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CHAPTER IV

CHANGES IN MECHANIZATION: NON-MANUFACTURING INDUSTRIES

MECHANIZATION tendencies in the non-manufacturing industries vary widely in type, cause, rapidity of change and effect. Mechanization on the farm has depended in large part upon the gasoline engine; in the home, upon the electric motor. Evolution has been in the direction of larger units in the railroad locomotive, the freight car, the paving mixer, and the farm tractor in the dry farming areas, but towards smaller tractors, for example, in row-crop farming areas. In building construction, the trend to steel and cement involves the use of materials made under more highly mechanized conditions and requiring more machinery in erection. In coal mining, on the other hand, there has been little change in the work to be done but rather an adaptation of mechanical equipment for established procedures. The labor-saving qualities of the harvester-thresher combine are felt directly in the harvesting process; those of the pulverized coal system in power production indirectly in the decreased amount of coal that must be mined. Declining traffic has stimulated the adoption of the one-man street car; the expansion of cement highway construction has encouraged the contractors to make investments in central proportioning plants, larger pavers, finishing machines, and motor truck haulage. Legislation has favored the introduction of the mechanical stoker on railroad engines but discouraged the use of the spray gun in painting. In mining, the undercutting

machine is near the saturation point; the mechanical loader is just getting a good start. The total number of telephone operators has increased despite the spread of the dial telephone; also the employment opportunities for licensed motion-picture operators have increased with the introduction of the sound movie; but, on the other hand, this innovation has sharply reduced employment opportunities for theater musicians. The sound movie brought a swift and revolutionary change in the methods of providing theater music; but the mechanization of railway maintenance has proceeded slowly and without major alterations in maintenance procedure. The printer telegraph has tended to displace the skilled Morse operator; but improved handling devices in bituminous coal mining, building construction and retail coal distribution, and likewise improved equipment in highway construction, are in large part competitive with the unskilled workman. Mechanization in the mine has limited somewhat the traditional independence of the coal miner's working habits and lessened his isolation; in the home and on the farm the increased use of machinery has lessened the necessity of employing hired workers and hence increased the isolation, and, in a sense, the independence with which the housewife and farmer carry on their work.

These examples are but illustrations of the variety of mechanization movements briefly described in the following summaries.

Agriculture [1]

We may conveniently distinguish hand-power, horse-power and mechanical-power stages in the development of agriculture. The hand-power stage lasted until about 1850.

[1] The volume of annual sales of selected types of farm machinery is given in Table 39; and summaries of available information on extent of

Then the introduction of such horsedrawn implements as the steel plow, the reaper, mower, and corn planter, together with the post-Civil War expansion of agriculture, carried us swiftly into the horse-power stage.[2] About 1910 the use of generated power on farms became sufficiently important to justify the designation of the succeeding decades as the mechanical-power stage.[3]

It has been estimated that the total power of all kinds in use in agriculture increased from 1.32 horsepower per agricultural worker in 1849 to 2.52 in 1909, and 4.74 in 1923, at which time animals were contributing about 42 per cent of the total power, windmills 1, gas tractors 17, trucks 15, stationary gas engines 14, steam engines 6 and electric motors 5.[4]

IMPORTANT DEVELOPMENTS IN THE MECHANIZATION OF FARM OPERATIONS

The key to the modern movement towards farm mechanization is the internal combustion engine. By it are pro-

use in Table 48. The sources of information are stated in the footnotes to these tables.

[2] For a description of the developments of mechanization in early agriculture in the United States, as well as some recent changes, see the *Monthly Labor Review,* Ref. 45.

[3] Though still the source of a large part of the power used, the number of horses and mules on farms fell from 26,436,000 to 19,476,000 in the years 1919–29. If we include the decline of horses in cities, the total decrease is still greater, with the result that many million acres of land formerly required to produce feed for work animals have been released for other purposes. W. I. King estimates that a shrinkage of six and one-quarter million work animals from 1920 to 1928 decreased the acreage required for production of feed by 21,000,000 (*Journal of Agricultural Economics,* January 1929, p. 71).

[4] The estimates in this paragraph are from C. R. Daugherty (Ref. 31, pp. 47, 54 and 71); his figures, in turn, are based chiefly upon estimates by C. D. Kinsman (Ref. 25).

pelled the farmer's auto, truck, tractor and many other machines. Motor trucks on farms increased from 139,000 in 1920 to 900,000 in 1930 and have altered the entire system of marketing livestock and other farm produce. Also the passenger automobile has been integrated into the farm system and a substantial part of its use may be charged to farm business. Automobiles on farms numbered 2,146,000 in 1920 and 4,135,000 in 1930. Other applications of the gas engine of large importance are the tractor and the tractor-drawn equipment of various types.

Tractors

The tractor is essentially an automobile specialized for draw-bar or belt power rather than for speed. The number on farms in 1920 was 246,000, in 1925 it had increased to 506,000, and by 1930 to 920,000.[5] In the 'twenties the annual sales of tractors in the United States usually exceeded one hundred thousand machines.

The dollar value of power machinery sold compared with that of other types is presented in Table 6. The very important role played by gasoline tractors in the mechanization of farm operations is indicated by the proportion of the total value of farm implement sales that they constituted: over one-fifth annually from 1922 to 1928, and over one-third in the last three years of the decade. The influence of the tractor is also evidenced in the increasing percentage that tractor-drawn equipment is of the total for implements of the specified type. The percentages for tractor-drawn moldboard plows, disk plows, listers, grain drills, cultivators and

[5] The statistics on automobiles, motor trucks and tractors are from the *1930 Census of Agriculture,* Vol. II, Pt. I, p. 2, and are expressed to the nearest thousand.

TABLE 6

CHANGES IN PROPORTION OF POWER FARM EQUIPMENT SOLD [1]

Dollar value of engine-power equipment expressed as a percentage of combined sales of hand-power, horse-power and engine-power equipment of same type

TYPE	*1920*	*1921*	*1922*	*1923*	*1924*	*1925*	*1926*	*1927*	*1928*	*1929*
Gas tractors (percentage of all farm equipment)	34.3		[2] 23.5	20.5	26.6	27.2	28.8	33.6	30.5	33.9
Tractor-drawn										
Moldboard plows	50.8	36.7	47.0	31.9	34.1	40.6	39.6	50.1	56.2	65.6
Disk plows	76.0	75.3	64.4	58.4	66.2	71.0	69.5	84.2	85.3	83.2 [3]
Listers	14.2	13.6	16.3	6.4	15.3	15.5	26.7	45.8	34.9	[4]
Grain drills	2.3	4.0	5.3	1.8	0.6	2.6	5.6	13.9	17.7	30.7
Cultivators	[2]	2.2	2.5	2.5	[2]	1.9	3.1	8.3	9.9	16.6
Disk harrows	47.3	52.7	46.1	39.9	48.1	47.8	48.8	53.1	54.9	60.5
Corn shellers	[2]	83.5	81.4	82.8	82.3	83.7	77.0	80.7	84.4	82.8
Hay presses	75.8	70.9	80.4	74.6	78.0	79.9	81.2	79.8	82.3	84.4
Feed grinders and crushers	93.5	97.2	95.9	92.7	89.2	98.2	96.9	97.0	98.4	98.6
Cream separators	[2]	[2]	6.8	5.2	2.1	7.4	6.1	6.5	7.4	[4]
Spraying outfits	[2]	42.9	76.6	62.0	60.2	54.7	63.8	67.3	67.6	69.0
Combines (percentage of all harvesting machinery)	11.7	26.8	16.3	11.3	17.0	14.2	33.2	41.9	49.8	51.9

[1] Computed from data given in the publications listed in footnotes to Table 39.

[2] No data available for these years.

[3] Not including 'one-way disk tillers' which were reported in 1929 for the first time.

[4] Comparable data not available.

disk harrows all reach their maxima in the closing years of the decade.

Tractors were first used extensively in the great wheat-growing areas, but later the development of lighter and more easily manipulated tractors has encouraged their introduction into the more humid area of the Corn Belt. Not

only are they used for plowing with multiple-bottom plows, but also various processes of seed-bed preparation are now combined with the plowing proper. A large tractor may draw a disk harrow, pulverizer and grain drill all in one operation. Also there is a marked tendency towards an increasing use of tractors suitable for both soil preparation and cultivation. And in order to make the cultivator equipment for tractors approach the capacity of a machine capable of doing the heavier draw-bar work, three- and four-row cultivators are now regularly on the market.

Harvester and thresher combines

The combine for cutting and threshing grain in one operation was first developed as a harvester of wheat in the Pacific slope region of the United States. Skepticism as to its usefulness in the more humid hard winter wheat area was not demonstrably overcome until 1917. One-half of the wheat in this area was so harvested in 1927,[6] and more combines were sold in the next two years than ever before. The use of the combine has spread from the Pacific Coast to the Atlantic, and its applications have increased with its territorial range. While it has long been utilized to some extent for the harvesting of wheat and other small grains, it has more recently been adapted to clover seed and soybean threshing. However, in the Corn Belt and other livestock-producing areas only a small percentage of the small grains is harvested with combines.

The sales of combines ranged from less than 3,000 in 1920 to nearly 20,000 in 1929; and the ratio of the dollar value of combines to the value of all harvesting machinery

[6] W. E. Grimes, *Journal of Farm Economics*, January 1928, p. 226.

sold ranged from less than 12 per cent in 1920 to over 5(
in 1929.

Cotton-crop machinery

In the cotton regions, particularly the uplands of Texa
and Oklahoma, the increase in the acreage a man can culti
vate with a tractor is effecting a revolution in crop growing
Whereas 10 to 20 acres of cotton is the family-sized crop i
the older cotton area, one man with modern machinery ca
prepare the soil, seed and cultivate as much as 200 to 25
acres of cotton in this upland area. Hand picking has als
been a limiting factor in cotton growing. Since cotton ca
be left on the stalk until the entire crop matures only in th
dry upland area, it is there alone that mechanical pickin
has met with any substantial degree of success. The cotto
sled or stripper, a device which is drawn through the fiel
and combs the cotton boll from the plant, has been used mos
extensively when prices were low. It "harvests cotton six o
seven times faster than can be done by hand picking, an
gathers a large per cent of the cotton." [7] When the broke
bolls and other trash are removed by special ginning proc
esses the value of the cotton is only slightly less than whe
it is picked by hand. There has also been some experimenta
use of mechanical cotton harvesters of the picker type.

Corn-crop machinery

Corn is usually planted in rows and cultivated with horse
drawn one- or two-row cultivators, although three- and fou
row cultivators are on the market for use with light 'al

[7] D. L. Jones, *et al.*, *Mechanical Harvesting of Cotton in Northwest Texa*
Circular No. 52, Texas Agricultural Experiment Station, p. 31.

purpose' tractors adapted to row cultivation. Possibilities of further labor saving are seen in the rotary hoe,[8] which may be used under favorable soil conditions, that is, in soils free from stones, to cultivate corn to a height of 6 to 9 inches. This eliminates the tedious early plowing which is difficult with multiple-row cultivators. The combination of 2 or 3 units drawn by a tractor cultivates as much as 75 acres per day with one operator.

The greater part of the hand labor required in the production of corn is in the snapping or husking of the ripened ears. Machines for this purpose have been available for many years but the early types obtained their power from the forward movement of the machine as it was drawn through the field, the power being transmitted to the husking apparatus by the revolution of a lug-wheel in contact with the ground; consequently their use was difficult when the fields were slippery. Since the perfection of devices to transmit power from the tractor to accessory machines the performance of the picker has been more satisfactory. One type is dragged behind the tractor, the other is so constructed as to be fitted onto and be carried by the tractor. The picker is still little used but was gaining prior to the depression of 1929.[9] It has not been adopted more extensively in part at least because a certain percentage of shelling is unavoidable when the machine is used, not all the ears are picked if the corn stalks are 'down', and the stalks are left broken over in

[8] This tool consists of one or more rows of pronged wheels on a common axis, the prongs perforating the ground and stirring it to a depth of 1 to 3 inches, depending upon the condition of the soil. The teeth are small and so set that almost no damage is done to small growing crops but the weeds are destroyed. It can also be used to cultivate soybeans drilled broadcast. Rotary hoes were used for most of the cultivation on 4.3 per cent of Illinois farms included in a survey made in 1928 (see Appendix B).

[9] In 1928 mechanical corn pickers were used on 11,000 Illinois farms, or 4.9 per cent of those over 50 acres in size.

such fashion that deterioration is more rapid in bad weather and hence the fields are less valuable for stalk pasture in the livestock areas.

Other labor-saving equipment

Farm machines are now manufactured in almost endless variety. While those previously described seem to be the major recent innovations, others are very definitely labor saving in the sense of being substitutes for hand labor. Potato-digging machines are now being combined with a grader and bagger. Farm water systems, farm lighting plants and feed and litter carriers are all important elements not only in the saving of labor but also in increasing the amenities of farm life.[10]

Rural electrification

The gas engine is the principal source of power in farming operations, but with the growing availability of electricity the electric motor is gaining in importance, especially for use with labor-saving devices in farm homes and barns. It has been estimated that the percentage of farms electrified rose from 1.9 in 1924 to 10 in 1930.[11]

FARM CONDITIONS, 1920–29

After the decline from the War-time level, the prices of agricultural products were at substantially lower levels than those for non-agricultural, taking pre-War conditions as

[10] Data on the annual sales of some of these devices are presented in Table 39; and memoranda on the extent of their use, in Appendix B.

[11] Based on estimate that 125,000 farms were wired for electricity by 1924 and 650,000 to 700,000 by January 1930; *Farm Implement News*, December 19, 1929, p. 22.

standard. Agricultural depression was accompanied by a large migration of the rural population to the cities until this urban movement was checked by the 1929 recession in industry. The farm population is estimated to have fallen from 31,000,000 on January 1, 1920 to 27,222,000 on January 1, 1930. The natural increase due to excess of births over deaths is greater in the rural regions; but the annual net loss due to migration from farms to cities, 1922–30 inclusive (exclusive of 1923 for which comparable figures are not available), was about 700,000.[12] Exactly how much of the urge cityward may be ascribed to conditions for which mechanization on the farms is responsible may be a moot question; but at least it is clear that the rapid exodus from the rural regions favored mechanical substitutes for manual labor.

TENDENCIES

Since the use of the tractor became extensive the development of power machines has tended towards, on the one hand, larger and larger units, and, on the other, lighter and smaller units. The rapid adoption of the all-purpose tractor in the areas of row-crop cultivation is an important illustration of the latter tendency. The further development of rotary power by power take-offs from the tractor, such as are now used for binders, combines, corn pickers and mowers, seems probable.

The conditions created by the industrial depression of 1929 will doubtless sharply check the progress of farm mechanization, although, once initiated, there is a certain momentum to the mechanization process. The farmer who owns a tractor finds potent arguments for supplementing it with tractor-drawn tools in order to utilize better his entire equip-

[12] *Yearbook of Agriculture, 1931*, p. 1031.

ment. The greater use of the multiple-row tractor-powered cultivators, the combine, the farm-size grain separator and the corn picker may be considered as phases of this process of integration. Moreover, since hired men customarily live with the farmer's family, the farmer may prefer to use more machinery rather than take outsiders into his home.

Mining

BITUMINOUS COAL MINING

The percentage of bituminous coal obtained by strip mining rose from 1.2 in 1919 to 3.8 in 1929.[13] The coal is made available by the removal, by means of power shovels or similar appliances, of the entire surface overlying the vein. In underground mining, mechanization developments of interest are in the process of undercutting the coal prior to blasting it down, in loading the coal from the mine floor to the pit cars, and in gathering and transporting these cars to the surface.

Statistics of 'machine mined' coal usually refer to the percentage undercut by machine, even though the coal is subsequently loaded by hand. The undercutting machine is not a recent innovation. Its manufacture for sale began in the United States about 1880, and as early as 1891 there were 545 in use, cutting 5.3 per cent of the bituminous coal mined. By 1900 this percentage had risen to 24.9, by 1920 to 59.8, and by 1929 to 75.4 There has been, likewise, an increase in the annual tonnage per machine, from 11,328 in 1891 to 24,224 in 1928.

This increase in the mechanization of the undercutting process doubtless accounts in part for the increase in tonnage

[13] Unless otherwise stated, the statistics cited in this section are compiled from reports of the *Geological Survey*.

per man-day in the bituminous mines from 2.57 in 1891 to 4.85 in 1929, despite shorter hours. Since nearly three-quarters of the total tonnage of bituminous coal is now undercut by machine and its use is not economically advisable in all mines, prospects of further substantial reduction in the labor requirements lie in the loading rather than in the undercutting process.

In the typical bituminous mine, the coal, after it has been broken down, is shoveled by hand into small mining cars and drawn into the heading, where it is picked up by mule or electric motor. This heavy manual work of loading coal has been described as "the most widespread form of drudgery existing in industry today", and the major current developments in coal mine mechanization are in the way of substituting mechanical for manual loading.

Some types of mechanical loader are self-feeding; others require mechanical shoveling to the lifting and car-loading conveyor.[14] The development of the various types of mechanical loader is the result of experimentation which began over forty years ago. Attainment of a recognized commercial status has been slow, although much more rapid in recent years. Two or three types of loading device introduced as early as the period 1908–11 have continued in use. The next period, 1912–17, is characterized by the introduction of conveyors and scrapers in thin and pitching seams. From 1918 to 1923 developments were along various lines and a "great number of mechanical loading devices were improved to the extent that they could be commercialized". In the four following years interest in mechanical loading increased markedly and a noteworthy stage was reached in September 1928 with the signing of the wage agreement in Illinois, as

[14] For description of the various types of loader and statistics on extent of use, see the *1929 Coal Mine Mechanization Year Book*, Ref. 2.

this was "the first state contract that dealt with mechanical loading devices and made it possible for the operators to negotiate local agreements covering working conditions". A state agreement was likewise made in Indiana in November 1928.

The tonnage of bituminous coal loaded by self-feeding loading devices increased from 1,880,000 in 1923 to 19,291,000 in 1929. With similar rapid increases in the tonnage handled by non-self-feeding loaders, the volume of mechanized loading, including both types, increased from approximately 2,000,000 tons in 1923 to 37,862,000 tons in 1929.[15] Obviously, the statistics of the growth of mechanized loading are impressive, not so much in the total volume attained as in the rate of growth in recent years.

Mine cars are hauled by locomotives, chiefly of the electric trolley or storage battery types, by power cable hoists, mules and horses, and, to a minor extent, by hand power. Hand and animal haulage is chiefly in the initial stages of gathering. The principal device in the typical mine, especially for the longer hauls, is the electric industrial locomotive, capable of handling rapidly a considerable train of mine cars.[16] Messrs. F. G. Tryon and L. Mann, of the Coal Division, United States Bureau of Mines, state that "in the field of haulage, mines equipped with one or more electric locomotives now supply 85 per cent of the output, and 33 per cent is produced by mines in which even the gathering is done electrically and no animals whatever are employed".[17] Some additional mech-

[15] *Mineral Resources* (Ref. 32), 1929, II, 758–9. In 1929 the number of mechanical loading devices in bituminous coal is given as: mobile loading machines 488; scrapers 126; duckbills and other self-loading conveyors 99; pit-car loaders 2,521; other conveyors, in 130 mines (*ibid.*, p. 764).

[16] For annual sales of electric mining locomotives, see Table 47; for extent of use, see Table 53.

[17] Ref. 2, p. 21.

anization in haulage is to be expected, especially with the further development of mechanized loading.

ANTHRACITE COAL MINING

Undercutting machines were introduced into the anthracite area as early as 1910, but, because of the thin and variable veins, their use has not become nearly as extensive as in bituminous coal. In 1929, the 137 machines in use cut only 1.6 per cent of the coal. On the other hand, interest in loading coal mechanically from the face appears to be growing. The depletion of the thicker seams has, in fact, stimulated the use of mechanical loading devices, of which the scraper and conveyor types have proved most valuable. Mr. H. D. Kynor reports that in the Pennsylvania anthracite field in 1928 there were 293 scraper units, 184 conveyor units and 13 loading machines, loading mechanically over 2,000,000 tons, or about 3 per cent of the total output (Ref. 2). In addition, 3.4 per cent was mined by stripping with power shovels.

METAL MINING

The decade 1920–29 has seen substantial increases in output per man-day in the metal mines. An examination of the technical literature of metal mining indicates that these gains in productivity are the result, not of a few sweeping changes, but of a steady stream of minor improvements. Probably, however, the chief labor-saving changes in the period have been those which reduced the amount of hand mucking or ore loading either by changing the methods of mining so as to take more advantage of gravity in removing the ore from the working face or by the substitution of mechanical loading devices for hand mucking. Also, in open-

pit mining electric shovels have been extensively substituted for steam-driven shovels, and more caterpillar mounting used.

Van Barneveld records the introduction of some mechanical loading devices into metal mines as early as 1912, but until the War and post-War years brought a coincidence of a large demand for ore and a relative shortage of labor, especially unskilled, mechanical loading did not receive extensive attention. In the decade of the 'twenties it made substantial progress.[18] The introduction of mechanical loading has been most rapid in the eastern half of the country, notably in three districts: the southwest Missouri lead district; the Birmingham district of Alabama; and in the Lake Superior iron districts. In the Minnesota iron mines open-pit mining is almost entirely mechanized, and even in the underground mines, according to Mr. Tansig, "hand shoveling or mucking the ore into cars is a thing of the past in most mines, loading into cars and chutes being done by slushers or scraper loaders." [19] In the Michigan copper mines also "the employment of mechanical loaders and scrapers has replaced shoveling in large measure".[20]

Building Construction

The construction industry is one of the last strongholds of the traditional handicrafts. The transition from hand to machine methods was later in getting under way than in manufacturing and has reached a less advanced stage. There was, in fact, no substantial movement towards mechanization

[18] See Ref. 22, p. 396; and Lucien Eaton, Mechanical Loading in Metal Mines in 1929, in *Mining Congress Journal,* July 1929, pp. 536–7.

[19] *Iron Age,* 122:1430–1, December 6, 1928, Mechanizing Minnesota Iron Mines, digest of a paper by A. Tansig.

[20] U. S. Bureau of Mines, Ref. 30, based upon data collected in 1927.

in the building industry until the present century.[21] The subsequent evolution and expansion of the industry has been accompanied by mechanization along three major lines: (1) the use of materials produced under more highly mechanized conditions than were the older materials; (2) an increasing amount of mill and shop preparation before the material reaches the job; (3) an increasing use of power equipment in the actual erection.[22]

One outstanding development underlying the three tendencies mentioned has been the increase in the height of buildings, necessitating the extensive use of hoisting machinery for construction operations and requiring materials whose preparation and erection is in other respects a more highly mechanized process than is involved in the traditional lumber, brick and stone structure.[23] Cement and steel are essentially machine industries; also their competition for the building trade has probably stimulated mechanization tendencies in the industries producing the older types of material.

INCREASE IN PRELIMINARY SHOP WORK

With the shift to steel and other substitutes for lumber, much of the material that goes into a building comes to the job more nearly ready for installation than does wood. The

[21] Aside from information obtained in our direct inspections of construction operations and from manufacturers of construction equipment and others familiar with the industry, the major source of information for this section is the scholarly treatise on *Industrial Relations in the Building Industry*, by William Haber, Ref. 13.

[22] For further discussion of these points, see Haber, Ref. 13, pp. 24–35, 45.

[23] This increase in the height of buildings has been dependent largely upon the use of structural steel skeletons, the development of the power elevator, particularly the electric elevator after 1890, the invention of the pneumatic caisson method to facilitate the sinking of foundations adequate

work on structural steel beams, metal window frames, etc., is largely done in the shop; and even when wood is used there is an increasing tendency towards standardized forms prepared in the mill or shop with more mechanical aid than is ordinarily available on the erection job. Likewise, the invasion of the stone-planer not only displaced skilled stonecutters using chisel and hammer but also shifted the work of preparing stone more largely to the quarry. "From 1895 to 1900 they [stone-planers] were rapidly introduced in the Bedford limestone region, and by 1915 they had become a necessary part of stone-working equipment in all parts of the United States." [24]

MECHANIZATION ON THE JOB

On the erection job itself, though much of the work is still done by hand, there have been, since the beginning of the century, many increases in the use of mechanical equipment. In the excavation of basements, the power shovel has largely displaced the hand pick and shovel on the larger jobs and in the quantity production of houses such as is sometimes seen in suburbs, and has become a familiar sight on smaller excavation jobs. The development of the small, full-revolving type with caterpillar tread has made it possible for the shovel to do work for which it was formerly not well adapted. The caterpillar tread and the increasing substitution of gasoline and electric shovels for steam are relatively recent developments.[25]

for higher buildings, and the development of reinforced concrete as a cheaper substitute for much of the steel required in the steel skeleton building as first developed.

[24] Barnett, Ref. 3, p. 31.

[25] Of 49 contractors who reported their labor-saving changes to us in the period 1920–25, 5 had replaced wheel-tread shovels with the caterpillar tread type, 2 of these replacements being the gasoline type for steam. The gaso-

The growing popularity of the contractors' sizes of power shovels is indicated by increases in the annual sales of a group of manufacturers who were producing as early as the first decade in the century. They sold 485 in the first decade; 2,715 in the second; and over 4,000 in the next five years (Table 41).

In the erection of steel girders, derricks and power hoists are essential; also hand riveting has given way to the pneumatic riveting machine, invented in 1898. A pneumatic device has been tried for passing the hot rivets from the heater to the riveter (they are customarily tossed up) but does not seem to have been adopted generally. Also, electric welding has begun to supplant riveting on steel work.

The power hoist—steam, gasoline or electric—has come into extensive use for elevating other materials as well as steel to the upper parts of the building; and has largely, though by no means completely, taken the place of the hod carrier in brick construction. Hand lift-trucks have also been used to lighten the labor of the hod carrier.[26]

In cement construction, the power-driven concrete mixer has practically displaced hand mixing. Furthermore, on

line motor, it was suggested, obviated the necessity of laying a water pipe and 'getting up steam' an hour beforehand every morning. One contractor estimated that caterpillar tread and a gasoline motor increased efficiency 30 per cent over the old shovel; another that a higher lift and caterpillar treads increased the efficiency of his shovel 25 per cent; and another that, in general, the efficiency of the excavating shovel had been increased about 15 per cent since 1920 by the substitution of caterpillar treads for wheels and gasoline motors for steam.

[26] In the small group of 49 building contractors reporting labor-saving changes to us, 7 reported changes or additions in their hoisting service, usually reducing the crew a man or two by substituting gasoline or electric hoists for steam-driven hoists. Only one reported a direct substitution of a gasoline hoist for hod carriers; he estimated that the hoist would take the place of from 3 to 10 men, depending upon the height material was to be lifted.

many concrete construction jobs the mixture is mechanically dumped from the mixer to distributing tower hoists which elevate it to the upper part of the structure in process; it is then gravity-fed through chutes to the cement forms.

Also a machine for mixing lime-and-cement mortar has been introduced. In floor finishing, "for surfacing hardwood, terazzo, marble, tile, cork, composition and many other types of flooring, power surfacing machines have so completely demonstrated their superiority that they are today almost universally used." The compressed-air paint-spray gun and the plaster gun are invading the painting and plastering fields respectively. "The spray is used extensively in rough work and, where the union does not control, for general painting." The rapidity of its introduction has been retarded somewhat by doubts concerning the quality of the work done and by some state legislation restricting its use on health grounds.

LABOR-SAVING CHANGES REPORTED BY CONTRACTORS

To obtain data concerning changes over a specific period of time is unusually difficult in the case of contracting operations. The scene and type of operations shift, the staff personnel changes, records are negligible, the memories of foremen and other executives are none too certain, and their 'attitude towards 'investigations' often indifferent if not suspicious. However, our inspectors did obtain statements from 49 contractors on the 100 construction operations surveyed, giving the labor-saving changes, if any, made in their methods of operation between 1920 and the time of inquiry in 1925.[27]

[27] Of these 100 inspections 47 were in New York City and other parts of New York State, and the balance were distributed in Connecticut, New Jersey, Pennsylvania, West Virginia, Baltimore, Richmond, and the Middle West, in the spring and summer of 1925. More effort was made to get samples of operations involving excavation than for the later stages of erec-

These reports, we believe, understate the changes actually made, but they serve to indicate what came to the minds of a group of builders when questioned concerning labor-saving changes in the years immediately following 1920, and, taken in connection with the more general discussion above, help to indicate the nature of developments in the early part of the decade. We have previously noted reported changes in the use of power shovels and hoists. One contractor had added belt and bucket conveyors in excavation work which had cut the labor requirements 10 to 25 per cent. The substitution of a gasoline-motor crane for a steam crane saved one man on the crew. Three contractors mentioned the acquisition of air compressors and pneumatic tools for drilling, trenching and pavement-breaking jobs, to take the place of hand tools, one estimating that 3 men operating the engine and drills did the work of from 12 to 15 men. An increase in the use of small concrete mixers was reported, and substitutions of gasoline for steam power with mixers. One contractor had purchased mortar-mixing machines for all brick-laying crews. Others reported labor savings through the use of motor trucks in place of teams or trucks with larger wheels to enable more efficient operation in wet weather. Three contractors mentioned the purchase of gasoline-power saws for cutting rafters, planing, matching, and miscellaneous cutting. Two had purchased sanding machines for floor finishing, one estimating that with the machine the labor time required for finishing hardwood floors was reduced more than half. In some instances these machines were owned by the dealers in materials rather than the erecting contractors. One con-

tion and finishing; and 21 of the inspections cover excavation, trenching and earth handling only; 30 cover foundations or foundations and excavation; 45 cover various stages of erection and finishing residences and other types of buildings; and the remaining inspections include subway, curb and sidewalk construction, and street repair.

tractor ascribed labor-saving qualities to patent mortars; another, to metal closet partitions. In steel erection, one contractor reported having tried a pneumatic rivet passer from forge to hammer-men but found it impractical. Others made general statements of increased use of machinery in the five years; but 27, or over half of the group reporting, disclaimed having made any labor-saving changes in this period, one remarking "I have not bought a new machine for 10 years."

Rural Highway Construction

The history of the development of mechanization in the highway industry is largely a recital of the displacement of animal power by mechanical power. In the grading operation, more or less common to all types of road, the horse-drawn scraper has given way on many jobs to the power shovel and the elevating grader, and the truck has partly displaced the horse in hauling away the excavated dirt; in the haulage of materials to the paving crew, the horse-drawn wagon has been almost entirely displaced on the larger jobs by the industrial railway and, to an even greater extent, by the power truck; and the old method of dumping paving materials on the subgrade and delivering them to the mixer by wheelbarrow has given way to centrally-located proportioning bins from which the delivery trucks are loaded and which in turn dump their load directly to the mixer. In the paving process proper, the subgrader, the power mixer, and the mechanical finishing machine have come to dominate.

GRADING EQUIPMENT

The power shovel was first utilized in road work about 1910, its success resting chiefly on the development of the full revolving type and of small portable units of from 5/8

to 1 cubic yard capacity. It was still hampered by a lack of full portability on the job, however, and its use increased but slowly until the adoption of the caterpillar type of tread about 1920. A canvass of grading contractors in fifteen states in 1926 indicated that the caterpillar tread had made the power shovel much more adaptable to road work. Since 1926 its relative use has advanced still further. It is most effective where heavy cuts are necessary.

The elevating grader is simply a loading device, combining in one operation the loosening and loading of the earth.[28] It may be drawn by either horses or tractors, and is especially adapted for use in long and relatively shallow cuts through rockfree soils. It first made its appearance on highway work in those states just west of the Mississippi to whose soil it is particularly adapted. Confined to this location for several years, it began to spread about 1921 and has since appeared in numerous states east of the Mississippi.

Of 48 grading jobs inspected by us in 1925, power shovels were in use on a dozen, elevating graders on 20, and scrapers on the remaining one-third. At that time horse-drawn wagons were still extensively used in hauling away the excavated earth.[29] In more recent years a greater part of haulage is by motor truck and tractor.

[28] A disc plow, mounted on a heavy four-wheeled frame, turns its furrow onto a belt conveyor, which is operated by the turning of one of the wheels. The conveyor elevates the earth to the proper height and dumps it into the horse-drawn wagon or motor truck which follows alongside the grader.

[29] Only one of the 16 scraper outfits was mechanically powered. Of the 20 elevating grader outfits, 5 were drawn by horses and served by horse-drawn hauling equipment; 13 were power-operated but likewise served by horse-drawn hauling equipment. Of the power shovel outfits all but one were served by horse-drawn hauling equipment.

PAVING EQUIPMENT

In the paving process for cement-concrete surfacing, the principal items of equipment are the subgrader for finishing the grade to the appropriate degree of smoothness before spreading the concrete; the paving mixer; the finishing machine, and tractors for hauling the subgrader and other machines. The subgrader came into use in 1922, and was rapidly adopted throughout the paving industry so that by the middle of the decade it was employed on most paving jobs.[30]

The specialized type of power concrete mixer adapted to paving purposes was first evolved about 1910; it came gradually into use, and at present is found on all large paving operations. The tendency in the development of pavers has been in the direction of a large increase in capacity, made possible by the use of caterpillar treads which, first introduced in 1918, had, in a few years, almost replaced the wheeled mixer. On most of the jobs inspected in 1925, the pavers in use were the 21E or 5-sack capacity. By 1926 both the sales demand of the manufacturers and the expression of opinion on the part of the contractors from whom we made inquiry indicated a growing preference for the 27E 6-sack paver, and it has subsequently become the standard size in use.[31]

[30] This machine is rather heavy and consists of a truck on four small wheels which use the side forms as tracks. Mounted on the under part of the truck are adjustable blades, which, as the machine is dragged along the steel forms, cut the subgrade to the exact elevation desired, leaving the excess earth in windrows to be shoveled out by hand. As the machine itself carries no engine, it must be hauled either by truck or tractor.

[31] It has been found practicable not only to increase the size of the batch used with the 27E, but also to shorten the mixing time. See report by T. C. Thee, Assistant Highway Engineer, U. S. Bureau of Public Roads, in *Public Roads*, January 1932, pp. 269–89.

The finishing machine, for shaping the surface of the concrete, was put on the market about 1916. Its first extensive use was in Illinois in 1917; from then on the increase in its use was rapid, and in 1925, at the time of our field inspections, only two or three states still required hand finishing.[32]

In 1926 we inquired of state highway departments concerning the causes of increased productivity in paving operations. Of 28 replies received, all but one cited the use of larger pavers, and all but 6 better methods of hauling materials as either first or second in importance. Opinion voiced at that time by representatives of several of the states that were active in building roads, and supported by subsequent studies by the Bureau of Public Roads, indicated the improvement in efficiency of the paving-crew organization afforded a real opportunity for further increases in output.[33]

CENTRAL PROPORTIONING

About 1920, specifications of many states were revised so as to prohibit the practice of dumping materials on the subgrade and wheeling in barrows to the paver.[34] In addition,

[32] Reports from 27 state highway departments in 1926 indicated that machine finishing predominated in 11; in 9 both machine and hand finishing were used; and in 7 hand finishing predominated. Of 23 contractors reporting on their use of the machine, 7 had used it for the first time in 1924 and 1925. It was in use on 32 of 39 paving operations inspected by us in 1925.

[33] See J. L. Harrison, Efficiency in Concrete Road Construction, *Public Roads*, March 1926.

[34] In the older method the material for a concrete highway was loaded on dump wagons or trucks, hauled to the job, and dumped on the subgrade in approximately correct quantities for the distance between piles. From these piles, a crew with wheelbarrows proportioned and loaded the material to the mixer skip. In the central proportioning-plant method, the materials are concentrated at a single place called the proportioning plant,

a more accurately proportioned batch was demanded. The resulting transition from wheelbarrow proportioning to the central proportioning bin has both reduced the crew required and greatly increased the pavement yardage the contractor can lay in a day. Highway officials and contractors estimated that about 25 per cent had been saved in labor by the new process while yardage increases averaged about 50 per cent.

LABOR-SAVING CHANGES REPORTED BY CONTRACTORS

The contractors engaged on the highway construction jobs inspected by us in 1925 were asked to state what labor-saving changes they had made since 1920.[35] Of the forty-seven changes reported, 10 were for the grading phase. These included the substitution of a power shovel for a steam roller and scarifier in tearing up the old surface; of tractor and trailers for horse-drawn wagons in earth haulage; of tractor and scraper for team and scraper; of tractor and blader for horse-drawn wheelers; of power blader for horse-drawn blader in rough grading (3 instances); and of power shovel and team haulage of earth for wheelers and bladers. In the haulage of paving materials, trucks displaced wagons in 4 instances, industrial railways displaced trucks in 2, and 7 contractors substituted central proportioning plants and direct

in stock piles and storage sheds. A portable power crane is used for unloading sand and gravel, building stock piles, and keeping the proportioning bin filled. The bin delivers by gravity automatically-proportioned batches of sand and gravel to the transporting units.

[35] These sample inspections included 61 operations of various types in 5 middle western states then active in highway construction (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) and 5 in eastern states. To supplement the field inspections, inquiries were made by mail of equipment manufacturers, state highway departments, and highway contractors.

dump to the mixer for wheelbarrow handling from roadside dumps.[36]

About half of the total labor-saving changes reported were in the paving operation. They consisted in the substitution of horse-drawn or power-drawn subgraders for hand methods (8 instances), of finishing machines for hand strike boards (7); the use of larger pavers in 3 instances; and 4 changes in the curing system, chiefly in the way of chloride spreaders for hand spreading. Two contractors mentioned saving labor through the substitution of form-line trenchers for hand trenching.

Steam Railways

Mechanization in the steam railways has proceeded along divers lines. Among the noteworthy developments in the operation of trains we may mention the greater size of locomotives and freight cars, the further installation of automatic locomotive stokers, the partial transition to electric and oil engines and the increasing use of automatic devices and methods in train control.

IMPROVEMENTS IN CARS AND LOCOMOTIVES

In 1929, as compared with 1920, the average locomotive was more powerful by some 23 per cent; the average capacity of freight cars had increased from 42.4 to 46.3 tons; on the average more cars were hauled in one train and the average speed had increased from 10.3 to 13.2 miles per hour; and, largely as a result of these several factors, the gross ton-miles per freight-train-hour increased from 14,877 to 24,539. With

[36] All but one of the changes from the old wheelbarrow method of handling paving materials were reported as made prior to 1923, indicating that this method had been rather generally adopted early in the decade.

longer and faster trains, fewer engine and train men are required to handle the traffic.[37]

The mechanical stoker for locomotives reduces the coal to the requisite fineness, conveys it from the tender, and distributes it in the fire-box, usually by steam jets. Its use makes the handling of more powerful locomotives feasible, lightens the manual work of the fireman, and reduces his exposure to extremes of cold and heat incident to the opening of the fire-door in hand firing. Commercial application of mechanical stokers began in 1910, and they were rapidly installed during the War period. In 1917, 1,611 of the leading makes were reported in service, and on January 1, 1919, 3,717. By June 1, 1924, 8,989 stokers had been applied to locomotives.[38]

The increase in the proportion of electric and oil-burning engines is altering the task of the locomotive engineman. By December 1930, the number of electric locomotive units in freight and passenger service on Class I roads had reached 618. The number of oil-burning locomotives increased slowly from 7,326 in 1924 to 7,472 in 1930 while the total number of steam locomotives was declining from 65,006 to 55,875.

AUTOMATIC CONTROL OF TRAIN OPERATION [39]

Labor-saving changes in the train control phase of railway operations have been especially rapid since 1921 and have materially affected the employment of Morse telegraphers.

[37] Annual data for these changes in equipment capacity and operating results are given in *Statistics of Railways, 1930,* by the Interstate Commerce Commission; and *A Review of Railway Operations in 1931,* by the Bureau of Railway Economics.

[38] Estimates in this paragraph are from various reports cited in *Railway Age,* 66:1705, and 79:533.

[39] This section is based largely upon an article in the *Monthly Labor Review,* Ref. 54.

The principal changes include (1) a continued encroachment of the telephone on the telegraph in the control of train movements; (2) "the elimination of operators by the substitution of automatic for manual block-signal systems;" (3) "the displacement of Morse operators and messengers in the handling of message traffic by typists as operators of printer telegraphs;" (4) "the economizing of labor in the control of train movements, by the development of remote control, especially in the form known as centralized traffic control." In 1908 only a small mileage (10,819) was controlled by the automatic block-signal system. By 1921, the mileage had risen to 38,544, and by 1932 to 63,531. In 1908 only 8 per cent of the mileage under manual block signals was under telephonic control. By 1921 the percentage had risen to 52, and by 1932 to 61.

In subsequent paragraphs we note the transition from the Morse system of telegraphy to the printer telegraph in commercial offices, news agencies and market quotation agencies. A similar transition has occurred on the railroads. As a result of this and the other technological changes affecting telegraphers, the total of railroad employees designated as "telegraphers, telephoners and towermen" declined from 27,226 in 1921 to 13,187 in 1929.

The number of crossing and bridge flagmen and gatemen decreased from 23,007 in 1924 to 19,835 in 1930, the decline being ascribable in large part to the installation at grade crossings of automatic signals of various types.[40]

TRACK AND ROADBED MAINTENANCE

The maintenance of way and structures department probably employs more unskilled labor than all the other depart-

[40] For description of these changes and their effect on employment of watchmen, see *Monthly Labor Review*, Ref. 53.

ments of a railroad together. For example, in 1922 track and roadway section laborers on Class I steam railways numbered 200,675, and extra-gang and work-train laborers 39,680.[41]

Data are lacking for a precise chronological statement of the progress in mechanization of maintenance of way operations. All we can do is to sketch briefly some of the mechanical devices that have been introduced and give such fragmentary information as is available concerning the extent of their use. Some of the devices mentioned were, in an experimental way at least, inaugurated before the War and post-War period. Maintenance of way operations may conveniently be classified as (1) transportation of the work crews; (2) ditching and drainage preparation; (3) tie renewal; (4) rail maintenance and renewal; (5) cleaning and weed control.

For decades, section crews transported themselves to and from the piece of track on which they were working on hand-propelled cars. After the invention of the gasoline engine the newer models of section cars were equipped therewith at the time of construction, and to many of the old hand cars an engine was added. Data from three manufacturers show annual sales of from 2,500 to 3,000 motor section cars 1914–27 (Table 41). By 1927 some 55,000 were in use, representing, it is estimated, about an 83 per cent motorization of the railway section car (see Table 54). This phase of mechanization has about reached the saturation point; that is, section crews are equipped with the motorized car in most instances where its use is advantageous.

[41] Maintenance jobs of such magnitude as to be beyond the scope of the section crew are done by these extra gangs, consisting largely of foreign labor recruited from employment agencies. On many railroads Mexicans are being employed for this work more than formerly; see Paul S. Taylor, *Mexican Labor in the United States: Chicago and the Calumet Region*, p. 32.

When rough labor was plentiful, hours long, and wages low, the ditching and ditch cleaning requisite for track drainage were done by hand; later by teams and scrapers; within recent decades, hand and team work have been largely displaced on the more extensive jobs by the steam ditcher and the ditcher-spreader. The latter machine "will trim the ballast, shape the subgrade, and at the same time dig a uniform ditch of standard cross-sectional area, the flow line of the finished ditch being on the same grade as the track."

A great deal of labor is required in tie renewal. On some roads tie renewal labor has been reduced some 5 or 10 per cent by various methods of treating ties to make them last longer. A power tie lifter has been devised to aid in unloading ties. For packing the ballast beneath newly-inserted ties the power tie tamper (pneumatic or electric) is coming to take the place of hand tamping with pick, shovel or tamping bar. The improved quality of the tamping is a chief factor encouraging its use.[42] "From statistics supplied by 12 roads (in 1927) it appeared that three of these roads were fully equipped with tamping outfits and that the other nine roads were increasing the number in use each year."[43] On the whole, however, the use of machines has not become general in tie renewal.

In weed control along the right of way, the hand scythe and brush hook is being displaced on much-traveled tracks by the power mower and disc weeder, operated from a moving railway car, and by various types of chemical, steam-jet, or oil-burner weed destroyers, mounted on motorized railway cars.

In ballast cleaning (necessary to maintain good drainage),

[42] Also, "eleven railroads, replying to a questionnaire in 1926, reported an average saving of 37 per cent over the cost of hand tamping."

[43] *Railway Engineering and Maintenance Encyclopedia* (3d ed., 1929), p. 182.

the old ballast is dug up, cleaned, and the cleaned ballast returned to the roadbed. Removing the ballast from between the ties is still a manual operation in large part, and formerly the cleaning was done manually with ballast forks. Now machines have been developed for power screening and for handling the ballast from between two lines of track and on the shoulders. There is also a rotary ballast sweeper, consisting of a steel brush equipped with a conveyor system, for removal of cinders and other surface dirt. Snow removal is largely motorized.

Other tendencies and equipment which have some bearing on the amount of maintenance of way labor are the increasing use of metal posts for fencing, and of spray guns in painting bridges and buildings, and the possibility of economizing the available supply of track labor by a reduction in the seasonal variation of track and structure maintenance. Such stabilization has long been under discussion but the monthly statistics of expenditure and employment on maintenance operations do not indicate that much has been accomplished.

Obstacles to mechanization

Despite the various labor-saving devices available after fifteen years or more of intensive development of mechanical devices for maintenance of way operations, the number of workers in the maintenance of way and structures department increased nearly 13 per cent from 1922 to 1929; the total of all other railroad workers in Class I railways declined slightly. The explanation is to be found partly at least in the fact that the increasing volume of traffic, together with heavier locomotives and cars, has thrown a greater burden upon the maintenance of way department. Furthermore, the use of the various devices mentioned is by no means uni-

versal. Mechanization has been retarded by the conservatism of railroad executives, arising from the very nature of railroad operations which tends to develop strong traditions in methods of organization and operation. Methods and equipment that have proved safe and workable for decades are changed reluctantly and slowly. One technical difficulty is that the free movement of trains is a first consideration in railroad operation, and on heavy traffic lines the necessity for frequent removal of a machine from the track handicaps it as against the more mobile gang of workers with hand tools.

MAINTENANCE OF ROLLING STOCK

The repair work involved in the maintenance of railway rolling stock does not lend itself readily to the mass production methods which account for rapid productivity gains in some lines of manufacture. Cars and locomotives are of many different models and the repair work required varies from car to car. However, many improvements have been made in the metal-working tools required; some shops have installed extensive motorized systems of handling materials; lacquer painting has gained some foothold; and it is reported that the adoption of the progressive system of car repairs is the most important development in working methods in the shops and "has brought about a revolution in car repair in practically all parts of the country". In this system, the cars are worked through the shop in a certain number of spottings, with each crew more or less specialized in one phase of repairing.[44]

[44] It is stated that in shops where it was previously an effort to maintain a schedule of 100 to 125 cars a month, it is now possible to turn out 350 to 400 cars. *Railway Mechanical Engineer*, 103:595–7, October 1929.

Street Railroads

The street railroad is engaged in a struggle for existence against the competition of the private automobile and the motorbus. From 1922 to 1927, the number of employees declined from 300,523 to 267,115, and the number of passenger cars from 77,301 to 70,309. Among the changes made in the effort to reduce costs may be mentioned various improvements in shop practices and in track construction, such as the use of electric track welding; and the increasing use of the one-man car and the two-car train. The number of one-man passenger cars increased from 11,628 in 1922 to 19,771 in 1927, despite a decrease in the total number of cars.[45] Street-car lines in numerous cities, including, for example, Buffalo, Bridgeport, Kansas City, Missouri, Newark and Jersey City, are now operating one-man cars exclusively.

Highway Transportation

In 1929 the passenger cars registered in the United States numbered 23,121,589, the trucks 3,379,854. Some 92,500 motorbuses were in operation that year, 48,350 being revenue carriers and most of the others school buses. The total of livestock hauled by truck in 1929 was estimated at 14,500,000 head; and 73 per cent of fruits and vegetables for metropolitan use were hauled by motor truck in 1928.[46]

The motorization of highway transportation evidenced by these statistics has had a profound effect on other industries. The bus and passenger automobiles have taken part of the

[45] From reports on *Electric Railways* (1922); and *Electric Railways and Affiliated Motor Bus Lines* (1927), U. S. Bureau of the Census.

[46] Estimates in this paragraph all quoted from the National Automobile Chamber of Commerce, *Facts and Figures of the Automobile Industry*, 1930 ed.

passenger traffic of the railroads and street car lines, and the truck has become an important competitor in freight handling. In urban transportation, the cab driver and teamster have been largely eliminated; in rural communities, the automobile has reduced the time required to market commodities. Employment in truck and passenger car operation, service and maintenance has greatly increased, but this gain in employment is offset in part at least by declines in the industries curtailed by the skyrocket growth in motorized highway transportation. In the handling of coal, gravel and similar bulk commodities, the labor-saving tendencies of motor truck transportation, as compared with horses and wagons, have been accentuated by the development of the automatic-hoist dump-body feature on trucks.[47]

Stevedoring

A stevedore is one who contracts to load and unload ship cargoes. The men whom he employs to do the work are known as longshoremen. The principal port facilities involved are wharves and docks, transit sheds for the temporary storing of cargoes, and more or less hand and mechanical equipment for the hoisting and lateral movement of goods.[48]

Much heavy manual handling is involved in the work of

[47] See the sections in this chapter on Rural Highway Construction and Retail Coal Handling.

[48] The principal sources of information for these paragraphs are inspections of stevedoring operations and interviews with stevedoring agencies in 1925 by Mr. G. T. Benson of our staff, at the ports of New York, Boston, Baltimore and Philadelphia; the recently published report of the Bureau of Labor Statistics of a three-year study of productivity in port operations made by Boris Stern (B. L. S., Ref. 42); a series of reports issued by the Engineer Corps of the War Department with detailed description of the facilities in the United States ports (Ref. 66); R. S. MacElwee, *Ports and Terminal Facilities;* and various articles in the technical journals.

the longshoreman, hence the essential requirements for th job are "a mighty arm, a hard muscle, and a large stron back". Nevertheless, a considerable experience and a certai type of skill are required for that part of the work involvin the handling of ship's gear and the stowing of cargo in th hold. The work of the longshoremen and the equipmen used by them vary widely with the type of ship, the port and the cargo handled, not to mention differences betwee docks in the same port. Ocean-going freighters are ordinaril loaded through hatches in the deck, but the cargoes of lak and coast vessels are frequently loaded and discharged fron the side. Bulk cargo is shipped in mass without containers and 'general' or 'package' cargo in units or packages.

In most ports, little stevedoring is required in the han dling of bulk cargoes. Petroleum in bulk is pumped to an from the oil-carrying ships. Grain is largely loaded by grav ity and unloaded by chain-bucket conveyors or pneumati elevators using suction. Ore handling on the Great Lake was highly mechanized even before the War-time impetus t labor saving. The car dumper—a mechanism that lifts a open-top car loaded with coal and turns it over, so that th coal can flow into the ship by gravity—is the basis of large scale cargo coal loading.[49] In the handling of such bulk ca goes as grain and cargo coal, the work of the stevedore i ordinarily limited to rigging or adjusting the equipment and to trimming, that is, moving the cargo to and from thos parts of the hold that cannot be reached readily by th mechanical loaders or unloaders. Even here the machine en croaches, for "most of the coal piers are now equipped wit automatic trimmers which are capable of shooting the coa

[49] At the Sewall's Point, Virginia, coal-handling plant of the Virginia Railway Company, there is a double car dumper which can handle tw 60-ton cars or one 110-ton car; MacElwee, *op. cit.*, p. 349.

nto the farthest and most inaccessible compartments of the hip, thus at times completely dispensing with the services of longshoremen as coal trimmers".[50]

Standardized package cargo includes such commodities as bananas, cotton, flour, coffee, sugar, lumber, cement, case oil, and newsprint paper rolls. The methods for handling standardized package goods often do not differ from those for handling miscellaneous package cargo in the same ports. Standardization, however, facilitates mechanization, and for many of these commodities specialized handling devices have been developed at some ports. The Bureau of Labor Statistics concludes that "labor productivity in handling these uniform cargoes has recently greatly increased, due to the use of the newer types of pier equipment.[51] Differences in the equipment, methods, and productivity at the various ports and piers are still substantial.

Miscellaneous package cargo is shipped in bags, barrels, bales, boxes and crates, of all shapes and dimensions, and sometimes in no containers at all. It is in the handling of this heterogeneous type of cargo that hand methods make their most effective resistance to the advance of mechanization. The two principal difficulties in the way of mechanization of miscellaneous package cargo handling are the requirement for individual attention in the stowing of the goods in the hold of the ship, and in the sorting of packages in the discharging process.

The transference of goods from the apron of the pier to ocean-going ships is largely by mechanical means even in miscellaneous package handling. In United States ports the

[50] B. L. S., Ref. 42, p. 9.

[51] B. L. S., Ref. 42, p. 15. For description of methods in handling bananas, ase oil, raw sugar, newsprint and coffee, and illustrations of gains in productivity, see pp. 44–61. For differences in productivity, see pp. 52, 65 and he General Tables, pp. 113–559.

ship's gear, that is, the booms and winches with which eacl freighter is equipped, is largely used. Side-port loading an discharging is generally accomplished by longshoremen witl hand trucks passing back and forth between the vessel an shore along a gang-plank, except when there is a low tid creating too steep an incline between the side port and th pier platform.

Also, the machine has come into use in handling miscel laneous package freight on the pier. The once universa 2-wheel truck, and its later development in the 4-wheel plat form truck, have given way in part to the electric truck, th tractor and trailer, and various types of portable conveyor and elevators. The machines have made most headway in th piling of goods and in relatively long hauls from shipside t warehouse. The low-lift type of electric truck for use witl skids (interchangeable trays or platform bodies) and th high-lift type and crane-equipped trucks, for tiering, hav demonstrated their special usefulness in cargo handling o the piers.

On the 22 stevedoring operations inspected by us in 1925 inquiry was made of the stevedore or foreman as to "change in gear or method made in the last five years". In 12 in stances, no change had been made. Two had added Henshav portable escalators, which engage the axle of hand truck and help them up inclines, and estimated the increases in ton per man-hour to be from 0.88 to 0.95 and from 0.80 t 0.86, respectively. Four stevedores had inaugurated partia use of electric trucks. One stevedore was using two truck on trial; another had added a couple of lift trucks, an estimated that the output of the gang of 21 had increase from about 20–25 to 28–30 tons per hour. In the handlin of dates hand trucks were replaced by electric trucks witl demountable and interchangeable bodies to enable som selection of the cargo according to consignee's marks at th

ship's side, thus lessening the amount of sorting necessary when the loads were brought to the storage space, and increasing productivity for a gang of 22 from approximately 32 to 40 tons. Similarly in the handling of sugar, hand trucks had first been displaced by a gasoline tractor and then the tractor by electric trucks with demountable bodies; output had been thereby increased from 29 or 30 to 48 tons per hour for a gang of 18. In hauling lumber, a Fordson tractor had been added for long hauls, increasing the output of the gang of 17 from 8,000 to 10,000 board feet per hour. At an ore-handling pier, a mechanical trimmer had been added to aid in moving the last part of the cargo so that it could be more readily reached by the unloading buckets; this sharply increased the man-hour productivity in the trimming operation. At a coal-handling pier, the two Boston towers had been rebuilt and the size of the buckets increased from one ton to one and one-half tons, with man-hour output increased from 10 to 16.5 tons. At a general cargo pier, 4-wheel trucks had been substituted for 2-wheel, and flat wooden platforms or 'aeroplanes' for cargo nets, in hoisting drafts of general cargo from the ship, with an estimated change in productivity from 0.95 to 1.4 tons per man-hour.

On the whole, stevedoring has been backward in the introduction of machinery. But the above examples will serve to illustrate the tendency for mechanization to nibble away at the hand operations despite the diverse nature of the cargo and the greater adaptability of hand methods to the large amount of sorting required, rough and narrow pier surfaces and other physical limitations of some docks. The diversity in productivity shown by Stern's study suggests the possibilities of further gains by modifications in methods and equipment.

COMMUNICATION

Recent mechanization developments of special interest i the field of communication are the automatic telephone, th printer telegraph, and the high-speed stock ticker.

THE AUTOMATIC TELEPHONE [52]

The first commercial installation of an automatic switch board was in 1892. It has been estimated that in 1922, 5. per cent of the total number of telephones were automati The decade of the 'twenties witnessed a steady increase i the introduction of dial telephones. The percentage whic they constituted of the total in the Bell system increase from 1.7 in 1919 to 2.7 in 1921, 15.5 in 1926, and 31.9 i 1930.[53] By 1929 over four million stations were served b automatic switchboards in the Bell system. The dial tele phone is not restricted to urban districts but is coming int use in the rural districts and also in railroad telegraphy.

The automatic switchboard does not eliminate operator entirely, for during the period in which the automatic systen is being introduced and some offices are still manual addi tional apparatus and labor is required for the satisfactor

[52] This section is based in part on information made available by th courtesy of the Bell Telephone system (see Table 41), and in part on th results of a survey by the United States Bureau of Labor Statistics, reporte in the *Monthly Labor Review,* Ref. 50.

[53] Full records of installations are available only for the Bell system, bu inasmuch as in 1930 this system owned 86 per cent of the manual telephone and 92 per cent of the dial telephones, and had on its payrolls 88 per cer of the workers in the employ of commercial telephone companies, the recor for the Bell system may be taken as approximately representative of th trend and status in the industry as a whole. The lead in the introduction c dial phones was taken by the independents but by 1930 the percentage c automatic phones in the Bell system exceeded the percentage for the ind pendent systems.

andling of calls between different types of switchboard. urthermore, toll or long distance calls are, on the whole, andled by manual operators, though the recent trend has een rapidly towards the automatic handling of the simpler ypes of toll call.[54]

HE PRINTER TELEGRAPH [55]

The principal branches of the telegraph industry are the ommercial telegraph systems, handling messages for the eneral public; railroad telegraphy; the news-gathering or- anizations, such as the Associated Press; and the market uotation systems. All of these have been affected by the rinter telegraph and allied developments.[56]

In the manual or Morse system of telegraphy the message, oded in dots and dashes, is sent by the intermittent depres- ion of an electric contact key by an operator skilled in the Morse system; a Morse operator is also required at the re- eiving end. The principal inroads upon the Morse system ave been made by the printer telegraph and associated evices, such as the new high-speed stock quotation ticker.

The printer telegraph (also known as the teletypewriter r teletype) in appearance and mode of operation resembles n ordinary typewriter. The depression of a key causes the

[54] For further discussion of labor-saving qualities of the automatic tele- hone, see Ch. X, and the *Monthly Labor Review,* Ref. 50; for the extent id effects of its increasing use in private exchanges, see *Monthly Labor eview,* Ref. 56.

[55] Based upon studies reported in the *Monthly Labor Review,* Ref. 51, 52, , 55 and 56.

[56] The displacement of Morse telegraphers by the printer telegraph in ilroad telegraphy is closely associated with other technological changes, ch as the automatic block-signal system, and hence is discussed in a preced- g section dealing with changes in railroad operation. The printer telegraph also extensively used in private wire systems (Ref. 56).

electric transmission of a character impulse and the characte is automatically printed, in ordinary characters, on a 'blinc printer at the receiving end of the wire or on several ma chines connected by telegraphic drop circuits.

The introduction of the printer telegraph in commercia telegraphy was slow at first. In 1902 only 0.8 per cent and i 1907 only 1.6 per cent of the mileage of commercial telegrap systems had automatic circuits. During and after the Worl War, the use of the automatic telegraph increased rapidly. By 1931 about 90 per cent of the commercial message han dling of one of the leading companies and 80 per cent o the traffic of another was by printer telegraph.

There are several large news-gathering organizations an many more which render specialized services, such as finan cial news and syndicated news features. Their telegraphi handling of news is by means of leased-wire trunk-line ci cuits tapped by drop circuits connecting the individual new papers with the main circuits.

The news agencies began to use printer telegraphs i 1915. By 1922, 416 out of 1,597 drop circuits in the principa news organizations had printer service; and by 1930, 2,31 out of 2,715. The number of Morse operators increase from 1,114 in 1915 to 1,549 in 1922, despite the printe telegraph, but from 1922 to 1931 declined to 586, whil the number of printer operators increased from 67 in 192 to 335 in 1930.[58]

[57] "Conversion of the principal circuits to multiplex printer operatio continued till 1928, when the program was merged with, and in a measu superseded by, the installing of simplex printers", the introduction of whi had begun in 1926. With the 'simplex system' the use of the printer feasible under lighter traffic conditions than formerly necessary for ec nomical use.

[58] It is estimated that in 1931 the work of the printer operators w equivalent to 243 full-time positions, and that to operate these and th 2,317 receiving positions which they serve, with a complete Morse manu

The ticker is a variation of the printer telegraph. Ticker service for reporting market quotations originated shortly after the Civil War.[59] At first, direct circuit service was restricted to the financial district of New York and a few great financial centers,[60] and the transmission of market quotations to other points was handled by Morse telegraphers. In some instances quotations so relayed were redistributed by local ticker circuits.

For the principal market-quotation services the number of tickers in use increased from 3,706 in 1921 to 13,736 in 1929, but decreased to 11,178 in 1931. The extension was especially rapid in the late 'twenties. In 1926 only 121 cities in 24 states were receiving service for New York Stock Exchange quotations by 5,267 stock or bond tickers. By 1929, the service had been extended to 336 cities in 41 states, using 10,505 tickers. In 1930 there were more than 30 security or commodity exchange ticker systems, some of them local or regional.

Under the impetus of the expansion of stock-exchange operations a new high-speed ticker service capable of handling the enlarged volume of quotations with a minimum of delay and error was introduced in 1929 and installed in 1930 throughout the country. "On September 2, 1930, for example, it automatically printed the New York Stock Ex-

system, would require 3,737 Morse operators, or in the ratio of about fifteen Morse operators to one printer operator.

[59] Data on the extent of ticker service and productivity of the operators in the New York Stock Exchange ticker service are available from 1890 to date. *Monthly Labor Review,* Ref. 55, p. 1271.

[60] In direct circuit ticker service, the operator types the symbols in which the market quotations are expressed on the master transmitter, and the identical symbols are simultaneously printed on tapes by the tickers in the receiving offices.

change quotations on 8,623 stock tickers in 43 States and Territories and in Canada, with circuits in 377 cities." [61]

The important displacement effect of the ticker is on the number of Morse telegraphers employed in intermediate and receiving service by brokers, newspapers, and local ticker services though the number displaced cannot be determined. Thus it is seen that alike in commercial, railroad, news-service and market quotation telegraphy, the opportunities of the Morse operator have been lessened by the printer telegraph and associated technological changes.

UNITED STATES POSTAL SERVICE (Ref. 59)

An estimate by the Bureau of Labor Statistics, using conservative methods, places the gain in output per employee in the United States postal service, compared with 1908, as 20.7 per cent by 1912, 67.3 by 1926, and 71.8 by 1930, with a decline of 5 per cent from 1930 to 1931 arising from the decreased volume of business. About 197,000 additional employees would have been required to do the 1930 volume of work at the 1908 level of efficiency.

A Congressional committee reported in 1908 that there was "a lamentable lack of labor-saving devices practically throughout the whole Postal Service". Subsequent improvements are ascribable in part to mechanical labor-saving devices and possibly in still larger part to administrative changes for the promotion of efficiency. Among the mechani-

[61] In the high-speed system, the quotations are first typed by several printer telegraphs in code on perforated tapes, then automatically reperforated on a single tape and fed into the master transmitting ticker, which is geared at a speed of 500 characters per minute. The action of the master transmitter is synchronized with that of each of the several thousand receiving tickers throughout the country, and reception and printing by them is entirely automatic.

cal changes may be mentioned the motorization of the collection of mail, mechanical facing tables in the larger offices for arranging letters for the canceling machine, improved postmarking and canceling devices, postage-metering machines, automatic conveyors of many varieties, and in the accounting division, the extensive use of "many kinds of the most efficient types of bookkeeping and calculating machines".

Among the administrative steps contributing to increased productivity are "a definite budgeting of funds for encouraging invention and for buying or renting and maintaining labor-saving devices", the establishment of a division of cost ascertainment "for carrying on a continuing study of the various phases of income and expenditure . . . remarkable economies in the money-order accounting system," . . . and "surveys for the purpose of discovering the most efficient methods, formulating plans for standardized procedure and making available to the entire system the best methods found anywhere in the system." (Ref. 59, p. 746). Recently a system of efficiency ratings has been developed, and intensive study has been made of labor management and administrative organization and methods, illustrated by surveys carried on between October 1929 and April 1931 in 55 of the largest offices in the country. The continuing adaptation of the physical plant to changing conditions and needs has played a large role in raising the level of efficiency.

Retail Coal Handling

The usual operations in retail coal handling are (1) receipt into storage; (2) screening if necessary; (3) loading to delivery trucks or wagons from overhead bins or ground storage; (4) haulage; (5) unloading to customer's storage.

Our study of retail coal handling at first hand was re-

stricted to a survey covering 16 anthracite coal-handling establishments in New York City and five establishments in Connecticut towns; together with somewhat less complete data concerning a group of 7 dealers in Binghamton, New York; and information by mail from 10 New York dealers. Obviously this is not a large or representative sample of retail coal handling for the country as a whole. Nevertheless, if its limited scope is kept in mind, it may be useful as suggesting some tendencies in coal handling.[62]

At the time of inspection, the 21 plants in New York City and Connecticut were quite well mechanized. For the bin-loading operation, largely from barges, all had power equipment of some kind; all but five had some sort of mechanical cleaning system; and all loaded for delivery by gravity chutes or used portable electric loaders where loading from ground storage. For haulage, all establishments had gasoline one- to ten-ton trucks (168 in all) with power-hoist dump-bodies, and hired additional motor trucks when needed.[63]

The information concerning the equipment used in the 7 Binghamton retail coal plants illustrates a less mechanized type of establishment. Only four of the yards were equipped with portable power loaders. Only two had any motor trucks of the power-hoist dump-body type. Six were using horse-drawn wagons with non-dump wagon bodies.

Except for some of the overhead wooden bins, all the equipment in use in 1925 had been rebuilt or added since

[62] The 21 establishments surveyed in New York City and Connecticut had daily capacities of from 70 to 850 tons and employed about 666 men when in full operation.

[63] In addition, three of the establishments had horse-drawn trucks or wagons totaling 26 in number, most of these being equipped with hand-operated dump-bodies. The only reason given by the coal dealers for continuing to use horses was that some of their old drivers could not learn to drive a motor truck; the horses were being retained until these drivers were retired.

1907, either as initial equipment or to replace older types. The Boston towers took the place of mast-and-gaff loaders or bucket elevators, from 1910 to 1916, or were initial equipment. The mast-and-gaff loaders and the locomotive cranes had all been installed by 1917 as initial equipment or to replace bucket elevators or cruder types of hoist. The mechanical screening apparatus was initial equipment in 4 plants and had been substituted for hand screening in 12 plants, all in the years 1915–19, with the exception of 2 changes as late as 1924.

In 8 of the coal-handling establishments surveyed, the power-dump trucks in use in 1925 had displaced horses and wagons in the years 1914–18 inclusive. In 12 additional establishments they displaced horses and obsolete and worn-out motor trucks in the period 1912–24. The portable electric loaders had been added since 1920.

It will be noted that most of the changes we found in retail coal-handling establishments had been made during or before the World War. Of one group of 21 establishments 15 reported that they had made no change since 1920 considered significant from a labor-saving point of view.

Production of Power

Noteworthy tendencies in the production and consumption of power in the 'twenties were the increasing use of electric power, a shift from produced to purchased power on the part of manufacturing plants, more use of oil and powdered coal for fuel, the further displacement of hand-fired coal-burning furnaces by mechanical stokers, and centralization of electric power production in favorably located plants operated by electric light and power companies.[64] From 1917 to 1927,

[64] See Ch. VI for the increasing proportion of electric power in manufacturing. The change to oil burners was reported by a score of our in

though the number of central stations decreased from 6,542 to 4,335, the number of employees increased from 105,541 to 251,020 and the power generated by them increased even more—from 25 to 75 billion kilowatts. Power production is so far mechanized and the number of workers employed relatively so small that large savings in labor are no longer possible.[65]

The size of equipment units in central stations has been increasing rapidly. For example, from 1922 to 1927 the average horsepower of prime movers increased from 1,499 to 2,868, and the average rated capacity of generators from 1,127 to 2,157 kilowatts.[66]

In the smaller power plants the crude labor-consuming method of stoking furnaces with hand shovels is still prevalent but in the larger industrial and electric power plants it has been generally displaced by various types of automatic stoker, such as the endless-grate system.[67] Stoking labor has been reduced also by the increasing use of oil burners and the introduction of pulverized coal equipment.

formants, who emphasized the resulting improvement of working conditions in the powerhouse. The number of men involved in power production is not large and the reduction in the number was ordinarily small, ranging from 1 to 6 in most instances, although one large manufacturing plant reported a reduction of its powerhouse crew from 57 to 11. Electrification tends to eliminate the powerhouse crew and, according to some of our informants, also reduces the maintenance crew because of the absence of shafting, belting, etc., incident to steam-engine drive.

[65] Information received in 1925 from 120 power plants, 52 of which were equipped with mechanical stokers and the remainder hand-fired, showed a total of 506 firemen, coal passers, etc., or an average of only 4.2 men per plant (*Industrial Management*, April 1925, Vol. 69:242).

[66] Data on central stations taken from 1922 and 1927 issues of *Census of Electrical Industries: Central Electric Light and Power Stations.*

[67] See Table 41, for annual sales of mechanical stokers. "During 1928, of the coal burned for the production of electric power, 97.7 per cent was fired mechanically, while 2.3 per cent was burned under the hand-fired boilers still used by a few small plants" (Ref. 57, p. 255).

PULVERIZED COAL

The pulverized coal system was first used on a considerable scale in a commercial power plant at the Lakeside plant in Milwaukee, built in 1921, after a period of experimentation in another Milwaukee plant. This plant is equipped with a mechanical car dumper to the crusher, and from the crusher the coal is mechanically carried through all subsequent processes with no manual handling. One man watches a battery of furnaces. According to statistics published by the Bureau of the Census for 1930 and 1931, new orders received by the principal manufacturers of coal-pulverizing equipment totalled 433 pulverizers of the unit-system type and 4 of the central-system type.

AUTOMATIC DISTRIBUTING STATIONS

About the limit in the elimination of human labor has been reached in the remote control system for electric power distributing plants, first put in successful operation in 1921. On September 17, 1928, the New York Edison Company opened one of these manless distributing stations in New York City which will ultimately be able to supply power sufficient to light the homes of approximately 300,000 families. The plant is controlled from another station more than three miles away, and it is necessary for human beings to visit the station only about once a week to inspect the apparatus.[68]

[68] Mimeographed press release from New York Edison Company. The number of unattended substations in 5 representative electric light and power systems surveyed by the Bureau of Labor Statistics increased from 46 in 1920 to 193 in 1930; and "in one large system, in 1931, of a total of 325 substations in operation, 233 (72 per cent) were entirely automatic while the other 92 (28 per cent) required some attendance" (Ref. 57, p. 258).

FUEL ECONOMY

Of greater interest than the immediate effect of various changes on the amount of labor directly employed in power production is the remarkable advance in the efficiency of fuel utilization and the consequent reduction of labor required in the production of the fuel. In 1919 the average consumption of coal or its equivalent in the generation of electric power by the public utilities was 3.2 pounds to the kilowatt-hour. Each year since consumption has decreased, being in 1929 only 1.68 pounds per kilowatt-hour, a saving of 47.5 per cent in the decade. Similar improvements in fuel efficiency have been made in the consumption of coal by railroad locomotives and in the production of pig iron. As a result of the improvements in fuel efficiency, together with the competition of fuel oil, demand for coal has failed to keep pace with the general growth of industry.

Street Cleaning and Maintenance

In the interminable repair necessary on city streets, extensive use is made of pneumatic tools to break up old pavements. Motorized sprinklers and rotary street sweepers have been adopted (*cf.* Table 41). In the larger cities of the North, mechanical devices have been developed to aid in the removal of snow. On rural highways, an increasing mileage of which is kept open for motor traffic in the winter, the snow can be plowed to one side, but on a city street, complete removal is more satisfactory. A common practice has been to plow the snow over to the curb and then to load it to trucks, either by hand shovels or machine, to be hauled away and dumped elsewhere. When loading is by hand there is much idle truck-time while the process of loading is going on. In 1925 a member of the staff of the New York City bureau of

snow removal estimated that about 25,000 persons were employed in the city to remove snow after a large fall, of whom about 18,000 were casual workers. The equipment was estimated as about 1,000 snow-plows, 2,200 motor trucks, 900 horse-drawn wagons, and a few cranes and portable-conveyor type of snow loaders. The conveyor type of loader is a self-propelled, more or less self-feeding device, which drives into a windrow of snow and with a bucket conveyor feeds the snow rapidly into the body of the waiting truck.[69] The motor trucks used for haulage are equipped with automatic hoist bodies.

The facility of removal arising from the development of the machine snow loader has probably resulted partly in a decline in the amount of labor required, partly, however, in an increase in the volume of snow removed. The introduction of the machine has been retarded by the tradition that snow removal is a means of providing temporary employment for large numbers of unemployed, and especially in a depression period, public sentiment and political interests are adverse to it.

Technological Changes in the Amusement Industry [70]

In the introduction of the sound movie, the motion-picture branch of the amusement industry underwent an exceptionally rapid technological revolution. The first sound picture was produced in August 1926. The introduction of

[69] An observer from our staff clocked one of these loading snow on the New York streets, under almost ideal snow conditions, and found that it loaded six 9-cubic-yard trucks in less than nine minutes. In another check, 22 trucks were loaded in 96 minutes, including 26 minutes stoppage while waiting to be shifted.

[70] Unless otherwise indicated, the quoted phrases and facts in this section are based upon articles in the *Monthly Labor Review* (Ref. 44 and 46).

sound-producing machines was relatively slow at first but rapid in 1929 and 1930, so that by January 1, 1931, 13,128 of a total of 21,993 theaters in the country were sound equipped.

The chief displacement effect of the 'talkie' arises from the 'canned music' feature—the synchronization of the musical score with the picture, making unnecessary the employment of living musicians in the projecting theater. Formerly even the straight motion-picture houses ordinarily employed from one to seven musicians. As a result of mechanical music, these musicians have been largely dispensed with, and consequently, the number of employed musicians declined in the two years ending June 30, 1931 by some 9,885, or about 50 per cent. In Washington, D.C., a reduction, in all theaters, of slightly over 60 per cent was made in October 1930, by agreement between the motion-picture theater owners and the local union of musicians.

As a partially offsetting factor, there is a growing demand for local musicians by the local radio stations, and it has been estimated "that from 500 to 600 musicians throughout the country earn a living through radio broadcasting". Nevertheless a study of the status of 101 displaced musicians in Washington indicated that the earnings of a majority have been reduced subsequent to their discharge from the motion-picture theaters; and even when able to get some sort of a job, only a few have improved their status. The adjustments that the majority have had to make have been extremely painful.

On the other hand, the change from the silent to the sound movie has been accompanied by an improvement in the status of the motion-picture machine operator, both by replacing the customary boy helper with a licensed operator, and by increasing the average earnings of the projectionists. "Representatives of the five large moving picture circuits

claim that the 13,000 theaters which installed sound equipment in the last few years have added more operators than the approximately 10,000 musicians who lost their jobs through the introduction of the sound picture."

In the small 'translux' theaters, the picture is projected from behind the screen, obviating the necessity of a darkened theater; and here the ticket taker has been replaced by a turnstile operated from the cashier's booth, and the ushers and pages dispensed with.

The employment of musicians in the vaudeville houses and the theaters giving combination vaudeville and motion-picture shows has not been directly affected by the sound movie; but the popularity of the straight motion-picture house is indirectly responsible, at least in part, for changes in the legitimate stage and the passing of the vaudeville house. In 1922 there were nearly one thousand 'big time' and 'small time' vaudeville theaters. Most of these have become straight motion-picture houses or part-time vaudeville in combination with motion pictures, the elimination of the vaudeville feature being hastened by the depression. With the elimination of the vaudeville artist "also go the musicians and the entire back-stage crew".

Office Equipment

The extent to which the machine has a recognized and growing place in the modern office is evidenced by the dollar volume of sales of selected types of office equipment (Table 7).[71] In 1929 adding machines with a factory value of about

[71] In the 94 insurance companies, public utility companies, publishing firms, chain stores, mail order houses, banks and investment firms covered by surveys of industrial change in clerical work made in Philadelphia and St. Louis by the Women's Bureau, "438 women worked on bookkeeping or billing machines, only 177 women being found who still carried on this

TABLE 7

VALUE OF SELECTED TYPES OF OFFICE EQUIPMENT PRODUCED, 1925, 1927, 1929[1]

(unit: $1,000)

TYPE OF MACHINE	*1923*	*1925*	*1927*	*1929*[3]
Adding	[2]	33,830	33,386	25,910
Addressing and mailing	5,769	9,035	9,788	10,537
Calculating	[2]	[2]	10,614	11,617
Card-punching, sorting, and tabulating	[2]	[2]	4,850	[2]
Check-writing	2,489	2,093	1,780	2,346
Manifolding (mimeographs, multigraphs, etc.)	[2]	3,884	3,779	3,489

[1] Compiled from *Census of Manufactures, 1929,* II, 1098–1100.

[2] No comparable data available for these years.

[3] Number of machines in 1929: adding, 157,740; calculating, 57,201; check-writing, 63,576 (incomplete); typewriters, 959,627.

$26,000,000 were produced in the United States; and the value of the calculating machines and addressing and mailing machines amounted to over $10,000,000 each. About one million typewriters were manufactured.

A partial census of adding and calculating machines of the principal American makes, manufactured to March 1928, records 1,707,400 full keyboard type, 326,500 10-key keyboard type, and 314,000 miscellaneous non-listers.[72] An officer of one of the companies manufacturing dictating machines estimated for us early in 1928 that approximately 200,000 dictating machines were in daily use in the United States and that the number was increasing at about 10 per cent a year.

It would be difficult to estimate the man-power equivalent of the great number of typewriters, adding and calculating

work by hand." Mary Anderson, The Clerical Worker and Industrial Change, *American Federationist,* vol. 39, p. 1025.

[72] Letter, March 22, 1928, from Equipment Research Corporation, Chicago publishers of *The Business Machines and Equipment Digest.*

machines and other mechanical office equipment, and the results when obtained would be somewhat misleading if taken to indicate the labor displacement arising from machines; for it is probably true that in large part the work now done by the machines would not be done at all were it not for the facility of output with machine equipment. If letters were all written by hand, and computations all made by laborious and expensive human effort, there would be a marked shrinkage in the volume of correspondence and computation considered necessary and economical.

Mechanization of Household Tasks

Many modern tendencies lead indirectly to an increased mechanization of household tasks by transferring them from the home to the factory. The increasing proportion of families who live in apartments and perform few household tasks; the rise of the power laundry; the increasing resort to canned goods, prepared breakfast foods and bakery goods —are illustrations of tendencies which either reduce the labor required to maintain a household or transfer much of it from the individual household to the more or less specialized factory with its relatively greater use of mechanical equipment. Some of these tendencies are by no means entirely new, but most have been accelerated in the post-War period. From 1919 to 1929 the number of wage earners employed, on the average, in establishments with value of product $5,000 or more, had increased from 130,489 to 233,187 in power laundries; from 18,408 to 59,148 in dyeing and cleaning establishments using mechanical power; from 76,326 to 98,866 in the canning and preserving of fruits and vegetables; and from 140,477 to 200,841 in the manufacture of bread and other bakery products. In 1919, 35 persons in each thousand of the total population were employed in the four

industries just mentioned; a decade later, 49 persons. In the same period, employment in manufacturing as a whole was declining.

ELECTRIC APPLIANCES

The decade of the 'twenties witnessed a rapid increase in the use of power appliances in the home, chiefly in the way of electric-motor-driven equipment. Estimates of the rapidity of introduction and changes in the extent of use, derived largely from statistics furnished by the manufacturers and published in the trade journals, appear in Tables 43–45. Estimates of the number sold each year, 1923–30, are given in Table 43; estimates of the number of users of selected electric household appliances at the close of each year, in Table 44; estimates of the percentage of wired homes at the close of each year equipped with the specified electric appliance, in Table 45.

Most power-driven household labor-saving appliances are electric, and the extent of use is frequently expressed in terms of the percentage of wired homes equipped with the given device (Table 45). It is estimated that the number of persons living in electric-lighted dwellings in the United States increased from about 35 million at the beginning of 1920 to about 85 million at the close of 1929, or from 33 to 70 per cent of the total population.[73]

The number of users of electric washing machines has increased from about three and one-half million in 1924 to over seven million in 1930, but these labor-saving devices are still lacking in nearly two-thirds of wired homes. Electric irons are even more extensively used, the number of homes equipped with them having about doubled from 1924 to

[73] *Electrical World,* January 7, 1928, p. 32; January 4, 1930, p. 10.

1930, when the number is estimated at 20,000,000. The more elaborate ironing machine (for flat work) has been installed at an annual rate of some 50,000 to 100,000 or more, the number of users increasing from slightly over 200,000 in 1924 to about 680,000 at the close of 1930, but even so only a small proportion of wired homes were equipped with ironing machines.

About one million electric vacuum cleaners were sold each year, and the number of users increased from about 5,000,000 in 1924 to about 9,000,000 in 1930, with some 44 per cent of wired homes equipped. Electric floor polishers were much less common, annual sales numbering about 50,000.

In the six years, 1925–30, some 1,818,000 electric sewing machines were sold, but the electric type is still far outnumbered by the foot-power type.

A small but increasing proportion of wired homes are equipped with electric cookers and ranges (Table 45); and by the close of 1930 there were some 2,625,000 users of electric refrigerators, in about 13 per cent of wired homes. Numerous minor aids to the preparation of food are in use but in a relatively small number of homes. Electric dish washers, for example, were in 1925 used in less than one per cent of urban homes, according to the Women's Club Survey,[74] and total sales, 1925–30, are estimated as only about 57,000.

HEATING

Several recent developments tend to reduce the household labor incidental to heating, notably the introduction of the automatic oil burner, and, to a lesser extent, central steam heating plants, automatic coal stokers, gas furnaces and

[74] Based on mimeographed reports of surveys made under the direction of the Industrial Survey and Research Service for the General Federation of Women's Clubs (Table 51).

electric heating. By 1929 several hundred thousand homes were equipped with oil burners, requiring ordinarily little or no attention from the housekeeper.

Commercial Preparation of Food and Drink

Since for some services in hotels and restaurants personal attention is ordinarily requisite, the extent of mechanization is limited, yet the machine has made substantial inroads upon manual labor. Both light and heavy vacuum cleaners are extensively used in hotels. Dish-washing machines have long been common and more recently dish-drying machines have come upon the market. In the preparation of food various types of mechanical peelers, slicers, dough mixers and fruit-juice extractors are extensively used, particularly in the larger hotels and restaurants. The series for bottle-washing, dough-mixing, dish-washing and vegetable-paring machines in Table 42 suggest some of the lines along which mechanization is proceeding in dairies, hotels and restaurants. Doubtless, considerations of sanitation and of greater certainty of accomplishing the work within time limits, as well as labor saving, are factors in encouraging the use of bottle- and dish-washing machines; and at least some types of vegetable-paring machines are said to be less wasteful of food than hand paring.

Other Mechanical Equipment

We might list innumerable other labor-saving machines in various stages of development. Practically no field of human endeavor is free from the competition of the machine. For example, the electrical integraph, developed in the Massachusetts Institute of Technology, has been described as a 'mechanical mind', which readily makes mathematical

TABLE 8

VALUE OF SELECTED TYPES OF MACHINERY PRODUCED[1]

(unit: $1,000)

TYPE OF EQUIPMENT	*1919*	*1921*	*1923*	*1925*	*1927*	*1929*[3]
Air compressors	18,650	15,729	27,762	29,473	29,319	39,683
Canning machinery	[2]	5,139	9,691	9,766	7,339	8,535
Clothing-pressing machines	[2]	[2]	6,282	8,409	9,078	7,216
Dish-washing machinery	[2]	[2]	1,066	1,474	2,018	3,424
Laundry machinery (for commercial laundries only)	10,801	12,983	19,077	24,198	27,204	28,893
Lawn mowers, power	[2]	[2]	[2]	930	1,979	2,521
Lawn mowers, hand	[2]	[2]	[2]	7,117	7,290	8,432
Machine tools	[2]	[2]	[2]	91,459	105,555	186,061
Milking machine units	[2]	[2]	941	1,118	1,339	1,778
Packaging machines	[2]	[2]	3,484	4,387	5,038	5,757
Sewing machines, household						
Electric	[2]	[2]	[2]	[2]	12,700	16,482
Foot and hand	[2]	[2]	[2]	[2]	9,094	8,613
Sewing machines, industrial						
Electric	[2]	[2]	[2]	[2]	9,607	11,145
Other	[2]	[2]	[2]	[2]	801	857
Slicing machines	[2]	[2]	3,539	4,860	4,680	4,507
Stokers, mechanical	4,280	7,161	14,095	9,420	10,213	14,054
Typesetting machines	[2]	19,650	27,088	23,581	20,077	18,750
Welding machines, electric and other	[2]	[2]	[2]	[2]	7,091	13,583
Vending machines	1,646	2,466	3,777	4,202	7,059	8,821

[1] Compiled from the *Fourteenth Census of the United States,* X, 368–74 for 1919 data; *Census of Manufactures, 1927,* pp. 1081–6, for 1921 and 1923; and *1929,* II, 1098–1102, for 1925, 1927 and 1929 data.

[2] No comparable data available for these years.

[3] Number, in 1929: clothing-pressing machines, 16,602; dish-washing machines, 7,033 (incomplete); power lawn mowers, 16,527; electric sewing machines, 323,474 household type, 113,890 industrial type; mechanical stokers, 8,838 (incomplete).

calculations too complex for the human brain. To enumerate and appraise, even in a sketchy way, the innumerable labor-saving devices in use would require an encyclopedia.

In Table 8 we give the dollar value of the output in recent census years of divers types of machinery which illustrate the many points at which mechanization is proceeding, each of which runs into millions of dollars.

The air compressor, of which nearly $40,000,000 worth was produced in 1929, is the mobile power plant for the ever-increasing variety of pneumatic tools. Canning and dish-washing machinery represent in part direct or indirect substitutions for household labor. Clothing-pressing machines represent, in part, the inroads of the machine in the field of valet service. The power lawn mower is becoming an important factor in the care of large lawns. The annual production of milking machines nearly doubled in value from 1923 to 1929. Mechanical stokers, of both industrial and domestic types, are replacing the hand stoking of boilers and furnaces. In household equipment, the dollar value of electric sewing machines has come to exceed that of foot- and hand-power machines. The electric sewing machine dominates the industrial field. Machine tools, the master tools of manufacturing industry, exceeded $186,000,000 in 1929.[75] Packaging machines, of many ingenious types, are steadily increasing in dollar volume. Some $20,000,000 of typesetting machines are turned out each year. The production of welding machines almost doubled from 1927 to 1929, and they are being employed for an increasing variety of purposes.

[75] The 'machine tools' industry does not, of course, cover all productive machinery but only that part of metal-working machinery which conforms to the definition: "any machine operating other than by hand power which employs a tool for work on metal".