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CHAPTER II

INDUSTRY

PART 1.—CHANGES IN NEW AND OLD INDUSTRIES

By Dexter S. Kimball

Every observer of American industry is impressed with its size and rate of growth. In a later chapter, Dr. Mills presents a table showing economic movements in the United States from 1922 to 1927. According to these figures, primary production has increased each year 2.5 per cent; production of manufactured goods, 4 per cent; and ton-miles of freight carried, 4 per cent.

We are producing more than two-fifths of the world's supply of coal, about seven-tenths of all the petroleum, practically all the natural gas, and more than one-third of the water power.

An outstanding fact has been the improvement in the efficiency of fuel consumption which has tended to check the growth in demand for coal, while other sources of energy were expanding, notably those of water power and of oil and gas. Bituminous and anthracite coal, which contributed 85 per cent of the world's total energy in 1913, furnished but 71 per cent in 1927, and but 64 per cent in the United States.

The growth of the electric light and power industry has also been phenomenal; about one-half of the total world capacity is in this country. The consumption of electric energy has been increasing at a rate about three and three-quarters times the increase in population. Production of electric current in 1927 was about 676 kilowatt-hours per inhabitant, as compared with 630 kilowatt-hours in 1926. The percentage of electrification of manufacturing industries was about twice as large in 1927 as in 1914.

In the production of iron and steel the United States has an annual output representing approximately half that of the entire world, the greater portion of which is consumed in this country. The production for 1927 was about 51 per cent greater than the average for the years 1910–1914.

Not only have most of our industries greatly increased in size, but there has also been a rapid increase in the size of industrial equipment and industrial structures. Buildings, engines, locomotives, steamships, and bridges have increased in size at a rapid rate in recent years. The new bridge over the Hudson River at One Hundred Seventy-first Street,

New York, with a clear span of 3,500 feet, towers 625 feet high, and four supporting cables 36 inches in diameter, is without doubt the greatest and most difficult construction ever undertaken by man. And it should be remembered that the basic tools by means of which these great undertakings are built have increased proportionately in size and capacity.

Another fact of great importance for industry as a whole is the increase in the size and variety of consumer demands. These changes have helped to create and to quicken the constant flow of new materials and new products, some of them, like rayon, of startling economic significance, others like radio, appearing at present as mainly another addition to the crowded field of personal amusement. And a more searching examination of this flow of new things would uncover scientific research activities and applications of the results of research far in advance of anything existing a few years ago.

In addition to the more tangible and visible changes in size of industries and products, there has been a great advance in the last few years in what may be called the theoretical side of production. One of the most outstanding of these movements, and one that is intimately related to mass production, is standardization. The economic advantages of standardized products are now so fully recognized as to make the problem of standardization not only a national problem but also an international one. Our largest manufacturing plants produce largely standardized products and the lowest unit costs are found in connection with standardized production.

These varied phenomena have been much more in evidence since the World War than prior to that event. Yet the war developed no new basic productive processes. In this respect it differed from the Civil War which was instrumental in developing modern automatic machinery. The basic mechanical productive processes in use to-day are in general those in use before the World War. Chemical processes have come into more extended use in connection with the production of certain new materials, and processes like electric and oxyacetylene welding have appeared; but there have been no radical advances in the basic industrial processes.

The war, however, did focus attention upon the advantages of mass production. In the preparation of war material, many plants were narrowly specialized and many "single purpose" plants were organized. The Hog Island shipyard, with its many feeder plants, was in some respects the largest attempt at mass production that has ever been attempted, and the influence of this effort in calling attention to the advantage of mass production must have been considerable. The war also greatly expanded our industrial equipment, and the effort to keep this equipment in operation has been one influence in the vast production of recent years.

In any case there has been a decided movement toward the use of semiautomatic and automatic machinery wherever this is warranted, and in the larger industries some highly developed special machinery has resulted.

The last few years have witnessed a tremendous effort upon the part of factory managers to lower productive costs. This effort is twofold in character. First, close scrutiny has been given all methods and processes, and, second, an effort has been made to check avoidable wastes. The movement to check industrial wastes inaugurated by Herbert Hoover, when Secretary of Commerce, is of wide scope and great economic significance. American industry has been proverbially wasteful, and the gains that have already been made in some industries by waste elimination would indicate that we have here a hitherto neglected factor of great importance to industry.

The last ten years have also witnessed a fuller appreciation of industrial research and many interesting and important applications of the results of research. Many new materials have appeared and a number of new industrial processes. We are probably somewhat behind some European nations in this respect, but the realization of the importance of industrial research is growing rapidly.

One of the important influences has been the change in efficiency of rail transportation.[1] In 1927, goods were moved with the greatest rapidity in history, gross ton-miles per train-hour increasing 47.5 per cent as compared with 1920, and ton-miles of revenue freight carried exceeding by 42 per cent the performance of 1913. Between 1901 and 1913, the ton mileage of the carriers had practically doubled. Employee productivity showed an important increase, the index of traffic units handled per employee, based on 1913, being 134.4 in 1927.

An important element in the increase in output has been the rapid abandonment of inefficient plants. In a recent survey of the merchant blast furnace industry, it is reported that "of the 37 plants furnishing data for the prewar years 1911–1914, 15 were both hand filled and sand cast, while only 8 were mechanically filled and machine cast. But in 1926, out of 49 plants furnishing data, only 3 were both hand filled and sand cast, while 34 were both mechanically filled and machine cast."[2] The significance of the record lies in the fact that in 1911–1914, the modern methods were known but were applied in but three plants. In 1926, nearly three-fourths had adopted the improved machinery.

Until comparatively recent times, the problem of industry was to produce in sufficient quantity to supply the demand. To-day the problem of industry is largely that of disposing of its products. If

[1] See Chap. IV, Transportation, Part 1, p. 285.

[2] United States Bureau of Labor Statistics, "Productivity of Labor in Merchant Blast Furnaces." *Bulletin* No. 474. Washington, 1928.

manufacturing industry should devote all of its energies to the production of *necessities* alone, it would be difficult to dispose of the output intelligently. The problem of industrial production has been temporarily solved, and as a consequence we have passed from a "sellers' market" to a "buyers' market."

These rapid glances at industrial changes suggest the significance of shifts in consumer demands and the importance of technical improvements in recent years. Without mass consumption there could not be mass production.

Mass production necessitates mass financing and mass management. Large enterprises are comparatively more difficult to organize and manage than small ones and, as a result, a great deal of thought and experiment have been expended in recent years upon the problems of management. It is significant that these problems are now sufficiently crystallized to form the nucleus of instruction in colleges of high standing. The growth in the size of industrial plants, and the consequent advantage that may be taken of the principles of standardized quantity production, will depend to no small degree upon our ability to finance and manage large plants upon sound economic principles.

Out of these changes has developed the astonishing increase in productivity which is discussed in Part 2 of this chapter. But it is obvious that not all industry is prosperous nor all industrial leaders progressive. Anyone well acquainted with industry knows that there is much inefficiency in both management and production. The fact remains that the field of industry as a whole has made marked advances during the last decade, and the productivity per worker in most industries has been advanced markedly. Never before has the human race made such progress in solving the problem of production. If poverty and industrial distress still exist, it is because of our inability to keep our industrial machinery in operation and to distribute equitably the resulting products. It is not sufficient to be able to produce abundantly; we must also be able to distribute intelligently.

In recent years the developments in new productive methods have been so startling as to force themselves upon the attention of all men. But these developments are the result of changes which began many years ago, and which have gathered such momentum during the last few decades as to raise serious questions as to their present influences and probable future effects. For the purpose of this discussion these changes may be listed as follows:

(a) Disappearance of old industries and callings.
(b) Changes in character of old industries.
(c) Growth in size of old industries without change in character.
(d) Development and growth of new industries and callings.[3]

[3] A new industry is one which is producing a new product, such as rayon, or which involves a new process or technique, such as electric welding. A new trade or calling

It would be superfluous to recount the advent of the Industrial Revolution with its constantly increasing tendency to undermine and eliminate handicraft production. It should be noted, however, that the growth of modern factory methods[4] in the United States was comparatively slow during the nineteenth century, handicraft production either by individuals or in handicraft factories predominating until about 1850, and production by these methods was quite common as late as fifty years ago in some callings.

By the year 1900 the value of manufactured goods exceeded that of agricultural products, and therefore the census of 1900 may be taken as a datum from which to measure industrial changes. Furthermore, this census contains certain comments upon the new industrial methods, then just assuming great importance, which are most illuminating in view of recent developments and which will be alluded to later on. The biennial census of manufactures for 1925 is the latest corresponding document, and since no marked changes have occurred since then, comparisons between these two statistical reports are enlightening.[5]

Disappearance of Old Industries and Callings.—A comparison of the industries listed in the census of 1900 with the corresponding list given in the biennial census of manufactures for 1925 shows that few industries have actually disappeared. Nearly all of those listed in 1900 appear also in the list of 1925. There are some interesting exceptions. Thus, blacksmithing and wheelwrighting, which in 1900 employed over 5,800 men, is not mentioned in the 1925 list. Distilled liquor is, of course, not included in the 1925 list but appears as ethyl alcohol, and there are a few smaller industries, such as lock and gun smithing and watch and clock repairing, which are not considered important enough for the 1925 list. But, in the main, the list of industries cited in 1900 is included in some form in 1925.

Some of the industries listed in 1900 and 1925 have declined greatly. Thus, in 1900 there were 7,632 establishments employing 62,540 workers

is one which requires a new body of knowledge or a new specialized skill on the part of the worker. Thus electric welding and chauffering may be considered as new callings, whereas there are probably no new trades involved in the production of radio apparatus.

[4] The term "modern factory methods" is used here to define production by the use of "transfer of skill" and extended division of labor. The most important machine tools upon which modern manufacturing depends are the turret lathe, the automatic screw machine, and the milling machine. These appeared in America about the middle of the nineteenth century and gave a tremendous stimulus to manufacturing. Grinding machinery, which has become almost as important as these machines, was a later development.

[5] It should be remembered that the population of the United States increased from 74,607,225 in 1890 to over 113,493,000 in 1925. Also, all such statistics as are expressed in dollars must be interpreted with reference to the relative value of money at the two dates discussed.

making carriages and wagons. In 1925 there were only 152 establishments employing 4,833 persons in this industry. As might be expected, saddlery and harness-making show a corresponding decrease.[6]

The development of factory methods during the period under review has practically eliminated some handicraft callings. Thus the 1900 census distinguished between custom or hand-made shoes and the factory-made product. The census of 1925 makes no such distinction, practically the entire product being factory-made. In a similar way, other callings, such as custom-tailoring, village blacksmithing, cooperage, and cabinet making, have succumbed almost, if not entirely, to factory processes. There are, of course, survivals of some of these handicraft callings to-day, but their total output is negligible compared to the factory-made articles. However, the basic building trades, such as carpentry and bricklaying, have survived, though they have been supplemented by many other building trades. The basic machine crafts, such as machinist, boiler maker, foundryman, and pattern maker, are still important and to a certain degree unchanged, though their places in industry have been changed and their tools greatly improved. These callings, as will be seen from a later discussion, must necessarily survive since upon them rests the entire industrial fabric. Comparatively few industries, as such, have disappeared, though many of them have greatly changed.

Changes in Character of Old Industries.—While many industries which are listed in the 1900 census appear under the same name in 1925, it is well known that they have been greatly changed as to methods and process. In some instances they bear little relation to the industries of the same name of 50 years ago. As an illustration, consider the men's clothing industry. The census of 1900 lists 28,014 establishments employing 191,043 persons with an output valued at over $415,000,000. The 1925 census lists only 4,000 establishments employing only 174,332 persons but with an output valued at over one billion dollars. Again,

[6] It has been suggested that an inventory of the idle manufacturing plants might be something of an index to industrial change. The writer is skeptical as to the value of such a survey, except as it would show that industry has been and is now in a state of flux. Idle plants should not be confused with the disappearance of trades and industries. Plants become idle for a variety of reasons, such as exhaustion of resources, bad management, supercession of other products or processes, and migration of industry as a whole to other localities. American industry presents, and will probably present for some time to come, just such a picture. Some reasons for this phase of industry are to be found in certain basic changes in our manufacturing methods which are discussed in a succeeding section and with which this report is primarily concerned. As a corroboration of this statement, the census of 1900 gives a detailed list of the idle plants at that date. They numbered 3,864 with a total capitalization of about one million dollars and included 188 different industries. No doubt a similar survey at any time will show similar results. Further discussion of obsolescence is found in Chap. III, Construction, p. 226; Chap. IV, Transportation, Part 1, p. 263; Chap. V, Marketing, p. 330.

in 1900, there were 23,560 custom shoemaking establishments employing 9,689 persons as compared to 1,900 factories, so-called, employing 143,000 persons. In 1925, there were only 1,460 establishments, but they employed 206,992 persons and their output was valued at $925,383,422. This industry has been almost completely changed from handicraft to machine production with corresponding changes in the workers involved. Practically all of the older industries which have survived have been affected more or less in a similar manner, either by the introduction of new processes or new methods of production.

Growth in Size of Industries without Change in Character.—Many of the industrial plants of the old type have greatly increased in size for three reasons. First, the size of the product needed has greatly increased. Engines, locomotives, ships, bridges, for example, have all increased enormously in recent years, necessitating corresponding increase in the size of the physical equipment of the producing plants. Or the size of the productive units has been increased so as to secure greater economy of operation. A blast furnace of 500-ton capacity is much more economical than one of 100 tons; and it requires no more men to operate a 4,000 horse power locomotive than it does to operate one of 400 horse power. Many old industrial plants, however, have expanded in size with no marked changes in product, solely to secure the benefits of quantity production in the matter of productive costs.

Development and Growth of New Industries and Callings.—By far the most interesting and important development is the rise of new industries and new callings. For it is in the character of the productive methods by which new industries have been built that we must look for the answer to some of our industrial problems. Some of these new industries, like the automobile and the airplane, are built upon and are extensions of old trades and callings. Others, like the electrical industries, while resting primarily upon old trades and callings, have developed many ramifications and adaptations of these old trades into what are practically new callings. Others again, while having their genesis in chemical processes, must necessarily be constructed through the use of the old mechanic arts. And all of them have been affected by modern productive methods. The magnitude of some of these new industries is impressive. Thus the automotive industry, not mentioned in the 1900 census, is credited in the 1925 census with employing over 400,000 men, with an output valued at over $4,000,000,000. Rayon, mentioned specifically for the first time in the census of 1925, employed 19,128 workers, and the product of radio manufacture, an enterprise only a few years old, was valued in 1927 at about $191,000,000. The value of the telephone and telegraph apparatus produced in 1927 was estimated at over $119,200,000. The chemical industry, a new growth, employed 38,075 workers, with an output valued at $6,438,027,000.

A new industry that produces a product which tends to supplant the product of an old industry does not necessarily eliminate the old industry, even though the new product may be superior in many ways. The new product may find an enlarged field, leaving the old product to do the same and to hold part of its old field. The telephone did not supplant the telegraph nor does the radio supplant either of them. The electric light did not eliminate gas any more than oil has entirely supplanted coal, and the motor truck and auto-bus seem to be progressing toward co-ordination with older methods of transportation. By similar procedure, rayon is making its own place, and probably will not eliminate cotton and linen. We shall no doubt witness the development of many new synthetic products to supply the lack of natural animal and vegetable products as the supply of these diminish, and we may expect to see many new products to satisfy new or old needs.

Basic Principles.—The oldest and most important economic principles of production are division of labor and transfer of skill. Both have been used by men from time immemorial, but in recent times they have assumed commanding importance. The first is so well known and understood as to need little or no comment, except to elucidate its close connection with the second principle. Transfer of skill and its effects are not so well understood. The principle is inherent in the use of tools of every kind. Whenever the tool is improved, less skill is required upon the part of the operator to produce a given result. The true significance of the Industrial Revolution was that it carried transfer of skill to such a degree as to make the worker an adjunct to the tool, whereas formerly the tool was an adjunct to the skill of the worker. Modern industry differs from handicraft primarily in this particular. Yet, strictly speaking, there is no such thing as an automatic machine since all require human attention, and the terms automatic and semiautomatic are comparative only.[7]

[7] It should be noted in passing that the development of all modern machinery rests upon the use of so-called machine tools. These basic tools are the lathe, the planing, drilling, milling, and grinding machines and their variations and deviations. These basic tools have been highly developed both as to size and accuracy, and fill a most important rôle in modern production. With such basic callings as foundry work, pattern making, and rolling mills, all other industrial machinery is produced. And what is equally important, they can be made to reproduce themselves. The growth in the size of these basic implements should also be noted. The first lathe, built about 1800, could be carried by one man. Large modern lathes can machine a cylinder 10 feet in diameter, 40 feet long, and the largest boring mill in America can machine work up to 60 feet in diameter. More important still, much larger tools can be constructed, so that, if other conditions warrant it, the size of industrial products can be greatly increased. The sizes that locomotives, bridges, and steamships may attain in the future will probably be governed by economic considerations, and not by the size of our basic tools.

These new methods naturally tend to extend the principle of division of labor. Specializing an industrial plant automatically specializes the workers. And even in industries which are not highly specialized, division of labor is accomplished by separating the operations to be performed and assigning a single operation, or a limited number of them, to each worker. As a corollary, when the operations necessary to produce a product are thus separated, it is easier to design a special machine for each operation. Transfer of skill and division of labor are mutually supplementary.

It should be remembered, also, that just as there may be division of manual labor so there may be division of mental labor. Thus the engineering and designing function was long ago separated from the work of actual production. The development and extension of this principle, as applied to modern management, will be discussed elsewhere in this survey since it is the most important principle in so-called scientific management. The importance of the principle in this particular discussion rests upon the fact that labor-saving management is similar in its effect upon the worker, in many ways, to the results produced by the application of transfer of skill. The growth of knowledge, both scientific and nonscientific, the discovery of new methods and processes, and the invention of new products, all tend to extend the use of division of labor and transfer of skill.

The Effect upon the Economic Status of the Worker.—One of the most significant effects of the extension of transfer of skill has been the increase in the capital investment per worker. The biennial census for 1925 gives the investment per worker in 1849 as about $560. By 1919 this ratio had risen steadily to nearly $5,000, the yearly increase in capital being always greater in proportion than that of the workers employed. In addition to the limitations set by the increasing cost of the tools of production, the use of power is increasing. From 1914 to 1925, the horse power per industrial worker increased from 3.3 to 4.3. It should be noted also that, while the agricultural worker still owns his implements to a large degree, he no longer makes them himself. Analogous to the growing separation of the industrial worker from ownership of the tools of production, the separation of agriculture from the mechanic arts, that started with the Industrial Revolution, is becoming complete.

Effect upon Unit Costs.—It is an established principle that unit costs can be reduced by the use of transfer of skill and division of labor. The gain through the use of division of labor follows mainly from the increased skill and speed which accrues to the operator through repetitive effort. But the gain from the use of improved machinery rests upon different economic grounds. The principle holds true, that unit costs can be decreased as the quantity to be produced is increased, and, therefore,

where the quantities are very large, great expenditures can be made for improved machinery. Possible limitations to this principle will be discussed later.

The truth of these statements is borne out fully by the census reports. The increase in capital investment per worker has already been noted. The increase in the value of output per worker is equally significant. In 1900, this value was about $1,600, while in 1919 (the last census available) this ratio had risen to about $7,500. Making allowance for the changed value of the dollar, this is a great gain in value produced per worker, and it can be attributed only to improved methods of production. The ratio of the value of products to capital investment in 1890 was 1.04. In 1919 this ratio was 1.4. But since the value of the dollar at present is much less than in 1919, the true ratio is probably less. In all probability we may look for a diminution of output per dollar of invested capital, if for no other reason than because of the operation of the law of diminishing returns.

It will be clear, therefore, that the degree to which use may be made of transfer of skill and division of labor depends upon the quantity to be made. The greater the quantity, the more complete and costly may be the tools. But the more highly developed the tools, the cheaper becomes the product, and a decrease in the cost of the product stimulates the demand for it. This in turn increases the number that can be made.

Standardization, Simplification, and Interchangeability.—One of the most important sources of industrial waste is the variety in which many articles are manufactured. As has been explained, the unit cost of any article can, in general, be decreased as the quantity to be produced is increased. For a given total production of any article, the greater variety in which it is produced, the smaller must be the number of each size or model, and consequently the higher must be the unit cost. This principle is well known by most manufacturers, but there are often other considerations which lead them to produce a given line of goods in such a variety of patterns and sizes as greatly to reduce, if not entirely eliminate profits.

On the side of the manufacturer is the natural desire to have something different from his competitors in order to put forward a real or imaginary superiority in his product. There is, therefore, a natural tendency to bring out new and "improved" models, while possibly continuing to manufacture the old lines. There is also the desire and need to produce a line of goods to satisfy varying purchasing power of customers. Thus phonographs and automobiles are produced in a wide range of qualities and prices. This tendency upon the part of the manufacturer has been greatly increased by the attitude of the modern aggressive salesman who, in order to combat the resistance of a purchasers' market, demands new and more attractive designs.

On the part of the purchasing public there tends to be a demand for products having individuality. Many people wish to have writing paper, pocket knives, or automobiles, unlike their neighbors'. In wearing apparel and other personal accessories, the demand for changes in fashion is pressed both by the purchaser and the manufacturer. As an extreme illustration of this tendency, colored bed-linen has lately been put upon the market. These desires upon the part of both producer and consumer have brought about such a complexity as to give rise to a well-defined movement not only to check this tendency where possible, but also to eliminate one of the existing wastes due to it. The movement is characterized broadly as "standardization," but a highly important part of the movement which has been developed by the Department of Commerce has been aptly called "Simplification."[8]

The United States Bureau of Standards is the source of and sponsor for all basic scientific standards, while the American Engineering Standards Committee, representing 33 American engineering and scientific societies, is sponsor for the standardization of engineering standards, safety codes, and similar standardizing literature. These and other similar movements have greatly aided and influenced standardization, in a general way, in standardizing nationally many machine elements such as bolts, nuts, and gear teeth. The movement as a whole is far from being well-organized, and much remains to be done before national standardization can be said to be effective. The problem is complex and difficult, and it may be that, at the most, in many lines of production we shall obtain only partial success.

Standardization in a manufacturing sense is the reduction of any line of product to fixed types, sizes, and characteristics. No doubt great savings can be made by extending the principle, even though full standardization may be neither necessary nor desirable.

The work of simplification is stimulated by the Division of Simplified Practice of the Department of Commerce. The general method of attacking such a problem is to study it thoroughly and then, calling together representatives of manufacturers, distributors, and consumers of the article under discussion, to seek their agreement to the elimination of certain types and sizes. In this manner, 62 out of 66 varieties and sizes of paving brick were eliminated, the sizes of building lumber were greatly reduced, and many similar reductions have been made in other lines of product. There can be no doubt as to the economic significance of the adoption of a national policy of simplification. Vast savings can be

[8] It is not necessary to discuss the broad general aspects of international and national standardization as pertaining to basic scientific standards. We are concerned here only with those aspects of the movement which affect actual production in this country, though such standardization may be of great importance nationally, to an industry as a whole, or to a single plant.

made by simple reductions in types and sizes in many lines of products, with no sacrifice of appearance or utility.[9]

A basic principle in quantity production is that every element of the product shall be, as nearly as possible, exactly like every other similar element or part. Every manufactured product is, in general, the work of many men, and is built up on the assembly floor (or corresponding place) from parts made by workmen who may never see the finished product. A modern factory producing automobiles, sewing machines, clocks, or shoes, is like a river, the various elements *flowing* like tributaries from the several departments and merging smoothly into the stream of finished product which comes from the assembly floor. The success of such methods depends on every element being exactly right or "standard," as such requirements are called.

The interchangeable system of manufacturing is not confined to any *quality* of product. It is applied to the production of the cheapest and also to the most expensive article, where any quantity is produced. The degree of refinement or limits of accuracy may vary, but the principle is the same. The mechanical limits in the best work are remarkable. Our best standard dimensional gauges, as actually used in factories, are accurate to the three-millionths of an inch. The component parts of apparatus, such as typewriters and automobiles, are made to such accurate and close dimensions that no fitting of individual parts is required or permitted on the assembly floor. When it is considered that these results are often produced by semiskilled workers, the refinement of transfer of skill, as illustrated in modern tools, is astonishing. The economic results are no less astonishing. Without doubt, the most remarkable and most perfect product in many ways that man has produced is the automobile. Without doubt, also, the greatest value per man-hour of labor ever offered upon the market is to be found in some of these cars of moderate price. The extension of the principles of standardization to the human element in production is a most important and growing field of activity.

Time-Saving Management.—Modern machinery involving transfer of skill is usually spoken of as *labor-saving machinery;* it is also *time-saving.* The normal work of operating a modern semiautomatic machine may be much greater than to perform the same operation upon a standard machine. The output of the semiautomatic is, however, much greater *per unit of time,* hence the labor *per unit of product* is less. The full automatic machine, therefore, is both a time-saving and a labor-saving machine, for the parallel development of transfer of skill and the application of power have both been applied to the construction of the machine. Modern management, commonly called scientific management or industrial engineering, is concerned with the saving of time as well as labor.

[9] For results of simplification, see pp. 116 to 119.

The net influences upon the worker are identical with those that follow transfer of skill.

Power, Transportation, Communication.—A discussion of industrial change of necessity involves a consideration of the growth of the use of power, the development of transportation facilities, and of the art of communicating intelligence and information. These will be discussed in detail by others elsewhere in this survey, but it is necessary to mention here their net effect upon the growth and change in industrial plants.

The increased use of power is most important and significant. Data are lacking in the census of 1900 as to the total horse power then in use, but the census of 1925 shows an increase in manufacturing horse power from 22,264,343 to 35,772,628, from 1914 to 1925. The total prime mover capacity in the United States to-day is probably in the neighborhood of 800,000,000 horse power. It is estimated that this is about four times as great as that of Great Britain or Germany, and ten times as great as that of France. More significant still, the per capita wealth in the United States bears the same ratio to the per capita wealth in Great Britain that the total per capita horse power here does to the per capita horse power there. Our productive capacity, therefore, rests largely upon the fact that our productive machinery is not only *time saving* in character but *labor saving* also.

The growth in the size of central station machinery should be noted. The first large turbo-generator built by the General Electric Co. about 1900 was of 5,000-kilowatt capacity. To-day, single units of 50,000-kilowatt are common, combined units of 100,000 not unusual, and one of 208,000-kilowatt capacity is under construction. The new State Line Power House of the Chicago Edison Co. will have a final capacity of 1,000,000 kilowatts, and there is no apparent diminution to the growth of such plants, either as to size or number. A survey of our public utilities in the *Blakemore Analytic Reports*, dated December 20, 1926, gives the total horse power of prime movers in this industry as 3,000,000 in 1902; 12,000,000 in 1912; 24,000,000 in 1922, and a prospective 30,000,000 in 1930. As an index of the increased use of power, these figures are most impressive.

The art of communication, as developed in our postal service, telegraph, telephone, and radio systems, has had a tremendous accelerating influence upon all industry. This influence cannot be quantitatively measured, but its effect upon modern life is profound. Not only has the art of communication developed great new industries for the manufacture of its own products, but it has also greatly aided in the transformation of other industries. In connection with transportation, it has affected the location and the migration of industry. It is also greatly modifying and reducing the amounts of raw materials that are carried in stores by manufacturing plants. Quickness of communication and

rapid transit, as developed by modern freight service, have brought the entire chain of manufacturing very much closer together. The development of means of rapid communication, like the development of tools of production and the development of sources of power, is one of man's ancient problems which, in the period under review, has advanced remarkably toward solution.

Modern industry, then, develops in two ways, first by the growth and expansion of old industries, and second by the development of entirely new industries, producing new products. The old industries tend constantly to change in character internally, through the use of improved and new methods and further division of labor. They tend to partake less of handicraft and to employ more transfer of skill. As a consequence, the output per man constantly increases and this, coupled with the changes due to the introduction of time-saving apparatus, tends to unemployment without reference to good or bad times. Some of the workers thus displaced find employment in other old industries and many are absorbed by the growth of new industries. The extent of this unemployment, so far as skilled workers is concerned, is hard to gauge, and data are lacking. But the phenomenon of what in current discussion is called technological unemployment is nothing new. It is as old as the present industrial system and it is inherent in this system.

The census of 1900 comments upon this type of unemployment: "A factor that has had a real tendency to lower the actual earnings of the wage earner in many industries is the displacement of the skilled operator by machinery which permits the substitution of a comparatively unskilled machine hand. This tendency is noticeable in many lines of industry. Its effects are twofold: To reduce the number of employees producing the same, or an increased quantity of product, and hence to lower the total wages of the group; and to reduce the average rate of wages because of the lower degree of skill required. The effect of the introduction and improvement of machinery upon the condition of the skilled artisan is an economic question of the greatest importance." The census report gives statistics supporting this view, and cites, as an instance, the case of the boot and shoe industry where "an increase of 18.3 per cent in value of products resulted from an increase of 22.2 per cent in value of machinery and tools used, with only 6.9 per cent increase in number of wage earners and an apparent decrease of 2.5 per cent in wages paid." This is a true picture of the effect of modern methods as far as it goes. It does not, however, give a most important item, namely, the change in the unit cost of the product. Nor does it take into account the growth of the shoe-machinery industry.

The recorded experience of the period from 1900 to 1925 does not bear out the fears expressed in the census of 1900. That census lists the number of workers in the shoemaking industry, both handicraft and

factory, as 153,620, and gives their earnings as $63,304,344, or about $415 per person. In 1914, the number employed was 191,555, with earnings of $105,695,404, or about $522 each. In 1925, there were 206,992 workers, with earnings of $225,787,981, or about $1,090 per person. The purchasing power of the dollar of 1925 was about 66 per cent of that of 1913 and 53 per cent of that of 1900, but even with these allowances there has been a gain in real wages since these dates. Furthermore, in 1900 there were 4,649 children under 16 years of age employed in this industry, with earnings of $822,648, or about $177 per child. No such conditions are tolerated to-day in progressive states.

Again, in the printing industry the census of 1900 lists the number of workers as 162,992 with earnings of $84,249,963, or about $517 per person. The census of 1925 gives 251,276 persons thus employed, with earnings of $438,832,974, or $1,746 per person. Here again, allowing for the difference in the dollar, there has been a decided gain. Furthermore, such statistics do not take into account the increased employment due to the production of machinery for these industries. In 1925 the value of the printing machinery produced in the United States was $69,216,683, and the corresponding value of shoemaking machinery was $11,769,137, and each of these industries have ramifications that would be difficult to follow. An analysis of other industries over any period of time would no doubt show similar tendencies.

The expansion of old industries, however, is not sufficiently rapid, apparently, to absorb the rising generations, but up to the present time the increase over and above those absorbed by the old callings has been taken up by the new industries. These new mass production industries deserve more than passing consideration. Most of them, such as those that build automobiles, cash registers, and telephones, have not developed for the most part on a basis of handicraft skill, but have been constructed from the beginning as mass production enterprises. A modern mass production factory is not an accretionary affair, but it is designed in the beginning for full use of transfer of skill and division of labor. The number of skilled and experienced workers may be small as compared to the actual semiskilled producers and those who conduct the highly divided office functions. The employees of such an enterprise may not be recruited to any large degree from older industries, but from young men and women who have had little or no experience in the particular line of work to be produced. And because of modern methods they can soon take part in the production of such highly refined products as telephones and radios, which under older methods would require a high degree of skill and experience.

Summary.—From the foregoing it will be clear that American industry is in a state of flux, with changes occurring not only in the character and personnel of many industries, but also in their economic status. Some of these changes or tendencies are as follows:

1. There is a continuing tendency for the handicrafts to disappear in favor of factory processes, except in such industries as the building trades. Even in these callings, however, new methods such as electric welding are making themselves felt.

2. In all factory work there is a tendency to extend transfer of skill and division of labor not only in actual production but also in the managerial side which is becoming mechanized at a rapid rate. This tends again to break up the trades and callings into small functions which can be performed by people of less skill and training.

3. A distinction should be made between the disappearance of industries and their *transformation* by the introduction of modern methods. The census reports show that few industries have disappeared, the list given in 1900 appearing for the most part in the census list of to-day. These industries, however, have in many cases been greatly changed internally by modern methods. Thus, shoemaking and clothing manufacture still bear the same name, but they are really, in most respects, new industries.

Many industries that survive in the same form externally, such as shipbuilding, locomotive building, and the machine trades in general, have grown in size and capacity. The product is often much larger; the equipment as a consequence much larger. No limit as yet has been reached, apparently, to the size of product. We expect to see larger locomotives, bridges, ships, buildings, and tunnels.

4. On the other hand, the last quarter of a century has seen a great increase in new industries, the result of scientific discovery and of mechanical development. These are well illustrated by the telephone, radio, automobile, rayon, refrigerators, electric welding, chemical and electrical industries. These are of more than passing importance, for many of them have grown into great enterprises employing many thousands of men and producing new products in vast quantities that have found ready markets. These new enterprises really constitute the most remarkable and most important phase of modern industry, and their true economic significance probably holds the clue to our industrial and economic future.

5. There is an increasing tendency, therefore, toward mass production, particularly in the case of these new products, with the object of reducing the price and extending the market. This principle is being applied not only to articles of real worth, but also to many products of doubtful economic value. This tendency naturally increases the size of manufacturing plants, and this is reflected in the constant increase in the relative number of plants that are owned corporately.

6. Modern productive methods tend to be more highly functionalized under four groupings, namely, management, design, toolmaking, and actual productive operation. The design of the product and also of the

general methods of production and plant layout has become a calling of its own, almost entirely separated from the actual production itself. In a similar manner, the actual tools of production are provided by machine tool builders and builders of special machinery. Lastly, the actual production in large quantity-production plants is performed largely by the "operator" type of worker, that is, a person who by special adaptation has been taught to operate a tool or process in which there is a high degree of transfer of skill. Automobiles, typewriters, shoes, sewing machines, etc., are not produced by skilled mechanics but by semiskilled operators to whom the field of manufacturing has been "extended" by these new methods.

7. Paralleling these developments is the rapid growth of power producing plants, driven by steam, oil, or water, and greatly increasing the output per person, with modern transportation facilities and improved means of communicating intelligence speeding up the entire industrial mechanism. Necessarily this has made industry more sensitive and more mobile. These influences tend to change and level up the economic advantages of different sections of the country and to develop new industrial centers.

8. It should be noted that industrial development is becoming less and less a matter of accident so far as basic scientific data are concerned. A few years ago new ideas came into industry largely as the result of the work of independent inventors experimenting empirically, or as the result of work in university laboratories. To-day the idea of organized industrial research is thoroughly established both in university laboratories and in many industrial enterprises.

9. Finally, experience shows that the shifting of labor, called technological unemployment, is a constant accompaniment of progress in modern industry. Like other wastes of our industrial system, it calls for examination. In all probability, our hope for a higher economic level rests as much upon increased efficiency and avoidance of waste as upon new processes and inventions.