest of any year in national history, in comparison with 222 in 1919, whereas the number of wage-earners was almost the same—at an index of 191 in 1919 and 194 in 1937.[3]

As might be expected, the drafting of manpower for military service was at first offset by this increase in labor productivity. Output of manufacturing industries in 1941, as compared with the average for 1935-1939 (a different base from that used in the preceding figures), reached the highest point on record, represented by an index of 161, with an index of 130 for employment. In steel during 1941 the index of production stood at 178, with

[1]Reproduced on p. 165.
[2]Cleveland Trust Company Business Bulletin, vol. 24, no. 5, May 15, 1943.
[3]See Table 4, p. 161.

employment at 138; in shipbuilding the production index was 442, with employment at 342; in aircraft the indexes were 982 for production and 850 for employment.[1] These figures show that production increases faster than employment; that is, the same labor force produces more and more.[2]

Often described as a war of engines, the new world war obliged industry to use the newest materials and most up-to-date processes which technology had developed since the armistice of 1918. At the same time one of the first effects of the war, through cutting off European markets and shipping facilities, was to restrict exportation of agricultural products, which the first World War had greatly stimulated. Thus the second World War seemed likely at first to accentuate the already existing tendency toward declining employment in agriculture, while it expanded the new industry of aircraft and developed shipbuilding and other forms of transportation, requiring of the industries of fuel, steel, and other branches of metallurgy the materials needed for the new types of transportation and fighting equipment. Later, after the entrance of the United States into the war, demand for food for the armed forces both at home and abroad, and a forecast of the need for agricultural products for future relief in European countries established new goals for expanding production on the farms, while shortage of manpower began to deprive the farms of labor.

During the first period of industrial expansion for war, with increased opportunities for employment, the purchasing power of the workers stimulated the manufacture of consumers' goods to supply their needs. At the same time, reluctance of private business

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[1]See van Kleeck, Mary, "Labor's Contribution to Production," in American Labor Legislation Review, June, 1942, p. 64.

[2]General Motors Corporation, in a quarterly report to stockholders, in November, 1942, described savings in man-hours, costs, materials, and time, and used the following illustration: "In the case of the machine gun, it became possible through changes in manufacturing methods to double production in the same man-hours, to cut costs to half the original amount and to build additional quality into the guns." (New York Times, November 4, 1942, "War Materials Output Speeded By New General Motors Methods—Skills and the Experience Gained in Mass Production in Peacetime Cut Down on Man-Hours, Cost and Material, Sloan Says," (quoting Alfred P. Sloan, Jr., chairman of the corporation.) The growth described for the year 1941 continued in 1942 and was still advancing in 1943, demonstrating the new productivity in the present war industries. Even industrialists have not been aware of the total potentialities for production in technological changes since the last war.

to expand production installation for the market of uncertain duration, provided by war, forecast curtailment of production of goods for the use of the population, while resultant higher prices for the necessities of life seemed to indicate the danger of so-called inflation of the currency. Fiscal problems—the tasks of financial management, imposed upon a government at war under these modern conditions—pressed for solution.[1]

WAR ECONOMY

War economy must be an organized economy; and therefore war, like unemployment, which appears to be its opposite, calls for understanding of the nature of the new productivity. The need for co-ordination of different branches of production was already noted as one of the lessons of the last war when the War Industries Board made its report to the President on December 24, 1919.

> The Board was inspired by a picture of our industry so mobilized, and with all conflicting efforts so synchronized, that the fighting forces of the world could tap it at will for such supplies as they needed . . . and . . . do all of this with the least possible dislocation and destruction of the essential features of our ordinary industrial life.
>
> Through application of the principle of priorities, the processes of manufacture and trade were made to move in response to a national purpose rather than in response to the wills of those who had money to buy.[2]

If moving "in response to a national purpose" was necessary in the last war, how much greater is the need for co-ordinated effort toward a unified national aim in the present war, with its instruments and their production shaped, as they are, by the new technology. It is too early, in 1943, to write the history of production in this war, but the experience of the first four years has already demonstrated that organization must be developed in accordance with the compelling requirements for integration which characterize the new technology. Social adjustment to this same technology

[1]For a study of this subject, see Crum, William Leonard, Fennelly, John F., and Seltzer, Lawrence Howard, Fiscal Planning for Total War. National Bureau of Economic Research, New York, 1942.

[2]War Industries Board, American Industry in the War. Report by Bernard M. Baruch, Chairman. Government Printing Office, Washington, 1921, p. 29.

in time of peace will likewise require a unifying national aim. In a democracy no aim which falls short of the general welfare can unify the nation.

POST-WAR UNEMPLOYMENT

Looking back to the post-war unemployment of 1921, and viewing the transition from the unemployment of 1939 to the new demands for labor forecast in the new decade, the opportunity is offered to note the possible effects of war on employment and living standards under conditions of the new technology. We may well recall what kind of consumer the war of 1917-1918 proved to be, and what was the effect of its purchases upon production and consumption in the ensuing period of peace.

Expressed in statistical terms, as already shown in Chapter VI,[1] employment in manufacturing rose to a high point in 1919, and volume of production to a still higher level, but both fell off sharply by 1921, when idleness of wage-earners became so widespread as to result, in September, in the calling of the President's Conference on Unemployment, the first of its kind in the history of the nation. Not only were wage-earners unemployed, but business large and small was seriously depressed. The President's Conference reported the greatest distress among farmers.[2] These conditions had already been forecast by the War Industries Board in its unsuccessful effort to prevent them.

Unemployment and depression in business at that time were not limited to the United States; nor should the renewed and more excessive unemployment which began in 1929 be overlooked as in part, at least, a consequence of war. Studies of unemployment in several regions of the world between 1910 and 1930 were summarized as follows in 1931 for the World Social Economic Congress, held at Amsterdam, Holland, under the auspices of the International Industrial Relations Institute:

> Unemployment today is not a problem of employment, but of markets and finance. It is an economic crisis displaying the aspect of the crisis of unemployment prevailing within the several nations. . . .

[1]See Table 4, p. 161.

[2]President's Conference on Unemployment, Report, September 26 to October 13, 1921. Government Printing Office, Washington, 1921; especially pp. 152-153, Report of Committee on Agriculture.

> Drawing on several studies of the causes of this general economic crisis, [it was] found that the initial circumstance most often indicated was the fall in prices, especially since 1925, in the majority of raw materials and foodstuffs. The causes of this fall have raised many questions for debate among economists. . . .
>
> The majority of French economists refused to emphasize either the demand of the market or the supply of currency, but held to a simpler idea, that prices fell for those products of which overproduction had begun to be evident—raw materials and foodstuffs. Their principal producers are the United States and other new countries comparatively free from the war's disasters, if not even enriched thereby. *They overestimated the future demand of an impoverished Europe and underestimated the future capacity of production of Europe restored.* The first error explains the crisis of 1920-1921; the two errors together, especially in wheat and sugar, led to the 1929 and the present crisis.[1]

Added support for this position, as well as subsequent data, may be found in a study issued in 1936 by the International Labour Office, which contained the striking summary that "the total loss of the world economic system between 1930 and 1934 as a result of the depression (as far as production, commerce, and transport are concerned) amounted in round figures to between 149,000 and 176,000 million '1928 dollars,' or from 100,000 to 120,000 million '1913 dollars'—a fateful figure, equal to the total cost of the Great War."[2]

Post-war conditions of the past, and a forecast of the future, are illuminated in the summary of findings from which the following significant statements may be quoted:

> The *immediate* cause of all the calamities of the depression was the shrinkage in industrial production.[2]
>
> Thanks to the divergence in prices, a fraction of the loss of output of the industrial countries could be passed on to the agricultural countries. . . . Three industrial powers of Europe [Great Britain, Germany, France] were able, as a result of the discrepancy between industrial and agricultural prices, to transfer to the agricultural branch

[1]Lazard, Max, "The Significance of World-Wide Unemployment" as summarized in "Analysis and Review of the Congress," in World Social Economic Planning. International Industrial Relations Institute, The Hague, 1932, pp. 12-14.

[2]Woytinsky, Wladimir, The Social Consequences of the Economic Depression, International Labour Office, Geneva, 1936, p. 300.

of the world economic system losses amounting in all to about 7,500 or 8,000 million "1929 dollars" from 1930 to 1933 and probably 10,000 millions for the five years from 1930 to 1934.[1]

According to the statistics of these three countries the fraction of the loss of national production that was passed on to foreign countries was as follows:

for Great Britain (1930-1933) over 50 per cent;
for Germany (1930-1933) over 15 per cent;
for France (1930-1932) over 36 per cent.[1]

During the depression the agricultural countries suffered a loss of *national income* for which the decline in their *production* offered no justification.[1]

The industrial countries were able to keep up a comparatively high standard of living, but they suffered from a steady increase in unemployment. The agricultural countries maintained their usual volume of output and even increased the volume of their exports, but their population was reduced to extreme poverty.[1]

PROPOSALS IN 1918 FOR POST-WAR REORGANIZATION IN THE UNITED STATES

In the light of the long continuance and world-wide consequences of post-war unemployment and depression, the proposals made in 1918 by the War Industries Board in the United States take on new significance. It was natural that the Board should wish continuance of the co-operation which had proved effective in time of war. While the Board's recommendations were directed toward the possibility of another war, rather than continuance of controls by government in time of peace, nevertheless it was suggested that some form of organization, looking toward better co-operation, was needed, especially as such a procedure had already been tested and found effective.

> In line with the principle of united action and cooperation, hundreds of trades were organized for the first time into national associations, each responsible in a real sense for its multitude of component companies, and they were organized on the suggestion and under the supervision of the Government. . . . Many business men have experienced during the war, for the first time in their careers,

[1] Woytinsky, Wladimir, The Social Consequences of the Economic Depression, p. 302.

> the tremendous advantages, both to themselves and to the general public, of combination, of cooperation and common action, with their natural competitors. To drive them back through new legislation, or through the more rigid and rapid enforcement of present legislation, to the situation which immediately preceded the war will be very difficult in many cases, though in a few it is already occurring spontaneously. To leave these combinations without further supervision and attention by the Government than can be given by the Attorney General's Department, or by the Federal Trade Commission in its present form, will subject business men to such temptations as many of them will be unable to resist—temptations to conduct their businesses for private gain with little reference to general public welfare.[1]

While pointing out the possibilities of great advantage to the public through co-operation to eliminate waste, to increase efficiency of production, and to establish a certain degree of organization of the market, the War Industries Board noted nevertheless the tendency of American industry to restrict or retard production.

> These combinations are capable also—and very easily capable—of carrying out purposes of greatest public disadvantage. They can so subtly influence production as to keep it always just short of current demand and thus keep prices ever high and going higher. They can encourage a common understanding on prices, and, without great difficulty, can hold price levels at abnormal positions. They can influence the favoring of one type of buyer over another. Nearly every business man in the country has learned by the war that a shortage in his product, if it be not too great, is distinctly to his advantage. Trade associations with real power can, in respect to most of the staples, so influence production as to keep the margin of shortage at a point most favorable to high prices and rapid turnovers.[2]

Turning to the question as to the kind of government organization which could be devised "to safeguard the public interest while these associations are preserved to carry on the good work of which they are capable," the Board believed that its own experience pointed

> to the desirability of investing some Government agency, perhaps the Department of Commerce or the Federal Trade Commission, with

[1]War Industries Board, American Industry in the War, p. 99.

[2]Ibid., pp. 99-100.

constructive as well as inquisitorial powers—an agency whose duty it should be to encourage, under strict Government supervision, such cooperation and coordination in industry as should tend to increase production, eliminate waste, conserve natural resources, improve the quality of products, promote efficiency in operation, and thus reduce costs to the ultimate consumer.[1]

In a sense, following the stimulus of the President's Conference on Unemployment, the essential points in these recommendations of the War Industries Board were carried out. The Department of Commerce, from 1921 to 1928, under the direction of its Secretary, Herbert Hoover, was a center for voluntary co-operation by trade associations. They constituted an advisory service of businessmen to the government, especially the Department of Commerce; and in turn the Department organized its staff for a program of standardization, improvement of quality, elimination of waste, and increase in efficiency. Studies were published, under the general title, "Elimination of Waste Series," sponsored by Mr. Hoover.[2]

It is significant that with the inauguration of the New Deal in a period of depression, in 1933, the National Industrial Recovery Act opened the possibility for the trade association in each industry to receive a delegation of authority from the President to administer the act, under the National Recovery Administration (NRA). Nevertheless it was this delegation of authority which was challenged by the Supreme Court in its opinion adverse to the National Industrial Recovery Act in 1935. Again, in the new war, a notable concentration of war orders has occurred in the same leading companies which predominated in some of these trade associations. Moreover, it is the representatives of these industries who serve on the policy-making boards concerned with production for the present war. Will it be possible in the new post-war period to avoid the

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[1]War Industries Board, American Industry in the War, p. 100.

[2]See President's Conference on Unemployment, Report, September 26 to October 13, 1921, Government Printing Office, Washington, 1921; Federated American Engineering Societies, Committee on Elimination of Waste in Industry, Waste in Industry, McGraw-Hill Book Co., New York, 1921; President's Conference on Unemployment, Committee on Recent Economic Changes, Recent Economic Changes in the United States, prepared by National Bureau of Economic Research, McGraw-Hill Book Co., 1929; and President's Research Committee on Social Trends, Recent Social Trends in the United States, McGraw-Hill Book Co., 1933. The last was a forerunner of the National Resources Committee's report, Technological Trends and National Policy.

danger of misuse of power, especially in those industries in which pre-war trends toward monopoly have been accentuated by immense war orders?

TRANSITION TO PEACE

The problems of adjustment to a future peace are likely to be more serious than in 1919. In historical perspective the year 1937 will be seen as the period of maximum development of the new technology in the pre-war decade. During the war, data accumulate for new studies of the behavior of our economic system in relation to the new technology. While war demands the best that technology has to offer, it is already clear that the new technology, with its new productivity, is likely to create even greater strains in the sphere of economic relations than in the last post-war period. In proportion as this new technology and its use for production for war have been developed also in other countries, the necessity for planned adjustment of productive capacity and standards of living will be world-wide.

This does not mean, however, that world organization should take precedence over the local community—nor powerful industrial nations over agricultural countries and producers of raw materials. Community organization at all levels, from agricultural village to world economy, must be directed toward making accessible to all peoples the potential benefits of the new technology, to be utilized for their livelihood and living standards.

Appendix I
Optimum Productivity in the Workshop

MEMORANDUM PREPARED FOR DEPARTMENT OF INDUSTRIAL STUDIES OF THE RUSSELL SAGE FOUNDATION BY MARY L. FLEDDÉRUS, DIRECTOR OF INTERNATIONAL INDUSTRIAL RELATIONS INSTITUTE, MAY, 1938[1]

INTRODUCTORY STATEMENT

Optimum productivity may be defined as

> the best possible achievement, quantitative and qualitative, in output and performance directed toward the highest standards of living, material and cultural, which are attainable with rational conservation of resources, human and material, and full utilization of the human and physical sciences, invention, and skill.[2]

Thus optimum productivity is a very complete concept. In aim it is ideal. As a process it is realistic. Its antithesis may be conceived as "waste," both human and material, in all its various forms, actual and potential.

The most direct approach, therefore, to the problem of optimum productivity in any given situation is likely to be that of the consideration and elimination of all possible waste, both in its immediate manifestations and as an indirect and potential factor in the sense of unused opportunities for a more truly economic conduct of industry in its bearing on resulting standards of living.

During the last decade much knowledge has become available with reference to measurement and elimination of waste, both human and material. This has constituted an important contribution to the science of management. Optimum productivity, however, is a wider concept. It is more nearly concerned with the inherently possible than with the

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[1]This memorandum was presented in mimeographed form at the 1938 study conference of the International Industrial Relations Institute at The Hague and published as one of the Institute's papers in Synthese, a scientific journal (Laren-Gooi, Holland), vol. 4, no. 5, May, 1939.

[2]The development of this definition resulted from the work on this memorandum. The definition was first presented in the memorandum on "Optimum Productivity in the Workshop as an Area for Social and Technical Research," prepared for the Oxford Management Conference, March 31 to April 4, 1938, by Mary L. Fleddérus and Mary van Kleeck and published in British Management Review, July-September, 1938, vol. 3, no. 3, pp. 166-180, with a concluding paper by Mary van Kleeck, on "Social Implications of Optimum Productivity," pp. 181-197.

actually existing, with unused opportunities than with immediate achievement. This finds expression in its definition, which requires "full utilization of the human and physical sciences, invention, and skill," as prerequisites to "the highest attainable standards of living, both material and cultural."

While it is probably true to say that scientific management is primarily concerned with the conduct of industry, optimum productivity relates itself directly to the standard of living in all its various phases which together build the community.

High standards are possible in the power age of potential abundance. They are no imaginary belief. On the contrary, the very failure to utilize opportunities now brought within reach through development of technology with electric power as the driving force has, in itself, disorganized standards of living. What should have made for productivity and wealth has turned to impoverishment and waste.[1]

To strive for elimination of this basic waste is beyond the scope of individuals or single groups. Its realization belongs to the realm of more universal, co-operative consent. At the same time, however, by consciously limiting the area of technical investigation to the workshop—with continuing awareness of its social implications—studies can be made which are fundamental in any given economic system. Thus envisaged, the perhaps most complex and humane science of optimum productivity can be fruitfully developed.

GENERAL APPROACH

If waste is the antithesis of optimum productivity, study of the process of its elimination is sure to lead us to the center of the area to be investigated.

Waste, as indicated, can be of two essential kinds. It can be either human or material. In the process of production, however, an *a priori* distinction between these is not likely to lead to a complete picture of a given situation or development. On the contrary, any investigation in industry which has not due regard to its entirety will fail to evolve the factors conducive to optimum productivity.

Also the need for full utilization of the available human and technical sciences becomes at once apparent. To these should be added invention and skill. Thus viewed, the concept of optimum productivity in the workshop may be developed as a frame of reference for optimum pro-

[1]In this paragraph was implied the need for investigation of "the changing technological basis for production as affecting employment and living standards," which became the subject of the present study.

cedure in any given situation. Again, concentration on waste, both human and material, will almost certainly afford the proper key.

At the outset it must be recognized that the prevailing economic system, within which the workshop must function, is an increasingly wasteful system. Its wastefulness is due to the fact that it does not allow for primary direction or control in the interest of standards of living. Its balance has traditionally been controlled by competition. (Monopoly, paradoxically, is the extreme of the development of this competitive system, representing, as it does, the success of the few in eliminating their competitors and hence in controlling the market for profit by restricting production and dictating prices.) Competition is a wasteful motive power. Co-operation is its antithesis. Therefore optimum productivity in the workshop faces odds and limitations. Its very dilemmas, however, should increase the value of the study of its essential factors.

Fundamental in importance to both industry and the community alike is the length of the working day and the question of remuneration. Together they are dominants in the standard of living. The one is directly related to leisure; the other, to consumption, including enjoyment of services and cultural opportunities. More leisure stimulates consumption. Together they highly influence production. A study, therefore, of the length of the working day, including a close scrutiny of the factors which enter into the whole question of hours of work, may well prove a most illuminating way into the problem of optimum productivity.

HOURS OF WORK IN THEIR BEARING ON OPTIMUM PRODUCTIVITY

Consideration, then, of hours of work—or length of the working day or the working week—is likely to bring forward a range of closely related problems which may prove central in their influence on productivity and its optimum. As foremost among these may be regarded, on the one hand, the question of perfection of machinery and tools by technicians with a view to increasing output and eliminating waste, and, on the other hand, possible adaptation in human effort on the part of the worker to compensate for reduction in hours. Simultaneously the question of reduction of hours of work is bound to call for improved methods of organization and administration.

Investigation into these questions will, at the same time, reveal the nature of different industries and their varying inherent possibilities and exigencies. For instance, in some industries the machine element is large and human labor correspondingly small. Hence compensation through adaptation of human effort for reduced working hours can hardly enter into the planning of production in relation to length of working day. In such highly automatic industries the best possible productivity depends almost wholly on perfection of machinery and methods, suitability of raw materials, and proper organization and administration. By their nature these industries belong to the so-called continuous industries. The "optimum" of their productivity is likely to be determined by length of running time and rate of speed of machinery, coupled with methods of technical and financial calculation. However, the proportion of men and women engaged in industry on work of a character that allows for compensation by adaptation of human effort is considerable.[1]

Again, the possibilities of such compensation will vary for different industries and for different departments of the same industry.[2] This latter fact may, incidentally, prove to have a definite bearing on such modification of working hours as might be made through the introduction of shift systems.

For the purpose of obtaining true insight into the nature of the various industries which are being operated today, and into the problems of their productivity, a survey of the history of the machine-tool-building industry (as the industry which makes machines and tools required to make machines) is likely to afford the greatest illumination.

The whole concept of hours of work and length of working day is no longer one of simple addition. Where human labor is concerned, longer hours of work do not necessarily produce more. On the contrary, it has already been demonstrated that, within given limits, they produce less. Scientific investigation has made us familiar with some of the considerations which enter into a study of hours of work in their effect upon productivity. In the length of the working day lurks a considerable measure of waste.

RELATED WORKING CONDITIONS

As already stated, this waste may be either human or material. As a rule it is both, for in industry human states and aptitudes and material conditions closely interact. Much depends upon the adjustment of machinery to the worker to facilitate operations, coupled with relief and rest pauses; much, also, upon general conditions, such as proper

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[1]For Great Britain this was estimated at well over 50 per cent and possibly two thirds, in 1929, by H. M. Vernon. See Rational Organization and Industrial Relations, pp. 56-57; conference proceedings of International Industrial Relations Institute, 1929.

[2]Cf. International Labour Conference, 23d Session, Report of the Director. International Labour Office, Geneva, 1937, p. 35.

lighting, regulation of temperature, humidity, dust, fumes (sometimes poisonous), noises. Extremely important are selection and training with due regard to temperamental fitness. Methods of remuneration and wage incentives play a considerable role. Highly important is the rate of speed and possible control (or absence of control) of automatic machinery to which the worker must conform.[1]

Of all the conditions and hazards enumerated, this last undoubtedly presents the gravest modern danger. The danger is the greater because of its subtlety. Most other industrial hazards are either obvious or fairly well known through scientific investigation, and a technique of measuring them has been evolved. Their relation to optimum productivity and hence to elimination of waste—in the sense of the best possible achievement, quantitative and qualitative, in output and performance, with rational conservation of human and material resources—can be fully ascertained. Human and mechanical adjustments can be made. The subtle nature, however, of nervous overstrain through increased automatic machinery and constantly accelerated speed causes a gradual exhaustion for which there may be hardly any redress, once it has become fully apparent. Moreover, such adjustments as can be made are predominantly or wholly mechanical. For, in the nature of things, the worker can do little or nothing to adjust himself. He cannot react, but must merely conform. As far as conservation of human resources is concerned, the automatic process and those who direct it alone can decide. Here, undoubtedly, enters the immediate question of where normal productivity ends and human waste begins.[2]

That this human waste is far from being a negligible factor, but that, on the contrary, it is predominant in the consciousness both of the workers and of those who have due regard for their interests, was clearly brought out at the round-table conference arranged for by the

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[1]In this connection the following quotation from the 1937 annual report of the Director of the International Labour Office seems of interest. Mr. Butler states: "Although in most industries his [the worker's] productivity has been considerably enhanced, although the pace of operations has been greatly accelerated, the worker as a rule has not received compensation for his additional output in the form either of increased wages or of increased leisure. In some countries the desire for higher wages is stronger than the demand for more spare time, but in all countries the demand for shorter hours as the recompense for higher output and as an offset to increased nervous tension resulting from modern methods of production is growing in intensity." (International Labour Office, Report of the Director. Geneva, 1937, p. 39.)

[2]"The needs of the workers for leisure and for protection against excessive fatigue set maximum limits ["optimum" would better denote our point of view] within which management must be competent to devise methods of production to fulfil these social needs." (Industrial Employment Code, Sec. V, "Hours of Labor," in Bulletin of the Taylor Society, vol. 16, no. 1, February, 1931, p. 21.)

Department of Industrial Studies of the Russell Sage Foundation with representatives of industry and of scientific management on December 23, 1937.[1] A paper especially prepared for this round-table discussion by the president of the United Textile Workers of America presents clear evidence of this. The workers call these automatic processes the "stretch-out" and the "speed-up." They react to them by "slow-down" and "sit-down" strikes. The 1934 general textile strike was attributed almost wholly to the "stretch-out" system. The workers had been driven to their utmost, and felt that they had little to lose by striking.

The Winant Board report, which closed the 1934 textile strike, has defined and analyzed the "stretch-out" system in the textile industry. The following reference has been made to it:

> The problem of regulating the use of the stretch-out system is to find the proper balance between the fullest possible utilization of devices that will result in increased efficiency and at the same time give protection to the worker from an improper increase in work load.[2]

Here, evidently, is a problem of "optimum" productivity.

The textile strike in 1934 was not the only significant one in this connection. There have since been others, such as the "sit-down" strikes in the rubber-tire industry and in the automobile industry. For the rubber-tire industry this was the more significant, as there was hardly

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[1]The following are some of the immediate problems brought forward during the discussion as being especially relevant to the subject of optimum productivity:

1. The "stretch-out" and the pseudo-scientific "Bedaux System" in the textile industry.
2. "Speed-up" in other industries, such as rubber tires and the automobile industry, resulting in "sit-down" strikes.
3. "Technological displacement" and "unemployment" through greatly increased mechanization (steel mills).
4. Need for labor's co-operation in scientific management, and education of labor as to its value.
5. Need for balanced loading of machinery, and measures to meet seasonal declines. Need for availability of proper raw materials during seasonal demand. (It was roughly estimated that 50 per cent of possible cost reduction falls in these groups.)
6. Need for good condition of tools and machinery, and proper training of workers for running machines at full speed. (It was roughly estimated that 90 per cent of productivity on these lines was in control of management; 10 per cent, in control of workers.) Conclusion: Organized labor therefore should demand scientific management.
7. Essential need for shop committees to consult and collaborate with management.
8. Need for test shops.
9. Importance of appropriate overhead of machinery and equipment, their influence on cost price being greater than direct labor cost.
10. Disadvantages of present loans by government (through Reconstruction Finance Corporation) in lessening need for development of greater efficiency in methods of production; keeping alive plants with bad working conditions and others causes of inefficiency.

[2]Winant, John G., Smith, Marion, and Ingersoll, Raymond V., Report of the Board of Inquiry for the Cotton Textile Industry to the President, September 17, 1934. Government Printing Office, Washington, 1935, p. 13.

any union organization in the Akron rubber-tire plants. These strikes have been interpreted as a spontaneous reaction by the workers to "speed-up" practices of which they are fully aware, even though they cannot precisely locate them. Here, also, research into the "optimum" of productivity would be extremely illuminating.

WORKERS' PARTICIPATION IN MANAGEMENT FOR OPTIMUM PROCEDURE

In any consideration of the whole complex of modern industry it must increasingly be realized that a new period was entered upon with the change from steam to electricity as a basic driving power. Productivity became immensely accelerated. In fact, there are hardly any limits to its acceleration, as far as machinery is concerned. Hence around 1900, industry started upon a new period which may perhaps be considered a parallel to the early days of mechanization a century earlier, when protective legislation against industry's obvious evils became the answer to aroused public opinion. Today, however, public opinion can as yet not be sufficiently aware. The new problems are of a different nature. They can be ascertained only by scientific management in collaboration with workers' experience. Together these can establish scientific criteria,[1] in response to which not public opinion but trade-union organization can demand legislation.

The form which such collaboration should take can only be that of workers' participation in management. For this purpose they should be carefully trained and should train themselves in shop committees and works councils. The tasks of these committees and councils should be technical. They should be advisory to the trade unions. They should be highly instrumental in satisfactory collective bargaining.[2]

For the establishment of scientific criteria by management and workers, the contributions of the technical and the human sciences are fully needed. Together they can establish these criteria for optimum procedure. For it is this "optimum procedure" which at any given moment determines what is optimum in workshop productivity.

[1] "I do not agree that the [Taylor] Society should be more human and less scientific. Science is the foundation of humanity. To be humane, one must work out plans by study and careful thinking. The Taylor Society has done a very fine thing in standing for the idea that says, Let's get at the facts for the benefit of humanity." (Glenn, John M., in "The Taylor Society Looks Ahead," discussion at conference dinner of directors and guests, New York, April 28, 1927 [mimeographed report], p. 21.)

[2] "Unprejudiced study of the most effective forms of organization of labor for functioning in relation to management as a science is an obligation resting upon progressive managers, in the interest of good management as well as in recognition of the importance of satisfactory human relations in industry." (Industrial Employment Code, Sec. X, "Employes' Group Relationships," in Bulletin of the Taylor Society, vol. 16, no. 1, February, 1931, p. 23.)

Appendix II
Synopsis

NOTE TO READER

THE DECADE inaugurated by the memorable year 1929 witnessed the phenomenon of unprecedented unemployment and inadequate standards of living for large sections of the population, coexistent with greatly increased industrial (including agrarian) productivity, resulting from new science and invention. Such a situation would appear to constitute a new and great challenge to society to utilize this new productivity for livelihood and living standards.

Following this decade, the year 1939 saw the beginning of war in Europe and defense preparations in the United States. Many of the unemployed were absorbed in the military forces. The needs of the situation, moreover, suddenly called for all available and potential production for the manifold purposes of war. Co-ordination of scientific knowledge and synchronization of production methods were required in a total but elastic production plan, at the service of the armed forces and their strategy. Thus our high-powered production apparatus came to be guided by a unifying aim, a guiding motive absent from our peacetime economy.

Nevertheless, also in peacetime the new technology, by its very nature, increasingly makes these same demands for co-ordination and adjustment toward an agreed and socially desirable end. Society has as yet failed to adjust itself to the new basis for security of livelihood. Livelihood is the living won by work. The new technology in itself is setting new tasks of organization of life and labor in the local community, the nation, and the entire globe.

The present inquiry makes use of significant information accumulated in reports by governmental agencies. It attempts to contribute toward that basic orientation which is a prerequisite to conscious utilization of productive forces for human life.

PART ONE—THE NATURE OF TECHNOLOGICAL CHANGE IN BASIC INDUSTRIES

CHAPTER I—CHANGE IN PRODUCTIVE FORCES THROUGH SCIENCE AND INVENTION

1. Electricity. Production of the necessaries of life is at all times a matter of primary human concern. Production for cultural ends adds to life's expansion. Invention of the steam engine inaugurated the industrial revolution and created the modern world of the eighteenth and nineteenth centuries. The immensely accelerated and constantly increasing productivity of the twentieth century is due to the new sciences of electricity and chemistry and their practical applications. Electricity is a fundamental quantity in nature, an ever-present potential energy which can be generated by steam turbines and waterfalls. It is an unlimited fluid force, in contrast to steam power, which is energy tied directly to the location of its source. The steam engine required centralization of industrial production, and hence urbanization. Electric power, continuously generated, can be stored and transmitted over great distances. Hence it permits of decentralization and universality. The electric motor is increasingly the conveyor of limitless cheap power, the infinite multiplier of human strength and provider of plenty. Electrical equipment, permitting of automatic operation, perfects the product and dispenses not only with many human manipulations, but even with human perceptions and judgments.

2. *Chemistry.* While electricity has to do with the movement and force of energy, chemistry is concerned with substances and their changes. The combination of heat-generating electrical processes and new chemical science, as evidenced, for instance, in metallurgy, has created entirely new materials and endowed them, so to speak, with a productivity of their own. Today the potency of the materials of industry ranks increasingly with its prime movers—power and machinery. Moreover, new scientific research has been made possible through availability of hitherto unobtainable, highly refined precision equipment, the fabrication of which has become possible only through the new electrical and chemical potentialities.

Study of methods of progressive social adjustment, which such basic technological change requires, is overdue. Of primary importance in new social research will be a true evaluation of the impact of the resulting highly accelerated productivity upon requirements for human labor.

Chapter II—Mineral Industries: Increasing Productivity and Changing Labor Requirements

A century ago, existing metals, other than gold and silver, were practically limited to iron, steel, copper, brass, zinc, bronze, lead, and tin. Today electrochemical and electrometallurgical processes have created thousands of new metals through their ability to combine elementary materials into alloys. These alloys improve upon the basic metals to the extent of endowing them with countless new qualities. As a result, objects, instruments, and mechanisms have become available which could never have been produced in earlier days. To the layman the most obvious examples may be the automobile and the airplane. To the engineer entirely new and powerful equipment opens up endless vistas of undreamed-of technological development.

During the last two decades mining of the basic ores and the auxiliary industries of smelting and refining have undergone increasing mechanization, resulting in highly increased productivity and decreasing need for human labor. Blast furnaces used to turn out five to ten tons of pig iron per day. Present furnaces can produce 1,000 tons per day, while not using more men. In making steel, many hand operations have been eliminated through use of continuous mills which roll the steel ingot into the finished sheet. Similar mills are being developed for rolling brass and copper. Synchronization of processes has made possible the continuous pouring of iron castings, resulting in a large saving of human labor. At the same time new high-speed tool steels have immensely accelerated cutting speeds, raising productivity throughout the metal industry, while making many earlier operations unnecessary. In the metallurgical industries technological processes, not men, are rapidly becoming the principal producers. As processes become more and more complex, requiring expensive equipment and technically trained personnel, large-scale enterprise is thereby fostered. At the same time an abundance and variety of metals have become available for improving material standards and conditions of life.

The same phenomenon of increasing mechanization, high productivity, larger units, more highly trained personnel, and decreasing labor requirements can be observed in the coal-mining industry and its auxiliary processes of cleaning and loading. In the bituminous coal industry, where coal lies nearer the earth's surface, electrification has made possible the new and increasing development of highly mechanized strip and open-cut mining.

Petroleum and natural gas have become the additional new fuel resources of our electrified and motorized industrial civilization. They supply the great new need for gasoline and lubricating oil. Oil also substitutes for coal in heating. The newly developed construction of pipe lines makes possible the transportation and incidental storage of crude oil. New techniques and equipment are conducive to increased flow, rediscovery, and conservation of oil wells. This industry offers certain new employment opportunities both to technically trained and to unskilled workers. Greater knowledge of the properties of gasoline led to the important invention of the internal-combustion engine, while invention of the cracking process resulted in a highly increased potency of gasoline and a large saving of the crude oil needed in the refining process. Characteristics of gasoline obtained by cracking have also permitted important modifications of engines, resulting in their more economical construction and operation. Possible substitute raw materials for oil are coal and oil shale, both of which are plentiful in the United States. With techniques as at present known, however, their use would considerably increase the cost of oil.

In summary it may be said that, owing to new and revolutionary electromechanical techniques and electrochemical processes, mineral scarcity has been turned into profusion. While this situation makes possible increasing satisfaction of both old and new needs, it also, within our present environment and relative to increasing population, results in decline of opportunities for livelihood, the living won by work. The same situation prevails in the industry of agriculture, once the greatest employer of human hands.

Chapter III—Agriculture: The Battleground of New Productive Forces

1. The Land. Agriculture, the world's oldest industry, is directly concerned with our primary natural resource, the land. While the soil was originally regarded as a static and unchanging medium, possessing or lacking in certain elements which could to some extent be supplied, the new science of pedology establishes various soil types, with their chemical, physical, and biological properties and their inherent response to scientific treatment, with resulting productivity. The same new science is contributing to knowledge of soil erosion and its control. For, except on areas of perfectly flat land, all agricultural development furthers the process of erosion.

Modern technology has developed equipment which makes possible new large-scale methods of drainage as well as irrigation, thus greatly extending the areas available for cultivation. At the same time, man is likely to disturb the balance which nature conserves. It is the role of forestry to restore this natural balance, through planting of vegetative cover which absorbs rainfall and maintains water in the soil, thereby conserving the soil through prevention of floods and ultimately of dust storms. Forest, range, and wild lands, moreover, shelter wild life, valuable for food, fur, and aesthetic purposes. Wood is a most useful industrial raw material giving rise to many socially important products and by-products. But immediate gain, rather than a long-time program for lasting productivity through conservation, has thus far largely motivated human activity in this domain. Forests have been mined and woodlands overgrazed, leaving ghost towns and depressed agriculture in their wake.

Potential productivity of the land is further greatly heightened by the growing science of chemical fertilization. The three chief fertilizing elements are nitrogen, phosphorus, and potassium. Until recently, the United States was self-sufficient only as regards phosphorus. Today technological progress has developed the synthetic nitrogen industry, which utilizes the inexhaustible supply of nitrogen in the air, while it has also created procedures for exploiting the newly found large natural beds of potassium salts, thus insuring all present and future needs of chemical fertilization for increased soil productivity. Of great additional value are the new chemical and engineering contributions made to elimination of insect pests which attack agricultural crops and livestock.

If the new technology could be administered in conformity with socio-technical requirements, the land could provide considerable employment, create successful homes and prosperous communities.

2. *Cultivation and Farming.* Though agriculture represents the largest single industry in the United States, it nevertheless continues to be made up of many small units. At the time of the industrial revolution, agricultural implements were still those of ancient times, limited to the plow, the hoe, and the digging stick. Farm machinery began to develop between 1830 and 1860. It was driven by hand, wind, water, or steam. Not until the invention, in the present century, of the internal-combustion engine—which resulted from the new technological developments in chemistry and the petroleum and natural gas industry—could such modern machinery be developed as the many-purpose tractor, the harvester-thresher, and other combines, all of them great savers of human labor. Motor-truck transportation greatly stimulated commercialization of agriculture, as did application of refrigeration to farm products. Though these developments all stem from electrification and motorization, it is nevertheless true that the possible application of electric power to farm operations far exceeds its actual use. Further use of electricity could immeasurably increase farm productivity, create abundance, and facilitate work. Even under present conditions farm productivity has been greatly augmented, with constantly decreasing need of human labor. Of all persons gainfully employed in the United States between 1840 and 1930, the percentage of agricultural workers dropped from 77.5 to 21.5.

To a large extent, application of modern technology in agriculture is conditioned by the scale of its many and varying single units. Tractors and others of the more specialized agricultural machines and equipment can seldom be purchased or operated by small farms alone. A logical development in agriculture, therefore, has been co-operative action, such as co-operative ownership of farm equipment, co-operative buying of fertilizer, feed, and other materials, co-operative farm management, co-operative marketing. Entirely new distribution and conservation techniques for agricultural produce have originated in response to modern conditions and requirements. At the same time it has been true that within our present environment, and without regard to the intervening needs of war, potential productivity of agriculture has far outrun its ability to find outlets for its produce. Competition seems destined to result in increasing concentration of production on fewer farms. Smaller landholders are likely to be relegated to subsistence farming. Those who cannot survive will wish to migrate to industrial centers. But with constantly increasing productivity in all industry, they may either find no work or displace those hitherto employed.

Chapter IV—The Construction Industries and Changing Living Conditions

Applied science, utilizing the same powers of electricity and chemistry which revolutionized the mineral industries, has likewise profoundly affected the industries of construction and, consequently, the conditions under which we live. Modern construction increasingly demonstrates the mutuality of technical and social change. This does not imply, however, that the prevailing environment within which the construction industries function necessarily permits of their full development. In the building of homes many comforts, technically available, remain economically unobtainable for large numbers of people. The role played by land values, by undepreciated investment in structures already obsolete, and other restricting influences often prevent slum clearance for expansion of desirable housing projects and such developments as integrated neighborhoods, unified commercial districts, modernized farm buildings, and others. It would appear that technological advance in the construction industries is finding its greatest realization in public works. Construction of modern highways, airports, tunnels, dams, waterworks, sewage-disposal plants, and other structures of public service has become feasible, on the one hand, through availability of new power equipment, and, on the other hand, through chemical knowledge of the properties of entirely new building materials. At the same time, new and much more speedy construction methods have diminished both cost per unit and need for human labor. Mass production of prefabricated parts, moreover, has considerably reduced actual work on the site of installation. Thus many structures have become technically, financially, and humanly possible that formerly could not even have been contemplated.

While in the building industries requirements for human labor per unit of construction have greatly decreased, increased building activity to accommodate an ever-expanding and constantly shifting population, even though highly irregular, has in some measure compensated for this. Well-planned and continuing programs of public construction, financed by governmental funds, would serve the twofold purpose of providing employment in construction and its various allied industries and of improving living conditions in many areas and for large sections of the population.

Chapter V—Transportation and Communication: Their New Social Implications

The same forces which transformed the construction industries and consequently profoundly affected and changed living conditions, brought into existence our modern transportation and communication systems, with their resulting all-pervading social implications. Characteristics of modern transportation are speed and flexibility, made possible through continuing improvement of all types of engines, whether electric, steam, or internal-combustion. Of special significance is the Diesel engine, which practically represents an independent, mobile electric-power plant, able to move the new lightweight streamlined trains at very great speed. While electrification of railway lines and use of Diesel engines would offer great advantages to the public, both from a technical and from a social point of view, their substitution for the steam engine is being delayed by such obstacles as the continuation of old and the need for considerable new investment. This situation has resulted in the preferred use of greatly improved steam engines. Owing to the same basic technological progress, affecting construction of all engines and all transportation facilities, steam locomotives of today are very different from and highly superior to those built twenty years ago. This very fact helps to delay or restrict electrification and Diesel traction.

Water transportation has likewise been subject to technological improvement, especially as regards construction of its propulsive machinery. Both Diesel engines and high-pressure steam turbines are increasingly being used. The replacing, in shipbuilding, of the riveting process by the new process of welding, has been conducive to many improvements and considerably raises the construction tempo.

Pipe-line transportation, while the least conspicuous of all transportation methods, is at the same time the most modern way both of moving and of storing the products of our equally modern petroleum and natural-gas industry. Diesel or electric engines increasingly take the place of steam equipment for pumping oil and gasoline into pipe lines.

Our most conspicuous, rapid, and continuous progress has been made in air transportation. This means that new types of planes and equipment become rapidly obsolescent. Private investment in air lines is therefore a matter of considerable difficulty. It is for this reason that air lines are sometimes governmentally subsidized, while, unlike railway lines, they rely in any case upon many federal and municipal aids, such as air terminals, lighting of airways, and radio-broadcast and radio-beacon stations.

Most immediate, most general, and most apparent are the social implications of private automobile and motorbus transportation. They have fundamentally changed the whole pattern of social life. Equally fundamental are the changes wrought by our modern means of communication, such as the telephone, the telegraph, the radio, and other new technical devices.

Like modern construction, the transportation and communication industries require skilled and often highly trained personnel. Integrated development of construction projects and transportation, planned in the public interest, could greatly expand both employment and the availability of important services to an increasingly mobile population.

PART TWO—LABOR REQUIREMENTS AND EMPLOYMENT OPPORTUNITIES UNDER THE IMPACT OF TECHNOLOGICAL CHANGE

CHAPTER VI—CHANGING LABOR REQUIREMENTS AND INCREASING PRODUCTIVITY IN MANUFACTURING

It is in manufacturing and its many stages that the output of the basic industries is transformed for ultimate use by the consumer. The same technological developments which re-created the basic industries likewise inaugurated entirely new manufacturing processes, resulting in fabrication of ever new materials, goods, and articles. Here, as in all other branches of production, the same phenomenon of an ever-increasing productivity, accompanied by relatively decreasing labor requirements, can be observed. Though this declining need for human labor is in some measure compensated for by the fabrication of many new products, it is this tendency of constantly increasing output with ever-diminishing need for human work, which is of paramount importance. For with the many new articles manufactured today, such as the automobile with its various accessories and service requirements, total employment in manufacturing between 1919 and 1937, the period of the newly emerging productive forces, registered merely an insignificant gain. Relative to an increased population, this means that a comparatively smaller rather than a larger labor force was at work. Expert sources confirm this fact by the statement that between 1899 and 1940 physical output for manufacturing as a whole increased approximately fourfold, while the total number of wage-earners increased less than twofold. The significant turn of the tide in employment came around 1923. Before that date, expanding production was accompanied by an increasing number of wage-earners. Since 1923 basic technological developments, such as greatly increased electrification, motorization, and automatization, together with improved organization, seem definitely to have replaced growth of the labor force as the primary factor in expanding production.

Modern manufacturing has, moreover, been accompanied by the familiar and recurrent fluctuations of business, with their unfavorable influence on employment. The highest level of productive capacity ever achieved, as registered in 1929, was followed by the worst depression the country has ever known, adding greatly to an already existing and continuing unemployment. Thus, while technological productivity and human output are ever on the increase, business alone is apparently unable to turn these to human advantage by maintaining regularity of employment and improving opportunities for livelihood.

Chapter VII—Occupational Change and Employment Opportunities

Under the impact of technological developments, occupational groupings of the population have been changing. During the period from 1900 to 1930 the number of workers needed to serve each 1,000 in the population declined from 277 to 241 for the combined industries of production, transportation, and communication, while the number rose from 106 to 157 in the groups concerned with trade and with public, professional, clerical, domestic, and personal service. Most significant is the occupational decline in agriculture, where numbers needed fell from 172 per 1,000 in 1870 to 85 in 1930. Employment opportunities in manufacturing and mechanical industries, while increasing continuously, did so at a declining rate with each census after 1900. All these data seem to confirm the fact that labor requirements per unit of product have decreased, with actual loss of employment opportunities in the basic industries.

Important also is the trend which, according to the 1930 census, shows an increasing percentage of the population hired for wage or salary, selling labor rather than remaining self-employed. Employment of women outside the home, in place of their traditional contribution to the family's livelihood, has steadily increased. In general, however, opportunity for independent work has become more and more restricted. Besides agriculture, trade and distribution continue to offer some scope for individual, small-scale enterprise.

Technological change has increasingly resulted in rendering the apparatus of production inaccessible to the individual worker. Livelihood depends, in ever larger measure, on the opportunity to be hired for employment, and no longer on independent self-direction. Standards of living are determined both by regularity of employment and by the wage or salary received, relative to prices charged for the necessities of life. Factors also in living standards are number of hours a worker is required to spend at his job, and speed of work.

Thus it is clear that basic technological developments, pervading all industry, have brought about great changes both in the occupational distribution of the population and in their working conditions and employment status. While the highly increased actual and potential productivity accompanying technological progress might logically be expected to lead to greater security of livelihood and more satisfactory living standards, it is evident from prevailing deficiencies and recurrent unemployment that such expectation has not been generally fulfilled.

Chapter VIII—Summation: The New Technological Basis for Livelihood and Living Standards

No longer does production—the bringing forth of nature's resources and their transformation for human use—depend, as in Leonardo Da Vinci's sketches of the laborer's task, on spontaneous effort of the human body, or the use of simplest tools. The early industrial arts have given way to the technological science of the present century. Nature's power in electricity and chemical action, which inherently requires direction by operational and organizational techniques, has replaced personal human effort and individual initiative. The change which has come about is the greatest of all time. As a result, man's relation to the means of production has been fundamentally altered. To earn a living, he must increasingly be hired to work in association with others. The conditions of his employment, and even the need for his labor, upon which his livelihood depends, are beyond his personal control. Thus livelihood has become insecure for the individual, even in a century of potential abundance.

To make employment secure and to prevent unemployment, production, on its new technological basis, must be so administered as to utilize output for living standards. If new productivity is to be fully utilized, standards of living must be progressively improved with advances in technology. Achievement of optimum standards of living, i.e., the most favorable for the life of the individual in the community, is the guiding aim which can result in socially desirable utilization of productive capacity. If such optimum standards are to be generally established, organized utilization of productive resources for human life must become a major task in every community, from village to nation and world. In this task which technology has imposed, new social research must be extensively developed as the means of evolving the necessary knowledge for socially desirable administration of new productivity.

Postscript—War and the New Technology

The war which began in 1939 demonstrated at once the nature of the new technology and its highly accelerated productivity. It likewise illuminated the previous failure to achieve full utilization of both existing and potential capacity. By 1941 industrial output had doubled as compared with the middle of 1938, when output approximately equaled the production level attained in the earlier World War. In addition to immediate full use of idle plant facilities and available unemployed labor, the new World War called for the newest materials and most up-to-date manufacturing processes. Thus the frustration which had characterized the peacetime economy quickly gave way to utmost production in an economy organized for the common purpose of war, financed by government from taxation and loans. The things produced, however, were the destructive weapons of war, and not the goods needed to achieve an improved standard of living for the nation's population.

Will nonuse of installed and potential productive capacity, unemployment of human beings, and hence frustration and poverty again follow this temporary war economy? Or will there be a new awareness of the imperative need for planned adjustment of productive capacity and living standards?

Appendix III
Sources of Information and Scope of Inquiry

OUR STUDY has been concerned primarily with evidences of long-time fundamental trends in the changing relationship between employment and production. These trends were already evident but attracted little attention before 1929. It was in the economic crisis of the 1930's that their significance was forced upon the attention of those concerned with the problems of unprecedented unemployment. The situation seemed to require analysis of all occupations and their changing rank over a long period, in order to obtain a complete picture of present trends in opportunities for work. The necessary data for statistical analysis were available from the census, which alone is sufficiently comprehensive to cover all occupations and the total population. These comprehensive figures, however, could be interpreted correctly only in the light of full understanding of the nature of underlying technological change. Fortunately, the descriptive materials necessary for this purpose were obtainable from authoritative sources, though they had to be assembled and combined in relation to the subject of our inquiry.

GOVERNMENTAL STUDIES OF TECHNOLOGICAL TRENDS

Outstanding among these sources, for the purpose of our inquiry, was the study already mentioned in "Note to Reader," entitled Technological Trends and National Policy, Including the Social Implications of New Inventions. Issued in 1937 by the Science Committee of the National Resources Committee,[1] the purpose and scope of the report were outlined in the Committee's letter of transmittal to President Roosevelt, as follows:

> This document is the first major attempt to show the kinds of new inventions which may affect living and working conditions in America in the next 10 to 25 years. It indicates some of the problems which the adoption and use of these inventions will inevitably bring in their train. It emphasizes the importance of national efforts to bring about prompt adjustment to these changing situations, with the least possible social suffering and loss, and sketches some of the lines of national policy directed to this end.

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[1]The National Resources Committee, whose predecessor, the National Planning Board, was established in the Federal Emergency Administration of Public Works on July 30, 1933, was transferred on July 1, 1939, to the Executive Office of the President, and became the National Resources Planning Board.

The Science Committee was composed of nine members, three each designated, respectively, by the National Academy of Science, the Social Science Research Council, and the American Council on Education. Thus, significantly, it combined the so-called natural or physical sciences with the social sciences and education. The report was prepared by the Subcommittee on Technology, appointed by the Science Committee, with a membership of three, including John C. Merriam, of the Carnegie Institution for the Advancement of Science; Edward C. Elliott, president of Purdue University; and William F. Ogburn, chairman, who was director of research for this study. Professor Ogburn, sociologist, of the University of Chicago, had directed research in the previous administration, when President Hoover initiated the comprehensive study of Recent Social Trends in the United States,[1] including a chapter by Professor Ogburn, on "The Influence of Invention and Discovery."

The National Resources Committee, in its study of Technological Trends and National Policy, had not only the benefit of advice from these scientists, but assigned sections of the report to specialists loaned by various universities, laboratories, and governmental bureaus, including the United States Departments of Agriculture and of Commerce, Bureau of Mines, Government Printing Office, Federal Communications Commission, Federal Power Commission, and four universities, Columbia, Chicago, Yale, and Purdue. These various contributors, in turn, secured the co-operation of co-workers in their own and other institutions, so that their analyses may truly be said to represent a group product. In a section entitled "Technology in Various Fields" one or more specialists in each domain described "the kinds of new inventions which may affect living and working conditions in America in the next 10 to 25 years."

Analyzing the combined report of this group of scientists and experts in various branches of production who had written under governmental auspices, we, in effect, put our questions to them. We arranged their answers, not in the order of their own presentation, but in the sequence which seemed to us to show best the nature of the new productivity inherent in today's technology. These answers, in the form of direct quotations, constitute the basis for Part One of the present publication. Its theme may be described as the potentialities of the new productivity for living standards, despite the evidences of adverse effects of new labor requirements upon employment opportunities. This is a different emphasis from that of the National Resources Committee, which appears concerned mainly with the maladjustments resulting from the introduc-

[1]President's Research Committee on Social Trends, Recent Social Trends in the United States. McGraw-Hill Book Co., New York, 1933.

tion of new inventions and the possibility of a national policy to prevent unfavorable social consequences.

Another significant study, governmental in character, has been useful in our inquiry. Sponsored by the New York City Housing Authority and the Works Division of the Emergency Relief Bureau of the City of New York, it was published under the title, Report of the National Survey of Potential Product Capacity. As its name indicates, "potential product capacity" is the focal emphasis in this report. Various definitions of "product capacity" are offered, but the one selected as a working basis is "the capacity of the existing plant if production were limited solely by physical factors and knowledge (i.e., resources, man-power, and technology)."[1] The method of study of potential product capacity, the sources of data, and the qualifications of staff members, who were, also, specialists working collectively, are described in a foreword, as follows:

> The staff of the Survey was selected from engineers, technical men, and statisticians whose experience covered the full range of our national economy. The sources of their information are given in our bibliography, which lists over two hundred and fifty documents, including the Federal Census and trade reports of various industries. . . . Authorities in nearly all lines of production have been interviewed and our estimates were checked against their knowledge.[2]

NATIONAL RESEARCH PROJECT AND OTHER STUDIES

In giving weight in our inquiry to the two governmental reports described above, we have not overlooked other available sources of information. Among these one of the most valuable is a long series which has constituted the work of the National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques, begun under the auspices of the Works Progress Administration.[3] The director of the National Research Project, David Weintraub, wrote the section on "Unemployment and Increasing Productivity" for the report of the National Resources Committee, already described. This section contains the main results of the comprehensive investigations of

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[1]New York City Housing Authority and Works Division of the Emergency Relief Bureau, City of New York [sponsorship and publishers], Report of the National Survey of Potential Product Capacity. New York, 1935, p. xiv.

[2]Ibid., p. xiii.

[3]The National Research Project on Reemployment Opportunities and Recent Changes in Industrial Techniques was carried on under the auspices of the Works Progress Administration until July 1, 1939. On July 1 the Works Progress Administration was transferred to the Federal Works Agency and the name changed to Work Projects Administration. Beginning on September 1, 1939, the National Research Project was sponsored by the National Resources Planning Board in the Executive Office of the President.

the National Research Project. Therefore we have not so fully quoted from these studies, though several references are made to them in the text.

Other investigations, both governmental and unofficial, throw light on the subject. Technical developments in the various industries are constantly being described in periodicals, books, and pamphlets. Iron Age, the technical journal of the iron and steel industry, and Science News Letter, sponsored by leading national organizations of scientists, both record authoritatively these technical developments and from time to time give indications of their social consequences. The inventory of metal-working equipment, mentioned in the Postscript,[1] was made, as therein explained, by American Machinist, technical journal of the machine industry, which has repeated this inventory periodically since 1925.

Related economic and social studies are voluminous. For example, the Temporary National Economic Committee, appointed by Congress in the spring of 1938 on recommendation of the President to investigate monopoly, turned its attention in 1940 to technological change. Hearings brought forward testimony by representatives of management and of trade unions in various industries.[2] A special staff of investigators prepared monographs, and the final report of the executive secretary constituted an excellent summary both of hearings and investigations. These materials have been examined in connection with our inquiry.

WORK OF INTERNATIONAL INDUSTRIAL RELATIONS INSTITUTE

For substantial contributions toward defining standards of living, and for preparatory work on the subject of productive capacity in relation to employment, acknowledgment is due to the International Industrial Relations Institute. In the World Social Economic Congress, held under the Institute's auspices in Amsterdam, Holland, in 1931, analyses of unemployment during the preceding two decades in various regions of the world, including the United States, led to a formulation of the essential problem of preventing unemployment as "the necessity for the planned adjustment of productive capacity and standards of living."[3] In

[1]See "Postscript—War and the New Technology," p. 193, footnote 2.

[2]U. S. Congress, Temporary National Economic Committee, 76th Congress, Third Session, Hearings on Investigation of Concentration of Economic Power. Part 30, Technology and Concentration of Economic Power, April, 1940. Government Printing Office, Washington, 1940.

[3]International Industrial Relations Institute, International Unemployment: A Study of Fluctuations in Employment and Unemployment in Several Countries, 1910-1930; and World Social Economic Planning: The Necessity for Planned Adjustment of Productive Capacity and Standards of Living; both edited by Mary L. Fleddérus and published by the Institute at The Hague in 1932.

the following decade this formulation was further substantiated in conferences of the Institute held at The Hague and in New York and Mexico City, where the study of pertinent factual data and relationships was continued.

At a regional conference in New York in 1936 the Institute's Research Group suggested that attention be given by its members in various nations to productivity in the workshop, with a view to determining especially what rate of output and speed of production are socially and technically desirable. A few months later, in 1937, the Department of Industrial Studies of the Russell Sage Foundation began work on the subject, inviting to its staff, on a special term appointment for that purpose, the director of the International Industrial Relations Institute, Mary L. Fleddérus, of the Netherlands. Her first report,[1] completed in the spring of 1938, was a memorandum on "Optimum Productivity in the Workshop," which defined that term in its relation to the social economic environment of industry and suggested related projects for research. The definition was significant for the present inquiry, in that it would establish "standards of living" as the direct objective of production.

OPTIMUM PRODUCTIVITY AS AN AREA FOR SOCIAL RESEARCH

Obviously, social research is needed to give content to the implied relationships between production and social and living conditions. Therefore a further exploratory memorandum was undertaken in 1938, under the title, "Social Consequences of Industrial Productivity."[2] It brought together material from technical and social economic studies, so arranged as to throw light on the areas of research related to the question of optimum productivity. Among these studies was the report of the National Resources Committee, on Technological Trends and National Policy, which had just become available.

Issued in first draft for confidential circularization among "co-workers in social research," the memorandum was submitted in August, 1939, at The Hague, Holland, to the annual summer study conference of the International Industrial Relations Institute. Participating in this conference, which took place in the momentous week preceding Germany's invasion of Poland and the declaration of war, were social scientists at work on similar problems in Europe. Thus the material was given an

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[1]Reprinted as Appendix I, p. 205.

[2]Fleddérus, Mary L., and van Kleeck, Mary, Social Consequences of Industrial Productivity: Memorandum on Optimum Productivity as an Area for Social Research. [Mimeographed.] Department of Industrial Studies of Russell Sage Foundation, New York, July 21, 1939.

international exposure, and its significance for other nations, whatever the stage of their technological development, became evident.

Only after this process of thoroughgoing examination of the growing volume of research materials on various aspects of this complex subject, with data transcribed on investigators' "5 by 8" sheets, permitting rearrangement to reveal new relationships, was the subject finally formulated, in 1940, as *the technological basis of livelihood*. Described then as "a new approach to the problem of unemployment," the course of research itself has developed a more fundamental statement of the subject as "an inquiry into the changing technological basis for production as affecting employment and living standards."

RECOGNITION OF PROBLEM BY LEAGUE OF NATIONS

Recognition of the importance of this subject was given in a report, also collective, by the League of Nations Economic Committee, presented in a memorandum on a Preliminary Investigation into Measures of a National or International Character for Raising the Standard of Living.[1] The following twofold subject was analyzed:

> (a) The general character of the economic adjustments which are necessary if technical progress is to result in further advances in human welfare;
> (b) The relationship between low standards of living and low productivity in several different regions of the world and the general character of measures likely to encourage improvements in production and consumption.[2]

The work of the League of Nations on this subject was authorized in the following resolution by the Assembly in 1937:

> The Assembly,
> Recognising that technical progress in industry, agriculture and transport has made possible further advances in human welfare;

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[1]League of Nations, Economic Committee, Preliminary Investigation into Measures of a National or International Character for Raising the Standard of Living. Memorandum prepared by N. F. Hall. Geneva, 1938. The author, director of the National Institute of Economic and Social Research, London, was formerly professor of political economy in the University of London. A parallel study made by the International Labour Office, at the request of the League of Nations, entitled The Worker's Standard of Living, should be noted in this connection. (International Labour Office, The Worker's Standard of Living. Series B, no. 30, Geneva, 1938.) Useful, also, though not explicitly connected with the League's memorandum, was a study of The Social Consequences of the Economic Depression, sponsored by the International Labour Office. (Woytinsky, Wladimir, The Social Consequences of the Economic Depression. International Labour Office, Geneva, 1936.) All three of these reports are economic and social, rather than technological, in their data and viewpoints.

[2]League of Nations, Economic Committee, op. cit., p. 6.

> Recognising also that such advances depend upon economic co-operation between the nations:
> (1) Invites the Economic and Financial Organisation of the League, in collaboration, when appropriate, with the International Labour Office, to take whatever steps it may deem appropriate for the examination of the following problems:
> (a) Measures of a national or international character for raising the standards of living, the first stage of the enquiry being limited to a preliminary investigation, if necessary with the help of experts, in order that the next Assembly may be enabled to devote further attention to this question.[1]

This resolution in 1937 should be recognized as a high point in the expressed purposes of the fifty or more nations included in the membership of the League. In the light of developments in the succeeding two years, leading to war instead of international co-operation, the aspirations which the resolution expresses will appear to the cynical to be wholly utopian. A sober view, however, of the potentialities of the new technical progress mentioned in the League's resolution suggests rather that the whole problem and an international program for dealing with it should be regarded simply as "unfinished business" for the nations of the world.

SIGNIFICANCE OF THE YEAR 1937 IN TECHNOLOGICAL TRENDS

The year 1937, when the report of the National Resources Committee, on Technological Trends and National Policy, was issued, proves to have been a good choice as a focal point for analysis. In the United States it was also a year of a biennial census of manufactures, which made possible a statistical background for description of technological change. Other studies, here and abroad, were made in approximately the same period. It was the year, also, when the League of Nations adopted the resolution just quoted.

In retrospect, 1937 can be seen as the highest point in production and employment in the United States in the decade following the crisis of 1929 and preceding the second World War. Trends evident in that year can be accepted for all time as typical of highest pre-war technological development in the nation which may be regarded, moreover, as one of the world's laboratories for observation of the impact of technological change on social economic conditions.

War, of course, leads to further changes in the technology of production, but no change so far observed in the present war is out of line with the trends in the new technology already evident in the pre-war period.

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[1] Ibid., p. 5.

In the developing productivity of the United States, war must be regarded as an interlude. The postscript to this inquiry, entitled "War and the New Technology," may be regarded as merely a preface to studies which will be required on the many related problems of post-war adjustment. For such studies, technological development and its consequences in production, employment, and living standards in 1937 in the United States will continue to constitute an indispensable base.

M. v. K.

New York, November, 1943.

Index

The index contains names of authors and organizations mentioned, but not subject titles. Footnote references to quotations from reports of the National Resources Committee are not indexed.