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CHAPTER V

# CHANGES IN MECHANIZATION: HANDLING OF MATERIALS

THE 210,959 establishments listed by the Census as engaged in manufacturing in 1929 are classified into 326 separate industries. Even among the establishments in these separately listed industries there is frequently a wide variation in the kinds of materials utilized and the processing to which the materials are subjected. The result is a bewildering diversity of processing method and equipment, a diversity that makes a reasonably brief description of changes in mechanization and generalizations concerning their nature extremely difficult. There seems little in common between a giant press that can shape a steel ingot, a silk loom that can weave a complex pattern, a machine tool that can cut steel to minutely precise dimensions, and a mill that can grind cement so fine it will pass through a mesh with 40,000 holes to the square inch. The processing operations and the equipment used in processing are in large degree peculiar to each industry. In the immediately preceding chapters we have mentioned some of the major labor-saving developments in processing equipment in important industries, but a detailed recital is impracticable. However, even the most diverse industries have one operation in common—handling. In all it is necessary to move materials from one processing operation to the next.

## Handling Equipment

The equipment involved in handling may be continuous or intermittent in action; operated by gravity or power; used for loading, conveying or unloading; adapted to bulk materials or package goods. One classification distinguishes mobile, semimobile and stationary types.[1] The mobile type includes equipment that has no fixed route of travel and requires no track; for example, the storage-battery industrial truck and the gasoline or electric tractor with trailers. The semimobile type, such as the traveling crane, the ordinary freight elevator and the installed or non-portable conveyor, has a fixed path of travel. The built-in straight or spiral chute for lowering packages or loose materials is the best example of the completely stationary type.

In the section dealing with the labor-saving handling devices found in our field survey, we have relied largely upon a classification by mechanical construction. On that basis we may distinguish locomotive and overhead cranes, derricks, hoists, power dumps on trucks, monorails, industrial locomotives, electric trucks, tractors with trailers, rotary car dumpers, tiering machines, coal-handling towers, conveyors, portable wagon loaders, and so on for a long list.

As we shall note in more detail presently, many of the labor-saving developments in recent years have been in the substitution of mechanical means for hand labor in handling operations. Furthermore, the workers displaced by mechanical handling devices are largely of the unskilled type. Hence it is particularly pertinent that we should (1) indicate the relative importance of handling operations in modern industry, (2) inquire into the proportion of hand and machine labor in these handling operations, and (3)

[1] Statistics of annual sales of mobile types are given in Table 46; of fixed and semimobile types in Table 47.

note the development and extent of use of a few important types of handling equipment. First, however, let us define more fully what is included in the handling processes.

## Definition

Materials handling, or just 'handling' for a shorter term, is moving in contrast to processing. We may conveniently distinguish four phases in handling, although all may not be involved in any given operation: (1) loading or picking up; (2) moving horizontally; (3) elevating or lowering; (4) unloading. These may be performed in handling materials in yard or storeroom prior to the first processing operation, in interprocess movement, or in delivering the finished product to storeroom or common carrier.

Processing, on the other hand, includes grinding, crushing, sawing, cutting, boring, melting, molding, spinning, weaving, dyeing, painting—in short, any operation that changes the nature or form of materials.

Obviously, many operations, in whole or part, lie in a twilight zone between clearly defined instances of processing and handling. This introduces a margin of error into all calculations concerning the relative magnitude of the handling and processing operations in industry. Most processing workers do some incidental handling, and a large element of handling enters into many operations ordinarily considered processing. For example, laying brick is largely a matter of putting brick and mortar in the right position; but although the work of the hod carrier who brings the brick to the point of construction is clearly handling, the reader will probably agree that a common sense classification of operations will designate the work of the bricklayer as processing.

In this chapter we have not attempted to measure or allow

for the incidental handling performed by laborers whose primary work is processing, such as the operation of feeding a processing machine from a nearby pile of material, but have rather listed as employed in handling only those workers who are primarily engaged in moving goods.

## Importance of Materials Handling

The movement of materials constitutes almost the sole function of the industries devoted to the transportation of freight by railway or motor truck and its handling at marine and land terminals. Likewise, the retail coal yard, in its physical operations, is engaged chiefly in loading, moving and unloading coal.[2] Also, the operations and equipment involved in the excavation phase of construction are essentially similar to those in the handling processes in other industries. The narrow trench excavator is a form of the bucket elevator; the power shovel that excavates a basement is merely moving materials; and the construction of a highway consists in large part of the two processes of moving dirt to establish the desired grade, and of delivering the essential paving materials to the point of construction. Finally, intrafactory transportation and other phases of the movement of goods constitutes a large part of the processes of the manufacturing industries, particularly those engaged in heavy manufacturing.[3]

[2] See the brief discussion of these industries in Ch. IV.

[3] One indication of the growing recognition of the importance of the materials-handling phase of manufacturing is the increasing space devoted to articles dealing with the various aspects of the conveying process in magazines that give particular attention to the production aspect of manufacturing. For example, *Industrial Management* (formerly the *Engineering Magazine)* in 1900 devoted less than 2 per cent of its space to materials handling; in 1915, 6 per cent; in 1924, 16 per cent; and in 1926, 19 per cent.

## MAGNITUDE OF HANDLING IN MANUFACTURING OPERATIONS

The magnitude of handling as compared with processing in the manufacturing industries is indicated by the proportion of the labor force engaged in moving materials and of the manufacturing cost constituted by handling. Further evidence is afforded by computations of the actual volume of handling required in selected manufacturing operations. Table 9 gives the percentage distribution, in each of five

TABLE 9

PERCENTAGE DISTRIBUTION OF MACHINE AND HAND WORKERS, IN PROCESSING AND MATERIALS HANDLING, IN PLANTS SELECTED TO REPRESENT DIVERSE TYPES OF MANUFACTURING

*Percentage of total workers exclusive of supervisory workers*[1]

| PLANT | TOTAL PROCESSING AND HANDLING | PROCESSING | | | | HANDLING | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | TOTAL PROCESSING | MACHINE OPERATORS | MACHINE HELPERS | HAND | TOTAL HANDLING | MACHINE OPERATORS | MACHINE HELPERS | HAND |
| Auto body | 100.0 | 95.3 | 22.6 | 0.5 | 72.2 | 4.7 | 0.4 | [2] | 4.3 |
| Tire and tube | 100.0 | 83.5 | 47.5 | 7.4 | 28.6 | 16.5 | 1.9 | 5.4 | 9.2 |
| Steel foundry | 100.0 | 78.4 | 13.6 | 0.6 | 64.2 | 21.6 | 5.4 | 6.6 | 9.6 |
| Machine shop | 100.0 | 88.6 | 76.5 | 0.7 | 11.4 | 11.4 | 7.2 | 4.2 | [2] |
| Hosiery | 100.0 | 96.5 | 58.5 | 5.3 | 32.7 | 3.5 | [2] | [2] | 3.5 |
| Five plants combined | 100.0 | 91.3 | 36.5 | 2.9 | 52.0 | 8.7 | 1.4 | 1.9 | 5.4 |

[1] The total number of workers in these plants, with the exception of a few departments that could not be classified on the basis used in this computation, was 7,215, of whom 373 were reported as foremen, assistant foremen and similar supervisory workers. These supervisory workmen were excluded in computing the percentage distributions, inasmuch as they are associated with both the processing and handling phases in indeterminable proportions; hence the distribution applies to 6,842 workers. These data were obtained in 1926.

[2] Less than one-tenth of one per cent.

plants selected to represent industries of diverse types, of the workers engaged in processing and in handling; it also indicates whether they are manual workers or machine operators or helpers.

The percentage of total factory workers, exclusive of supervisory and office workers, engaged in handling varies from as low as 3.5 in the hosiery mill, which is very light manufacturing, to about 22 in the steel foundry, which is engaged in the production of heavy castings. For all five plants combined it is 8.7 per cent. The small proportion in the automobile-body plant, a relatively heavy type of manufacturing, arises in part at least from the use of power conveyors in some stages of assembly and painting. The writer believes these percentages are to some extent underestimates of handling in that they do not allow for the fact that in almost all manufacturing many process workers do some handling. For example, in one shoe plant inspected by the writer, a large part of the handling was done by the processing operators. When their particular operation on a group of shoes was completed they put them on special wheeled racks and pushed them to the location for the next operation.

Less than half of the workers assignable to handling in these five plants were machine operators or helpers. In the hosiery plant, as is quite common in light manufacturing, all the handling workers were manual rather than machine workers.

For a few of the pulp and paper mills included in our field survey we were able to ascertain the proportion of workers engaged in handling in yard and storeroom, shipping and conveying between processes. In 4 pulp-making plants 25 per cent of the workers were engaged in handling; in 4 paper-making plants, 22 per cent.

Somewhat more detailed evidence of the importance of

handling in heavy manufacturing industries is illustrated by special studies which we made of the volume of handling operations in foundries and brick plants.

*Volume of handling in foundries*

In a heavy industry like the manufacture of metal castings the lifting and moving of materials constitutes a substantial part of all the work. In 81 foundries inspected in 1925, we found 16 to 17 per cent of the workers engaged in occupations that were primarily handling. In a sample of 20 of these foundries, employing from 50 to 150 men each, 143 tons of pig iron and scrap, 24 tons of coke and 33 tons of new sand were used for each 100 tons of good castings produced. The average handling for each ton of good castings was equivalent to moving one ton of material 763 feet. These computations do not include the yard handling of materials prior to delivery to storage, the hauling of ashes and cupola droppings to distant points outside the factory grounds, or some minor movements such as the handling of limestone. However, they do include most of the handling within the foundry.

Machinery was used to some extent in each of the several handlings, the most highly mechanized movement being the transference of molten metal from the cupola to the molds. For all operations combined, 32 per cent, or nearly a third of the total handling, was by manual methods.

The several movements which make up the total of 763 ton-feet (68) are as follows, the figures in parentheses indicating the percentage handled by machine methods: coke, coal, pig iron and scrap from storage to cupolas and furnaces, 145 ton-feet (51); the disposal of ashes, burnt sand and cupola droppings, 107 ton-feet (43); sand to molds, core room and cleaning room, 45 ton-feet (44); molten metal from cupola to molds, 124 ton-feet (93); castings from molds

to cleaning, 144 ton-feet (68); castings from cleaning through storage to shipping, 198 ton-feet (98).

Although these computations apply only to a group of foundries of medium size and rest upon original data that were necessarily approximations, they afford a striking illustration of the large amount of heavy handling required in foundry operations.

*Volume of handling in brick plants*

The manufacture of common brick is another industry with a large volume of handling. For 45 common brick plants our field inspectors obtained data on the capacity of the plant, the distance material was transported while undergoing the manufacturing process, and the methods of transportation. The results are tabulated in Table 10, in both absolute and percentage terms. The first columns of the table give the aggregate distance traversed regardless of the volume of brick handled. Then follow summations of the products obtained by multiplying the distance transported by the daily capacity of the respective plants, to allow for appreciable differences in the methods used in the small and large plants.

The aggregate distance covered in interprocess handling in these 45 plants was 20,061 feet. Haulage from clay pit to preparation plant is not included. When each plant operated at normal capacity, each brick, or the clay from which it was made, was moved, after the clay had reached the preparation plant, about 475 feet on the average.

Much of this handling was manual. True, in 7 of the 45 plants no bricks were transported by wheelbarrow, but in the majority manual methods of transportation were extensively used and the bricks were loaded or unloaded some six or more times by hand. The handling was by wheelbarrows

for 31 per cent of the aggregate distance, by cars on tracks (either propelled by hand or moved by gravity) for 20 per cent, and by power methods for slightly less than half. Even when allowance is made for the volume of brick handled as well as for distance, over a quarter of this transportation was by wheelbarrows and only slightly over half by power methods of any kind.

An allowance for differences in the weight of brick in the several stages of manufacture would reduce somewhat the percentage of the total handling attributed to manual methods, as the processes are more highly mechanized in the earlier stages, and in these stages the brick contain more water and are some 20 per cent heavier than when dried and burned.

The least mechanized plants operated on the whole fewer months in the year than the more highly mechanized. Hence the proportion of the annual output handled by mechanized methods is greater than as estimated above on the basis of daily capacity. A computation based upon the reported total production in 1924 in these 45 plants indicates that 24.7 per cent of the annual aggregate interprocess transportation was by wheelbarrow, 19.6 per cent by cars on tracks, and 55.7 per cent by power methods. Even with this adjustment, it is evident that a very substantial part of the handling in this group of brick plants was by manual methods.

*Ratio of handling expense to payroll*

Handling expense constitutes a substantial part of total manufacturing cost. Some clue to this ratio is afforded by a survey made for *Factory* by the A. C. Nielsen Company.[4]

[4] Reported in *Factory*, August 1925, pp. 183–92, 224–72, 276–80.

TABLE 10

DEGREE OF MECHANIZATION IN INTERPROCESS TRANSPORTATION OF BRICK

*Proportion of work done by specified methods in 45 common brick plants when operated at capacity*

*I. HANDLING IN SPECIFIED MOVEMENTS*

| MOVEMENT | DISTANCE TRANSPORTED (FEET) | | | | DISTANCE MULTIPLIED BY DAILY CAPACITY (MILLION BRICK-FEET) | | | |
|---|---|---|---|---|---|---|---|---|
| | ALL METHODS | BARROW | CAR | POWER | ALL METHODS | BARROW | CAR | POWER |
| All movements | 20,061 | 6,240 | 4,049 | 9,772 | 1,413 | 368 | 266 | 779 |
| Preparation plant to molding machine[1] | 1,836 | 75 | ... | 1,761 | 114 | 3 | ... | 111 |
| Molding machine to dryer | 10,146 | 1,655 | 1,795 | 6,696 | 710 | 73 | 110 | 527 |
| Dryer to kilns | 5,324 | 2,715 | 1,629 | 980 | 386 | 155 | 127 | 104 |
| Kilns to storage and carrier | 2,755 | 1,795 | 625 | 335 | 203 | 137 | 29 | 37 |

One or more departments in 39 plants in various industries and cities were surveyed for cost figures, and the ratio between handling expense and payroll computed. Handling costs were shown to range from 5 to as much as 80 per cent of payroll, the average being 21.8 per cent, and for the majority of the departments surveyed the range was from 10 to 40 per cent. The plants selected had good conveying systems and it seems probable that the expense ratio would be even higher for the general run of establishments.

### PROPORTION OF LABOR-SAVING CHANGES CLASSIFIABLE AS HANDLING

Of 695 labor-saving changes upon which information was obtained in our survey, 40 per cent were in handling; and

TABLE 10 (*cont.*)

DEGREE OF MECHANIZATION IN INTERPROCESS TRANSPORTATION OF BRICK

*Proportion of work done by specified methods in 45 common brick plants when operated at capacity*

*II. PERCENTAGE DISTRIBUTION OF HANDLING*

| Distance Transported (per cent) | | | | Distance Multiplied by Daily Capacity (per cent) | | | | Movement |
|---|---|---|---|---|---|---|---|---|
| All methods | Barrow | Car | Power | All methods | Barrow | Car | Power | |
| 100.0 | 31.1 | 20.2 | 48.7 | 100.0 | 26.0 | 18.8 | 55.1 | All movements |
| 100.0 | 4.1 | ... | 95.9 | 100.0 | 2.5 | ... | 97.5 | Preparation plant to molding machine[1] |
| 100.0 | 16.3 | 17.7 | 66.0 | 100.0 | 10.3 | 15.5 | 74.2 | Molding machine to dryer |
| 100.0 | 51.0 | 30.6 | 18.4 | 100.0 | 40.2 | 32.9 | 26.9 | Dryer to kilns |
| 100.0 | 65.2 | 22.7 | 12.1 | 100.0 | 67.6 | 14.4 | 18.0 | Kilns to storage and carrier |

[1] Including movements from dump to preparation plant, if materials when hauled from pit are unloaded to dump rather than to the first preparation machine.

of 332 instances which we abstracted from various technical journals in the years following 1920, 63 per cent. Judging from these data, about half of the labor-saving changes in this period were in handling rather than processing operations. Quite possibly the improvements in handling were more fully reported than those in processing, but even allowing for possible exaggeration, it would seem clear that improvements in handling have been a very important factor in recent gains in industrial efficiency.

## Reported Labor-Saving Changes in Handling

Labor-saving changes in handling equipment since 192 to the number of 282 were reported to our inspectors i 1925 or given in reply to inquiries by mail in 1928. Addition to or modifications in semimobile equipment, such as ir stalled conveyors, cranes, hoists, monorails, cable hauls an industrial railways numbered 158. Changes affecting mobil handling equipment, such as electric trucks and tractors portable loaders and motor trucks, numbered 92. In a doze instances the reported labor saving in handling consiste merely of rerouting and rearrangement of machines. Th nature of the reported changes in each of these groups i briefly analyzed in the following paragraphs, except that th analysis of labor-saving changes arising from the introductio of electric trucks and tractors is deferred to the more genera discussion of these devices in a later section of this chapte

### REDUCTION IN THE VOLUME OF HANDLING

One marked tendency in the modern movement for greate industrial efficiency is the effort to reduce handling throug the rearrangement of equipment and processes to provid straight-line flow. The serialization of machines and processe reduces interprocess handling to a minimum and in its mor highly developed form provides for continuous assembling o processing on conveyor belts. Such reduction of handling b rerouting may conceivably be accomplished with no chang in the handling equipment, but it is more likely to be ac companied by the addition of conveyors or some other han dling device.

In a dozen instances the savings reported were ascribed t rerouting or rearrangement of machines. The centralizatio of finishing departments in one paper mill eliminated muc

handling and speeded up production by 30 per cent; another paper mill reduced its labor force by 30 men by a change in executives and some rearrangement of machinery; another cut the force by 75 men, chiefly by rearrangement and rerouting, increasing output at the same time about 10 per cent; the newer processes in tire manufacturing were reported to have eliminated much handling between operations; one furniture plant reported gains from a new plant with "no back-tracking", and another from "realignment of machines to save back-tracking"; a small copper rolling mill estimated a 50 per cent reduction in labor requirements from a reorganization of its processes; productivity gains of 15 per cent were reported by two foundries as resulting from new layouts; and minor gains of similar nature were reported by roofing, cotton manufacture, and brick plants.

A closer vertical integration of industries tends to reduce the handling required. For example, it is becoming an increasingly common practice for steel works to use pig iron in the molten state direct from the blast furnaces.[5]

### PROGRESSIVE-ASSEMBLY CONVEYORS

An important labor-saving handling device is the continuous conveyor used in the progressive-assembly method made famous by the Ford Model-T assembly belt and extensively used in automobile, tire and other industries. It is not exactly a new type. A forerunner of the modern continuous conveyor is the intermittently moving platform for conveying foundry molds from process to process. One of these has been in use for thirty years or more in a Pennsylvania foundry

[5] See Ch. III, section on the steel and iron industry. The reduction in handling labor that arises when goods are shipped in bulk rather than in packages, thus eliminating the filling and emptying of containers, may also be mentioned.

inspected by us. The progressive-assembly conveyor makes possible the performance of mechanical operations on materials while in transit from one point to another. Each occupation occupies an allotted space along the conveyor, in logical sequence, the direction of travel being towards the point of shipment or assembly into larger units.

The progressive conveyor is an important factor in much of modern mass production. It is used for assembly, and less frequently, for other processing sequences. For example, bricks are sometimes moved through the dryer, or castings through annealing ovens, on continuous slow-motion conveyors.

It will be readily understood that ordinarily the most effective organization of the handling work in a factory or other establishment will involve, not the exclusive use of a single type of equipment, but rather a carefully planned combination of several types, the particular combination depending upon the amount and type of material to be handled, the vertical and horizontal distance to be moved, the available space, width of doors, etc. Intermittent handling of small quantities through narrow aisles may be best done by special hand trucks; a steady stream of material over a fixed route, by a continuous conveyor or elevator; heavy loads over variable routes, by industrial truck and tractor and trailer; heavy loads over routes with a fixed range of variation, by the overhead traveling crane.

The instances of labor saving through the installation or remodeling of conveyor systems since 1920 number 105 and cover a wide variety of types. Seven were adoptions of progressive assembly or fabrication, all from a small group of informants in the automobile and tire industries. They cover the assembly of engines and bodies, the movement of bodies during the painting operation, the conveying of semifinished inner tubes through the finishing fabrication steps, and

gravity conveyor system for the mixing boxes used in assembling the ingredients for tire rubber stock. They replace systems of individual stands with intermovement by hand trucks or of building bodies by small groups where all material had to be moved to the body. One such change increased crew output about 300 per cent; another reduced the required crew 20 per cent; another, the number in the crew from 112 to 90; another, from 29 to 18.

### OTHER CONVEYORS AND CONVEYING SYSTEMS

In addition to the above-noted changes clearly identifiable as transitions from discontinuous to continuous fabrication or assembly, the reported savings included 98 other instances accomplished by the introduction or alteration of conveyors or conveying systems, many of these doubtless facilitating continuous assembly or fabrication. Both the types of conveyor and the industries represented are highly diverse and illustrate the versatility of this type of handling equipment. The products handled include such heavy manufactures as foundry castings, brick, coal, automobile bodies, paper rolls and smelting materials; such relatively light manufactures as shoes, butter and small electrical goods, bulk goods like coal, large units like automobiles, meat carcasses in process of disassembly, porcelain products passing through kilns, and packaged goods like soap and butter from the packaging machines.

About half of the instances reported were from the foundry industry, indicating the adaptability of the conveying device to this industry; however, this large proportion is not to be taken as representative of the use of conveyors in foundries as compared with other industries, for it is partly due to the relatively large portion of our total survey represented by foundries, and particularly by one or two large

and well-equipped automobile foundries, which made numerous labor-saving changes in their conveying systems in the period covered by the survey.

### CRANES AND HOISTS, AND MONORAILS

Relatively speaking, the devices in this group (consisting chiefly of electric and gasoline hoists, monorails and hot-metal carriers, overhead traveling cranes, and other types of installed or semimobile cranes and hoists) are not recent innovations in equipment. Nevertheless, some 45 instances of labor saving by their adoption were reported since 1920, chiefly in the foundry, building, coal-handling and machinery industries; that is, in industries requiring the handling of heavy materials. In most instances the reduction in crew reported is not large. Exceptions are a reduction from 30 to 5 men in a paper mill by installation of 3 boom grab-bucket cranes, over a period of years beginning before 1920, and a brass goods manufacturer who reported power hoists as enabling 30 men to do work formerly requiring 120. On the whole, the larger savings occur where the equipment is directly substituted for hand methods. In the hoist installations in building construction the substitution of electric hoists for steam were usually reported as saving one man, but a contractor who reported direct substitution of gasoline hoists for hod carriers states that this type of hoist displaced from 3 to 10 men, depending upon the height to which material was hoisted. Cupola-charging devices are a relatively new development. The 2 included in this compilation were stated to save 4 men each.

### INDUSTRIAL LOCOMOTIVES

Labor saving through the introduction of industrial locomotives or cable hauls were not of major importance in the establishments included in our survey. These are not new devices, half of the changes reported being prior to 1921, many of them in 1918. Of the 8 since 1920, 6 are substitutions for horses or mules. The crew reductions were not large. For example, a reduction of 2 men in a brick yard, with the introduction of a new type of locomotive; the reduction of a haulage crew from 5 to 4 in one bituminous mine, and in another from 25 to 18 men and the elimination of 25 mules.

### TRUCK HAULAGE AND CENTRAL PROPORTIONING

The change in the handling of materials in highway construction, from wagon haulage and wheelbarrow proportioning on the subgrade to central proportioning and truck haulage, began before 1921, and most of the instances reported to us occurred in 1919 and 1920, or in the years immediately following 1920 (*cf.* Ch. IV). The labor saved was substantial, usually about 60 per cent of the handling crew. Twelve instances reported involved reductions in crew of 161 men, or about 13 men per crew. If additional allowance is made for stated increases in yardage per crew, the reduction becomes equivalent to 17 men per crew.

Aside from a few instances of hauling around factories and uses in construction other than those included in the above paragraph, the reported labor-saving changes arising from the use of motor trucks were in retail coal yards, chiefly anthracite yards in New York City.

PORTABLE LOADER AND MISCELLANEOUS CHANGES

Among the important savers of unskilled shoveling labo should be mentioned the various types of portable wago loader, used chiefly for loading bulk materials, such as snov coal, sand or gravel, from a ground pile to wagon or truck The coal-car loader for use in mines is a variation of grea potential significance.[7] Portable loaders are usually of th continuous inclined bucket elevator type. The elevatin conveyor often dumps to a transverse conveyor or a chut from which the material is discharged to the wagon. If th frame, which carries the elevating element, is mounted o wheels, the unit must be trundled from place to place b hand; if it is mounted on a caterpillar tread, the unit propel itself. The most highly developed types are self-propelled self-feeding units. If the unit is not self-feeding, the materia is shoveled by hand to a hopper whence it flows to th buckets or belt. The self-feeding types have some sort o apparatus at the lower end—rotating blades, revolving disk etc.—which gathers the material from the pile.

Of the labor savings reported directly to us only a fe were ascribed to the adoption of portable loaders. On retail coal yard reported the saving of 2 men through thei adoption; another reduced its yard crew from 4 men to by "portable scoop electric loaders replacing hand shovelin from ground storage, with additional saving in the time o trucks."

The remaining miscellaneous group of handling change reported to us (some 20 in number) included pulp pump for a paper mill; hand-power lift trucks substituted fo

[6] For use in retail coal handling, see Ch. IV.

[7] See Ch. IV; also Table 40, for statistics of bituminous coal loaded wit self-feeding loading devices; Table 46, for annual sales of self-feeding wago loaders; and Table 52 for rough estimates of extent of use.

wheelbarrows; a mechanical litharge handling system in a paint factory, to avoid the hazard of lead poisoning involved in hand shoveling; a revolving car dumper in place of bottom-dump cars, reducing the crew required from 36 to 6 men; storage silos with gravity delivery of cement, in place of storage bins, reducing the evacuating crew from 61 to 6; and various other changes in handling methods or equipment.

### ELECTRIC TRUCKS AND TRACTORS [8]

Labor savings through the purchase of industrial electric trucks or tractors since 1920 were reported by 38 establishments, in widely diverse industries, including the foundry, automobile, cotton, stevedoring, smelting and refining, machinery, building tile, paper, brass, lumber and canned fruit. In about four-fifths of the reported changes the truck or tractor displaced carrying by hand or transportation with hand trucks.

Information on the number of trucks installed and the size of the crew before and after the change is not complete for all instances reported. A compilation based on 10 installations of tractors gives a crew reduction of 5 men per

[8] This class of equipment, aptly described as 'trackless transportation', is primarily for use inside buildings, in factory yards, or at marine and railway terminals. Industrial trucks, aside from various hand types, are self-propelled machines that carry their load. Gasoline engines or electric storage batteries furnish the power. The major types are (1) the non-lift platform truck; (2) the low-lift type; (3) the high-lift or tiering type; and (4) trucks equipped with cranes and other special apparatus. The low-lift type has a low platform or other carrying device which is run under loaded skids, then raised by the motor, and the skid and load transported to the delivery point. This method saves handling and also the time of the truck as skids can be loaded while the truck is busy elsewhere. In the high-lift or tiering type the movable platform may be elevated six feet or more for unloading to auto trucks or freight cars and for piling. The industrial tractor hauls its load in a train of trailers.

tractor; and 80 electric trucks, in 13 plants, reduced the crews involved from 336 to 112 men, or a saving of about 2.8 men per truck. This includes a few instances where part of the installations were made prior to 1921, and the effect of these earlier installations cannot be isolated from those made since 1920.

To what extent are the tendencies indicated by the analysis of reported labor-saving changes in the preceding pages representative of prevailing trends in industry as a whole? The data requisite for an answer to this question are most complete for electric trucks and tractors.

Railroad and marine terminals were at first the largest users of electric industrial trucks, but the metal products manufacturers and the automotive industry have now stepped into that position. Also, as is shown in Table 11, there is a

TABLE 11

ELECTRIC TRUCKS AND TRACTORS IN USE, 1920 AND 1928: BY INDUSTRIES [1]

| INDUSTRY IN WHICH USED | PRIOR TO 1920 | JUNE 1928 | INCREASE |
|---|---|---|---|
| Total number classified | 4,547 | 14,289 | 9,742 |
| Metal product manufacturers | 1,128 | 2,994 | 1,866 |
| Freight, marine and railroad | 771 | 2,580 | 1,809 |
| Automobile manufacturers | 391 | 1,749 | 1,358 |
| Iron and steel mills | 151 | 969 | 818 |
| Foundries | 143 | 917 | 774 |
| Food manufacturers | 188 | 678 | 490 |
| Chemical manufacturers | 251 | 639 | 388 |
| Ceramic manufacturers | 80 | 504 | 424 |
| Warehouses (public) | 273 | 426 | 153 |
| Textile manufacturers | 140 | 349 | 209 |
| Pulp and paper manufacturers | 35 | 346 | 311 |
| Printing and publishing | 6 | 103 | 97 |
| Jobbers and wholesalers | 2 | 39 | 37 |
| Miscellaneous | 988 | 1,996 | 1,008 |

[1] Based upon typed report made available for our use by C. B. Crockett, Secretary, Industrial Truck Association, January 29, 1930.

tendency towards extensive use of this equipment in such industries as foods, chemicals, ceramics, and pulp and paper.

The variety of uses to which electric trucks are put is indicated by the following estimate made available by the courtesy of Mr. C. B. Crockett, Secretary of the Industrial Truck Association. The percentages refer to the proportion of users which employs the trucks in the specified operation.

| OPERATION | PER CENT |
|---|---|
| Raw material from common carriers | 13 |
| Raw material from storage | 10 |
| Material moving through process | 11 |
| Material moving through assembly | 8 |
| Finished material from assembly | 10 |
| Finished material from packing | 8 |
| Finished material from storage to common carrier | 17 |
| Supplies from storage to process | 17 |
| Machines or parts to and from use | 18 |
| Millwright and repairs | 21 |
| Miscellaneous services | 17 |

Battery-driven trucks first appeared in 1904 at the Altoona shops of the Pennsylvania Railroad and were introduced in railway station use about 1906. These were the load-carrying, fixed-platform type. About 1913 the tractor and the low-lift type appeared. In 1915 the crane-equipped type came on the market and shortly afterwards the high-lift or tiering models.

The number of electric industrial trucks and tractors sold in the United States each year is given in Table 46. After 1916 the annual sales were between 1,000 and 2,000 in all but 3 years. For the first few years the distribution by years is only a rough approximation; for the second period, 1914–24 inclusive, the estimates are based upon sales data furnished by leading producers who manufactured about 60 per cent of the total number sold in the United States in 1925. The estimates for 1914–24, however, are not merely

TABLE 12

ELECTRIC TRUCKS AND TRACTORS IN USE, 1920 AND 1928: BY TYPES[1]

| TYPE | PRIOR TO 1920 | JUNE 1928 | INCREASE |
|---|---|---|---|
| Total number | 4,790 | 14,103 | 9,313 |
| Load-carrying | 2,508 | 4,188 | 1,680 |
| Low-lift standard | 1,206 | 4,560 | 3,354 |
| Low-lift special | 3 | 519 | 516 |
| High-lift standard | 62 | 1,203 | 1,141 |
| High-lift special | 6 | 414 | 408 |
| Crane trucks | 77 | 909 | 832 |
| Tractors | 926 | 2,133 | 1,207 |
| Others | 2 | 177 | 175 |

[1] Based upon typed report made available for our use by C. B. Crockett, Secretary, Industrial Truck Association, January 29, 1930.

for the sales of the companies furnishing data but for all producers and are based upon the assumption that the ratio between the sales of these companies and the sales of all producers did not change materially throughout this period.

The total sales from 1914 to 1929, as estimated in Table 46, are 17,995, and a few hundred machines were sold prior to 1914. As these machines are relatively durable, the majority of those sold are probably still in use. In Table 12 we submit estimates that 4,790 units were sold prior to 1920 and 14,103 were in use in June 1928.

The later models are on the whole larger, heavier, and often more specialized; hence the data on numbers alone, as in Table 46, somewhat underestimate the recent rate of introduction.

Since the sharp decline of 1921, the annual additions were relatively steady, although some truck manufacturers estimated in the latter part of the decade that scarcely half of those who could profitably use the types now developed were doing so; furthermore, the tendency is to widen their sphere

of use by the development of types specialized for particular uses.

### OTHER HANDLING DEVICES

For handling devices other than electric trucks and tractors the available data are less detailed and comprehensive. The annual output of conveyors, cranes, power shovels and trench excavators, respectively, runs into millions of dollars, as will

TABLE 13

VALUE OF SELECTED TYPES OF HANDLING EQUIPMENT PRODUCED [1]

*(unit: $1,000)*

| TYPE OF EQUIPMENT | *1925* | *1927* | *1929* |
|---|---|---|---|
| Conveying and elevating machinery [2] | | | |
| All types | 30,688 | 33,528 | 48,537 |
| Belt | [3] | 10,520 | 14,206 |
| Bucket | [3] | 10,726 | 9,387 |
| Gravity | [3] | [3] | 2,711 |
| Pneumatic | [3] | [3] | 1,780 |
| Other | [3] | 12,282 | 20,454 |
| Cranes (including hoists and derricks), total [2] | 43,936 | 44,454 | 57,840 |
| Locomotive and crawler types | 13,162 | 13,506 | 12,579 |
| Crawler type | [3] | [3] | 6,626 |
| Stationary | 11,601 | 12,340 | 22,202 |
| Overhead traveling | 19,173 | 18,607 | 23,059 |
| Excavating machinery, total | 41,389 | 48,098 | 57,103 |
| Power shovels [2] | 26,609 | 32,106 | 43,348 |
| Trench excavators | 3,130 | 3,512 | 2,427 |
| Drag lines and power scrapers | 9,006 | 8,830 | 7,242 |
| Other | 2,644 | 3,651 | 4,086 |

[1] Compiled from *Census of Manufactures, 1925,* p. 1031, and *1929,* II, 1098–1100.

[2] Similar data for earlier years (in thousands of dollars) are:
(1) all types of conveying machinery, 1923, 26,303;
(2) cranes, 1921, 20,446; 1923, 42,197;
(3) power shovels, 1921, 12,858; 1923, 23,684.

[3] No comparable data available for these years.

be seen from the statistics of value of output in the census years 1925, 1927 and 1929, presented in Table 13.

For part, but not all, of the machine types included in Table 13, the number as well as the value is reported, and by assuming that the average value per machine is the same whether the number is reported or not, we arrive at the following estimates of the number of machines produced in 1929: 2,400 crawler cranes, 390 locomotive cranes, 15,700 overhead traveling cranes, 80,700 stationary cranes, 35,500 power shovels, 2,900 drag lines and power scrapers, and 360 trench excavators. The last-mentioned types are excavating machines and not strictly speaking handling equipment; but there is a rather close kinship between, for example, a trench excavator of the bucket type and a bucket elevator for handling grain.[9]

## Extent of Use

In Table 52, we have assembled the available, but admittedly heterogeneous, information concerning the extent to which various mobile types of handling equipment had been sold or were in use at the time stated. For most types the information available is not as complete as that for electric trucks and tractors, hence in using these data the reader is cautioned to note the date or period to which the estimate applies and the type of information upon which it is based as indicated by the code at the beginning of Appendix B. We have not hesitated to use approximations with quite a wide margin of possible error when no better information was at hand, believing that even such approximations are useful in an effort to give as full a picture as possible of the growth and extent of mechanization. Similar

[9] See also Table 41 for sales of power shovels and narrow trenchers.

estimates for fixed and semimobile types of handling equipment appear in Table 52.

## Effects of Mechanizing Handling Devices

The increased regimentation of factory procedure that ordinarily accompanies a thoroughgoing and well-conceived mechanization of the handling operations facilitates the subdivision of processing, frequently saves working space, and expedites and cheapens production. It tends to decrease the demand for unskilled labor, both absolutely and relatively, because mechanization not only reduces the number of workers required in handling but also tends to substitute some semiskilled and skilled workers for unskilled. Manual methods of handling, as we have seen, are almost entirely by unskilled workers; but the operation of mechanical handling equipment demands, on the whole, a somewhat higher degree of skill and more repair men; also some skilled men in the construction of machines.[10] Concerning the total constructive displacement of workers by the handling equipment introduced in the decade of the 'twenties we have made one or two estimates for particular types of machine, but any estimate for the total of all types would be almost a pure guess (see Ch. X). Doubtless the man-power equivalent of the total installations runs into hundreds of thousands. To what extent this equipment actually displaced men and to what extent it merely accompanied an expansion in the volume of business is highly problematical.

## Summary

Handling operations, though more or less common to all industries, require, so far as the available evidence indicates,

[10] See discussion of the effect of mechanization on skill in Ch. X.

from only a few per cent of the total number of workers i some of the light manufacturing industries to 20 per cen or more in some of the heavy manufacturing industries, an to a much larger percentage in the industries primaril devoted to the transportation of goods.

Much of this handling work is manual. We found nearl a third of the heavy volume of handling in a group of 2 foundries to be manual, and in a group of brick plant nearly half of the interprocess transportation of brick wa by manual methods.

Here is obviously a large field for possible further mech anization. We find evidence not only of a growing recognitio of this fact but also of an advance in mechanization throug the development of new types of equipment and more ex tensive use of older types.

Interprocess handling has long been thoroughly mech anized in such industries as flour and meat packing. Mech anization of handling has more recently made marke progress in the rapidly growing industries such as automo biles and tires. A substantial beginning has been made i the better equipped plants in some of the older industrie like foundries, and a start has been made in the mechaniza tion of the loading process in mines. However, from th literature of the subject, from interviews with sellers an users of equipment, and from pondering over the availabl statistics, the writer has gained the impression that there still a large field for the gradual replacement of manual wit mechanical methods in the handling operations of factorie and mines, and even in the handling industries proper, suc as stevedoring.