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Chapter Author: Harry Jerome

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CHAPTER IX

FACTORS DETERMINING THE RAPIDITY OF MECHANIZATION

IN CHAPTER X we analyze the effects of the process of mechanization. These effects themselves are among the major factors conditioning the rapidity of mechanization, but it is also pertinent to our purpose to review first the other influences that may be expected to hasten or retard the advance of mechanization.

These influences are diverse and numerous. Some are always prevalent and do not fluctuate greatly in their potency; others are peculiar to the present status of industry or at least are more potent under existing conditions. Some are susceptible of objective treatment; others are less tangible though perhaps no less significant. By what means, for example, can we express in quantitative terms the part played by the reluctance of executives to abandon familiar methods or the force of labor opposition arising from the fear of machine competition? Nevertheless, our picture will be more complete if we mention the various factors involved, even though in some instances we must rest our statement with little more than a mere enumeration or at best a few illustrative examples.

Mechanization is not completely synonymous with the factory system, but there is so close an alliance between a highly mechanized industry and a well-developed factory system that we may initiate our review of the factors conditioning mechanization by asking what are the primary

requisites for the development of an extensive factory system.

First, before there will be adequate inducement for those in control of investment funds to hazard them in industrial enterprises, any excessive element of risk must be eliminated. Second, there must be an entrepreneurial class with sufficient initiative and ability to organize factory operations and adapt them to a relatively complicated labor and market situation. Also there must be a laboring class with a somewhat flexible standard of living, that is, a group of workers sufficiently discontented with their status to be willing to subject themselves to the factory regime in the hope of bettering their conditions.[1] Third, there must be a relatively extensive market.

However, since we are concerned primarily not so much with the conditions requisite for the inauguration of the factory system and the introduction of power-driven machinery as with the forces affecting their further development from the stage now reached in the United States, it is not unreasonable to assume the existence of the primary requisites for the factory system—subject possibly to qualifications for particular industries or sections of the country—and to state the problem in terms of the conditions that tend to accelerate or retard the process of mechanization.

For convenience in discussion we may classify the influences that tend to affect the degree of mechanization or changes therein as technological, pecuniary and psychological. An operation may continue to be manually performed because the technicians have not developed a satisfactory

[1] On this point, J. E. Orchard, in *Japan's Economic Position,* says: "It is one of the paradoxes of the Orient, of India and China as well as of Japan, that manufacturing industry suffers from a scarcity of labor. . . . The farms are overpopulated, but the people are attached to the land and labor is reluctant to enter the factory" (340).

mechanical device. Or the mechanized procedure, though technologically adequate, may be too expensive. Or, despite the availability of adequate mechanical devices, at costs not prohibitive, use may be limited because of the inertia, ignorance, distrust or active hostility of employers, workers or the public.

Obviously, the technological, pecuniary and psychological factors are not independent or mutually exclusive. If expense could be ignored, there are very few operations for which a technologically adequate machine could not be developed. Furthermore, such resistance to the use of labor-saving equipment as arises from non-pecuniary factors may operate to lessen the pecuniary gains to be expected from its adoption.

Technological Factors Limiting Mechanization

There is, as above noted, no sharp cleavage between technological and pecuniary obstacles to mechanization, for many of the existing technological difficulties can be overcome if expense is ignored. However, frequently the chief reason for not substituting mechanical methods is that some particular technical difficulty has not been overcome. In fact, the balance between alternative methods of production is constantly being disturbed by technical improvements in mechanical devices. Some take the form of revolutionary changes in process which surmount a difficulty by substituting an entirely new method of attack. Others consist in the perfection of mechanical devices for carrying out a known procedure.

Under modern conditions most technical improvements probably are not accidental but are the result of continuous experimentation, partly by the users of machines themselves and partly by machine producers who maintain a technical

staff whose primary function is to design special machines to meet requirements prescribed by the prospective user. It is scarcely too much to say that a machine can be manufactured to special order to perform almost any series of operations when the need becomes sufficient to justify the expense.

LIMITED SELECTIVE ABILITY

One difficulty that frequently stands in the way of mechanization is the limited selective ability of the machine. For example, machines have not been developed to supplant domestic labor in the care of children, to pick strawberries or to read addresses in the Post Office. Other illustrations are found in the sugar beet industry. Beets are planted in continuous rows and later 'blocked' with a hand hoe to leave a bunch every ten or twelve inches; then each bunch is thinned by hand to one plant. For neither of these operations have mechanical devices proved satisfactory. A blocking machine does not allow for the lack of a perfect stand and the use of judgment in shifting the block, and the machine must move too rapidly to enable the operator to make the necessary shifting. Likewise there is no obvious prospect of developing a machine for thinning beets. In the seed ball there are from two to four germs. These sprout together and, if allowed to grow together, would twist around one another, making small, imperfect beets. Therefore, we must pull out by hand all the beets of the bunch but one, leaving a single beet to continue its growth. Furthermore, no topper has been invented for use in harvesting beets that can cope with the vagaries in growth to which the topper must be adapted.

TEMPORARY AND LOCAL TECHNOLOGICAL LIMITATIONS

Many technological difficulties are temporary and will be surmounted through experimentation.[2] Other difficulties, peculiar to certain plants, may be overcome by reconstruction.[3]

There are two prerequisites for changes in industrial technique. First, certain scientific and engineering principles must be evolved; second, their application must be commercially feasible. Occasionally, an invention is perfected before economic conditions are ripe for it. On the other hand, occasionally an urgent or unusual economic situation concentrates attention on a technological problem and hastens its solution. Witness the impetus given to the development of mechanical cotton harvesting by the situation existing in some years in sections of the South where profitable harvesting was impossible by the customary hand picking methods.

[2] For example, formerly the inability of electric trucks to make steep grades on docks limited their use, but now, we understand, there are trucks that can negotiate the steepest grade fully loaded. Likewise, in the initial stages of our survey, the opinion was expressed by one mine operator that loading machines were probably then practicable in mines with adequate height in rooms, but would have to wait several years for general use until machines adapted to lower ceilings and more cramped quarters in general were developed. As indicated in Ch. IV, with their increasing adaptation to special mining conditions, the use of loading machines has been making substantial progress in recent years.

[3] For example, in the older cotton mills the portable type of tying-in machines, which is necessary for Jacquard looms, sometimes cannot be used because of narrow aisles. In the older foundries some roofs are too low to admit the installation of satisfactory overhead conveying systems. In one foundry surveyed the roof of the main building was so low that there was no overhead room for heavy-work cranes; consequently, large pit castings had to be dragged out. Likewise, at the time of our inspections, many piers along the lower East River, New York, were plank floored and very uneven, making the use of electric trucks difficult if not inadvisable on account of load shifting.

Pecuniary Factors

We have noted in the preceding chapter that even after a machine has become clearly practicable from an engineering point of view, many years may pass before its use becomes general in the industry; that ordinarily there is a considerable margin between the fullest use of a mechanical device that is feasible from an engineering point of view and the actual extent of use. Technical progress far outruns actual practice.

This margin of non-use is in part due to non-pecuniary factors but the major explanation is simply that, on the whole, industry must be conducted with profits as the immediate goal; hence the first and major consideration in any choice of method is not merely, will it do the work, but also will it pay?

Numerous collateral questions arise. What existing plant and equipment must be scrapped or reconstructed? What new capital will be required and how difficult will it be to obtain the necessary funds? What overhead expense will the machine add, especially in times of plant idleness? Is the market that may be counted upon of sufficient extent to justify the scale of production essential to make the use of the machines economical? How high is the wage level in relation to the costs of the other factors in production and what changes are taking place in the rates of wages for workers required in the production of machines as compared with those displaced by them?

Let us consider first the issues arising from the larger overhead expense of mechanized processes.

OVERHEAD EXPENSE

The adoption of a more highly mechanized procedure usually involves a larger investment in equipment,[4] and often also in plant structures, particularly if the machines are very heavy. For example, in its investigation of the window-glass industry in 1916 the Bureau of Foreign and Domestic Commerce found that the 37 hand plants surveyed employed only $0.74 of capital for each $1.00 of sales, while the 12 machine plants averaged $0.93 of capital for each $1.00 of sales.[5]

Dr. D. D. Kennedy cites examples of marked increases in overhead expense due to mechanization in the ice and coke industries.[6] He found that depreciation constituted only 8 per cent of the expense of producing natural ice and 26 per cent for artificial ice. Likewise, in the coke industry the transition from the almost completely manual methods of the old beehive process, first to the machine beehive and then to the by-products method, has brought sharp increases in overhead costs. "A forty-oven battery of the old beehive type would be valued at about $20,000, while a machine-operated battery would cost between $80,000 and $100,000." In a by-product coke plant, depreciation alone is found to constitute 21 per cent of total costs.

Where the adoption of mechanized methods requires a carefully planned reorganization of a factory, as is often the

[4] "Ability to make heavy capital investment has enabled the modern baking companies to install machinery whose price is prohibitive to the corner bakery, and which enables great savings in cost when bread is made in large enough quantities—though the price to the consumer is little reduced, if at all." George Soule, *New Republic,* April 4, 1928, pp. 210–1.

[5] *The Glass Industry,* Misc. Series No. 60, p. 43.

[6] Ref. 14, Ch. III, The Increased Importance of Overhead Costs, pp. 33–43. These estimates are based upon the records of a small number of individual plants.

case, for example, where an adequate system of mechanized handling of materials is introduced, the necessarily large outlay for engineering and reconstruction costs is feasible only when the capital market is favorable.

RELUCTANCE TO SCRAP EXISTING EQUIPMENT

Frequently the factory executive is deterred from introducing a machine, recognized as more efficient, because of a reluctance to scrap the existing equipment, which, though perhaps obsolete, still functions after a fashion. We were informed by various cotton mill executives that they were still using a considerable proportion of non-automatic looms because of the capital investment that would be required if these looms were scrapped before they had worn out physically.[7]

As the old machines wear out and it becomes necessary to discard them, this obstacle to the introduction of the newer device is, of course, removed. Meanwhile, however, average equipment lags far behind technical progress. The slow adoption of the automatic telephone may be cited as an illustration.

Difficulties arising from the nature of the existing equip-

[7] Mr. George O. May suggests the possibility that one cause for the greater tendency here to discard equipment than is noticeable in Europe may be an inadequate analysis of the advantages and costs of change. "Certainly for many years and in many fields there was a tendency to capitalize both the cost of original equipment and the cost of superseding equipment; for instance, it was notorious that the capital accounts of many street railways included the cost of original horse-car equipment; the cost of conversion to cable or electric cars, or perhaps to both in turn and possibly also a change first to an overhead and then to an underground electrical system. It is hardly surprising that ultimately the industry proved unable to stand the strain of such accumulated capitalization, and I have often wondered how far sound accounting would have had the effect of checking the rate of change in this and in other cases."

ment may be illustrated by reference to the conditions long prevailing in the handling facilities in the Port of New York. These, it has been pointed out, to a large extent just grew instead of being planned with a view to future conditions; consequently the design of the structures was such that without building new piers it was impracticable to equip them with the most efficient handling devices. As the old piers had many years of useful life under the then existing conditions of operation, it was difficult to prove the economic justification of new piers, even if physical conditions made possible the increased size. In brief, it appeared that the more complete mechanization of the cargo handling facilities of the Port of New York might be delayed until the useful life of the existing structures was exhausted.[8]

EASE OF FINANCING NEW EQUIPMENT

A device may save labor, and in the experience of other producers, also save money in the long run, but for various reasons it may be difficult for the management to arrange for the financing necessary to cover the purchase cost of the new equipment.[9] This is likely to be true particularly of industries for which the future is somewhat uncertain. The conditions of ownership may be one of the factors limiting

[8] See discussion of this point in an article by James A. Jackson as late as 1927; *Mechanical Engineering,* May 1927, pp. 411–3.

[9] A pertinent comment on this point appears in the report of a Subcommittee of Civil Research (with reference to the British cotton industry and known as the 'Government Cotton Inquiry'), as quoted in the *Manchester Guardian,* July 5, 1930: "One important reason why the question of improved methods and equipment has not received adequate examination is that many of the firms engaged in the spinning and manufacturing sections are financially weak."

ability and readiness to make additional investments in equipment.[10]

It has been suggested that the ability of vertical combinations like Ford and the United States Steel Corporation to finance new inventions was one factor furthering the mechanization of coal mining in the post-War period and helped to give the new non-union fields an advantage over the old fields.[11]

It may be noted that old plants for which the financing of reconstruction may be difficult or inadvisable and which have become so inefficient that their operation has ceased to yield a return sufficient to maintain the property and cover interest on the investment, may still continue to operate "as long as they will run without repair, in order to liquidate as much of the investment as possible." [12]

A major factor contributing to the era of post-War expansion in equipment was the availability of an unusually large volume of funds at low rates. "Probably never before in this country had such a volume of funds been available at such low rates for such a long period." Government debt reductions contributed to an abundant supply of capital. A substantial portion of the high corporate earnings was used for plant and equipment expansion. The net volume of domestic new capital issues increased at an annual rate of 7.7 per cent, or from $3,669 million in 1922 to $6,294 million in 1929.[13] An indication of the easy market

[10] In New England there are a number of old family mills; we understand that in some cases there has been a tendency for the family to expect regular dividends whether currently earned or not, and in their payment surplus has been exhausted, leaving no funds for needed investment in new equipment.

[11] C. B. Fowler, Soft Coal and Hard Facts, *Survey*, March 15, 1927, pp. 773–4.

[12] B. L. S. in merchant blast furnace study, Ref. 37, p. 66.

[13] F. C. Mills, *Economic Tendencies*, pp. 423–61.

for such securities is given by the decline in the average yield of 60 high-grade bonds, as computed by the Standard Statistics Company, from 4.98 in 1923 to a low point of 4.47 in 1927. With new capital available at low rates and wages relatively high, the financial incentives to mechanization were unusually strong in the years following the recovery from the depression of 1920–22.

REGULARIZATION OF PRODUCTION

Irregularity of production, a short operating season[14] and the availability of casual labor tend to discourage investment in machinery. The machine cannot be discharged in slack periods, but human labor can and is. We are not, of course, overlooking the very commendable efforts to regularize industry by progressive and farseeing employers, or the possibility that pressure for steady employment may be brought through special unemployment reserves or insurance schemes or provision for compensation for job severance; nevertheless it remains true that in periods of business depression executives believe it necessary and find it possible to make substantial cuts in their expenses by decreases in the number of their employees. Hence the executive who contemplates the substitution of machinery for manual methods will obviously take into consideration the fact that certain elements in his machine expense, such as interest and insurance, will continue through periods of idleness.[15] Consequently, forces that tend to reduce either

[14] An illustration is found in summer resort hotels. The manager of one, employing ten women and four men and having no vacuum cleaning units, wrote us as follows: "This is a resort hotel . . . . our season is short, nine weeks, and capital charges must therefore be watched closely. We do not, therefore, use machinery except in a very limited way."

[15] The uncertainty of net saving when overhead during periods of idleness was taken into consideration was the reason mentioned to the writer by one

cyclical or seasonal irregularities in industrial operation are favorable to mechanization.[16]

The effort to reduce seasonal irregularity in the building and other industries affects the supply of labor in a twofold way. First, to the extent that the movement towards regularization is successful it economizes the existing supply of labor by a more uniform distribution throughout the year; second, by lengthening the working period it encourages the substitution of machinery for manual effort. Some of the modern developments in building in the way of mechanized production, such as the use of structural steel, also further the reduction of seasonal irregularities by increasing the amount of fabrication prior to erection (Ch. IV).

The intermittent nature of stevedoring operations partly accounts for the large amount of manual work in marine terminals. On docks speedy handling is imperative and it is cheaper to take on, for a short time, a force sufficiently large to load or unload the freight quickly by manual methods than to keep ready adequate mechanical equipment.

large steel foundry executive to explain the fact that his plant has less labor-saving machinery than is commonly found in large foundries.

[16] In one way, cyclical irregularity may hasten the adoption of improved methods by the ruthless but effective procedure of eliminating the weaker units. Depressions sometimes eliminate obsolete plants or processes. For example, during the 1903–04 depression, the few remaining pot furnaces in the window-glass industry were driven out of business (*Tariff Information Series,* No. 5, U. S. Tariff Commission, 1918, p. 49).

On the other hand, it has been suggested that the realization of technical improvements is deferred during recessions; that the installation of new equipment probably awaits the beginning of revival and the subsequent acceleration of production; that, as business begins to pick up, "the accumulated technical improvements of several years may be vitalized." See Ch. X for discussion of the effect of mechanization on seasonal and cyclical irregularity of operation.

SHORTENING THE WORKING DAY

Unless the number of shifts is increased, a decrease in the length of the working day increases the expense of machine operation by spreading the overhead over fewer hours.[17]

LARGE-SCALE PRODUCTION

The relatively large initial expense of mechanized equipment, and the facts that in small plants there may not be sufficient work to keep a machine busy and that machines cannot ordinarily be transferred from one type of work to another without adjustments and additional expense, make high mechanization dependent in considerable part upon mass production. Hand methods survive chiefly where variety and distinction, quality and individuality are the primary considerations.

Numerous examples of the necessity for large-scale production if heavy investments are to be made in highly-mechanized equipment could be given. For example, one manufacturer of brick machinery writes us:

"Unless the product desired reaches about 6,000 brick per hour the plant will hardly justify the employment of the modern mechanical methods of digging clay and preparing it for moulding" . . . and "in the Chicago district unless the product is close to 300,000 per day the manufacturer can hardly afford to employ the labor-saving equipment necessary to compete in that market."

Even if a single plant is operated on a relatively large

[17] Mr. W. M. Carpenter points out with respect to the performance of factory machinery operating on purchased power in New York State (outside New York City, Niagara Falls and Massene, the last two of which are excluded because of the electro-chemical load) that the average load factor declined from 22.8 per cent in 1909 to 21.2 per cent in 1919, or about two-thirds of the percentage decline in average hours per week (*Electrical World*, June 14, 1924, pp. 1232–4)

scale, it may be handicapped because there are not many other plants producing similar goods. Because of the small market automatic machinery would have to be custom built, and hence would be more expensive than if relatively standardized machinery could be used.

There may be a tendency towards larger plants irrespective of any increase in the total size of the industry.[18] On the whole, these larger units can make more economical use of labor-saving devices than the smaller units.

Similarly, the increasing use of expensive machinery—the elevating grader and other mechanical devices—in highway construction in recent years has been due largely to the tendency for hard-surface highway construction to be taken over by the state and federal governments, with the result that contracts are let on a larger scale than when under the jurisdiction of local governments. The same principle applies in the mechanization of agriculture. Mechanization is furthered by large-scale farming.[19]

Industries subject to frequent style changes invest in labor-saving machinery with less certainty of adequate return on the investment. For example, it was suggested to our field investigator that the relatively slow adoption of automatic looms in the New Bedford branch of the cotton industry is ascribable to the circumstance that these mills specialize in quality goods subject to many changes in style.

[18] *Cf.* Ch. VI, section on Size of Establishments.

[19] A correspondent engaged in the production of sugar beets in America advises us that although a satisfactory machine for pulling and topping beets has not been developed for use in America, "they have a machine in Germany which does fairly good work but it is only adaptable to the very large farms that they have there, the Estate farms. This is pulled back and forth across the field by a cable attached to two engines sitting on each end of the field and driving winding drums in the manner of the Fowler plow . . .These are very expensive machines, only to be applied to very large acreages, and are not very completely practical even there."

As a rule, the small-scale production incident to a di versity of product is a serious handicap to the extensive us of machine methods. For example, one of the reasons fo the rather slow development of machinery in the pressed ware branch of the glass industry, in contrast to the window and plate-glass branches, is the multiplicity of products.[2] Since the hand plants could not compete with the machine in turning out quantities of common tumblers they are specializing in better quality, emphasizing etchings and decorations to appeal to individual tastes.[21] Likewise, in the manufacture of light bulbs,

> "hand production has been retained to make such of the large sizes and oddly shaped and colored bulbs as cannot be economically produced on the machine, partly because the molds are too expensive, but chiefly because such bulbs are produced in very small quantities. For this purpose and for the purpose of experimentation, which can be better controlled when the bulbs are made by hand, hand production, even if only a small fraction of the whole industry, will survive no matter what strides are made by the automatic machines." [22]

Also, where diversity in procedure is essential the simple hand device may be preferred. For example, in freigh handling the sorting of packages to different consignees is more easily done when hand trucks with small loads are used. Likewise, repair work, such as automobile and stree repairing, presents too diversified conditions to make com pletely automatic machinery practicable, although even here semiautomatics are used to an increasing extent. For ex ample, often on the never-ending process of repairing city streets, the old pavement is torn up with pneumatic dril or pavement plow.

We have previously noted that there is a tendency fo

[20] B. L. S., Ref. 36, p. 88.
[21] *Ibid.*, p. 135.
[22] *Ibid.*, p. 127.

the size of the machine unit to increase (Ch. VI). This sometimes necessitates the mechanization of associated operations. For example, as the average size of the locomotive has increased it has become less feasible to shake the grates by hand.

In general, then, large-scale production, both for single plants and for an industry as a whole, favors a high degree of mechanization. What conditions favor large-scale production?

AN EXTENSIVE MARKET

The primary essential for large-scale production is an extensive market, as a keen foreign observer has well stated: 'The most important point in the philosophy of American production is the home market of nearly 120,000,000 people . . .' With free trade within our borders "mass production is the logical result".[23]

STANDARDIZATION

Any influence that furthers standardization within the great domestic market for American manufactures accelerates the tendency to mass production and mechanized methods. A 'stereotyped clientele' enables producers to profit readily by manufacturing standardized goods. Standardized production necessitates standardized consumption, to which an impetus is given by national advertising, furthered in part through chain broadcasting systems. Mass distribution is the next step in providing an adequate market for the products of large-scale industry. The remarkable growth of chain stores in many lines of retailing intensifies,

[23] André Siegfried, *America Comes of Age*, p. 166.

suggests George Soule, the tendency to standardized mass production.[24]

The post-War standardization campaign is not restricted to consumption goods. In recent years the agitation for simplified procedure initiated during the War and later encouraged by the Department of Commerce has as its object the reduction of the multiplicity of types and sizes, not only in consumption goods, such as bedsteads, but also in production goods, such as bricks and screws. To the standardization of consumption goods, opposition may arise on aesthetic grounds, but objection to the standardization of production goods is less valid. In any event, it seems a justifiable assumption that the standardization movement will continue and thus offer increasing facility for large-scale production.

AGE OF THE INDUSTRY OR PLANT

In general new industries and enterprises are more susceptible to mechanization than those which have long been established. Automobile and tire plants, though among the youngest of the important industries, are noted for their highly-mechanized operations. On the other hand, the clay products industry, as old as history and long accustomed to the use of hand labor, has had difficulty, like other old industries, in divorcing itself from old processes. The lesser susceptibility of the older industries is due in part to the force of accumulated tradition, in part to reluctance to scrap existing equipment. Moreover, the newer industries are expanding industries. Under circumstances of expansion there is greater opportunity and encouragement for mechanization: new buildings can be more readily adapted

[24] *New Republic,* April 4, 1928, pp. 210–2.

to automatic processing machinery and efficient conveying systems, each plant can ordinarily absorb at least some of its machine-displaced labor, and hence both executives and employees are apt to be less concerned about the effect of machines on job security.

On the other hand, in an industry that is declining or for some reason is in a relative slump for the time being, the management is likely to try to retain as many of its staff as it can, and, with more men than it really needs, has little incentive to seek labor-saving changes.[25] When an industry is obviously on a permanent decline, as is the lamp-chimney industry, the owners hesitate to invest the additional capital required for further mechanization.

Older types of labor-saving machinery retard the distribution of new models. For example, when electric sewing machines for home use were introduced, many homes were already equipped with hand- or foot-power sewing machines giving sufficient satisfaction to make the acquisition of the electric type not urgent.

RAPIDITY OF EXPANSION

It is reasonable to presume, as noted above, that the impetus towards mechanization is greatest in the industries that are expanding most rapidly. Undoubtedly, for example, the rapid growth of the automobile and tire industries has greatly stimulated the development of mechanized conveying systems and other efficiency devices. However, technical

[25] The manager of a leather plant described his situation thus: "Shortly after the close of the war the country contained a large oversupply of leather of most all kinds . . . hence the business of those engaged in the cutting and manufacture of, for example, sole leather cut products had been considerably reduced." Consequently they had had a surplus of help which, however, they did not care to give up, expecting that the business would soon right itself and they would need their organization.

changes are so varied and their incidence so widely distributed throughout industry that it is difficult to find quantitative proof of the correlation between rapidity of mechanization and rate of growth. To test this relationship, we prepared scatter diagrams for 101 industries, comparing the rate of growth from 1899 to 1925 with the percentage increase in horsepower per wage earner.[26] In one comparison, the percentage increase in the number of wage earners was taken as the measure of the rate of growth; in the other, the percentage increase in the value added by manufacture. In neither case was there any discernible tendency towards correlation between rapidity of mechanization and the rate at which the industry had expanded. Either there is no close correlation or, as seems likely, the relationship is obscured by other influences.

LEVEL OF WAGE RATES RELATIVE TO OTHER COSTS

The relative economy of machine and manual methods is affected both by the level of wage rates compared with the prices of the other factors in production and by the relative wage rates for different grades of workers. Other things being equal, high wages encourage the use of machines and stimulate efforts to perfect them, while cheap labor retards mechanization. To this fact the extensive use of machinery in the United States and the prevalence of hand methods in such countries as China have been largely attributed. Likewise, some observed differences in the use of machinery as among the various geographical districts in the United States have been attributed to wage differ-

[26] The percentage increases in horsepower per worker were computed from the data in Appendix C; those for the percentage increase in the number of wage earners and in value added were taken from Day and Thomas (Ref. 27), pp. 130, 141 ff.

ıtials. Thus, cheaper labor in the South has made it advan-
ıgeous for most southern blast furnace plants to continue
› maintain the old methods of sand-casting (sometimes with
ıe aid of a mechanical pig breaker) rather than adopt the
ıore expensive but labor-saving pig machine. In general,
ew 'labor-saving machinery was introduced less rapidly
fter the War years of 1917–18 in the southern iron-produc-
ıg districts, and productivity increased less in this district
ıan elsewhere because of the plentiful supply of negro
ıbor.[27]

Likewise, this difference in wage levels may help to
ccount for the greater number of helpers used with draw-
ıg-in and tying-in machines in cotton mills in the South
nd in England than in New England. On the other hand,
ıe more recent construction of southern mills, as compared
/ith many of the New England mills, has been a factor
ıvoring the installation of more automatic machinery. In
929, for example, 80 per cent of the plain cotton looms in
he southern mills, but only 59 per cent of those in the
Jew England mills were automatic.[28]

Dr. Alfred Briggs, in an unpublished manuscript on the
evelopment of the glass industry, says that the success with
/hich the skilled window-glass trades, because of their
:rength, were able to maintain a very high wage level com-
›ared with other crafts went far to stimulate interest in
ıe perfection of glass-making machines and to hasten their
ıtroduction. However, even where wage levels are very
›w, labor may not be sufficiently cheap to prevent the
ıtroduction of some mechanical equipment. For example,
ı the low-wage Oriental countries we find an increasing

[27] B. L. S., Ref. 37, p. 15. Also see Ch. VII, Chart 1, and accompanying
iscussion for comparison of relative wage rates and mechanization.

[28] Computed from data in *15th Census of the United States—Manufac-
ıres: 1929*, II, 263.

use of mechanical devices, evidenced in part by our export of machinery to Japan.

CHANGES IN THE RELATIVE WAGE LEVEL

The trend towards mechanization is accentuated by a rising wage level such as was experienced in the years following 1921. In the period 1922–29 Carl Snyder's composite index of wages shows, in terms of current dollars, a 22 per cent increase; likewise, the average annual earnings of wage earners in manufacturing increased 17 per cent. In the same period, the prices of goods entering into capital equipment declined 3 per cent.[29] With wages rising in terms of both money and purchasing power, the prices of materials for capital equipment declining, and funds for investment in equipment available in abundance and at low rates, the situation was unusually favorable for extensive installation of capital equipment.

CHANGES IN WAGE DIFFERENTIALS

The introduction of machinery may be hastened or retarded by shifts in the relative wage rates for workers engaged in machine production and for those which the machines are capable of displacing. This possibility may be illustrated by a hypothetical example. Assume a machine that displaces unskilled workers and requires $100 per day for all direct and indirect expense, including operating labor, supervision, oil, power, repairs and maintenance, interest on investment, amortization of original cost and any other expenses due to it. Of this $100, assume $60 represents payment directly or indirectly for labor and that

[29] F. C. Mills, *op. cit.*, pp. 364, 502.

ne quarter of the $60 is for unskilled labor. Assume fur-
ıer that at the beginning of the period under consideration
ıere is a perfect equality between the expense of using
ıe machine and hiring unskilled laborers to do the same
'ork.

Under such conditions, how much margin of advantage
'ill accrue to the machine use from (1) a 10 per cent in-
rease in wage rates for each grade of workers, and (2) an
verage 10 per cent increase ($6 in amount) distributed
3, or a 6.7 per cent increase, to the skilled workers, and $3,
r a 20 per cent increase, to the unskilled?

The expense of the two methods, before and after the
ıcrease in wages, will be:

	MACHINE METHOD	MANUAL METHOD
aily expense before change	$100	$100
fter an increase of 10 per cent to both skilled and unskilled workers	106	110
fter an increase of 6.7 per cent to skilled and 20 per cent to unskilled workers	106	120

Under the conditions assumed, it is obvious that any
ıcrease in wage costs greater than the increase in other
tems of expense (assumed to remain constant in the above
xample) creates a differential in favor of the machine
ıethod, and this differential is widened if the increase is
ıroportionately greater for the unskilled worker.

In like manner, any actual shift in the relative wage
ates or in the relative costs of labor and the other factors
ı production may disturb the previous differential between
ıand and machine methods. For example, it seems reason-
ble to believe that, other things being equal, the immi-
ration restriction that has been in force, either by reason
f war conditions or by legislative enactment, for the greater
art of two decades, would, by decreasing the annual addi-
ions to the number of relatively unskilled laborers, tend

to increase the inducements for a greater use of those m
chines which are capable of doing the work for whic
immigrant laborers are adapted. True, any tendency th
such restrictive measures may have to create a relati
shortage of common laborers will to some extent increa
the expense of producing machines, but the increase in t
cost of the alternative methods of production will be sti
greater, for not all the expense of producing machines
labor expense. Furthermore, in the machine-producing i
dustry a substantial part of total wages is for labor of
grade with which the greater part of immigrant workers d
not come in direct competition.[30]

What actually did happen to the differential between t
wage rates of skilled and unskilled laborers in the post-W
period? As stated in *Recent Economic Changes* (p. 439
"the margins between the wage rates of skilled and unskille
labor narrowed considerably from 1914 to 1920 and the
tended to widen, but were left somewhat narrower in 19
than they were before the war." This conclusion of t
National Bureau of Economic Research is supported b
wage statistics computed by the National Industrial Confe
ence Board from data published by the United Stat
Department of Labor. The percentage ratio of the hour
earnings of male unskilled workers to those of male skille
and semiskilled workers, in manufacturing, declined fro
76.8 in 1920 to 72.8 in 1929, the low point in the interve
ing period being 70.7 per cent in 1925. Likewise, the pe
centage ratio of the hourly union rates for building labore

[30] We have estimated that expense for labor constitutes about 25 per ce
of the total sale price of machines if we include only the labor directly
the factory, and about 50 per cent if we include the labor required
marketing the machine or embodied in the materials and equipment us
in the machine-producing industry; furthermore, that of this expense f
labor about 20 per cent is for the services of unskilled workers (Ch. VIII)

) those for bricklayers declined from 62.4 in 1920 to 52.0 1 1929. Similarly in important cities—Chicago, Cincinnati,)etroit, New York—the high point in the ratio of unskilled ates to the rates for bricklayers was reached in the early ost-War years. In Boston the ratio increased from 54 in 913 to a peak of 67.5 in 1920–22, inclusive, then declined) 53 in 1930.

On the whole, despite the check to immigration, there is o clear tendency in the decade of the 'twenties for the vages of unskilled workers to increase more rapidly than hose of the more skilled groups. In fact, in the series exmined, the ratio was highest in 1920 or 1921. The implicaion is not necessarily that immigration restriction has had o effect upon the relative supply of unskilled labor. It is ntirely probable that had immigration not been restricted he ratio would have declined even more than it did; urthermore, to the extent that the check to immigration as set in motion counteracting forces such as an increased se of labor-saving equipment, these counteracting forces ave tended to offset any influence that immigration retrictions might otherwise have had in increasing the relaive rates for unskilled workers.

A further factor—somewhat hard to ascertain but neverheless significant—is the probability that, by reason of mmigration restriction, machine producers have been enouraged to develop plants adequate to manufacture, on a uantity basis, standardized machines such as trench diggers nd wagon loaders that can do the work of unskilled labor.

IARKETING POLICIES AND COMPETITION

The pressure for mechanization varies with the type and egree of competition that prevails in the manufacture and ale of the machine in question and also with the competi-

tive conditions in the machine-using industries, though is admittedly difficult to generalize on the precise effect such differences. If all the machines suitable for a give task are well covered by patents and their control center in one organization, it is quite possible, under such mono olistic control, that a rise in wages due to an increasi scarcity of labor would merely result in an increase, by t machine manufacturer, of the price of the machine sufficie to absorb most of the potential increase in gain that mig otherwise have accrued to the user. In such an event, t labor shortage, whatever its cause, would have little i fluence in accelerating the speed of mechanization. Und competitive conditions, however, producers will find th they must pass on to users more of the savings made po sible by the machine, and this should accelerate its intr duction. It is pertinent to note, therefore, that the m chines which more clearly are a monopoly are ordinari those which supplant more or less skilled workers, while t materials-handling devices, conveyors, ditch diggers, wag loaders, etc., which replace unskilled workers, althou sometimes patented in details, are in active competiti with other machines for the same type of work.

Sales policies may affect the rate of introduction. T holders of the patent of the cylinder machine used by t American Window Glass Company followed the policy issuing an exclusive license for its use. Some produce lease their machines; others sell outright. Leasing wou seem to require less original capital investment; but pu chase may be made to appear less burdensome by a libe credit policy.[31]

Intensity of competition in machine-using industries dinarily accelerates mechanization. If competition takes t

[31] See further discussion, Ch. VIII, section on Marketing Methods.

form of a struggle for a larger share in an expanding market, the producer is encouraged to adopt devices that promise to enable him to expand his output. This is a primary explanation of the boom in machine sales in periods of expanding prosperity. If competition, on the other hand, takes a form that necessitates close attention to the reduction of unit costs, the purchase of new machinery may not be encouraged but there is a strong stimulus to the search for procedures which most effectively utilize what machinery is at hand.

Industries with a localized market are shielded somewhat from intensive competition, and this may account in part for the slow mechanization of such localized industries as building and the manufacture of brick. We found several brick plants producing only for local markets that were still using quite antiquated methods. But, with increasing size of plants and increasing standardization of consumption, markets are widening and competition is probably growing keener, both as between producers of the same commodities and as between commodities. Radios and automobiles, for example, compete with food and clothing for greater shares of the consumers' income.

Increasing competition, however, does not always accelerate mechanization. If a new competitor arises with a differential advantage, such as a lower wage scale, the older producer may not modernize his plant as rapidly as technologically possible, for he and his bankers may hesitate to make investments in equipment in view of the uncertain future. It has been suggested that the backwardness of some of the New England cotton mills engaged in the production of plain grades of cloth may be due to the rising competition of the southern cotton mills.

On the whole, the pressure for mechanization is greatest when there is a large volume of new capital entering into

competition with the established plants. As stated by M George E. Roberts:

"There is no competition so irrepressible as that of new capital with t old. The stream of new capital which is always coming upon the mark is bound to force itself into employment somewhere, and it has an advanta over the old investments in being able to utilize the very latest offerings science and invention. In these days, when the frontiers of scientific knov edge are being rapidly extended, when the facilities for research are dai increasing, and when improvements in industry are constantly producing flow of new capital, it may be expected that the industrial pace will l faster in every succeeding decade" (Address before American Manufa turers' Association, December 26, 1927).

Thus the force of improved technology is cumulative, cr ating new capital which in turn brings pressure for furth improvements.

We may sum up our discussion of the pecuniary facto by the somewhat obvious statement that the rapidity invention and development of labor-saving machines vari directly with economic pressure. A few inventions may b the result of 'spontaneous combustion' but the adaptatio of labor-saving devices is likely to proceed largely unde pressure of a recognized need. If the employer finds th cost of a manual process rising, he will be stimulated to ca around for an automatic substitute, and mechanics will b hired directly or through specialized machine shops to wor out the desired contrivances. Invention is becoming systen atized.

Hence an increasing shortage of a given type of labo may be expected not only to bring available alternativ mechanical devices into more common use, but also t stimulate the perfection of new devices.

Psychological Factors

To distinguish certain other factors from the tech nological and pecuniary difficulties, we use the ter

'psychological', although it is none too accurate. These 'psychological' influences that affect the rate at which machines are introduced are many and diverse. For example, not infrequently overzealousness in pushing a machine in its early stages acts as a boomerang. When equipment is introduced before it has been technically perfected, where it is not suited to the particular requirements of the situation, or for which there is not an adequate amount of work to be done to make its use economical, the results may well be so unsatisfactory as to create a prejudice which retards its introduction even where its use would be distinctly economical.

Occasionally, also, there is opposition to a machine not only on the part of the workers directly involved but also on the part of the public, ordinarily expressed either through the press or legislation. In recent winters there has been some opposition voiced in the press to the use of machinery in snow cleaning, on the ground that unemployed men might do the work. Legislative restriction pertains chiefly to the use of equipment considered dangerous to the health of the workers. There has been, for example, some agitation to restrict the use of compressed-air guns in painting and regulations limiting their use have been put in force in several states. Also, in the current depression, some proposals have been advanced for the special taxation of automatic labor-saving machinery. But all the 'psychological' factors are not inimical to the progress of mechanization. Thus it is probable that sometimes the desire to reduce points of friction with workers leads an employer to "substitute docile machines for more vociferous units of human labor".

Also it doubtless happens frequently that pride in having as good equipment as competitors speeds up the process of mechanization and even leads to the use of machines

when alternative methods would be more economical. If one farmer plows with a tractor, his neighbor may imitate his example without full consideration of the pecuniary costs. It is in part this element of pride, of imitative action, that explains the waves of innovation characteristic of periods of active expansion in production.

ATTITUDE OF EMPLOYERS

The readiness with which a labor-saving device is introduced may be retarded by the slowness of executives in becoming cognizant of its merits; by a tendency, more or less inherent in human nature, to cling to old practices; and, in some instances, by a reluctance to make such reductions in labor force as may be necessary if an improvement in equipment is unaccompanied by a proportionate expansion in the market and increase in the total output of a plant.[32] Especially when a machine has been rather recently introduced, many entrepreneurs are inclined to wait for fuller demonstration before they themselves experiment with the new device. A great deal of educational work must

[32] For example, the manager of a rubber shoe plant explained that in half of his plant improved methods were in use but that he was awaiting an expansion of the market before changing the other half of the plant over to the new methods. The attitude of the employers in this case was probably influenced by the fact that the plant is in a rural community where the workers are almost entirely dependent upon the one plant for jobs.

An executive of a pencil factory stated that machines could be obtained for doing the packing work upon which considerable numbers of employees were engaged, but that they were not much faster; moreover, many of these workers were old employees whom he hesitated to discharge.

The sales manager of a power truck factory explained to our field representative that one reason they had had difficulty in getting their trucks installed in one of the cotton-handling docks was that the prevalent system was to let the handling contract out to small contractors who in turn hired a group of their friends to do the work. These small contractors did not wish to put in machinery and discharge their friends.

be done by those who attempt to introduce machinery that requires radical changes in method. Notably in the opinion of many observers there is a pronounced reluctance to hazard new methods in old industries that have been reasonably successful, and the management of which has continued in the hands of the same individuals or of the same family for long periods.

It has been suggested that the failure of executives to recognize quickly the merits of new improvements is especially pronounced with respect to improvements that are designed to decrease the expense of handling rather than of processing. Handling is ordinarily designated in factory accounting as 'unproductive' labor, and there seems to be some tendency for greater attention to be centered on the reduction of the costs of 'productive' labor.

LABOR OPPOSITION

The opposition of the worker to the advance of mechanization arises from an apprehension of its effect on his job. He fears it may oust him entirely or at least make serious inroads on his earnings. This hostility is likely to be especially keen when the machine threatens to destroy a substantial wage differential enjoyed by a group of skilled workers. On the other hand, the unskilled ditch digger, for example, threatened with the competition of the mechanical trencher, is not quite so likely to look upon the machine as depriving him of his best means of earning a livelihood. He may, rather, hope for a better job running the machine, or, at least, since his training is little specialized, he may expect to find elsewhere an equally good job. In any event, the unskilled worker is ordinarily not sufficiently well organized to make effective any antagonism he may feel.

The position taken by labor towards the introduction of

the machine has, in fact, varied over a wide range, from vigorous attempts to prevent its adoption and use, through discouraged indifference to its progress or acceptance qualified by restrictive control measures, to reluctant acquiescence, and, finally, to the stage of cooperation for efficiency where the worker not only acquiesces in but even helps to initiate innovations, with the hope of sharing in the resulting gains.

The actual measures designed to prevent the use of the machine may take the form of unorganized sabotage, treating the machine as a 'scab' and refusing to permit union members to operate it or endeavoring to boycott the machine-made products.[33] The union may make an indirect effort to prevent work going to machine plants by accepting wage reductions for hand workers. This was done in several instances in the glass trades. Sabotage probably occurs chiefly in the early stages of the introduction of a machine.[34] For example, when trucks have been introduced in dock handling, a few have been run into the harbor; and the introduction of the tying-in machine in cotton mills is said to have been retarded somewhat at first by occasional sabotage. On the whole, however, the impression received by the writer in numerous interviews with machine producers was that they do not consider sabotage a major factor in retarding the introduction of their products.

A refusal on the part of unions to permit their members

[33] For a discussion of the efforts of the cigarmakers to boycott machine-made cigars and in other ways to discourage the use of machines, see: John P. Troxell, Machinery and the Cigarmakers, *Quarterly Journal of Economics*, February 1934, pp. 338–47.

[34] One manufacturer of tiering machines reported to us that most of the workers' opposition to their machines took the form of minor sabotaging designed to discredit the machines. There were instances of repeated tinkering with the same machine, and one year when they kept an informal record, about 5 per cent of their installations were affected by some such sabotage.

to operate machines has rarely been effective for any considerable period. For example, when the machine was first being tried in the window-glass industry, the American Association of the four skilled window-glass trades passed resolutions clearly designed to prevent the window-glass manufacturers from introducing the machines, but by the time the machine was perfected and came to be of commercial importance, the four crafts had quarreled among themselves, and a great number of the cutters and flatteners had formed independent associations. These did not hesitate to sign up with the American Window Glass Company for the flattening and cutting of machine-made glass, and the hand workers soon found themselves under the necessity of accepting wage reductions in order that the hand industry might remain alive and compete with the machine producers.

From the standpoint both of their retarding influence and their effects on the position of the worker, measures designed directly to prevent the adoption of new machinery have probably been less important than the frequent measures designed to prescribe the conditions under which the machine may be used. Such restrictions have taken many forms—insistence that the former hand workers be employed as operators on the machine, limitations on the total output,[35] and stipulations that the size of the crew be not reduced and that the former level of earnings, or even, in extreme cases, the same piece rates as on hand work, be maintained.

[35] Barnett states that the use of the semiautomatic in the manufacture of small packers' jars, begun experimentally in 1891 in the Ripley factory, was discontinued because the Flint Glass Workers, who controlled the Ripley factory, insisted that the amount that might be made by a workman in a half day be fixed. The net result of the limit set was "that the machine labor cost was to be identical with the cost of hand manufacture" (Ref. 3, pp. 74, 143).

Cooperation for efficiency

When employer and employee can cooperate unreservedly for efficiency, conditions are highly favorable for rapid progress in mechanization and in efficiency in general. That goal may be far distant, but in recent years various steps have been taken towards it. The B & O plan has indicated some of the possibilities in cooperation for efficiency; the job severance compensation provision in a few trade agreements provides another method of lessening the worker's dread of the effects of increasing efficiency; [36] and finally, the so-called 'new wage statement' of the American Federation of Labor in 1925 indicated, to say the least, a growing recognition of the importance of productivity. In its convention at Atlantic City in 1925, the Federation approved a report by its Executive Council in which was formulated what was hailed in the contemporary press comment as a "new policy to meet the 'superpower' age". The essential features were a declaration that

"the best interests of wage earners as well as the whole social group are served by increasing production in quality as well as quantity and by high wage standards which assure sustained purchasing power to the workers . . ."

This statement was accompanied by a recommendation of "cooperation in study of waste in production".[37] This is, in

[36] Any policy that so arranges a change that the workers are not reduced in earning power should tend to lessen their opposition. There has been, for example, considerable development in this respect in the clothing industry. See article by W. G. Haber in *Journal of Political Economy,* August 1925; also agreement made between Hart Schaffner and Marx and the Chicago Joint Board of Amalgamated Clothing Workers for compensation to cutters displaced as the result of improved methods instituted by the company; *Unemployment in the United States,* Hearings before the Senate Committee on Education and Labor, 70th Cong., 2d Sess., p. 241.

[37] *Proceedings of the 45th Annual Convention, American Federation of Labor,* Monday morning session, pp. 231–3, 271.

essence, a declaration that labor should strive both to gain a just share in the advantages accruing from this era of power development and the constant substitution of mechanical for manual labor in industry and to cooperate with employers in increasing this advantage by studying wastes in production.

This resolution pointed the way to a constructive solution and gave some promise of a lessening in the opposition of labor to industrial change. To the degree that the policy of cooperation for efficiency becomes effective in the conduct of union activities it tends to lower the barrier that each innovation must hurdle. How high is this hurdle? How effective is labor opposition to new methods?

Effectiveness of workers' opposition

In summarizing his studies of the introduction of machinery in the stone planing and glass industries, Professor George E. Barnett states:

> "Experience has convinced the greater part of well-informed trade union leaders that the introduction of important labor-saving machinery cannot be permanently halted by trade union action" (Ref. 3, p. 141).

However, speaking of the opposition to the introduction of the stone-planer and of the attempt of the Flint Glass Workers' Union of America to stop the introduction of the semiautomatic bottle machine, Barnett concludes "that the opposition of these unions did retard the introduction of the machines is undoubted".[38] The general conclusions of these two quotations are borne out by the history of the introduction of other machines. In general, opposition is rarely if ever permanently effective, but probably in many instances it has some retarding influence. The press assistants'

[38] Ref. 3, p. 144.

union in the commercial printing industry in New York City is strongly entrenched, and Dr. Baker (Ref. 5) reaches the conclusion that "their bargaining power has been a retarding factor in the displacement of their men"; but despite their strength the press assistants lost 3.2 men to each 100 presses in the five-year period ended in the winter of 1928–29. When the undercutting machine was introduced in the coal mining industry, the union restricted its use by setting a machine differential and limiting the loaders, but W. E. Atkins and H. D. Lasswell say:

"the machines were invincible; their use has steadily increased even in the union districts until most of the coal is today machine mined." [39]

The effectiveness of labor opposition varies with the strength of the union. This is one reason assigned for the slow introduction of improved machinery in the British cotton mills. As stated in the 1930 "Cotton Report",

"One important reason why the question of improved methods and equipment has not received adequate examination . . . is that such improvements necessitate adjustment of hardly won and long-established agreements between employers and employed" (*Report of the Subcommittee of Civil Research,* published as supplement to the *Manchester Guardian,* July 5, 1930).

Conditions relatively favorable for effective opposition to technological change are found where there is a strong local union in a localized industry. For example, R. E. Montgomery, in his study of *Industrial Relations in the Chicago Building Trades* (p. 154), concludes:

"It is not improbable that throughout industry in general wage-earners are coming to regard opposition to technological change as being, in the long run, futile. But this attitude will be long in penetrating the Chicago construction locals. The essentially localized character of the industry is likely to mean that the workers will be in a position to enforce, to an extent

[39] *Labor Attitudes and Problems,* pp. 38–9.
See Table 40 for the growth and present extent of machine undercutting.

at least, their own demands regarding the use of machinery and the doing of work on the job instead of in the shop for some time after such opposition has—if it ever does—become a discarded part of the program of unionism in general."

On the other hand, in local operations such as highway construction, where there are no strong union organizations, it is probable that the highway contractor experiences little effective labor opposition to the introduction of new machinery, because he does not have a more or less fixed labor force with a feeling of vested interest in their jobs.

Opposition to the introduction of machinery, even if not completely or permanently effective, may result in deflecting the line of technological development. An illustration is found in the difference between the English and American cotton mills with respect to the speeds at which looms are ordinarily run. In England union opposition to the automatic loom has made it difficult for manufacturers to increase the number of looms per weaver as has been done in the United States, but they have made up for this in part by running the looms at higher speeds than are customary in the United States. Another probable effect of union opposition is to stiffen the resistance of employers to recognition of the union. The rules regulating the use of undercutting machines in coal mining have been one of the reasons assigned for the fact that the newer mining fields of West Virginia, Alabama and Colorado are predominantly non-union.[40]

Methods of lessening opposition

The natural opposition of workers to technological change may be lessened by a twofold process of education, that is, by educating the workers to see clearly the ultimate gains

[40] W. E. Atkins and H. D. Lasswell, *op. cit.*, pp. 38–9.

from improved efficiency, and by educating the public and the employer to recognize the importance of so managing a change that its immediate effects on the worker are not adverse. Care to see that, where feasible, a displaced worker is assigned other equally satisfactory work in the same organization; care to make changes chiefly when markets are expanding; provision for compensation for those who cannot be retained in the organization after changes are made; provision for reeducation of workers in declining trades; the revision of wage scales so that the worker shares in the gains—these are steps which should lessen the opposition to technological improvements.[41] Likewise, the movement for a shorter day or week is closely associated in the mind of the worker with the effect of technological improvements. For example, in the discussion of the 'new policy' of the American Federation of Labor in its 1925 convention, some apprehension of the danger that improved efficiency would increase unemployment was evident, and the desirability of offsetting this tendency by shorter hours was emphasized. This point of view was voiced by Delegate Lynch of the International Typographical Union and reiterated by him in an editorial in the *American Federationist* (Vol. 33, 1926, p. 292) in the phrase, "continual shortening of the working day is the only practical plan for solving this problem". In fact, in recent years the emphasis in the labor press has been upon the danger of machine-made unemployment, and the necessity of shortening the working day and week as an essential step in spreading a decreasing volume of work, rather than upon the possibilities of increasing pro-

[41] See a short article by O. S. Beyer, Jr. in *Factory* (February 1926, pp. 266–7), citing constructive measures which facilitated the introduction of machine molding, the substitution of welding for riveting, and the use of larger locomotives, by enabling the workers affected to maintain or even increase their earnings.

ductivity through labor-management cooperation in joint research for waste reduction and improved efficiency.

Summary

The primary factors that retard or hasten the development of new machinery and technique are technological difficulties, pecuniary considerations and mental attitudes not entirely determined by pecuniary considerations. Of the many factors listed in these three groups, which are of special interest to our present problem? Which may be considered as declining or increasing in influence? What is the net tendency?

Generalization concerning technological difficulties is hazardous, but with the larger stock of scientific knowledge and increasing attention to industrial research evidenced in recent decades, it would appear probable that technical difficulties will be hurdled with greater and greater ease.

A pecuniary factor favoring further mechanization in the future is the drive for standardization and the apparent tendency in some industries for continued concentration into larger units.

The psychological factors are even more difficult to weigh. On the one hand is the encouraging influence of some successful examples of cooperation for efficiency and the announcement by the American Federation of Labor of the 'new wage statement' in 1925. As the technique of cooperation develops this 'new policy' should become more and more effective. On the other hand, in recent years there has been a growing emphasis on the existence, real or fancied, of a great volume of technological unemployment. That this will tend to stiffen the resistance to technological changes is quite probable.

The net balance of the changing importance of the

favorable and unfavorable factors is, in the judgment of the writer, on the side of a renewal of the trend towards higher mechanization, at a moderate rate at least, when prosperity returns and where there is still considerable room for further reduction of manual operations. A major consideration leading to this conclusion is that the increasing mechanization and emphasis on efficiency in the post-War decade has given such an impetus to the search for new methods and the adoption of tried devices that the movement may be expected to continue of its own momentum even if other conditions are not predominantly favorable. The adoption of machinery in one process leads to the mechanization of complementary processes; the installation of machinery by one user leads to its adoption by others.