THE PRINCIPLES OF INDUSTRIAL MANAGEMENT

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THIS BOOK IS DEDICATED
TO ITS TWO
MOST INTERESTED WELL-WISHERS—
MY PARENTS

PREFACE

THE writer has long felt the need of a scientific treatment of industrial management. Hundreds of young men are now in our schools and colleges intending to engage in the world of affairs, and it is exceedingly important that they gain a clear conception of the principles underlying the successful conduct of industrial enterprises.

The material in this book is gathered from many sources. Merely to mention the people to whom the author is indebted for data within these covers would fill several pages with names. The writer has endeavored to give full credit in the text for the drawings, plates, and diagrams, and, unless accidentally overlooked, all books and articles from which he has received assistance have been cited. In the text, however, there is no mention of his obligations to Judge Elbert H. Gary and Mr. Richard Trimble, of the United States Steel Corporation, to Mr. Wm. Laughlin, of Armour and Company, Mr. H. C. Folger, Jr., of the Standard Oil Company, Mr. E. Collins, Jr., of the Sauquoit Silk Manufacturing Company, Mr. L. A. Osborne, Vice-President of the Westinghouse Electric and Manufacturing Company, and Mr. H. E. Neise, of the American Sugar Refining Company; so he takes this opportunity to thank them for their many favors. He is further indebted to his colleagues in the departments of Economics and Engineering of the University of Illinois, to his former associates at the University of Pennsylvania and Ohio State University. Professors E. H. Waldo and E. L. Bogart, his colleagues at the University of Illinois, have been very helpful; the former read all the chapters pertaining to the engineering matters, in addition to many of the others. Professor Emory R. Johnson, his former teacher at Pennsylvania, read the entire manuscript, and made many improvements in style and expression. This paragraph would be incomplete without special mention of his sister, to whom the writer is indebted for the work of preparing the manuscript for the printer. In addition to that onerous task she has given many suggestions as to form, expression, and selection of contents, which have been of very great assistance.

In registering his thanks, however, the writer does not wish to have anyone but himself blamed for any deficiencies which exist in the volume, as the plan and treatment are his own.

It is his hope that the book will be of service to the students of accountancy as well as to those of general business. The accountant should have knowledge of more than the mere methods of making entries in books and the drafting of financial statements therefrom. He should be able to appreciate the kind of information which the management needs, and the extent to which accounting records can gather the various types of information. The book is written to give both the accountant and the general student of business a brief presentation of the underlying principles of the science of management.

In teaching the subject the writer has found it exceedingly helpful to the instructor and profitable to the student to have frequent visits to modern plants and then have carefully written reports presented which discuss those factors which contribute to the success of the enterprise or tend to its failure. Such trips should be made with the teacher or with some competent guide, and may well be made the basis of interesting class-room discussion.

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PART ONE

THE ECONOMIC ENVIRONMENT

CHAPTER I

THE PROBLEMS

INDUSTRIAL plants and business houses of various kinds grow and decay. Industries prosper in some sections of the country, while in others they have either failed or are living a miserable existence. The census reports at times show certain territory having a most remarkable development in production which a decade before was unknown in the manufacturing world. Within the same area industries pass from one set of owners to another. Frequently within a generation, unknown workmen advance to the proprietorships of plants. Great establishments, whose positions were once impregnable and whose influences were enormous, have lived to see their power pass to other concerns prospering under different regimes.

Why do industries move from one section of the country to another? Why is it that firms in the section wherein the industries are located rise and frequently fail after having built up a large business and established a national or even world-wide reputation?

The prosperity of an enterprise depends in general upon four factors:

1. The economic environment.
2. The equipment of the plant.
3. The organization and management of the plant.
4. The selling department.

The economic environment provides convenient situations which make possible the cheap production and profitable disposal of the goods.

The equipment of the plant provides shelter for the employees and the tools, and also supplies mechanical means by which the raw materials can be changed into salable products.

On the organization and management of the plant depend the owners' ability to utilize to the best advantage their raw materials and the time of the men they employ.

The selling department makes an outlet for the goods.

The successful running of a concern resolves itself into ten problems:

1. Where shall the plant be located?
2. To what extent shall the business be integrated and concentrated?
3. To what extent shall the enterprise be specialized?
4. How shall the plant be built?
5. What form of power shall be employed to run the plant?
6. What shall be the basis of its internal organization?
7. How shall the labor force be handled?
8. How shall the raw materials be treated?
9. How shall we determine the efficiency of our equipment?
10. How shall the goods be distributed to the consumer?

This volume will confine itself to the discussion of the industrial problems, hence it will consider only the first nine of the above questions. The tenth is so important that it can be adequately handled only by making it the special topic of another treatise.

CHAPTER II

GENERAL THEORY OF INDUSTRIAL LOCATION

The census report of 1905 shows that the United States in that year produced nearly $15,000,000,000 worth of manufactured goods.[1] If we tabulate the fifteen most productive states in the order of their rank, we find that they arrange themselves as follows:

Rank.	*State.*	*Value of Products.*
1	New York	$2,488,345,579
2	Pennsylvania	1,955,551,332
3	Illinois	1,410,342,129
4	Massachusetts	1,124,092,051
5	Ohio	960,811,857
6	New Jersey	774,369,025
7	Missouri	439,548,957
8	Michigan	429,120,060
9	Wisconsin	$411,139,681
10	Indiana	393,954,405
11	Connecticut	369,082,091
12	California	367,218,494
13	Minnesota	307,858,073
14	Maryland	243,375,996
15	Rhode Island	202,109,583
	Total for 15 States	$11,876,919,313

If we exclude California and Missouri from the list, we find that the total productivity is reduced by little more than $800,000,000, and that three fourths of the entire manufactured goods in the United States are made within states having a total area of less than 450,000 square miles, less than one seventh of the entire area of the United States, excluding our insular possessions.

If we make an analysis by industrial districts, the fact is brought out still more prominently, as shown by the following table.

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[1] *Statistical Abstract of the United States,* 1909, pp. 192, 193.

AREA, POPULATION AND VALUE OF MANUFACTURING PRODUCTS FOR THIRTEEN SELECTED INDUSTRIAL DISTRICTS, 1905.[1]

Industrial District.	Area in Sq. Miles.	Population.	Value of Products.
New York[2]	702	5,294,682	$2,144,488,093
Chicago	500	2,116,000[3]	970,974,280
Philadelphia	501	1,688,000[3]	677,781,117
Boston	502	1,354,653	457,254,360
Pittsburg and Alleghany	198	722,000[3]	383,490,468
St. Louis	206	716,000[3]	319,709,859
Baltimore	246	610,000[3]	202,659,272
Cincinnati	151	498,000[3]	203,095,605
Cleveland	200	492,000[3]	179,184,277
Buffalo	201	423,390	168,111,658
Minneapolis and St. Paul	155	472,362	161,803,453
San Francisco	203	480,000[4]	159,033,080
Providence	154	344,521	156,299,965
Total	3,919	15,211,608	$6,183,885,487

Less than four thousand square miles of territory, containing about 15,000,000 people, produced more than $6,000,000,000 worth of manufactured goods out of the total United States production of $15,000,000,000. One per cent of the area of the country, and less than twenty per cent of the population, created forty per cent of the manufactures.

A careful study of the map on the opposite page (Fig. 1) will give some idea of the way industries are concentrated

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[1] Adapted from *Census Bulletin* No. 101, Industrial Districts, 1905, p. 10. In every instance the city named includes many suburbs and surrounding towns.

[2] New York includes Jersey City and Newark, N. J., and the surrounding towns in New Jersey.

[3] Writer's estimate based on *Statistics of Cities Having a Population of Over* 30,000, Special Reports, Bureau of Census.

[4] Based on estimates of 1904, as reported in Table 1, pp. 111 to 113, *Statistics of Cities Having a Population of Over* 30,000, Special Reports, Bureau of Census.

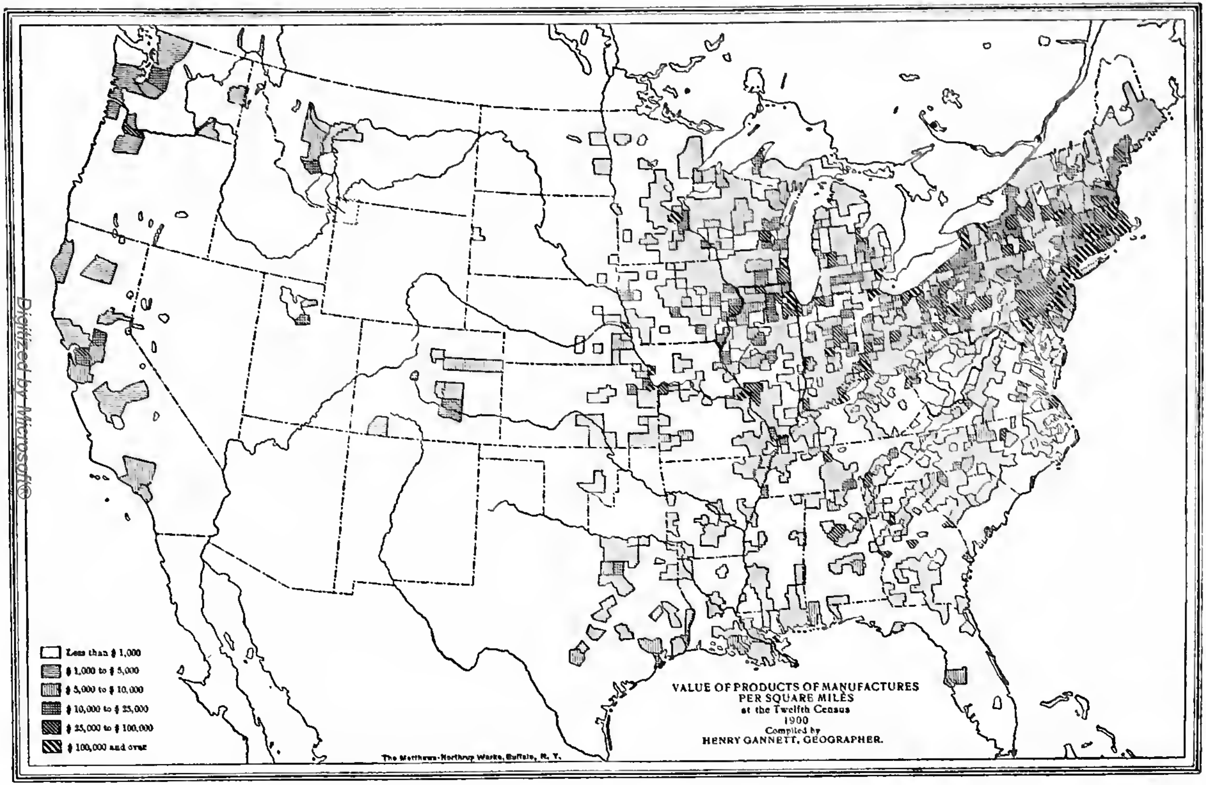
VALUE OF PRODUCTS OF MANUFACTURES
PER SQUARE MILES
at the Twelfth Census
1900
Compiled by
HENRY GANNETT, GEOGRAPHER.
□ Less than $ 1,000
▤ $ 1,000 to $ 5,000
▥ $ 5,000 to $ 10,000
▦ $ 10,000 to $ 25,000
▩ $ 25,000 to $ 100,000
▧ $ 100,000 and over
The Matthews-Northrup Works, Buffalo, N. Y.

FIG. 1.

into certain localities in the United States. The Industrial United States includes the section north of the Ohio River and the Mason and Dixon Line, and east of the Mississippi River, with smaller sections like the Birmingham district in Alabama, the Pueblo district in Colorado, and Kansas City in Kansas and Missouri.

The distribution of industries from the standpoint of the nature of the industry, shows that this great district has within it very marked divisions.

The little state of Rhode Island ranks first in the production of silverware and jewelry, second as a manufacturer of worsted goods, third in dyeing and finishing textiles, fourth as a maker of cotton goods. Connecticut is first in the production of eleven articles, typical products of which are needles and pins, ammunition, brass work, corsets, hardware, and cutlery. Massachusetts is preeminently a shoe and textile state. It ranks first in the production of cotton goods, woolens, and all kinds of shoe products. New York holds the record with twenty-nine first places, including clothing, furniture, men's furnishing goods, gas, paper and wood pulp, printing and publishing, sugar refining, and a number of other less important industries. New Jersey is first in dyeing and finishing textiles, as a producer of silk and silk goods, and as a manufacturer of sewing machines and attachments. Pennsylvania holds first place in nine departments of industrial activity, among which are carpet and rug manufacturing, cars, coke, foundry and machine-shop products, glass, iron and steel, petroleum refining, and leather tanning. It takes second place in the manufacture of silk goods, printing and publishing, women's clothing, electrical apparatus, hosiery and knit goods, lumber and planing-mill products. In the refining of sugar it ranks third. Illinois has six firsts, including meat packing, agricultural implements, bicycles, glucose, and distilled liquors. Ohio has three firsts—clay products, carriages and wagons, and carriage and wagon materials; is second in iron and steel, and third in foundry and machine-shop products. The great flour state is Minnesota, with New York ranking second and Ohio third.

Within recent years, the Southern States have become important in the production of certain lines of goods. Alabama is now fifth in the list of the iron and steel states, while in the manufacturing of coke it gives place only to Pennsylvania. South Carolina ranks second in the production of cotton goods, with North Carolina a close third, both having outclassed many northern rivals within a decade, and both states are still gaining.

The Industrial map (Fig. 1) shows that political boundaries are not recognized in the world of production. Eastern Pennsylvania is industrially different from western Pennsylvania. The great forests in the states of Wisconsin, Michigan, and Minnesota naturally give them first, second, and third rank respectively as producers of lumber and timber products. Alabama's development in iron and steel is readily accounted for because of its vast deposits of ore and coal, but the Southern States contain the only cotton-producing districts in the country, yet the greatest cotton-manufacturing state is Massachusetts. Illinois kills more cattle than any other state, yet Pennsylvania takes first rank in tanning, while Massachusetts is second, New York third, and Illinois seventh place. Montana is the greatest producer of raw wool in the country, yet Massachusetts makes more woolen and worsted goods than any other state in the Union. Pennsylvania and Ohio are the two greatest coal and natural gas-producing states in the land, yet New York is first in the production of gas for illumination and heating purposes. Forty years ago, Pennsylvania was a great iron and steel producing state, because of the great productivity of the iron works in its eastern portion. To-day eastern Pennsylvania is relatively unimportant in the iron and steel business. A generation ago Ohio imported almost all of its shoes from the east. To-day Ohio is one of the great shoemaking states in the Union, giving place only to Massachusetts, New York, and New Hampshire.[1] A score of other instances might be cited wherein industries have changed their location. It becomes evident, therefore, that there must be a number of factors which influence industrial location.

The twelfth census mentions seven factors which give rise to the localization of industries:[2]

"(1) Nearness to materials, (2) Nearness to markets, (3) Water power, (4) Favorable climate, (5) A Supply of labor, (6) Capital for investment in manufactures, (7) Momentum of an early start."

While all of these causes contribute to industrial location, there are but four primary factors, viz.: (1) Markets, (2) Raw materials, (3) Labor, (4) Power.

Climate, although sometimes important, as a rule has little influence in determining location, unless it acts in conjunction with some or all of the four primary factors, because artificial means can be taken to make a manufacturing establishment come up to nearly any requirement of heat, cold, or moisture.

The supply of capital and the momentum of an early start each have an important influence, but they are secondary factors, because some or all of the four primary factors must be present in order to give the initial impetus.

Generally speaking, the most important factor in the determination of any industrial location is the market, for without a means of disposing of the goods, a business could realize no profits. Consequently industries locate near the markets when no other factors are to be considered. This is noticeable in the iron industry in the United States. In the

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[1] *Twelfth United States Census* 1900, Vol. VII, Manufactures, Part 1, Table LXXVI, pp. clxxxiv to clxxxvii.

[2] Ibid., pp. ccx–ccxiv.

early history of the country the great consuming centers for iron were the cities and districts scattered along the Atlantic coast. Boston, New York, Philadelphia, Baltimore, and many other smaller towns were the iron users. The Eastern States had then, and still have, considerable deposits of valuable iron ore. The Schuylkill Valley was an especially favored district in that respect. It possessed access to iron ore, anthracite coal, and limestone. Blast furnaces, rolling mills, and other kinds of iron works filled the entire valley. A great number of the subsidiary industries found a profitable situation in that locality. The Schuylkill Canal offered cheap water transportation for the iron to Philadelphia, from which city it was easily distributed by rail and water to the consuming points along the eastern coast.

Sixty years ago, people knew that western Pennsylvania had rich deposits of iron ore, coal, and limestone. In 1856, no less than twenty-one furnaces in Pennsylvania had demonstrated that the western coals could be used for iron making.[1] Long before that time, however, nature had, by the gift of an ideal location, destined Pittsburg to be the great iron city. Three navigable rivers make a fortune building trinity for Pittsburg. Two streams, flowing from opposite directions, bring the raw materials together at a point where they can readily be changed into finished products; while the third river, formed by the union of the other two, flows through one of the richest valleys in the world, and affords a natural highway for the distribution of iron products. The development of the Ohio Valley has also been hastened by the presence of gas, which supplied the most perfect fuel known for the mere cost of tapping the ground.

After the Civil War, the great extension of railways through the West made such a tremendous market for iron and steel products that Pittsburg, with its favorable location,

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[1] Cf. *Tenth United States Census,* Statistics of Manufactures, Iron and Steel, p. 118.

became known the world over as the Iron City. Indeed, the great demands of the railroads for rails caused eastern managers and proprietors to start plants west of the Alleghenies. In the early nineties the Lackawanna Steel Company moved its entire plant from eastern Pennsylvania to the lower lake port of Buffalo.

Second in importance to the market for the development of an industry is the location of the raw materials. Pittsburg was not a great iron city until it had a market outlet. The Schuylkill Valley failed to produce steel and iron for the West, because the situation of Pittsburg in relation to the raw materials is far superior to that of eastern Pennsylvania. It costs less as a rule to transport finished steel products than it does to transport the raw materials, notwithstanding the fact that freight rates on finished goods are usually much higher than on raw materials. The reason for this is that a comparatively small percentage of the raw material is transported when the product is completed. To manufacture one ton of pig iron, the Edgar Thomson Plant of the Carnegie Steel Company, Pittsburg, requires in their blast furnace 17 cwt. of coke, 10 cwt. of limestone, and 32.2 cwt. of iron ore.[1] In other words, to transport raw material to within a proximity of the market requires the paying of freight on two and one half tons of material, of which only one ton is salable.

If a market is accessible and all other things are equal, a plant, to secure its greatest advantages, will always find it desirable to locate near raw material, where raw material is an important element in the cost.

In 1852, there were shipped from Marquette, Mich., six barrels of iron ore.[2] The amount was insignificant, but

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[1] "An Outline of the Metallurgy of Iron and Steel," by A. Humbolt Sexton, p. 146.

[2] "The Honorable Peter White," by Ralph D. Williams, p. 57, The Penton Publishing Company, 1905.

it was the forerunner of one of the most important developments in the iron and steel industry. It revealed to the world a source of raw material that was destined to give the United States first rank in this field. By 1889, the Lake Superior region produced more than seven and one half million tons of ore out of the fourteen and one half million total of the United States.[1] In 1907, nearly 52,000,000 tons of ore were produced in this country; and, of that quantity, the upper lake regions contributed nearly 42,000,000 tons.[2] The source of the raw material is 1,000 miles from Pittsburg, yet the deposits are so situated and so rich, and the lakes afford such excellent means of transportation that the total cost of mining and of carrying the ore to Pittsburg is less than $2.00 per ton. After paying all the expenses, providing for reserves and sinking funds, these ores sell in the Lower Lake Ports for from $4.00 to $5.00 per ton, depending on their quality.[3]

Why did not the cities about the Northern Lake become great manufacturers of iron products when they have such great deposits of ore near at hand? Ore is only one element in the production of iron and steel. Many attempts were made to turn the iron ore into finished products at the mines, so as to compete with the Pittsburg iron, but that city was near the market and the price of coke was so high, due to the expense of transporting it to the North, that the northern lake ports, long before the eighties, found that their great future was to be in the shipping of iron ore and not in the making of iron. For a long time, the mammoth vessels that carried the ore to the lower lake ports had to return without cargo. Later it was found that coal could be transported

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[1] *Mineral Resources of the United States,* 1903, pp. 41 and 45.

[2] Ibid., 1908, Vol. I, Metallic Products, p. 64. The year 1907 is selected because it was more nearly normal in its production than 1908.

[3] Ibid., 1908, Vol. I, Metallic Products, pp. 71, 72, and 77.

northward in the otherwise empty holds, and iron and steel could be made at a profit in these upper ports for the great northwest markets as long as the coal transported merely took up the otherwise vacant space in the vessels.

The Steel Trust, about three years ago, announced its intention of building a large plant in the vicinity of Duluth, in order to provide steel products for the northwestern market.

After Pittsburg lost its supremacy in the production of iron ore, blast furnaces and steel plants gradually moved from the meeting-place of the Monongahela and Alleghany Rivers to the cities along the lower lakes. Buffalo, Cleveland, and Chicago have become very important, while Pittsburg, although still increasing its output, is losing its preeminent position. In June, 1908, the *Iron Age* records the construction of the greatest steel plant in the world at Gary, Indiana, a few miles east of Chicago. That plant is located at the lower end of Lake Michigan, where the ore is taken directly from the boat to the furnace without any intervening railway service. In this way the new Indiana city is located near the market and the raw material.

Labor and power are not so important in determining the location of plants in the iron and steel industries as they are in some others, because of two factors:

1. The inventive genius of the American has been able to devise so much labor-saving machinery that the large majority of the operations have become almost, if not quite, automatic.

2. Coal and gas are raw materials for iron and steel. They likewise make power. Hence the iron and steel industries when locating near raw materials are bound to locate near power.

The extensive use of machines makes possible the payment of high wages without the reduction of profits. Labor thus can be brought to any vicinity where accessibility to raw material and market make a location desirable for steel making.

The textile industries are, on the other hand, but slightly affected by the source of raw materials as is shown from the following tables, the first of which shows the production of raw wool:[1]

State.	Rank in Value.	Value.	Rank in Pounds.	Pounds.
Montana	1	$5,911,920	2	32,200,000
Wyoming	2	5,644,800	1	36,000,000
Ohio	3	3,182,400	8	13,000,000
Idaho	4	2,945,250	3	17,500,000
New Mexico......	5	2,673,000	4	16,500,000
Oregon............	6	2,659,800	5	16,500,000
Utah...............	7	2,231,460	6	14,700,000
Michigan..........	8	2,208,000	10	9,600,000
California	9	1,854,020	7	13,300,000
Colorado..........	10	1,411,200	9	10,500,000

Another bulletin shows the following with regard to cotton:[2]

State.	Rank in Value.	Value.	Rank in Bales.	Bales.
Texas.............	1	$192,609,640	1	3,793,518
Georgia...........	2	101,867,948	2	2,027,144
Mississippi	3	84,725,223	3	1,668,556
Alabama..........	4	69,065,372	4	1,369,841
South Carolina...	5	61,964,522	5	1,242,012
Arkansas.........	6	52,136,939	6	1,027,714
Oklahoma	7	34,948,317	7	728,779
North Carolina...	8	33,875,637	8	701,356
Louisiana	9	24,221,407	9	493,467
Tennessee........	10	17,481,097	10	349,725
Total, 10 States........		$672,896,102	....	13,402,112
Total, United States...		$681,230,956	....	13,553,283

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[1] *Statistical Abstract of the United States*, 1908, pp. 142, 143.

[2] *Census Bulletin* No. 100, Cotton Production in 1908, pp. 7, 8, 17 and 18.

The ten largest woolen manufacturing states in the United States are many hundred miles removed from the sources of raw materials:[1]

State.	Rank.	Value of Woolen Products.
Massachusetts	1	$109,612,579
Pennsylvania	2	83,054,561
Rhode Island	3	52,640,763
New York	4	38,880,819
Connecticut	5	18,899,937
New Jersey	6	18,142,520
Maine	7	17,972,569
New Hampshire	8	14,284,480
Vermont	9	4,698,405
Ohio	10	3,586,528
Total, 10 States		$361,773,161
Total, United States		380,934,003

Of the entire ten wool-growing states, Ohio is the only one among the ten leading manufacturing states. The total value of the combined manufacturing output of the other nine of the wool-growing states makes a sum of $3,572,428, of which amount California gave $823,239; Oregon, $1,142,356; Michigan, $1,338,493, and Utah, $268,340. Ohio, with its comparatively small output in woolen manufactures, made over $14,000 worth of woolen manufactures more than the combined efforts of all the other great wool-growing states.[2]

From a study of the above tables it is evident that the position of the source of raw materials have small influence in determining the location of woolen industries. The presence of a good market is likewise not so important, as is evidenced by the fact that the middle west is the home of millions of people, and yet only one commonwealth finds a place in the list of the first ten manufacturing communities.

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[1] Adapted from Table 45, *Census Bulletin* No. 74, pp. 130–137.

[2] *Census Bulletin* No. 74, pp. 130–137.

In 1905 the ten leading cotton manufacturing states were:[1]

State.	Rank.	Value of Product.	Bales Consumed.[2]	Spindles.[3]
Massachusetts....	1	$129,171,449	906,100	8,411,249
South Carolina...	2	49,437,644	555,467	2,864,092
North Carolina...	3	47,254,054	497,947	1,880,950
Georgia..........	4	35,174,248	402,652	1,316,573
Rhode Island	5	30,628,843	161,583	2,049,522
New Hampshire..	6	29,540,770	260,928	1,301,281
Pennsylvania.....	7	24,136,813	49,442	266,097
Connecticut......	8	18,239,155	88,921	1,149,915
Alabama.........	9	16,760,332	198,820	758,087
Maine............	10	15,405,823	130,949	891,246
Total, 10 States.......		$395,749,131	3,252,809	20,889,012
Total, United States..		442,451,218	3,629,085	23,155,613

Comparing the tables showing the cotton-growing and those listing the cotton-manufacturing states, there does seem to be some connection between the raw material producing sections and those which manufacture. Is it a mere coincidence? Why does Massachusetts produce more than two and one-half times as much cotton goods as does its nearest rival state, South Carolina? Evidently other factors than raw material must be considered in locating textile industries.

The woolen industries in the United States in 1905 pro-

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[1] *Census Bulletin* No. 74, p. 61.

[2] Ibid., Table 9, p. 42. Pennsylvania owes its position to the importance of weaving. Much yarn is brought into the state. New York consumed a larger number of bales of cotton than did either Connecticut or Pennsylvania. Maryland, including Delaware, consumed a greater number than did Pennsylvania, viz., New York, 99,297 bales, and Maryland, including Delaware, used 55,429 bales. Table 9 of *Bulletin* No. 74 excludes Sea Island Cotton.

[3] *Bulletin* No. 74, Table 16, p. 51; New York and New Jersey exceed Pennsylvania in number of spindles, New York, 704,643; New Jersey, 436,764.

duced goods to the value of $380,934,003,[1] and New England made $218,108,733 worth, while New York, Pennsylvania, and New Jersey made goods to the value of $140,077,900.[2] Southern New England, New York, New Jersey, and Pennsylvania made $358,000,000 worth of goods out of a total production of $381,000,000—nearly 94 per cent.

The silk industry shows a like development, as indicated by the following table:

State.	Rank.	Value of Product, excluding Duplications.[3]	Consumption of Raw Silk. (Pounds.)[4]	Number of Spindles.[5]
New Jersey......	1	$41,066,556	3,553,090	527,409
Pennsylvania.....	2	31,061,188	3,970,044	1,203,617
New York........	3	19,114,170	1,006,793	251,367
Connecticut	4	13,981,394	1,320,509	196,624
Massachusetts....	5	6,471,206	739,004	107,787
Rhode Island.....	6	2,494,186	262,112	22,644
Illinois	7	575,932	78,100	11,880
California	8	332,649	46,255	3,846
All other States.........		3,436,279	596,876	128,414
Total, United States..		$118,533,560	11,572,783	2,453,588
Total, S. New Eng., N. Y., N. J. & Penn.		114,188,700	10,851,552	2,309,448

The Textile Industries seek their location for other reasons than raw material. The population map (Fig. 2) shows that the great textile states are located in the densest population zone of this country. A large population offers two great advantages to most industries, viz.: a profitable market and abundant labor. The fiber industries are peculiarly susceptible to labor conditions in that, to run successfully, they must be near a large supply of cheap labor which possesses sufficient training to attend the various kinds of machines. In large centers of population women and children can be employed to advantage in all kinds of textile

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[1] *Census Bulletin* No. 74, Table 1, p. 97.

[2] Ibid., adapted from pp. 130–137.

[3] Ibid., p. 172. [4] Ibid., p. 174. [5] Ibid., p. 183.

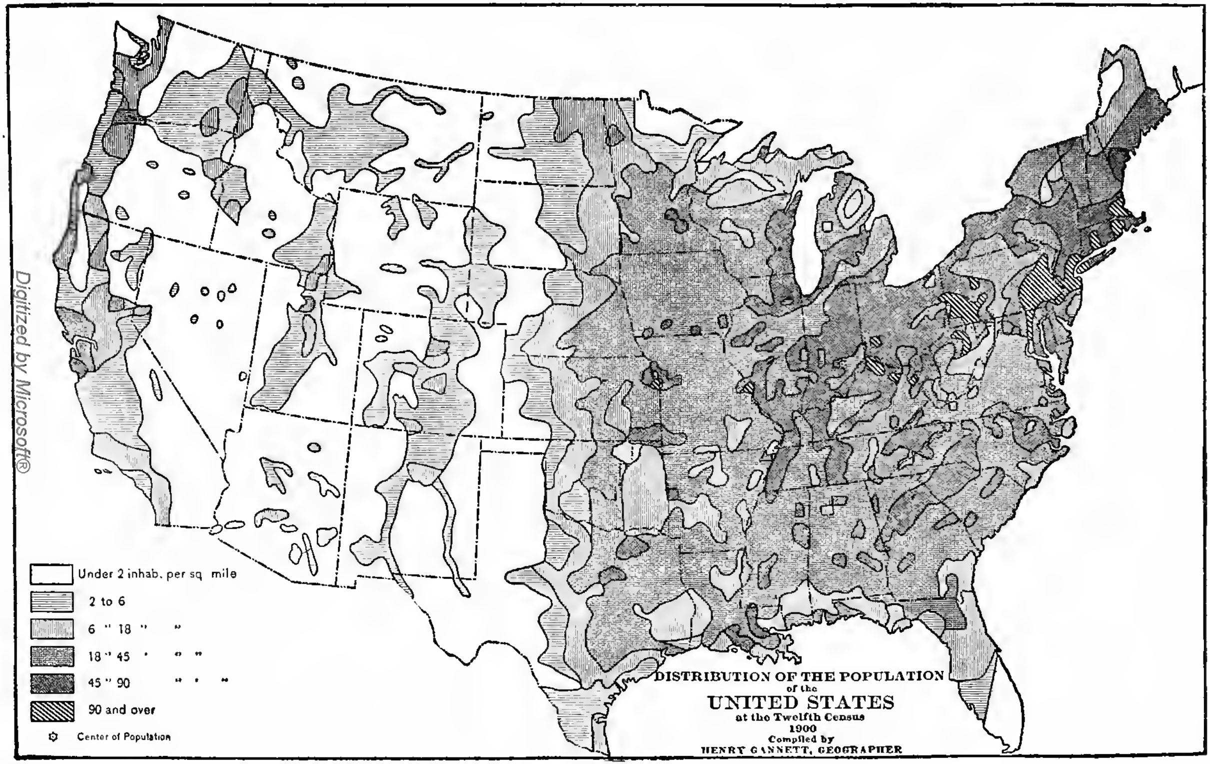
DISTRIBUTION OF THE POPULATION
of the
UNITED STATES
at the Twelfth Census
1900
Compiled by
HENRY GANNETT, GEOGRAPHER
Under 2 inhab. per sq mile
2 to 6
6 " 18 " "
18 " 45 " " "
45 " 90 " " "
90 and over
Center of Population

FIG. 2.

plants. They are quick to learn and have an innate dexterity which enables them to handle the light fibers rapidly and deftly.

Prior to the Civil War, the Southerners were an agricultural people. The ruling classes discouraged the introduction of industrial arts, save as they were necessary to meet local demands. Before 1880, there had been attempts to spin and weave cotton, but in the year 1881 the Governor of Georgia appeared at the Atlanta Cotton Exposition dressed in a suit of cotton goods, the material of which had the same morning been growing on the plant stalks.[1] This rather spectacular demonstration called attention to the fact that the South could manufacture as well as grow cotton. When the people awakened to the fact that they could manufacture the goods, they discovered that the country possessed a hitherto unrecognized class of people who would make excellent laborers. Mr. August Kohn in his work, "The Cotton Mills of South Carolina," gives a very vivid description of the methods taken to secure laborers for the mills of his state. The mountain sections of South Carolina, North Carolina, Georgia, and Tennessee, have been for many years a fruitful source of labor.[2] So great were the advantages offered to these mountaineers over their old conditions that they came down into the cotton mills by the scores and hundreds. On the other hand the labor was so profitable that many Southerners who started up mills made such large profits that Northern capital began to invade the Southern field. The mills, as a consequence, were so greatly increased in number and size that labor has begun to become scarce and wages are rapidly rising. The following tables are quoted from Mr. Kohn's report:

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[1] Cf. *Twelfth Census of the United States*, Vol. IX, Manufactures, Part III, p. 28.

[2] "The Cotton Mills of South Carolina," by August Kohn. Issued by South Carolina Department of Agriculture, Commerce and Immigration, E. J. Watson, Commissioner, pp. 23–25.

TYPICAL MILL, 1902.[1]

	Pay Roll, two weeks.	Men.	Women.	Children.	Total Employed.	Average per day.
Carding	$572.09	46	13	7	66	$0.72
Spinning	705.35	30	21	46	97	$0.60\frac{7}{12}$
Spool. and Warp..	204.68	3	4	27	34	0.50
Weaving	1,800.93	84	78	....	162	$0.92\frac{2}{3}$
Drawing	1,190.06	1	11	1	13	$0.76\frac{1}{3}$
Slasher...........	50.40	4	....	....	4	1.05
Cloth Room	158.81	15	....	5	20	$0.66\frac{1}{3}$
Machine Shops...	323.97	25	....	....	25	1.08
Outdoor Labor...	213.59	23	....	....	23	0.77
Total	$4,148.68	231	127	86	444	$\$0.78\frac{5}{9}$

THE SAME MILL IN 1907.

	Pay Roll, two weeks.	Men.	Women.	Children.	Total Employed.	Average per day.
Pick. and Carding	$1,269.45	100	11	14	125	$1.15
Spinning..........	1,442.80	45	35	77	157	1.06
Dressing, Spooling	533.25	22	40	....	62	1.02
Weaving	2,118.55	144	42	....	186	1.30
Cloth Room	342.55	21	15	10	46	0.83
Machine Shop....	321.70	21	....	....	21	1.39
Other Labor......	326.25	36	....	....	36	0.91
Total	$6,354.55	389	143	101	633	$1.13

Market and labor are the two dominating factors which determine the location of textiles. If, in addition, there are other inducements offered, such as proximity to raw materials or cheap power, the industry which can take advantage of these added factors will be the one to move to the favored section. Cotton is the textile which has the added advantage, and hence its move southward while the others remain in their old locations wherein they have the advantages of good market and abundant labor supply.

An important factor in the early manufacturing develop-

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[1] "Cotton Mills of South Carolina," p. 33.

ment of New England was the presence of a very considerable amount of water power. In 1905, Massachusetts alone consumed nearly 77,000 water horse power in turning the wheels of her textile mills.[1]

"The preeminence of Minneapolis in the manufacture of flour and grist-mill products is due principally to the early utilization of the water power furnished by the Falls of St. Anthony."[2] In New York the Chemical, Wood Pulp, and Power plants of Niagara Falls owe their existence solely to the presence of nature's great marvel located at that point.

The wood-pulp industry is a conspicuous example of one wherein power plays an important part in locating the establishment. The following table has been compiled from the Census Report of 1905:[3]

State.	Paper and Wood Pulp Production. Tons. 1905.[4]	Rank in Production.	Total Water H. P. Consumed in State.[5]	Total Water H. P. Consumed in Paper and Wood Pulp.[6]	Total other Power Consumed in Paper and Wood Pulp.[7]	Percentage of Water Power used in Paper and Wood Pulp.
New York...	606,014	1	446,134	325,472	70,430	82.2
Maine	456,921	2	203,094	116,508	47,563	71.0
Wisconsin....	241,537	3	112,665	83,138	24,870	76.9
New Hamp..	173,888	4	100,274	35,684	14,644	70.9
Penna	83,114	5	50,620	6,631	49,459	11.8
Vermont	60,747	6	76,237	36,697	6,976	84.0
Virginia	42,307	7	25,946	3,760	4,460	45.7
Michigan	38,612	8	39,342	12,655	18,765	40.2
Oregon	31,549	9	20,660	10,982	1,753	86.2
Ohio.........	29,274	10	18,149	4,190	32,999	11.2
West Va.....	28,695	11	6,404	1,310	3,266	28.6
Mass..	28,445	12	183,427	51,843	55,177	48.4
Tot. 12 States	1,821,103	....	1,282,952	688,870	330,362	67.5
Total, U. S..	1,921,768	....	1,647,969	717,989	404,575	63.9

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[1] *Census Bulletin* No. 53, p. 48.

[2] Ibid., No. 46, p. 16.

[3] Ibid., No. 80, p. 26.

[4] Adapted from *Census Bulletin* No. 80, p. 26.

[5] *Census Bulletin* No. 88, p. 18.

[6] Adapted from *Census Bulletin* No. 80, Table 19, pp. 32–43.

[7] Ibid.; includes steam, gas, gasoline, and electric power.

Water power is usually the cheapest source of energy that a plant of any kind may possess, and the above table reveals its importance as a primary factor in locating the paper plants. It is a significant fact that the great paper states in the above table which do not use water power are in the vicinity of abundant supplies of fuel. In Oregon, where waterfalls yield more than 86 per cent of the power of the paper mills, the output has, since 1900, increased from 1,154 tons to its present total of 31,549 tons.[1]

Seldom, indeed, does it happen that the existence of any one of the primary factors determines an industrial location. If, however, there is a combination of two or more of those influences, we have ground prepared for the development of industries, and the ones which will permanently flourish in the favored districts will be those which can count the greatest number of desirable primary factors.

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[1] Adapted from *Census Bulletin* No. 80, Table 19, p. 26.

CHAPTER III

THEORY OF PLANT LOCATION

In every manufacturing center, plants are erected and run by many different corporations. A number of years may pass by, and at the end of that time some of the plants will be doubled in size, a few will retain their old dimensions, while still others will have passed out of existence. Pittsburg, for instance, is a great location for the iron and steel industries, yet there have been many individual failures in that district—failures not altogether due to incompetence.

The city of Philadelphia is an ideal textile center, yet in that place there are dozens of plants which have gone to the wall, and not through actual bad management. A number of carpet mills located in certain sections of the district of Kensington have been actually forced out of their location because of the increasing value of the sites on which they stand.

In another section of Philadelphia is a conspicuous example of the working out of this tendency. In 1835, M. W. Baldwin built his locomotive shop at the corner of Broad and Hamilton Streets, a situation then on the outskirts of Philadelphia. As years went by, Broad Street, in that vicinity, saw the location of a number of other plants, and it likewise saw the building up of a large number of residences and other structures. At the present time this district is in the center of the city, and property values are enormous. The works cannot expand within this district save at a tremendous cost. By the year 1900 the plant had completely outgrown its bounds within the central part of the city, and had established part of the works along the Philadelphia and Reading Railroad in the vicinity of Twenty-eighth and Brown Streets. There again, however, expansion became too costly, so finally the company has purchased a tract of land, 184 acres in extent, at Eddystone, Penn., a small town about twenty miles from the center of Philadelphia. In this new location the firm has erected extensive foundries, smith shops, and other buildings, and in case it desires to move their entire plant to this location, it has abundant ground for present needs and sufficient space for indefinite expansion.

Even if the question of expansion cost were not considered, the tax rate, rental charges, and other considerations are matters of such considerable importance in a congested community that the profits of any concern may be seriously affected in a central location.

The position of a plant within the range of industrial centers has a profound influence in determining the success or failure of the establishment.

From the physical side the success of a plant is dependent on two main features: (1) its location; (2) its layout and equipment.

The location of a plant should be fixed in such a manner that the people interested in its success can sell the goods most profitably, buy supplies to best advantage, and manufacture with the least expense. To do all this, the most favorable location will be one that will include the greatest possible number of the following advantages:

I. *Selling.*

Nearness to a large consuming market, or at least a situation such that it can have a cheap and adequate outlet for the output.

II. *Buying.*

Closeness to supplies, or a situation such that supplies can be secured at a minimum expenditure for transportation and at the same time be obtained whenever desired.

III. *Manufacturing.*

1. Proximity to a large adaptive labor population.
2. Ready accessibility to repair shops.
3. Nearness to good banking and credit facilities.
4. Ability to build so as to suit special needs of industry.
5. Ability to expand plant cheaply.
6. Low rent and tax rates.
7. Freedom from restrictive ordinances or onerous legal or other requirements.
8. Adequate fire-fighting facilities and low insurance rates.

I. Selling, and II. Buying. *Nearness or Accessibility to Market and Supplies.*—To be successful a concern must have its plant accessible to market and raw materials. The location depends largely upon the nature of the goods manufactured, and to some extent upon the size of the establishment. A small firm should place its plant in such a position that it can be easily accessible to both market and supplies without the necessity of depending upon any single railroad service. Such a plant cannot command sufficient traffic to make it worth while for a road to give it special service, hence if it is in an isolated community, it must accept a poor or indifferent service with consequent loss of business. If, however, the small plant locates in a community where there are many like itself, it will be in a position to secure better service because the roads will be able to handle the traffic of many concerns from a central point, and they will arrange their train schedules to accommodate the combined needs of a large number of manufacturers.

The map (Fig. 3) shows a small portion of the city of Philadelphia, with the location of the dye houses which dye carpet yarns. In addition are placed the carpet-weaving plants which are dependent upon the dye houses for their raw materials. The largest of the works in the entire district would be unable to give sufficient traffic to either road to make rate or service competition worth while, yet all the plants combined do make considerable traffic for both roads, and as a result the transportation service is good.

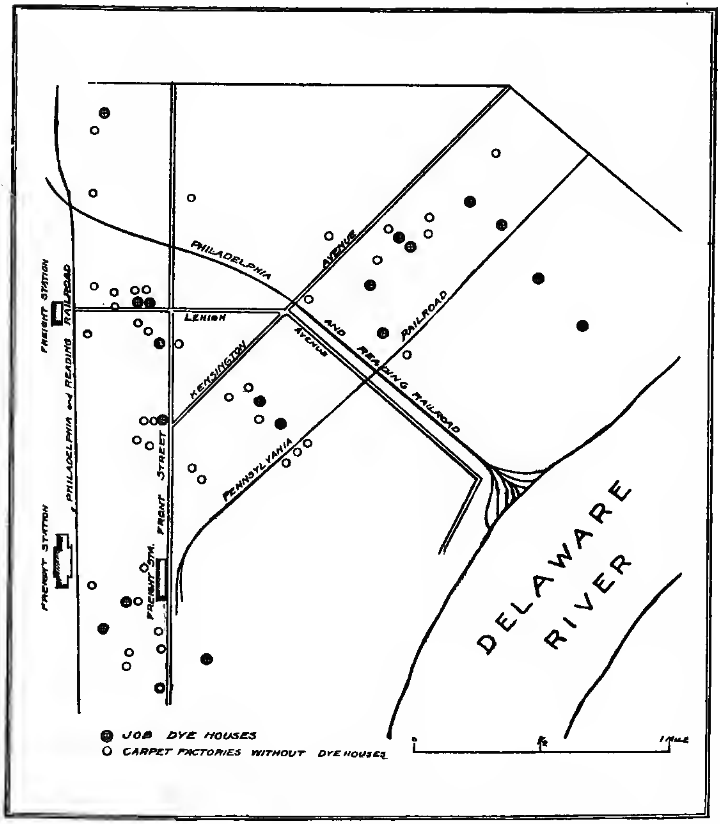

FIG. 3.—Map of a Portion of the City of Philadelphia.

Were the dye houses in a different location, they would not have a market so accessible, while if the carpet mills were differently situated, they would not only have to pay freight charges for the yarn to the dye houses, but likewise from the dye plants to their mills. With both located in such proximity there is one freight charge for the raw material to the dye houses, a drayage expense from the dye works to the carpet mill, and then a final charge for the finished product to the consuming market.

If a plant grows so that its supplies and products demand large facilities for handling, and its consuming public is national or world-wide, then the question of market is one of accessibility and not one of proximity.

To be accessible, a plant should be so located that it has cheap inlets and outlets for its goods. The cheapest possible kind of an outlet a plant may have is one that will enable it to have a choice of a number of means of transportation. If a plant can be so situated that it can have competition between waterways and railroads, or between railroads, it is advantageously placed. At the present time roads do not give rebates, nor do they compete for freight by cutting prices below the published schedules, as they once did; but nevertheless, if a plant is placed so that it can secure competition from several lines, it will have concessions granted to it in the way of special commodity rates, of car supplies when needed, and will have its freight more promptly handled than if it is dependent entirely upon one road. This is true for two reasons. One is that it can have a choice of alternative routes for shipment, so that in case one is filled with orders, the firm will be very apt to secure accommodations on the other. Another reason is that if a road realizes that a freight consignment can be shipped over a rival's lines, it will be more likely to make efforts to take care of the freight in order to prevent the other transportation company from securing it. Figure 4 illustrates well the advantage that accrues to a firm if it is placed in a location whereby it has a choice of water and land shipment and competing lines of road. The Union Railroad shown on the map enables the Carnegie plants to ship their goods over any one of the four roads touching Pittsburg, namely, the Pennsylvania lines, the Baltimore and Ohio, Pittsburg and Lake Erie, and Bessemer and Lake Erie. In addition to that the

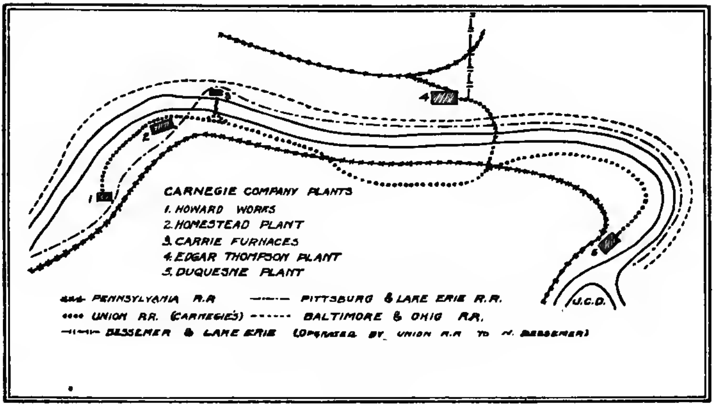

FIG. 4.

Monongahela River makes it possible to receive goods without using the railroad, and puts the plant at an advantage as compared with other plants which depend entirely upon one line for their receipts and shipments.

The United States Steel Corporation has always appreciated the benefits that can be reaped from adequate transportation facilities. Their new plant at Gary, Indiana, has a frontage of ten miles on Lake Michigan, and is located on or immediately adjacent to five trunk lines of railways, a significant indication of the far-sighted sagacity of the moving spirits in that great organization.

III. MANUFACTURING.—1. *Proximity to Large Adaptive Labor Population.*—Every establishment of whatever kind, to have the elements of success, must have a supply of trained laborers at the call of the management for the purpose of running the machinery and handling the raw materials through their various stages.

It is not only necessary for a factory to be located in the midst of a large population, but it is likewise essential that the population be one that can be depended upon to work efficiently and regularly. The two qualities, efficiency and regularity, are not always to be found in mere size of population. The most serious objections to the negro in the South is his unreliability as a worker in a plant. The writer knows of a number of iron plants located in the midst of a very considerable negro population, where the labor problem was one of grave concern. In two ways the negro cannot be depended upon. He will invariably take several days for a recess after each pay day, thus crippling the plant by his absence, and he cannot be made to attend to business while on duty. If he works on the night turn he is likely to go to sleep at some critical time when alertness is necessary to preserve life and property. It is only by the most vigilant oversight that the negro can be kept from getting into trouble when he consents to be present at a plant. In some sections it has been found advisable to import foreign laborers to the Southern mines and mills rather than to attempt to work with the local supply of labor.

The negroes are not alone in their unreliability as workers. In the mill districts of the Carolinas, one of the greatest difficulties with which the mill owner must contend, is absenteeism of the employees.

> "There are probably enough workers in the various mill communities to man all of the machinery, but the great difficulty today with the cotton mill labor is that it is not constant and will not work every day in the week, no matter what the inducements may be. Every cotton mill in this state recognizes the fact that to have a full complement of labor in the mill each morning, when

> the whistle blows for the work to begin, it is practically necessary to carry a surplusage of from 20 to 25 per cent of 'spare help.'
>
> "In a cotton mill in upper Carolina that has forty-seven weavers, who ought to make 564 days in a pay period, the president, to induce the maximum attendance of the weavers at their work, offered a premium for all who would report every day in the two weeks. In June there were $70\frac{3}{25}$ days lost out of the 564 that should have been worked. In August, with the same premium system in force, 161½ days were lost by the same help. This calculation does not account for the spare help that had to be used to fill in for the loss of time of the regular help." [1]

The great source of expense in a factory is its labor bill. If the plant is well supplied with orders, the wages paid to the workers are a profitable investment. If, however, there is a scarcity of orders, the first thing a plant should be able to do is to cut down its most burdensome items of expense. The only time the laborer can be a profitable investment is when he is producing goods, so that it is absolutely essential for the prosperity of the plant, especially if it is an industry where there are fluctuations in orders and output, that the plant be so established that when bad times come, it can cut down its labor force to suit the limited requirements of such intervals, and yet be so placed that when good times return it can reemploy trained laborers.

Mere numbers of people do not necessarily make a suitable labor environment, and what may be a good labor situation for one industry may be unfitted for another. Certain classes of production can employ only men, while there are others wherein women and children may be profitably engaged.

The Anthracite Coal region offers employment to thousands of men, but women cannot find work around mines. As a result, we find in mining sections a considerable population of available female labor. The textile industries were

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[1] "Cotton Mills of South Carolina," by August Kohn, pp. 61–63.

not long in recognizing the opportunity, and, as a result, we find located in the Schuylkill, Lehigh, and Susquehanna Valleys in Pennsylvania a number of silk mills, stocking factories, and other fabric industries which make use of this otherwise unemployed population.

The real question which the manufacturer should consider is not "are there many people in a given community?" but "will that community have available a sufficient amount of labor to suit my peculiar needs?"

2. *Ready Accessibility to Repair Shops.*—If orders are plentiful, and a break occurs at any point in the system, a firm loses in shortened output and prestige, if not by actually forfeiting posted guarantees. So important is the question of adequate repair facilities in the iron and steel business that the large plants have entire sets of engines held in reserve to be ready for any unexpected breakdowns. A small plant cannot afford to have reserve engines or duplicate apparatus to be ready for eventualities; and, if it is so located that the repair shop or the supplies for the needed parts are inconveniently distant, it is liable to sustain severe losses through a mishap. Hence for a small plant, proximity to repair facilities is a highly desirable asset. If a plant is large, it need not consider the question of placing itself in the vicinity of repair houses, because it can better afford to have its own repair shops.

Large steel plants, textile establishments, and other concerns invariably have their own repair equipment, and are constantly improving the mechanical end of their plants. In fact, if they are well organized and efficiently handled, the repair shops may do much more than merely act as repairing agents for the concern, and some plants have utilized their machine shops for the introduction of improvements through the entire establishment. The improvements, small as they are in individual items, amount in the aggregate to large savings for the firm, and the added expense that the repair department requires for its upkeep is really a money-making investment for the firm, because it keeps the machines continuously running at a high state of efficiency, giving a maximum output for a minimum expenditure of power and labor.

3. *Nearness to Good Banking and Credit Facilities.*—One of the most important assets a company may possess is good credit, without which it can hardly ever hope to advance during good times or even perpetuate its existence during stringent periods. A small concern is usually dependent upon nearby banks for its credit, and if it is inconveniently located, or is distant from good financial backing, it is putting itself into the business world with a severe handicap. If it is well known and near a number of good credit sources, it stands a much better chance of securing backing on a reasonable basis than if it is dependent upon one institution that has little or no competition.

A large concern is differently situated in the respect that its mere size gives it prestige in a wider financial circle, and enables it to get credit facilities in many ways and from many sources not open to small concerns. It can, therefore, practically ignore in its location local credit possibilities. In fact, a concern may get to be so large and important that it can dominate banks and financial institutions and largely create for itself a credit fortress; but those organizations are few. Generally speaking, the smaller the plant, and the more local its market, the more unavoidable is its dependence upon local banks, and the more discriminating the care which must be exercised in its choice of a site.

4, 5. *Ability to Build So As to Suit Special Needs of the Industry, and Ability to Expand Plant Cheaply.*—An organization, to realize its full measure of success, should build the plant in such a manner that the manufacturing process may be carried on with a minimum expenditure of time and material. The ideal plant is one that is adapted to its special type of manufacturing. The ideal location is one that will permit such a plant to be built, and at the same time give it sufficient clearance space on all sides to permit additions to be made without necessitating a rearrangement of the machinery and equipment of the original plant in case growing business demands an increase in facilities.

When a profitable business is increasing, a manufacturer can be in no worse position than to be unable to fill orders. If he does not fill them, rivals will soon appear in the field who will not only take his surplus business, but will become keen competitors for trade hitherto his own. Hence, if a plant is to be extended, it should be possible to make the enlargement in such a manner that at no time will there be any diminution in the output of the old plant until the new one can be utilized.

It has been found that a single plant may be enlarged to a point where further extension does not tend toward economy, and where it is cheaper to build a new factory or plant than it is to keep on increasing the size of the old one. When a plant reaches those dimensions, expansion room does not need to be provided, but until those proportions are attained, an organization should endeavor to make provisions for future growth. To provide for that future possibility, it is necessary, for the prosperity of the concern, that it shall not burden itself at the beginning to provide for future prospects. It should not tie up much capital in a big plot of ground or large building in anticipation of future needs, because by so doing it is putting an unnecessary burden in fixed charges upon a present business, that should have no heavy expense at all. With such a load, the management cannot experiment to improve the output, to cut costs in manufacturing, nor can it adopt a liberal policy to extend its market for the goods.

One of the surest plans a concern can follow, to prevent it from ever requiring expansion room, is to incur a heavy expense in securing a location that will permit future growth. In selecting a site, present demands should be amply satisfied. They should never be subordinated to future hopes.

6, 7. *Low Rent and Taxes, and Freedom from Restrictive Ordinances or Onerous Legal or Other Requirements.*—A selling organization must put itself in some conspicuous, easily accessible center; hence it would be false economy to accept a cheap location if it were away from a much frequented situation. Frequented situations are almost invariably expensive. Taxes and rents are bound to be high, but the increased business that can be done in such a position will more than compensate for the heavy burden involved in the location.

A manufacturing establishment has quite different conditions. Quality and quantity of output are the main factors which contribute to the success of a plant.

The managers cannot afford to stay out of the market, but it is not necessary to put the plant in an expensive location to have the goods accessible to the consumer. The promoters should endeavor to locate in the best possible place that will allow of cheap manufacturing, and will give easy accessibility to the trade.

The selling department, as a matter of fact, need not be in the plant at all, and in a great number of the largest concerns it is located in the commercial centers, far removed from the buildings which turn out the goods. In adopting this scheme, one can combine the advantages of a good selling location with economy in fixed charges for the producing part of the plant.

Not only should care be exercised in locating away from high taxes and rents, but investigation should be made of the question of restrictive ordinances that may affect the plant. Manufacturing establishments are frequently annoyed and even seriously hampered by local ordinances which prevent them from carrying on their work in the manner most satisfactory to themselves.

The people have a perfect right to pass laws and regulations which will make life pleasant in any given community. The property and welfare of a large number of people should not be sacrificed for any one group of citizens; yet, on the other hand, the manufacturer cannot afford to sustain restriction in output or unnecessary expense for some objection, either fancied or real, of the surrounding neighborhood. In selecting a site for a new plant, therefore, care should be exercised that the new factory shall not be the cause of hostile legislation.

Some years ago a certain company entered into a contract with the municipal authorities of a large city to dispose of the garbage by an incinerating process. The contract was one satisfactory both to the municipality and to the officials of the concern. Fortified by these considerations, the corporation purchased an abandoned white lead works and erected expensive apparatus for the purpose of reducing their garbage. No objection was made to the new installation, but it had not been in operation one week before there was a veritable hurricane of vituperation heaped upon everyone connected with the plant and upon those who made the contract. Injunctions were issued, within a month the company became involved in scores of law-suits, and finally had to vacate the premises.

8. *Adequate Fire-Fighting Facilities and Low Insurance Rates.*—A manufacturer in selecting his site should take into consideration the fact that a fire can injure his building in one of two ways. It may either originate within the walls of his own structure or invade it from the outside. The internal and private fire-fighting facilities will be treated later. Here we shall note the fire risk with respect to location.

Many towns in this country have poor fire-fighting facilities. As a consequence manufacturers in those districts pay insurance premiums disproportionate to the assessments, the structure of their buildings, and the nature of their business would otherwise demand. Insurance companies are very critical of the fire-fighting facilities of a community. In almost every town there is a fire-danger zone assessed at a higher rate than is the surrounding districts.

In taking into consideration the public fire-fighting facilities, the manufacturer does well to examine carefully the following features:

1. Water supply: By whom it is owned, its organization. Has the place high pressure mains? Is there ever danger of water famines, and all other points which may in any way affect its efficiency in fighting a large or small conflagration.

2. Fire department: Its organization, including the personnel, from the chiefs down to the least important man of the department. Is it a paid or volunteer company? The extent and nature of the equipment of the fire stations, the number and location of the stations. Have all the fire plugs standard couplings, and all other points which may affect the utility of the protection at a critical time.

3. Fire-alarm system: Here the investigation turns on the number of alarms in the community, their location, efficiency, design, and other similar considerations.

4. Fire department auxiliaries: Under this head are considered the efficiency of the police department, arrangement of the streets, the proximity to other communities which can give assistance, the possible value of such aid in time of need; is the district menaced with overhead wires? Are the building laws efficient and well executed?

Some cities have gone to the trouble and expense of installing within their fire-danger zones special water mains with equipment to keep the water pressure at a high point throughout the system. These mains are for fire use only.

In the year 1900, the insurance companies raised the fire rates in Philadelphia 25 cents per $100 on all risks located in the congested district. In 1904, a high pressure system, equivalent to twenty steam fire engines, was finished and turned over to the city. The stationary pumps at the water front can deliver to the hydrants a water pressure of 300 pounds to the square inch. The plant is run by gas, and the entire system can be put into full operation in seven minutes. Only forty-five seconds are necessary for the pumps to develop 300 pounds pressure. The plant is capable of supplying fifteen 1½-inch streams of water, which may be concentrated on any block within the protected district. When the plant was tested and accepted, the Fire Underwriters' Association reduced the fire rates to the old basis.[1] This is one of a number of examples which may be cited showing the importance of being in a good fire-fighting community.

If a person is manufacturing a class of goods not especially inflammable, it is inadvisable for him to erect his works near another plant whose commodities are noted for their inflammability. Proximity to such a building forces the former manufacturer to take especial precautions in erecting his plant. It necessitates the use of fire walls and other expensive devices, besides compelling him always to carry a higher insurance rate, while notwithstanding all these precautions his position is still precarious.

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[1] *Insurance Engineering*, Vol. XII, "High Pressure Fire Systems," by F. L. Hand, pp. 525–541.

CHAPTER IV

THE IDEAL SITUATION

THE type of manufacturing that is carried on by an organization determines to a very considerable degree the most favorable site for its plant. There may be three kinds of situations for plants, viz.: (1) country, (2) city, (3) suburbs, and each one of the three offers peculiar advantages.

1. COUNTRY.—The economic advantages offered by a country location are few in number, but for some industries they are exceedingly important. The country offers, as inducements to the manufacturer, cheap land, low rents and taxes, and freedom from restrictive ordinances. These favorable considerations enable interested people to purchase sufficient territory to permit of the adaptation of a plant to the special requirements of the process, and at the same time allow them to provide for space enough to grow without making it necessary for them to tie up too much capital in unproductive ground.

The country, however, offers a number of objections as a location for industries. In the first place, it is hard to draw to sparsely settled sections a sufficient body of skilled laborers to make it possible to keep the plant continuously employed. A firm of stove founders once conceived the idea of erecting a plant in a small town at a considerable distance from any large city. They were exempted from taxes for a term of years and had many other favors granted to them, yet in spite of all the assistance they eventually had to abandon the plant on account of its inability to hold skilled labor in the district. If the industry is one where skilled labor is not an important factor, it is sometimes possible to recruit workers from the surrounding districts. The cotton manufacturers in the South soon exhausted the labor in the small towns wherein they were located, and recruited their ranks from the back country by means of advertising throughout the district for workers. August Kohn in his book gives a number of illustrations of the advertising matter that was used, and speaks at length of the troubles the Southern manufacturer had in getting labor.[1]

The country offers very little inducement to working people to settle within the vicinity of a plant so situated, unless the plant is of considerable size.

Another objection that may be offered to a country location is that it is not near supply houses or market, and repair shops are apt to be unhandy. No one can afford to let a plant stand idle at any time, least of all when supplied with orders; so, if an accident happens to a running machine, the renewal parts should be available to make immediate repairs. If a plant is in the country, it is likely to be away from supply houses, and must, therefore, carry in stock a great many more duplicate parts of equipment than if it were in a large city. To carry duplicate parts, one must tie up money in unproductive material. The pieces may be used sooner or later, or it may happen that new machines will come in which cannot use those parts, and the material has nothing more than a scrap value.

A large plant can ignore the necessity of keeping in contact with supply houses and repair shops and similar advantages, because its mere size will make it possible for it to keep a repair department and likewise make it profitable for it to carry sufficient supplies to be independent of any outside concern. The plants of large companies, like the United States Steel Corporation, always have their own foundries

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[1] "The Cotton Mills of South Carolina," Article IV.

and repair shops as a part of the plant. The Gary plant at Gary, Indiana, has, in connection with its steel plant, foundries, boiler shops, machine shops, carpenter shops, and pattern shops, so that it is practically independent of all outside aid.

So far as the market is concerned, to the manufacturer of steel rails, structural iron, or any large and heavy material whose products go over the entire country, nearness to a city is of minor consideration, because their markets are widely scattered. With such production, transportation facilities and switching privileges are the essential needs rather than close proximity to a city.

2. City.—In a city, the cost of living is greater than in the country, but the city offers to working people a larger number of economic and social advantages than does the country. Wages, as a rule, are higher, and there are more opportunities for advancement open to the ambitious person, because city evening schools and other educational advantages present means of self-improvement that are not as a rule offered to country dwellers.

Commercial houses in large cities afford attractive employment to women and girls in the way of stenographic positions, clerical work, and bookkeeping, while the large department stores employ hundreds of girls as sales people. When a working family is located in a large city, every one in the family has a greater opportunity of securing employment. The family is not so dependent upon the earnings of the older male members as it is when located in the country.

Many industries peculiarly adapted to the employment of women and girls find that a city location is by far the more desirable. Textiles, as a rule, flourish better in a large community, the reasons for this being that women and children are more readily procured for employment. The northeastern part of Philadelphia is a great textile center, very largely because of the location there of large numbers of shipyards, machine shops, foundries, steel works, saw works, leather curing, and other plants which employ men almost exclusively.

Besides the fact that working people can get work more readily in the city, there is another consideration. The city offers more entertainment than does the country. The amusement and social side of life is usually more pleasant in the city than in the country. There is more gaiety in the town.

Aside from the question of labor, the city location is better for being near to a market. This is an exceedingly important consideration for industries directly dependent to a greater or less extent upon other plants, e.g., box factories, yarn mills, etc. Industries which are varied by styles or tastes of people do better if located in town. Small manufacturers can do better in a city because their selling expenses are lower. They can learn of selling markets more readily, and can make quicker deliveries because of better express service.

A third manifest advantage of a city location, especially for a small plant, is, as we have already seen, that it will be near to repair shops and supply houses.

In addition to being near supply houses and repair shops, a city environment usually contributes the advantage of local banking and credit-obtaining facilities. These latter items are of great importance to small concerns. A large plant, to carry on any of its important schemes, must be able to secure financial backing from the great money centers; hence, so far as credit is affected, location is not a matter of material concern. Moreover, a large organization can, either directly or indirectly, establish local banks and thus create for itself a credit source of considerable importance. To the smaller plant neither access to the large money centers nor ability to establish and dominate banks is possible. It must depend upon friendly outsiders who are in a position to know its managers and the success of the enterprise. If a small organization is near only one bank, it may have to consent to hard borrowing terms. If it is near many, it will have a much better chance to get reasonable concessions which will help it along the road of continued prosperity.

The main disadvantages of the city are high land cost, entailing large rents and taxes and a liability of being compelled to obey municipal ordinances which may restrict the output of the concern or increase its running expenses.

To summarize the entire situation, if there were no other place than a city or the country to establish a plant, a general statement might be made that for a small plant a city location is better, while for a large concern a country site would be more advantageous.

3. Suburbs.—The suburbs of large cities, however, offer a third situation. The suburbs possess the advantage of being able to combine to a great extent the advantages of both the city and the country. In the suburbs, land values are usually not so high that they unduly burden the concern to provide for future growth; and restrictive ordinances are likewise usually less frequent than in the cities. Labor is easily persuaded to come to the outskirts of large cities, because, as a rule, rents are lower and living is cheaper, while at the same time the trolley-car, telephone, and other conveniences have made it possible for the suburbanite to partake of the advantages of the city.

Suburban locations are likewise liable to be in the region of good railway facilities. Large cities are apt to be the meeting-places of a number of railways, and many communities have built belt lines connecting these various roads, making it possible for the suburban manufacturer to have the choice of several lines by which he can ship his goods. Where belt lines are not in existence, it is much easier for the suburban manufacturer to obtain private sidings to competing railways than it is in either city or remote country locations.

The suburbs can provide for the other considerations—accessibility to repair shops, supply houses, nearness to markets, banks, and credit facilities—nearly, if not quite, as well as the city itself.

In addition to the advantages naturally coincident with a location either in country, city, or suburbs, there are frequently other inducements offered by various bodies to encourage the industrial development of the community. Railroads are very anxious to have factories locate along their lines. The two bodies, the local community, and the railroad company, work in harmony, although each is working for its particular end, the former to secure plants, the latter to obtain traffic. The railroads have organized industrial departments which they call by various names. The officials in charge of these departments keep on file all available information relating to the natural and artificial advantages of the towns and districts tapped by their lines.

The artificial advantages of a town or district are those favors and concessions granted by the residents of the place to any newcomers who may be induced to bring a factory or some other kind of institution within its borders.

Few communities fail to see the advantages of the presence of manufacturing plants. Much of the recent increase in Southern prosperity has been due to the location of profitable cotton mills.

"The addition of such an industry as cotton manufacturing could not but increase the value of real estate in Spartanburg County very greatly for several reasons.

"1. The cotton mills have been located in all parts of the county. There have arisen small towns wherever the mills have been erected, and the property, which was formerly on the market as farming lands, is now sold on the basis of city lots, which has elevated values very much. The mills located in the vicinity of the larger towns have developed the outskirts of these towns; so that the property has become very valuable, while before the coming of the mills the property was not rated as city property.

"2. The enormous increase in the annual income of the county of Spartanburg, caused by the coming of the mills, has caused a general prosperity, and desirable property was soon purchased by those participating in the benefits. With the general prosperity came the desire to own homes and real estate. With ready purchasers always in sight there was a constant demand for real estate, and with the demand came the increase in value.

"3. The dividends annually paid out in Spartanburg go to swell the bank accounts of the people in the county, and this money is soon reinvested. Real estate is considered an excellent investment in Spartanburg, and many of the dollars paid out by the mills go to purchase real estate. There is always a demand for good real estate, and there is a large amount of property changing hands in this county each year." [1]

What is true of South Carolina and the cotton mills is likewise true of other parts of the country, and, as a result, communities scattered all over this land offer various inducements to factory managers. These inducements may be classified under the following heads, viz.: (1) free land, (2) free building, (3) exemption from taxes, (4) subscriptions to stock, (5) cash bonus, (6) miscellaneous favors.

(1) *Free Land.*—The Boards of Trade of many towns have committees appointed whose work is to advertise the advantages of their particular localities. These committees keep informed of new projects proposed by various outside concerns, and they endeavor to secure the interest of the promoters by presenting to them the advantages of their town, and at the same time these Board of Trade workers endeavor to secure the active co-operation of the citizens by having them contribute money for the purpose of investing in factory sites which will be at the disposal of the Board of Trade, to give to companies that are looking for a factory location. Sometimes promoters can interest a group of citizens to col-

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[1] "Cotton Mills of South Carolina," pp. 185, 186, quoting Mr. J. T. Rhett, Sec'y. Spartanburg Chamber of Commerce.

lect sufficient funds to purchase a site for their enterprise. Of course the citizens who will be interested in securing a factory site and are willing to contribute, will be the ones most likely to form the membership of a local Board of Trade; but this is not always necessarily true. The difference between the Board of Trade's action and the citizens' action is that the one is a systematic endeavor, while the other is an occasional one. In some cases the town itself may appropriate money to secure factory sites; and, in some other instances, a private citizen may give a piece of land for the same purpose. It is far more common, however, for the land to be contributed by the Board of Trade or the citizens acting as a body on some special occasion.

(2) *Free Building.*—Some years back it was not uncommon for the Boards of Trade and other organizations to encourage the location of factories by providing buildings. This building might be given outright to the factory owners, but more usually the arrangements were as follows: The townspeople were informed what type of building was desired, and they would erect the structure according to the specifications and then lease the building to the promoters of the enterprise for a sum of money which might or might not be nominal. It, at any rate, would be comparatively low. At the termination of the lease, the factory managers then had the option of buying the building for a fixed sum provided for in the contract, and usually they willingly paid this amount.

(3) *Exemption from Taxes.*—Tax exemption is probably the most common form of concession given to prospective manufacturers. The release from tax payments extends from one year to a decade, and in some cases even longer, although the latter is not common. This tax exemption as a rule means only municipal tax. It does not relieve the concern from the payment of state or county levies.

(4) *Subscriptions to Stock.*—Sometimes the citizens in

a community are not only anxious to have various kinds of factories locate within their borders, but are willing and even desire to invest in a proposed scheme if the promoters will locate in their vicinity. Frequent instances are on record in which some enterprising individual has enlisted the support of a community and put up a plant with the money supplied either wholly or in part by the residents. The residents may make various kinds of agreements with the promoters. In some cases the promoter becomes merely the managing employee of the concern, being remunerated by regular salary; and in case the plant is a success, he is given, at the end of a certain time, a percentage of the capital stock by vote of the board of directors. At other times the inhabitants subscribe to the stock and become stockholders in the firm, but do not have sufficient control of the enterprise to have more than one or two representatives on the board of directors.

(5), (6) *Cash Bonus and Miscellaneous Favors.*—In some rare cases communities offer cash inducements. An illustration of such a concession is afforded in Urbana, Illinois. When the Big Four Railroad Company desired to build its car and repair shops for the Peoria division, the towns along the line started an active competition. Urbana secured the shops by offering a bonus of $40,000.

Other inducements granted are sometimes free gas, or free power for a limited period of time. One town put a fire-fighting system into a plant as one of its inducements. The citizens of another town are now contemplating the building of a belt line to connect competing railroads, and are offering factory sites at a very moderate cost along the proposed belt line. There are numbers of other inducements of a minor nature, all of which are given to secure an industrial population.

These artificial inducements are not peculiar to any section of the country, nor to either country, suburbs, or city, although it is more common for the country or small town communities to make the offers than for the large centers of population. When a person is contemplating the building of a factory, it is well indeed for him to secure all the possible concessions and inducements that a district will yield; but if the natural advantages are not present, it is a poor plan to take advantage of some extraordinary offer. The artificial inducement may give the organization a start; but unless the natural factors are also present, it can do nothing more, and the plant will then have to struggle along under a severe handicap and must eventually fail. The artificial factors should be considered only when they supplement natural advantages, and should never be the determining consideration in making a factory location.

CHAPTER V

BUSINESS CONCENTRATION AND INTEGRATION

WITHIN the past decade, there has been in the United States a remarkable development of industrial activities. The year 1898 marks the opening of the era of widespread plant consolidations. Between that time and June 30, 1900, of the 185 industrial consolidations which then controlled 2,040 active plants, no less than 112 had been consummated within those thirty months.[1] In *Moody's Manual* for the year 1908 there are recorded about 400 industrial organizations which, if we include the bonded indebtedness, have a capitalization exceeding $5,000,000,000. The total investments represented in industrials in the United States is no less than $12,686,000,000.[2] When we consider the enormous number of plants and establishments these investments must represent, and realize that stockholders are ever clamoring for dividends, we can appreciate the fact that successful managers must be in great demand.

No one can reasonably hold a person responsible for the successful running of an enterprise unless the organization is in such a condition that the person in charge can have a fair chance to administer the affairs of the firm profitably.

The capitalization of prospective earnings has been one

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[1] Cf. *Twelfth United States Census,* Manufactures; *Bulletin* No. 122, December 30, 1901, Industrial Combinations, pp. 2 and 3. Also cf. *Twelfth Census,* Vol. VII, Manufactures, Part I, p. lxxvi. The discrepancy is probably due to the discovery of some errors in the former volume.

[2] *Statistical Abstract,* 1909, p. 192.

of the most fruitful causes of industrial shipwrecks. Enterprising promoters have endeavored to assure the prosperity of their projects by concentrating into one organization all the larger rival interests, thus obtaining a practical monopoly. In some instances this scheme has turned out successfully; in others, the subscribers to the projects have found the schemes to be merely expensive methods of purchasing richly engraved paper.

A plant to be a profit-making investment should be able to manufacture goods at the least possible outlay, and dispose of them to an ever-ready market. It should not be burdened with a load of fixed charges in the way of a heavy bonded indebtedness or preference dividends, neither should its official salary list be unduly large nor its administrative expenses excessive.

If a promoter regards a proposition merely as a device to inveigle money from the confiding public, he will not concern himself seriously about the soundness of the corporation's standing, provided he is able to sell its securities, and is safe from criminal prosecution. Sound business policy does not consist in gathering together a heterogeneous lot of plants and factories to create a large corporation. The size of the company should be a mere incident in the general scheme of instituting a profit-making creation. Indeed, to increase the size without at the same time acquiring compensating advantages weakens the company. The burdens of management are heavily increased unless the widening scope of the plant's activities means possibilities of obtaining cheaper raw materials, of developing less expensive means of production, or of obtaining better and more secure markets.

Financiers should carry out the idea of business integration rather than that of excessive concentration. Business integration is the process whereby the owners of an enterprise secure a more or less complete control of all the steps of manufacturing and distributing a commodity from the raw materials to the finished product.[1] Concentration, on the other hand, means the assembling of like plants for the purpose of eliminating selling competition.[2] Consolidation means a combination of both integration and concentration. All large corporations are to some extent a combination of both integration and concentration; but as a general proposition no combination can be secure in its position unless some form of integration is dominant in its consolidating process.

In our recent development there have been brought to prominent notice five classes of consolidation, and each one has many successful concerns represented in its ranks. These classes may be stated as follows:

1. The complete integration of the manufacturing process, wherein the product is made under the direction of one management from the securing and preparing of the raw material to the placing of the finished goods on the market.

2. The integration of conveyance and manufacturing, and the concentration of factories. Here the producer does not own the sources of raw material, but controls the cheapest possible means by which raw materials can be conveyed from the sources of supply to the manufacturing plants where he carries on the manufacturing process through every possible phase to the making of finished products from the raw materials.

3. An integration and concentration of factories and distributing houses. In this case, the manufacturer does not own, neither does he control, the sources of supplies or the transportation facilities. He builds or acquires plants which are specially adapted to handling the products of various sec-

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[1] Cf. "The Integration of Industry in the United States," by William Franklin Willoughby, *Quarterly Journal of Economics*, November, 1901, Vol. 16, pp. 94–115.

[2] Cf. "The Concentration of Industry in the United States," by William Franklin Willoughby, *Yale Review*, May, 1898, Vol. 7, pp. 72–94.

tions where the raw commodities are made. The presence of these large plants in a community does not necessarily imply that the organization will force unfair price concessions from the producers of the raw goods. In fact, it may even raise prices, but in so doing it is assured that rival concerns must pay at least an equally high amount for the same or for even an inferior quality. In addition to securing the goods on this basis, the firms further guard themselves by developing great selling departments by which they reach the consumer directly, and always keep an outlet for their manufactured products.

4. Integration wherein the manufacturers secure profits by utilizing all possible by-products which may be derived as the primary commodity is being made.

5. Integration and concentration wherein the product is protected by patents and distinguishing trademarks, and a market is created for the goods by wide-spread advertising. As the market expands, plants are erected at strategic points to facilitate selling and lower distributive expenses.

The United States Steel Corporation is the classic example of the first of these combinations. When it was organized in 1901 it included thirteen different organizations in part or whole, and since that time it has acquired no less than twenty large corporations. If we examine into the properties that have been acquired by the steel corporation, we shall note one feature that reflects the profound judgment of the moving spirits in that great organization. In every case where an acquisition has been made, the properties acquired have been ones which will contribute to the importance of the organization in one of several ways.

1. Give it better supplies of raw material which will be used in the manufacture of iron and steel products.

2. Give it better transportation facilities and cheaper means of bringing the raw material to the furnaces and mills, and likewise of taking the finished product away.

Map showing Properties of Subsidiary Companies of United States Steel Corporation 1908

3. Give it an outlet for its own products by making finishing plants which will change its unfinished goods into commodities that can be directly consumed.

4. Give it control of complete units which are situated at strategic points with respect to market and raw materials. The map (Fig. 5) shows the extent of the corporation's properties and the types of plants and possessions it holds.

Even if we are skeptical of the high values placed upon the following inventories, we cannot fail to be impressed with the types of properties. The industry is completely integrated. The following tables have been taken from *Munsey's Magazine* and the "Eighth Annual Report of the Steel Corporation." The first one shows an inventory of the properties of the corporation. The second one compares the production of the properties for the years 1908 and 1909. In looking over the first table we are struck by the mere physical bigness of the corporation. The second one gives us an insight into its multitudinous activities. In the one we see the possession of all material necessary to change crude material into any grade or kind of finished material, from pig-iron into the most highly finished steel product. The second table shows us what these plants produce. It tells us that the corporation is ready to market all kinds of materials.

AN INVENTORY OF THE PROPERTIES[1]

Ore and Mining Timber Properties

Unmined ores located in the Lake Superior districts on the Marquette, Menominee, Gogebic, Vermilion and Mesaba iron ranges, and in the Baraboo district, Wisconsin, in all an estimated tonnage of 1,182,815,200 tons of all grades, exclusive of the Great Northern ores, at sixty cents per ton	$709,689,120

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[1] This inventory appeared in *Munsey's Magazine*, June, 1908, and is quoted by permission of Mr. Frank A. Munsey.

Brought Forward	$709,689,120	
Mining plants, improvements and development work, at active mines, including mine and stripping equipment, tracks, etc., and cost of removing overburden from ore not yet mined, mine dwellings, etc.	23,432,886	
Timber property—803,868,000 feet of standing, mining, and saw-log stock; 1,461,000 cords of logging, pulp wood and cord wood; 191,837 acres of land—all located on above named iron ranges	5,744,011	—$738,866,017
Coal and Coke Properties		
Unmined coking coal in the Connellsville region, Pennsylvania—60,003 acres owned (coal only, not including surface), 1,515 acres leased on royalty basis, also, 21,100 acres of surface; and (of which 750 acres are river front) owned in connection with foregoing	93,656,200	
Unmined coking coal in the Pocahontas region, West Virginia—65,497 acres land leased—valuation in equity above royalties	3,274,850	
Unmined steam and gas coal in the Pittsburg district in Pennsylvania, in Ohio, Indiana, and Illinois—30,252 acres owned (coal only, not including surface), 3,548 acres leased on royalty basis; also, 998 acres of surface land owned in connection with foregoing	8,898,828	
Coking plants, comprising 20,225 ovens in the Connellsville region and 2,151 ovens in the Pocahontas region, including mine openings, shafts, slopes, tipples, power-plants, mine and over tracks, and all machinery and equipment in connection with the mining and coking of coal at the above plants; also, complement of tenement-houses for employees	29,875,150	
Coal mining and shipping plants at mines in the Connellsville and Pittsburg districts, not constructed in connection with coking plants	2,741,412	
Carried Forward	$138,446,440	$738,866,017

Brought Forward	$138,446,440	$738,866,017
Miscellaneous, including standard-gauge railroad equipment (6 locomotives, 700 steel cars, and 1,694 wooden cars), operated in connection with the foregoing properties; water-pumping stations, pipe lines and reservoirs; shops, office buildings, stores, telephone-lines, live stock, etc.	4,393,339—	142,839,779
Limestone and Natural Gas		
Unquarried limestone located at various places in Pennsylvania, West Virginia, Ohio, Illinois, Wisconsin and Michigan, at an estimated valuation of about three cents per ton, including quarry equipment	2,619,529	
Gas territory in Pennsylvania and West Virginia (leased), in all 208,985 acres, on which there are 376 gas wells and 5 oil wells, with about 600 miles of pipe lines, 12 pumping stations, telephone lines, field equipment, etc.	10,360,940—	12,980,469
Transportation Properties		
Standard gauge railroad lines, including the Bessemer & Lake Erie, 233 miles; Chicago, Lake Shore & Eastern, 282 miles; Duluth & Iron Range, 229 miles; Duluth, Missabe & Northern, 274 miles; Elgin, Joliet & Eastern, 230 miles, and other lines, 107 miles—in all, 1,355 miles of main lines and branch lines, with 298 miles of second tracks and 659 miles of sidings and yard tracks, but exclusive of docks and equipment	91,517,750	
Railroad equipment—692 locomotives and 37,902 cars of various classes	42,348,825	
Eight forwarding ore-docks on Lake Superior and two receiving ore-docks on Lake Erie, including equipment	7,396,700	
Seventy-six ore and freight carrying steamers and twenty-nine barges, plying on the Great Lakes, with a total carrying capacity of 635,250 tons of iron ore	21,440,700—	162,703,975
Carried Forward		$1,057,390,240

Brought Forward		$1,057,390,240
Manufacturing Properties (Exclusive of Gary, Indiana)		
Furnaces, mills, and factories, numbering in all 145 separate plants, including the sites (a total area of 8,089 acres), and all equipment and appurtenances other than manufacturing supplies and product on hand		382,248,897
Gary, Indiana, Plant		
Actual expenditure to January 1, 1909, for the real estate, about 9,000 acres; for construction work on the new steel plant, for development and construction work in the city of Gary, and for connecting railroad work		24,063,388
Sundry Real Estate		
Situated contiguous to manufacturing plants and improvements thereon (principally dwellings for employees); also, unimproved tracts of land owned, available for manufacturing sites and for terminal railroad and dock facilities, etc. Value of real estate, exclusive of improvements thereon	$4,975,900	
Improvements thereon	1,719,073 —	6,694,973
Tennessee Coal & Iron Company		
Including ore, coal, manufacturing plants and general equipments of a complete and independent steel manufacturing concern		50,000,000
Net Liquid Assets, December 31, 1907		
Includes cash, and accounts receivable, inventories and investments, in excess of current liabilities		261,789,885
Total		$1,782,187,383

The production of the several subsidiary properties for the year 1909, compared with the results for the year 1908, was as follows:[1]

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[1] Quoted from page 17, *Eighth Annual Report of the U. S. Steel Corporation.*

PRODUCTS.	1909	1908
Iron Ore Mined.	Tons.	Tons.
Marquette Range	899,002	830,087
Menominee Range	1,359,415	1,021,598
Gogebic Range	1,312,701	1,078,025
Vermilion Range	1,066,474	927,206
Mesaba Range	16,968,592	11,272,397
Tennessee Coal, Iron & R. R. Co.'s Mines	1,824,863	1,533,402
Total	23,431,047	16,662,715
Coke Manufactured.		
Bee-Hive Ovens	11,896,211	7,591,062
By-Product Ovens	1,693,901	578,869
Total	13,590,112	8,169,931
Coal Mined, not including that used making coke	3,089,021	3,008,810
Limestone Quarried	3,496,071	2,186,007
Blast Furnace Production.		
Pig-Iron	11,436,570	6,810,831
Spiegel	80,942	74,716
Ferro-Manganese and Silicon	100,838	48,861
Total	11,618,350	6,934,408
Steel Ingot Production.		
Bessemer Ingots	5,846,300	4,055,275
Open Hearth Ingots	7,508,889	3,783,438
Total	13,355,189	7,838,713
Rolled and Other Finished Steel Products for Sale.		
Steel Rails	1,719,486	1,050,389
Blooms, Billets, Slabs, Sheet and Tin Plate Bars	675,614	551,106
Plates	729,790	312,470
Heavy Structural Shapes	658,516	313,733
Merchant Steel, Bars, Hoops, Bands, Skelp, etc.	1,290,970	577,591
Tubing and Pipe	1,013,071	654,428
Rods	139,149	93,406
Wire and Products of Wire	1,607,689	1,275,785
Sheets—Black, Galvanized and Tin Plate	1,024,985	770,321
Finished Structural Work	530,766	403,832
Angle and Splice Bars and Other Rail Joints	190,226	84,669
Spikes, Bolts, Nuts and Rivets	72,076	40,252
Axles	68,366	24,057
Steel Car Wheels	67,985	7,223
Sundry Steel and Iron Products	70,971	47,670
Total	9,859,660	6,206,932
Spelter	27,853	28,057
Sulphate of Iron	33,582	26,411
	Bbls.	Bbls.
Universal Portland Cement	5,786,000	4,535,300

The United States Steel Corporation, with its tremendous possessions, is capable of controlling about 60 per cent of the steel output of the country. If its rivals should ever begin an aggressive onslaught on its markets, the company could easily defend itself by meeting all cuts in prices. Indeed, with its great possessions and equipment, the United States Steel Corporation could carry warfare into the enemy's camp and reduce prices to a ruinous figure for all outsiders.

In spite of a number of strong temptations the company has pursued a very commendable price policy. After the 1907 panic the Steel Trust was the last concern to attempt to secure orders by cutting prices, and it finally lowered only as a measure of self-defense against secret reductions of the independent rivals.

The company has solved its market problem by securing control of the raw materials and the transportation facilities, and by placing complete producing units in such positions that they are accessible at many consuming points.

The Standard Oil Company is the best representative of the second type of consolidation. This organization obtains its raw materials by leasing oil lands and securing exclusive purchase options on the output of oil fields. It does not attempt to buy outright great stretches of oil-producing territory, but rather seeks to maintain its position by developing along two lines, viz.:

1. It has obtained the best and cheapest means for the handling and the transportation of petroleum from the fields to the refineries, and from refineries to the markets.

2. It has the most complete set of refineries in existence, and has located them at strategic points throughout the country.

In the distribution of petroleum the Standard Oil Company employs 8,000 miles of trunk pipe lines, with 75,000 miles of feeders from wells; storage tanks for crude oil, holding 82,000,000 barrels; 10,000 tank cars in America and

2,000 abroad; 60 bulk steamers for ocean traffic and 12 for foreign coasting trade, with 150 steamers and barges at home; 3,000 tank stations in America and 5,000 elsewhere.[1]

The managers of the concern have developed refining apparatus which makes feasible every possible saving, and enables the preparation of all by-products. The process of manufacture does not end with the mere making of the oil. The cans which are destined to carry illumination into the peasant huts of rugged Italy, and the barrels which will hold lubricant for the shops of our own mid-continent are all made in the refineries.

The map (Fig. 6) on the following page is compiled from the report of the Commissioner of Corporations, entitled "The Transportation of Petroleum." On it are shown the location of the refineries of the Standard Oil Company and its competitors, and likewise the oil fields, pipe lines, and the territory supplied by the refineries of the Standard Oil Company. It is interesting to note the advantage that the Standard Oil Company takes of water transportation wherever it is possible. The seaboard territory has its most important points at Portland, Me., Boston, Providence, New London, Wilson Point, Conn., Richmond, Wilmington, Charleston, Savannah, and Jacksonville, all reached by boat. From these ports the oil is distributed inland to the local territories by rail.

The following excerpt is from the text of the report above cited:[2]

"ADVANTAGES DUE TO GEOGRAPHICAL DISTRIBUTION OF REFINERIES.—The great advantages which the Standard Oil Company enjoys over its competitors with respect to transportation are undoubtedly in part the direct outgrowth of the enormous scale on which it conducts business and of the favorable location of its refineries. They are in some degree, at least, natural advantages.

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[1] Cf. *Moody's Manual*, 1909, p. 2786.

[2] "Transportation of Petroleum," p. 60.

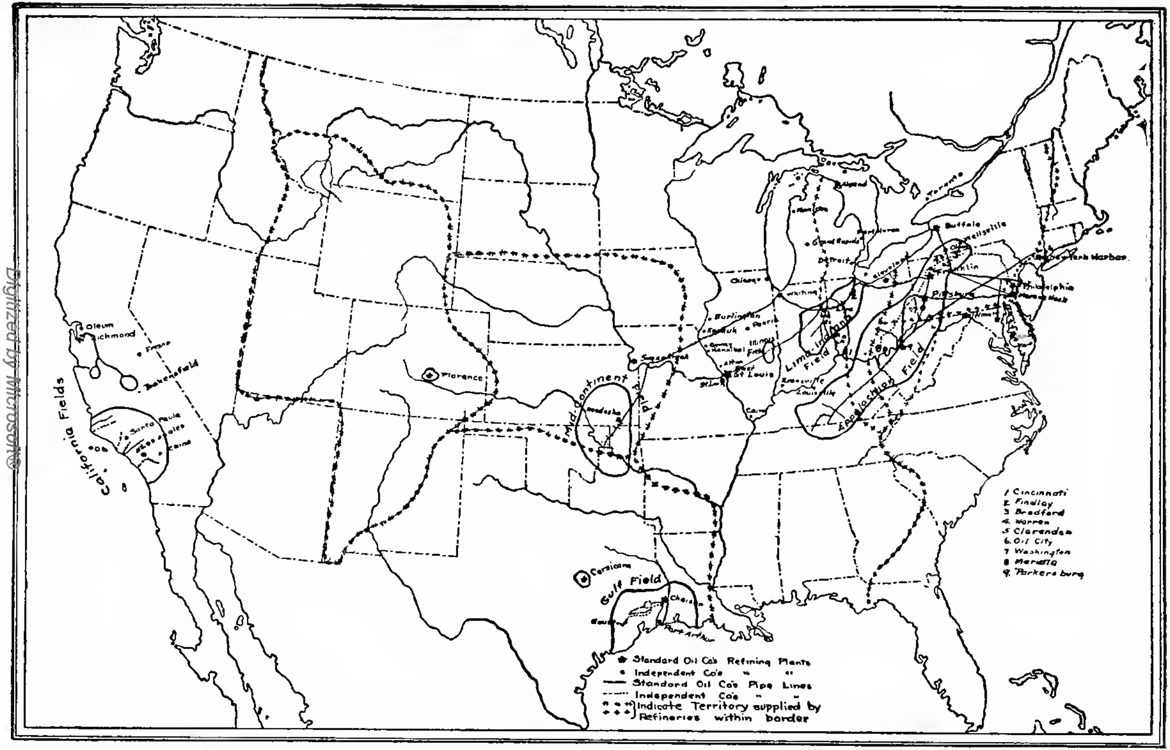
California Fields
Oleum
Richmond
Fresno
Bakersfield
Santa Paula
Los Angeles
Coalinga
Florence
Mid-Continent Field
Neodesha
Sugar Creek
Corsicana
Gulf Field
Port Arthur
Burlington
Peoria
Keokuk
Quincy
Hannibal
Illinois Field
Alton
East St Louis
St Louis
Cairo
Evansville
Louisville
Chicago
Whiting
Grand Rapids
Port Huron
Detroit
Cleveland
Lima-Indiana Field
Appalachian Field
Buffalo
Toronto
Wellsville
Olean
Franklin
Pittsburg
Philadelphia
Baltimore
New York Harbor
1 Cincinnati
2 Findlay
3 Bradford
4 Warren
5 Clarendon
6 Oil City
7 Washington
8 Marietta
9 Parkersburg
Standard Oil Co's Refining Plants
Independent Co's " "
Standard Oil Co's Pipe Lines
Independent Co's " "
Indicate Territory supplied by Refineries within border

FIG. 6.

Disregarding the question of the origin of the power of the Standard Oil Company, and considering only its present position, the advantages which it possesses with respect to transportation are certainly in part independent of any present discriminations from railroad companies.

"In the first place, the fact that the Standard Oil Company has numerous refineries gives it a marked advantage over the competitor who has only one. Even were it not for the transportation of crude oil by trunk pipe lines to long distances, and if the refineries were all in or near the oil fields, by having several refineries the Standard Oil Company would still be nearer to many markets than its competitors. Thus, by operating refineries in the oil fields of Pennsylvania, Ohio, Texas, Kansas, Colorado and California, it could supply each section of the country from the nearest plant, and could save much in the cost of transportation as compared with a refiner restricted to a single distributing point.

"ADVANTAGES DUE TO PIPE LINE TRANSPORTATION.—This advantage of location is, however, very greatly increased by the use of trunk pipe lines to transport crude oil to refineries much nearer to great centers of consumption than the oil fields themselves. The Standard operates enormous refineries at the sea-board. These are much nearer to several great centers of population than the majority of competing refineries, and they also offer the advantage of water transportation to a large area. Similarly, the Standard's great refinery at Whiting is several hundred miles nearer to the markets of the West than most of the independent refineries.

"The advantage of the location of the sea-board refineries, and of the Whiting refinery, grows out of the fact that the cost of pipe line transportation to them from the oil fields is much less than the cost of rail transportation, which the competitors have for the most part to pay in order to reach the same points."

This quotation has added significance, because it is taken from a document hostile to the Standard Oil Company. The report clearly shows that the founders of the organization saw two things: the importance of developing the cheapest methods of transportation and the advantages of strategic locations. It is those two factors which will account for its permanent success.

An excellent illustration of the third class of consolidation is afforded by the American Tobacco Company. This concern, according to the report of the Commissioner of Corporations in 1909, consists of eighty-six companies which have an aggregate capitalization of over $450,000,000, including bonds. This would be reduced to the net amount of $316,000,000, of stocks and bonds in the hands of the public if we were to eliminate duplication of intercompany ownership of securities.[1] The American Tobacco Company began its monopolistic combination in 1890 with the union of the five principal cigarette manufacturers in the country, in this way securing control of 90 per cent of the cigarette business of the United States.

In 1891, it began the policy of extending its dominion over other fields of the tobacco industry. By 1894, it started a vigorous campaign to secure the plug-tobacco business, and by 1898 the competitors of the American Tobacco Company were willing to be absorbed. After it had secured control of the cigarette and plug business, a powerful group of financiers, among whom were Thomas F. Ryan, P. A. B. Widener, and others bought up the Blackwell's Durham Tobacco Company, which was an important manufacturer of smoking tobacco, and the National Cigarette Tobacco Company. In addition to those companies, they had secured an option on the controlling interest of the Liggett & Meyers Tobacco Company, the control of which was exceedingly important to the American Tobacco Company. The American Tobacco Company at once realized the importance of the movement, and willingly made concessions by which this new combination was made a part of the old. A further integration and concentration was made in 1900 by the acquisition of the American Snuff Company, which included all the important American and Continental companies doing

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[1] "Report of the Commissioner of Corporations on the Tobacco Industry," Part I, p. 1.

business in this country. Further absorption was brought about in 1904, when the foreign tobacco interests became a part of the American Tobacco Company.

In 1901, the tobacco combination took another step toward integration by the organization of the American Cigar Company. By 1906, it had about 15 per cent of the cigar output of the United States; but it has not been so successful in dominating the cigar business as it was in the cigarette, smoking tobacco, plug tobacco, and snuff businesses.

In 1898, the tobacco combination, to secure for itself a sure means of distributing its goods, started the policy of subsidizing jobbing houses and wholesalers. By 1906, it owned stock in the following corporations engaged in jobbing cigars and tobaccos:[1]

M. Blaskower Company, San Francisco, Cal.
R. D. Burnett Cigar Company, Birmingham, Ala.
Cliff Weil Cigar Company, Richmond, Va.
J. & B. Moos, Chicago, Ill.
J. & B. Moos Company, Cincinnati, Ohio.
Le Compt, Dusel & Goodloe, Philadelphia, Pa.
J. J. Goodrum Tobacco Company, Atlanta, Ga.
Louisiana Tobacco Company, New Orleans, La.
Smokers' Paradise Company, Atlantic City, N. J.
Jordan, Gibson & Baum, Memphis, Tenn.

Not only has the American Tobacco Company entrenched itself in the jobbing business, but it has even gone farther by securing the control of powerful retail stores. In 1901, a concern by the name of the United Cigar Stores Company was incorporated in New Jersey. In 1906, it had an outstanding capital of $1,950,000, of which the tobacco combination held all the preferred stock and bonds and $340,000

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[1] "Report of the Commissioner of Corporations on the Tobacco Industry," Part I, p. 311.

of common stock, leaving only $110,000 of common stock outside of its control. In addition to the United Cigar Stores Company of New Jersey, the American Tobacco Company was controlling, through the United Cigar Stores Company, the following subsidiary corporations:[1]

United Cigar Stores Company (Incorporated), of Illinois.
United Cigar Stores Company (Incorporated), of Rhode Island.
United Cigar Stores Company Agency.
The Royal Company.
Moebs Cigar Stores Company.
William Baeder & Co.
United Merchants Realty and Improvement Company.

The total number of stores owned and controlled by these companies, including the parent company, amounted, in 1906, to 392.[2] In addition to this there were a number of premium stations, depots, and the National Cigar Stands Company, which was closely affiliated with the American Tobacco Company by heavy loans made by the latter company. The National Cigar Stands Company on March 2, 1907, had 2,062 contracts in force with retail druggists throughout the country.[3]

This does not complete the retail connections controlled by the Tobacco Combination. Jobbing houses do a retail business in connection with their other affairs, and they are very closely affiliated with the large corporations. The most important of these concerns are the Acker, Merrall & Condit Company of New York City, which operates ten stores in New York and has branches in Asbury Park, Baltimore, Md., Far Rockaway, Flushing, Greenwich, Conn., and seven other stores in the immediate vicinity of New York City.

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[1] "Report of the Commissioner of Corporations on the Tobacco Industry," Part I, p. 312.

[2] Ibid., p. 313.

[3] Ibid., p. 316.

Besides the Acker Company, the Tobacco Combination controls:[1]

Cliff Weil Company (Incorporated), Richmond, Va.
J. J. Goodrum Tobacco Company, Atlanta, Ga.
R. D. Burnett Cigar Company, Birmingham, Ala.
Le Compt, Dusel & Goodloe, Philadelphia, Pa.

Further integration of the Tobacco Combination's business is evident in its ownership of concerns which manufacture tobacco accessories. The following list of companies engaged in contributory enterprises, in addition to the above mentioned, is taken from the commissioner's report:[2]

MacAndrews & Forbes Company, Manufacturers of Licorice Paste. They have almost a complete monopoly of this important raw material for the tobacco business.

Mengel Box Company.
Columbia Box Company.
Tyler Box Company.
Golden Belt Manufacturing Company.
Conley Foil Company.
Johnston Tin Foil and Metal Company.
American Machine and Foundry Company.
New Jersey Machine Company.
International Cigar Machinery Company.
Standard Tobacco Stemmer Company.
Garson Vending Machine Company.
Kentucky Tobacco Product Company.
Kentucky Tobacco Extract Company.
Manhattan Briar Pipe Company.
Baltimore Briar Pipe Company.
Amsterdam Supply Company.
Thomas Cusack Company, a bill-posting concern.
Florodora Tag Company.[3]

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[1] "Report of the Commissioner of Corporations on the Tobacco Industry," pp. 315, 316.

[2] Ibid., pp. 16, 17.

[3] Ibid., p. 24, bottom.

In looking over this list of factories and enterprises which the Tobacco Combination owns and controls, one cannot help being impressed with the substantial unity of its acquisitions. Those factories which do not make some form of tobacco, manufacture something which is exceedingly useful for the tobacco producer. The tin-foil company make the wrapping for the various kinds of products. The box company's entire product is used in casing the output. The various ingredients necessary for the production of the tobacco are likewise under their control, as one can see from their ownership of the licorice business. When it comes to distribution, it owns not only stores, but advertising concerns. The Florodora Tag Company formerly did an immense business in the distribution of premiums. When it does not actually make the products it takes means to secure the raw materials at the lowest possible cost. The Amsterdam Supply Company was organized for the sole purpose of acting as a purchasing agent for the American Tobacco Company.

The by-product type of integration must have two essentials before a firm can afford to spend money on equipment to work up its subsidiary material.

1. It must have the assurance that the market conditions will be such that the by-products will always have a ready sale.

2. It must have a main industry sufficiently large to provide enough material to keep the by-product plants continually running.

As a consequence those industries that have developed the by-product features are almost invariably large concerns, and they are usually very active in developing their business by various schemes to keep their names before the public and create a demand for their goods.

The beef-packing industries present the most widely known example of the by-product type of integration.

Merely to mention the by-products obtained in the course of slaughtering is a task in itself. The average live weight of a beef is between 1,000 and 1,100 pounds, while the dressed weight ranges between 575 and 650 pounds.[1] Within a recent period, only the hides and tallow of the 450 pounds of non-edible material were saved. At present every ounce of this waste product is compelled to yield some tribute to the packer. From the horns and hoofs are made various grades of glues, buttons, and hair-pins, and they are made the basis for the manufacture of cyanide and chrome. The albumin in the blood is used to make an insoluble printers' ink. It is also used by tanners to finish leather, and by sugar refiners to make possible the inviting whiteness of their product. Dried blood, bones, tankage, and the ground waste of hoof and horn scraps make a fertilizer rich in nitrogen which, when combined with acid phosphate, becomes the source by which otherwise infertile soil is made to bring forth the necessaries and luxuries of our tables. The wool from the packing-house sheep is made into fabrics to clothe us, but before it is given to the textile worker, the oil is extracted, making the non-shrinking basis of wool soap and also the essence of various soothing skin lotions and toilet preparations designed to beautify the users. If we are sick, our jaded appetite may be tempted to accept gelatine extracted from the bones of calves; if convalescent, our system may be induced to increase in strength by absorbing "Soluble Beef," the predigested and concentrated substance of meat. The intestines of the animals are the casings for sausage which is made from meat otherwise unsalable. The gun we carry on a hunting trip is hardened with bone carbon, the handle of the knife which we use to dress our game is from the packing house. If camp fare disagrees with our

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[1] "Report of the Commissioner of Corporations on the Beef Industries," pp. 202, 203.

stomach, we can vary our diet with beef extract and allay the pains of indigestion with pepsin and pancreatin. The baby starts out in life using a bone-capped nursing bottle and teething ring. If in later years nature proves niggardly in her gift of hair, the switch on the end of the beef's tail will be offered to supply the deficiency. Collar buttons, pipe stems, and dice, brewers' isinglass, and brushes, soap and glycerine, washing powder, and sand paper are all products sent forth from the various departments of these great concerns. So minutely has the by-product feature been carried out that the glands of 100,000 sheep are carefully preserved and treated to produce one pound of suprarenalin, a substance whose astringent qualities have proven invaluable in delicate surgical operations.[1]

The National Biscuit Company and the Singer Manufacturing Company are two good examples of the fifth type of integration. Both concerns have fortified every distinguishing feature and improvement about their articles by patents and trademarks. Both concerns have been very careful to guard the quality of their goods, and neither forgets that advertising is necessary for publicity. Each one has built plants at various places to make easier the distribution of products to the consumers located in various districts.

The National Biscuit Company has sixty manufacturing plants situated at various points in the United States.[2] The Singer Company has plants not only in the United States, but also in Canada and Scotland.[3] It is a common practice for concerns to erect plants in foreign countries when duties on their products are high, because in so doing they avoid the tariff charges, and are thus able to compete with the foreign manufacturers on more equal grounds.

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[1] Cf. "The Packers, the Private Car Lines and the People," by J. Ogden Armour, Chapter IX, p. 201.

[2] *Moody's Manual*, 1908, p. 2397.

[3] Ibid., 1908, p. 2517.

In actual practice almost every large concern is successful, because it has utilized to a greater or less extent several of the above-mentioned methods of integration. None of the companies in the above illustrations are successful exclusively because of their characteristic type of integration. The United States Steel Corporation, for instance, derives a large part of its income from its extensive by-product manufacturing, while the packing houses are exceedingly careful to cultivate every possible market. They advertise their goods broadcast, and have their agents everywhere drumming up trade.

The question that the directors have to decide is, how far shall we push expenditures along any one line of consolidation? Will a thousand dollars spent in improving the methods of manufacture give as large a return as the same amount spent in advertising? Will lowering the cost increase our trade or profits so much as changing our selling methods or securing control of raw materials?

In the last analysis, all of these consolidations seek to do one thing—to secure sufficient control of the market to assure the manufacturer a profitable outlet for his goods. Some types of industries can secure this control most readily by obtaining the sources of raw materials, some by cutting factory costs, and others can get it only by developing the selling department to a high degree of efficiency. All are struggling for the patronage of the public, and the strongest appeal any one of them can make is to give the best value for the lowest price. When one secures control of the raw materials, he can make the lowest price in any community simply by compelling his rivals to pay a higher amount for the crude products. If, however, the supply of raw materials is such that all can purchase on an equal footing, the firm which can manufacture with the least cost is in the strongest position to gain the market, provided all other things are equal. In many instances, the best methods of carrying on an industry are so generally known that the rival interests have little or no advantage over each other in that respect. In those cases, the victory goes to either the one who has lowest distribution expenses and sells the cheapest, or to the one who by judicious advertising or other means secures a reputation for giving superior quality for standard prices.

CHAPTER VI

BUSINESS SPECIALIZATION

In the last chapter it was stated that consolidation could take place in the field of raw materials, manufacturing and selling. To secure control of raw materials is a financial problem that requires a different solution in every individual case. The manufacturing and selling phases of any business must be handled after the plant has been located and constructed. In another chapter it will be shown that even the most economical construction of a plant is almost entirely dependent upon the peculiarities of the processes that go on under the roof of the structure.

The university of a generation ago had few departments, as a rule; but those departments taught a great many branches. At that time a man could be Professor of Natural Philosophy, and within that domain he gave instruction in Geology, Chemistry, Physics, Physical Geography, Mineralogy, Meteorology, and perhaps a half dozen other allied branches. A professor of Political Economy would be likely to teach Economic History, Economic Theory, Public Finance, Private Finance, Transportation, Sociology, and an almost indefinite number of the derived topics. How different is the university of to-day. Natural Philosophy has vanished from all curricula. Even geology is broken up into Historical Geology, Paleontology, Inorganic Geology, and a half dozen other subdivisions. He is a bold man who pretends to know more than one or two of those subdivisions with any great degree of completeness. The science of Political Economy has been broken up into Economics and Sociology, and in those two orders of social science we find specialists who do not care to teach more than one small branch of their general division. At the present time we have professors of Transportation, of Insurance, of Farm Economics, Accountancy, Industry, Commerce, Finance, and a host of others. In the past we had the tendency to hit only the high places in our sciences. We were broad but not deep. Our institutions of learning have carried out the idea of specialization in education to exceedingly fine limits, and it has resulted in incalculable good to the cause of knowledge.

While the specialization has been going on in the higher institutions another movement has been taking place. The universities are getting into closer and more sympathetic relations with the high schools, and even with the grade schools, until, at the present time, in some states the entire school system is gradually getting welded into one big unit which has for its object the most perfect training that is possible to give each child in a community.

Twenty years ago, in the majority of industries, the plants were about as general in the scope of their work as were educational institutions. The history of a number of large concerns that have been in existence for over thirty years might be cited to show the great changes that have taken place in the character of their activities. Formerly, machine shops did every grade of work on the floors of a single building. One shop in an eastern city built printing presses, blowing engines, water turbines, marine engines, mill engines, mining machinery, pumps; in fact, everything conceivable in the machinery line for which they could obtain an order.

Textile establishments in days gone by manufactured a great variety of fabrics. One concern made ingrain carpets, Brussels carpets, velvets, suiting material, and many other types of fabrics. Knitting mills commonly made all kinds of stockings, underwear, and other knitted goods. Paper mills of the past turned out all grades of pulp materials, from the coarsest straw board to the finest writing and drawing papers. Shoe factories never thought of restricting themselves to any particular grade or kind of footwear.

At the present time such diversity of activities would be undreamed of for any one plant. Machine shops now confine their energies to the building of one or two classes of machinery. If a company is engaged in several lines of activity, it has a special shop or department for building each commodity. One concern builds nothing but cranes, another only milling machines, some plants construct planers and shapers, others locomotives. In the field of electrical equipment, plants may limit themselves to special sizes of certain goods. One concern now doing a profitable business confines itself to the building of motors of a few small sizes, and will not accept orders for larger ones.

In textiles, no thoroughly trained manager would risk funds in attempting to manufacture a great variety of goods under one roof. There are mills which confine their energies to the making of ingrain carpets, others make only rugs. One firm has invested over $1,000,000 in equipping an immense building whose only output is lace curtains. The knitting mill has been succeeded by the stocking and underwear factories. Some plants have even gone so far as to make a specialty of either men's, women's, or children's hosiery, and a few concerns have gone to the extreme limit of specialization by making only one or two grades of men's socks.

Shoe manufacturing is known everywhere as a specialized business. At present, the greatest factories make either men's or women's and children's shoes, and not a very great number of grades at that. Several concerns confine their energies to the production of one or two qualities of footwear, and endeavor to secure an immense market for their output by giving the consumer the choice of a great number of different styles. By specializing their outputs, factories can give such excellent quality and style for so low a price that once established, rivals will find it difficult to break into their domains.

Like tendencies are evidenced in the paper business. No longer do single plants manufacture a great variety of pulp material. Mills are now very apt to specialize on newspaper, bond paper, wrapping stock, or some particular kind of fiber goods.

In an almost indefinite number of industries the same change has taken place. The tendency is not confined to any selected group of activity. It is the expression of an ideal which is influencing our modern civilization. If we are to exist, we must conserve our forces. We set aside great tracts of land for forest reserves, the government is appointing commissions to draw up plans to husband our coal, vast sums of money are being spent to make the barren deserts fruitful fields. The states and the United States support great agricultural colleges and numerous experimental stations for the purpose of finding out for the farmer how he can save his land for future generations and yet get from it the maximum yield.

In manufacturing, the *entrepreneur* has long seen that his rewards depend upon methods of effectively handling raw materials and labor, and he has hit upon specialization to attain economy in manufacture. Specialization aids in a number of ways:

1. It reduces the preliminary costs incurred in all manufacturing.
2. It makes possible the extensive use of highly specialized machinery, buildings, and other equipment.
3. It simplifies managerial problems.
4. It makes worth while the introduction of numerous small savings.

Specialization is one of the greatest possible aids to industrial economy. How this is accomplished, is well illustrated in the building of a steam engine. In order to build a steam engine of several hundred horsepower in an unspecialized plant, the builders must proceed as follows:

The prospective purchasers of the engine advertise for bids on engines of the capacity desired, and they give the necessary data as to the work that the engine is expected to do. The concern desiring to secure the contract makes out drawings and sketches showing the type of engine they offer and the way it will look when completed. On these sketches the advantageous features of their engines are shown, and these sketches are frequently painted in water colors. They always represent considerable work on the part of the drafting department.

If the firm secures the contract, the chief engineer makes out the general specifications, such as the sizes of the cylinders, the length of stroke, steam pressure, type of valve gearing, and other main requirements.

The chief draftsman then takes the job in hand and allots the working out of the various details to under-draftsmen. These under-draftsmen calculate the amount of material that must go into the engine, figure out the sizes of the various parts, and show clearly the proper allowances to obtain the proper valve movements. They must see that all moving joints are properly provided with lubricating devices, so that there will be no binding at any point, yet the movements must not be so free that leakage of steam can occur in any place. The throttle-valves and other parts likely to be frequently used must be put in accessible places. Provision for taking indicator cards must be made, so that it will not be dangerous for one to make tests of the engine while it is running. Proper clearance must be provided for all moving parts. The oiling system should be such that lubrication can take place without undue waste of oil, and without involving danger to the attendant. Not only must all of those parts be looked after for the engine, so that it can run successfully, but care must also be taken to see that its parts are constructed in such a manner that the engine can be put together. The writer remembers an instance where several bolts were so placed that it was impossible to get a wrench on the nuts. As a consequence, the bolts were useless, but it fortunately happened that if left-handed threads were cut on the bolts the nuts could be tightened, and it was not necessary to redesign the whole part after the castings had reached the machine shop.

When the drawings of all the details are made and a general drawing showing the placing of all the different elements is completed, tracings must be made of everything. These tracings are inked in with great care, the different parts shaded and the dimensions of every piece indicated. After the tracings are all completed, every part must be carefully gone over and checked by some responsible person. This person is much like a proofreader. He looks out for every kind of a mistake that can occur, or is likely to happen, in the construction of the engine; and if he finds any inaccuracy, he must report it and see that it is corrected before the plans leave the drawing-room.

After the tracing is checked and everything is seen to be correct, the tracings are turned over to the blue-printer, and a number of blue print copies of every drawing in the engine are made. The blue prints are then turned over to the construction departments.

The first step in building the engine begins in the pattern shop. The pattern shop is the place where the various shapes of the proposed castings are made in wood which will serve the molders as the basis for the construction of the molds. The drawings in the pattern shop are first carefully gone over by the foreman who determines which parts are to be made by the various workmen. The workmen are then given the drawings and are expected to read them and make from them the correct form in wood. To do this is no simple matter. A good pattern-maker possesses a very high degree of intelligence. The drawings, in the first place, are often very complicated, and it requires considerable imagination to see in those conventional lines the picture of a form. The workmen's ingenuity is further tested by the fact that he must always remember that the wooden pattern must be reproduced in metal. The metal that is poured into the molds made by the patterns is in a molten condition. The pattern-maker must take into consideration that his pattern must be so built that after the sand is rammed tightly around it, it can be withdrawn without spoiling the mold. He must not forget to make the pattern large enough to give the casting sufficient material to permit of cutting and trimming in the machine shop. In the cooling there is considerable shrinkage of metal, and unless great care is exercised in making the patterns, cracks will develop in the castings. In the foundry, the molds must be built to suit the patterns in question. Some of the minor molds may be made in casting machines, but it is hardly worth while to get machinery of that kind unless a great number of pieces are made.

After the castings have been made, they are cleaned and passed on to the machine shop. The machine shop foreman will have in his office the complete set of prints of the engine. He will have the task of determining the order in which the various parts shall be finished. He will ascertain the machines best fitted to carry on the various machining processes on the different castings. In these machining steps, considerable time is lost in getting the pieces set up on the tools which are to make the engine parts ready for assembling. Every time each piece passes to a different tool or to a different step in the process, the various workmen in charge of the steps must decide upon the best way to handle the piece, the proper cuts to make on it, and, in general, its method of treatment.

Several years ago there were shops where fully 30 per cent of the time consumed in machining and assembling the parts was used up in preliminary operations. It is true that some of this time was wasted, but nevertheless, the greater part of the loss was due to the fact that the firms were working on new contracts most of the time, and could use little of the former work and material.

Imagine the same engine going through an establishment which has been specially constructed for the purpose of building engines of that class and horsepower. In the first place, the engineering and drawing expenses are reduced to an almost insignificant item for each order, because one set of drawings with a few alterations does for a number of engines. The pattern cost for each becomes an almost negligible item for the same reason. In the foundry it is worth while to construct special molding devices, which make the molding cost for each engine much smaller than it possibly can be when only one or two engines are constructed. In the machine shop, the foreman can work out a general scheme for the machining of the parts, and they pass from one tool to another without the necessity of any special direction. Moreover, tools can be adapted to the special purpose of handling the engine parts. In the locomotive business, boring mills are built for the one purpose of handling locomotive driving wheels. Special planers are designed to use in making the frames of the locomotives. In fact, every part of the engine is made on a specially designed machine. Jigs and other auxiliary devices are built which reduce the work of finishing the parts to a mere mechanical routine, and to a very great extent eliminate the possibility of error.

In erecting the engines, economies can be introduced by training men to do certain parts and keeping them at a few tasks.

When things are done on a large scale, specialized plants can be erected for the sole purpose of making one product. Every little feature in the process can be studied minutely, and economies which would be insignificant on one or two become very valuable savings on one hundred or more.

One of the greatest money-saving devices known to the modern manager is the interchangeable part. The interchangeable part is the device that makes possible the specialized plant, and the savings that have been noted above. With it, management becomes a question not of determining the best method of handling each new contract, but the best method of doing each little detail. The introduction of the interchangeable part has made it possible for American manufacturers to sell locomotives in Europe and far-off China. It is the reason why thousands of people within our own borders carry the dollar watch.

Specialization has, nevertheless, its limitations. A manufacturer will do well to investigate carefully the extent to which he confines his energies to the turning out of a single article. One can invest a large amount of capital in a plant which will reduce the output cost many per cent, but if the plant is specialized to such a degree that it can manufacture only one product, the investor may lose every cent he puts into the concern by the introduction of a new commodity that may capture his market. Thousands of dollars were lost by bicycle manufacturers when the bicycle craze died down.

A good rule to follow in plant specialization is to specialize to the limit in plants which manufacture necessaries, or partly finished products whose demand is not affected by any great improvements, things like flour, sugar, steel rails, steel plates, and articles of a similar nature. In goods liable to be improved and changed, the specialization of the equipment may be carried with safety to the point where an improvement or change in the product will not render useless the appliances of the establishment. One may, for example, safely specialize a loom to the point where it will make goods of a certain width and quality, but it would not be safe for the managers to install equipment which could turn out only cloth of a single pattern or coloring. It would even be safer for the loom to have some range of variation in width and quality.

If a product is of an ephemeral nature, specialization should not be carried past the point where the old machinery can be adapted to the manufacture of new things. Toy factories are never safe in investing large sums of money in machinery so specialized that it can turn out only one kind of toy.

In a word, there is a limit to specialization, and the nature of the goods should determine the danger point for the manufacturer.

PART TWO

THE EQUIPMENT OF THE PLANT

CHAPTER VII

CONTINUOUS INDUSTRIES, SYNTHETICAL

After the questions of location, integration, and specialization have been settled for any particular business, there arise the more technical problems affecting the successful activity of the concern. How shall we build the plant so that it will make integration and specialization possible? Can the plant be run in any kind of a building? The answer is emphatically, No. Even if a business has been placed in its most suitable environment, it cannot carry out the plans of integration and specialization unless it is properly housed. Neither can good management be possible unless the building is properly adapted to the work and the workers.

Every one has noticed that plants for different industries vary greatly in their structures and layouts. Every industry can be carried on best in a structure adapted to its peculiarities; and viewing industries in a broad way, it will be seen that there are two factors that play exceedingly important parts in determining the nature of the structure which will house the plant, viz.:

1. The type of manufacturing industry.
2. The nature of the goods handled.

From the standpoint of the industry one may have two kinds of manufacturing:

1. Continuous.
2. Assembling.

A continuous industry is one in which the product is all received at one place and the operations to change the raw material into finished goods are performed in a continuous manner on the entire mass of material. The raw materials go into one end of the plant and pass through various machines and processes without halting at any stage for other finished parts to be brought to them. When such articles thus manufactured are finished, they are completed as a whole, and not in sections that must be put together.

There are two classes of continuous industries:

(a) The synthetical.

(b) The analytical.

In chemistry the word synthesis is used to designate the process of making substances by bringing together various ingredients. In our food and clothes we consume things which have gone through synthetical processes. A bowl of soup and a piece of bread are results of synthesis, as are also stockings and steel rails.

A subdivision of the synthetical class of industries may indicate whether the industry produces incidental by-products or not. A very important influence is exercised on the lay-out of plants if it must handle by-products in the course of its manufacturing. The non-by-product industries are an exceedingly important group in the United States. In 1905, the textiles alone contributed nearly $2,150,000,000 to the wealth of the country. In addition, the tobacco, clay, paper, and printing and other industries, all non-by-product in type, added another $2,000,000,000 to this sum. In brief, more than one-quarter of our consumable wealth was made up of products coming from factories of this nature.[1]

Since the textile industries are the most important class of this non-by-product group, their plants are instructive. Into such plants are brought raw materials that are worked upon during the entire time of manufacturing.

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[1] Cf. *Census Bulletin,* No. 57, Census of Manufactures, 1905, p. 25.

Any single textile industry may be regarded as a unit industry in the sense that the entire plant is devoted to the production of one thing only—the working up of certain fibers. This does not mean, however, that there is no wasting of the raw materials as they go through the various manufacturing steps. In every textile plant the cleaning and handling of the material causes some loss in every machine. In cotton manufacturing, the subject of the utilization of cotton-mill waste is becoming one of increasing importance.[1]

Figure 7 shows the steps through which cotton passes to be made into its different finished products. While the material is passing through the various machines, waste occurs in dropping from the opener and scutch machines, the brush-strips from the cylinders and doffer cards, the card-room sweepings, and comber waste; the bobbin waste, from fly frames and spinning machines, the hard ends from cop bobbins; and there is also the oily waste. The quantity wasted varies with the conditions and the character of the raw cotton, the effectiveness of the machinery, the ability of the operator, and the character of the products manufactured. The aggregate average of this loss amounts to about 8 per cent of the raw cotton worked. It has been estimated that for the entire United States the mill waste would total to the figures of 175,000,000 pounds, about 87,500 short tons.[2]

These figures are impressive. To rework all this waste in the United States would keep 1,000,000 spindles employed 52 weeks in a year.[3] Great as it is in the aggregate, however, few mills find it profitable to rework their waste material, the reason being that the waste of each machine is different, and requires unlike treatment, if not different machinery, to make it a salable product. Waste spinning is an

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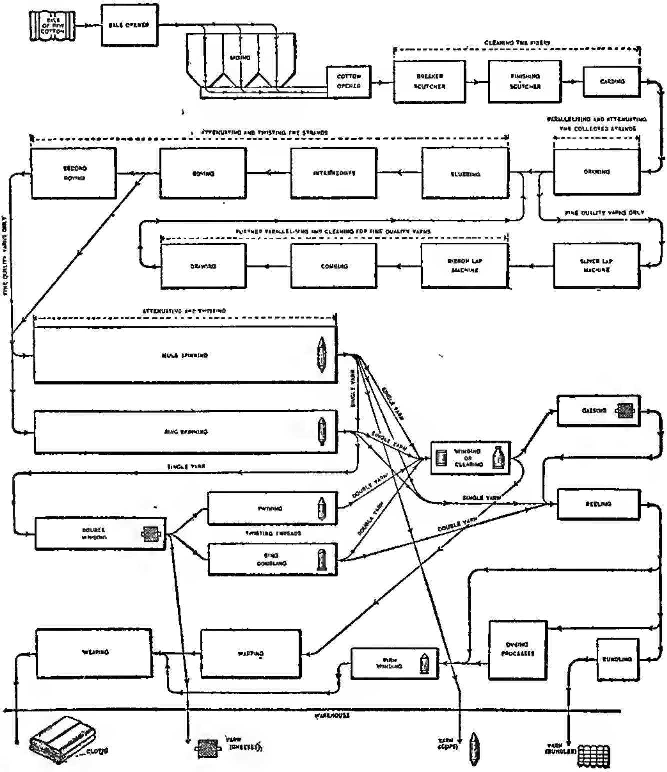
[1] *Census Bulletin*, No. 97, p. 35.
[2] Ibid. [3] Ibid.

industry by itself, and requires as much skill in all of its branches as does the manufacturing of a higher grade of goods. As a consequence, the textile manufacturer finds it more profitable to sell his waste product for what it will bring, and to confine himself to the production of one commodity or class of products.



From Census Bulletin No. 90, p. 27.

FIG. 7.—Diagram of Cotton Manufacture.

In order to understand the requirements of an ideal textile plant it is necessary first of all to know the steps in the manufacturing process. The working up of cotton offers an excellent illustration of a textile industry. The diagram (Fig. 7) on page 86 shows the steps in the manufacture of cotton goods from the bound bale to the cloth.[1]

The machines carry the fiber through twelve main steps.

1. *Loosening Out the Fibers So That They May Be Cleaned.*—This is done by the bale-opener or bale-breaker and the mixing machines. The cotton, in order to be made suitable for transportation, has been tightly compressed, and as a consequence, it is very closely matted and quite lumpy when it comes out of the bale. In order to make it fit to enter the cleaning and carding machines, it is put through the mixers and openers where the lumps are teased out and the cotton itself is made into the form of a broad, loose sheet of indefinite length, which can readily enter the machine used in the next step.

2. *Cleaning.*—The cleaning of the fiber is usually done by air blast in scutchers, but the fiber is as yet in a rather crisscross, loosely matted condition, and in that state is unsuited to the making of thread. In order to fit it for the threads, the fibers must go through the next process.

3. *Paralleling the Fibers.*—The main work of paralleling is done in the carding and drawing machines. Some cleaning, of course, goes on in the carding machine, but it starts the step of paralleling the fibers, which is continued by the drawing frame. After the fibers are made parallel, they come off the drawing machine in the form of a very loose sliver, which could hardly be used for spinning, so it must pass on for some further operations.

4. *Attenuating the Slivers or Strands.*—The strands are attenuated on the various slubbing frames or roving devices.

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[1] *Census Bulletin*, No. 90, p. 27.

It is in these stages of the process that there arises a difference in the work put upon the different grades of product. Very fine goods go through a very great number of machines, while the coarser grades pass through but one or two. When the strands have been attenuated and slightly twisted in order to prevent matting, before they are spun, they pass on to the fifth step.

5. *Spinning.*—Spinning is the process of making the loose strand into a compactly spun thread, and is done by twisting the strands a great number of times. There are two kinds of spinning machines, the mule spinner and the ring spinner. The former attenuates while it is spinning, and is used on high-grade products. The ring spinner is used on inferior grades of yarns, and does not attenuate so evenly as does the mule.

6. *Doubling and Winding.*—From the spinning machines are sent forth single strands of yarn. To make a strong and serviceable thread, two or more of these single strands are twisted together on various twining and doubling machines. These machines likewise wind it on different kinds of spools, so that the yarn may be used for different purposes, as knitting and the like.

7. *Reeling.*—If the yarn is to be dyed or is to have any further preparation before it is woven, it is made up into skeins on the reeling machine; and if it is to be sent out to be dyed, or is to be sold as yarn, it is made up into bundles to facilitate transportation.

8. *Dyeing.*—In this step the yarn is given its color. After it is colored and dried it is then ready for the final steps of cloth-making.

9. *Pirn Winding.*—In this step the dyed yarn is wound in a form so that it can be put into a shuttle, which will be easy to use in the loom to make the cross threads of the cloth.

10. *Warping.*—The preparing of the longitudinal threads

of the cloth in such a manner that they can be put into the loom.

11. *Weaving.*—The interlacing of the shuttle or filling threads with the warp threads to make the cloth.

12. *Finishing.*—In the finishing process the woven cloth is cleaned, starched, and treated in various ways to fit it for its particular market.

The diagram shows how direct the process of manufacture is. The building, therefore, best adapted to carrying on the cotton industry is one in which the machinery is arranged in a direct line from the bale breaker to the finishing room.

There are two possible ways of building a plant so that this end can be accomplished. It can be built over a great stretch of territory, with the receiving department at one end and the shipping department at the other, and the goods may pass in a generally horizontal line through the plant. Another form of plant is one in which the floor space is limited to within comparatively narrow bounds, but the structure is made high, so that the goods will pass in a more or less vertical direction. The diagrams in Fig. 8 show examples of both types of plant.

The textile industry is one in which the labor problem and proximity to a large consuming market are very important. This makes it desirable to locate the plant within the vicinity of a large population, but where land values are bound to be high. As a consequence, textile establishments are usually built on the vertical plan in order to bring their fixed charges in taxes, rentals, etc., down to as low a level as their location permits. On account of the weight of the material handled and the comparative lightness of the machinery, there is no engineering difficulty connected with the building of the structure, and no great expense is involved in elevating the goods. The cost of handling the goods is so small compared with the savings due to the high structure that textile plants have long since been made tall structures.

There are, however, some disadvantages in a high building, especially if it be in a crowded city. It is very apt to be so located as to have some difficulty in securing all the light desirable for the carrying on of the processes within

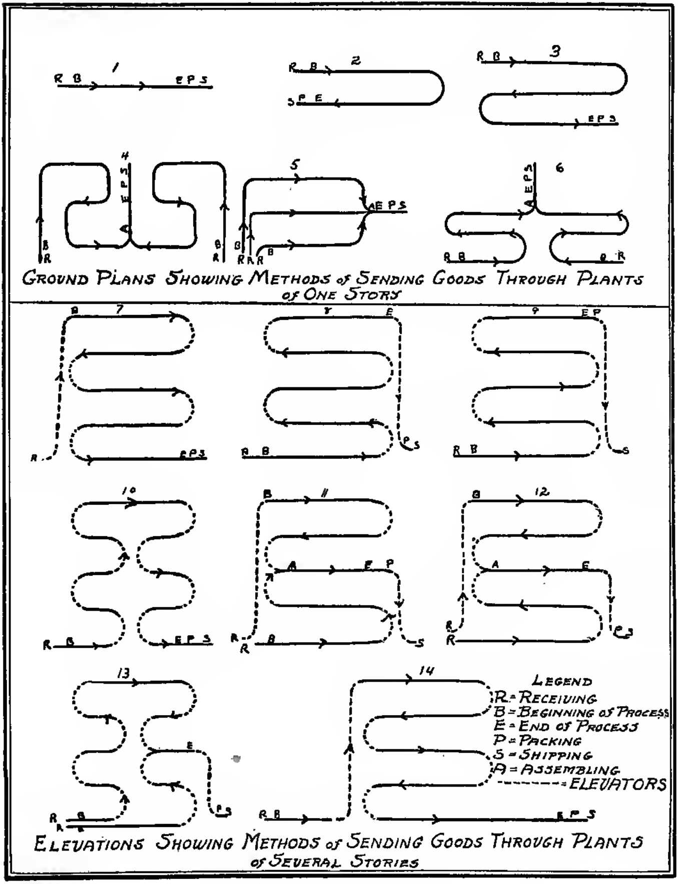

FIG. 8.

the plant. Until the spinning of the fibers begins, comparatively poorly lighted rooms can be used; but when the spinning and winding steps commence, a well-lighted room is required. In warping and weaving it is even more necessary. On account of the lighting problem, textile plants have frequently been compelled to vary the sequence of the operations in such a way as to put the most delicate operations in the parts of the building where they can get the maximum amount of light.

The textile industries afford an example of the continuous industries of the non-by-product type, and the characteristics of the layout and structure of those plants can be applied equally well to industries of a similar character. These characteristics are, in brief:

1. The plants may be built either high or low, without necessarily affecting the continuity of the process. Hence they may be built in congested districts without incurring rental and taxes unduly high or other overhead expenses which would become oppressive.

2. They should be well lighted and ventilated, and must use large window space.

3. The wash-rooms and lavatories should be placed in positions convenient and yet not obstructive.

The most important industry of the by-product type is the iron and steel group. The production of this one group amounted in 1905 to nearly $2,180,000,000.[1] It affords from its importance and natural characteristics the best example of the continuous synthetic industry of the by-product type. In a previous chapter, it was shown how completely the steel industry is integrated. This integration has been carried so far that nearly every plant is a complete unit in the sense that it starts out with the raw material and ends with the finished product.

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[1] *Census Bulletin*, No. 57, p. 25.

Three main ingredients enter into the production of steel, iron ore, coke, and limestone. The iron ore is a compound consisting of one or several oxides of iron mixed with a considerable proportion of other materials, known under the general name of gangue. The coke has the quality of extracting the oxygen contents from the ore, and leaving behind the iron in a metallic state, but intimately mixed with the molten gangue. Limestone has the quality of dissolving this nonmetallic content, and separating it from the molten metal. It sometimes happens that the iron ore will have a greater or less percentage of sulphur or phosphorus associated with it in some form or other. If it contains the former, the ore must be treated to a roasting process, to burn out the deleterious content before it can be fit for the blast furnace. Phosphoric iron receives its treatment farther along in the steel furnace itself. The diagram on page 93 gives some idea of the steps in the preparation of iron and steel products (Fig. 9).

A few years ago nearly all coke was prepared in the vicinity of the coal mines, in bee-hive ovens, which did not yield any by-products. This was following out the well-known principle that all unnecessary ingredients of the raw material should be removed at the source of supply in order to save freight rates. Within the past few years, however, it has been found that the products so carelessly lost by the bee-hive oven are by no means worthless.

Probably people were thoughtless of the by-products in coal because of the location of the iron and steel industries. Pittsburg was in the center of the richest natural gas region in the world. Heat and power were given with such a free hand by nature that the iron masters could not afford to trouble themselves about saving the riches in coal. Since the opening of the Pittsburg district, great changes have taken place in the steel industry. It has moved away from the regions of natural gas, and the gas itself has largely given out. Heat can no longer be had for the mere tapping of the ground,

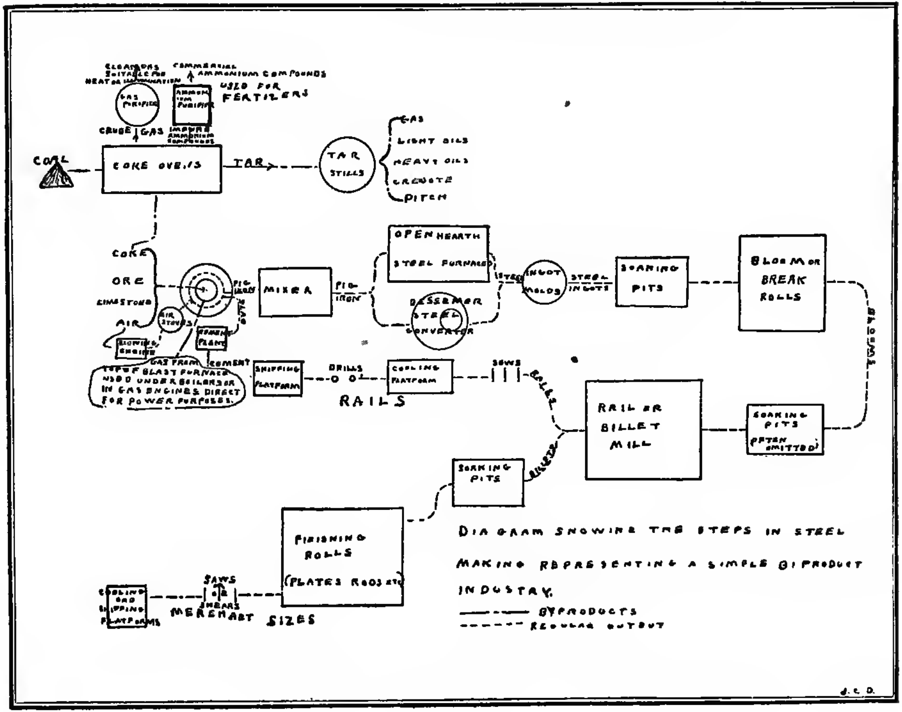

ILLUMINATING GAS SUITABLE FOR HEAT OR ILLUMINATION
COMMERCIAL AMMONIUM COMPOUNDS USED FOR FERTILIZERS
GAS PURIFIER
AMMONIUM PURIFIER
CRUDE GAS
IMPURE AMMONIUM COMPOUNDS
COAL
COKE OVENS
TAR
TAR STILLS
GAS
LIGHT OILS
HEAVY OILS
CREOSOTE
PITCH
COKE
ORE
LIMESTONE
AIR
AIR STOVES
BLOWING ENGINE
PIG IRON
SLAG
CEMENT PLANT
CEMENT
GAS FROM TOP OF BLAST FURNACE USED UNDER BOILERS OR IN GAS ENGINES DIRECT FOR POWER PURPOSES.
MIXER
PIG IRON
OPEN HEARTH STEEL FURNACE
BESSEMER STEEL CONVERTER
STEEL
INGOT MOLDS
STEEL INGOTS
SOAKING PITS
BLOOMER OR BREAK ROLLS
BLOOMS
SOAKING PITS (OFTEN OMITTED)
RAIL OR BILLET MILL
RAILS
SAWS
COOLING PLATFORM
DRILLS
SHIPPING PLATFORM
RAILS
BILLETS
SOAKING PITS
FINISHING ROLLS (PLATES RODS ETC)
SAWS & SHEARS
COOLING AND SHIPPING PLATFORMS
MERCHANT SIZES
DIAGRAM SHOWING THE STEPS IN STEEL MAKING REPRESENTING A SIMPLE BY PRODUCT INDUSTRY.
BY PRODUCTS
REGULAR OUTPUT
J. C. D.

FIG. 9.

but must be secured by a more costly method. Human ingenuity has been equal to the occasion; the bright luminous flame that burst from the top of the old bee-hive oven was a beacon inviting the scientist to explore an unknown world of wealth. The gases which served to make useless flames are now carefully husbanded and burnt where they will create wealth for the owners. Coke is now made on the grounds of the steel plant and in by-product ovens.

Chemistry has revealed the fact that coal can be made to produce three valuable by-products aside from coke, namely, gas, ammonia, and tar. The latest type of the by-product coke oven saves all three of those products. The gas is collected and purified and sent to the various parts of the plant for heating and power purposes. The tar is merely collected and sold. In America the greater percentage of the tar is purchased by people who have been instrumental in installing the by-product ovens, and is worked up by them into various substances, as, for example, aniline, creosote, and pitch, each one of those products being a representative of the three main divisions, into which the tar can be broken, viz.: light oils, heavy oils, and pitch. The ammonia which is driven off from the coal appears largely in the form of a sulphate and, after being purified, is largely used as a fertilizer. As a result apparatus to purify the gas, collect the tar, and treat the ammonia is connected with the coking department of the steel plant.

Limestone does not require any preliminary treatment aside from being broken and screened into suitable size for the furnace. It is, however, the basis of the slag, which comes from the blast furnace and which yields some further by-products.

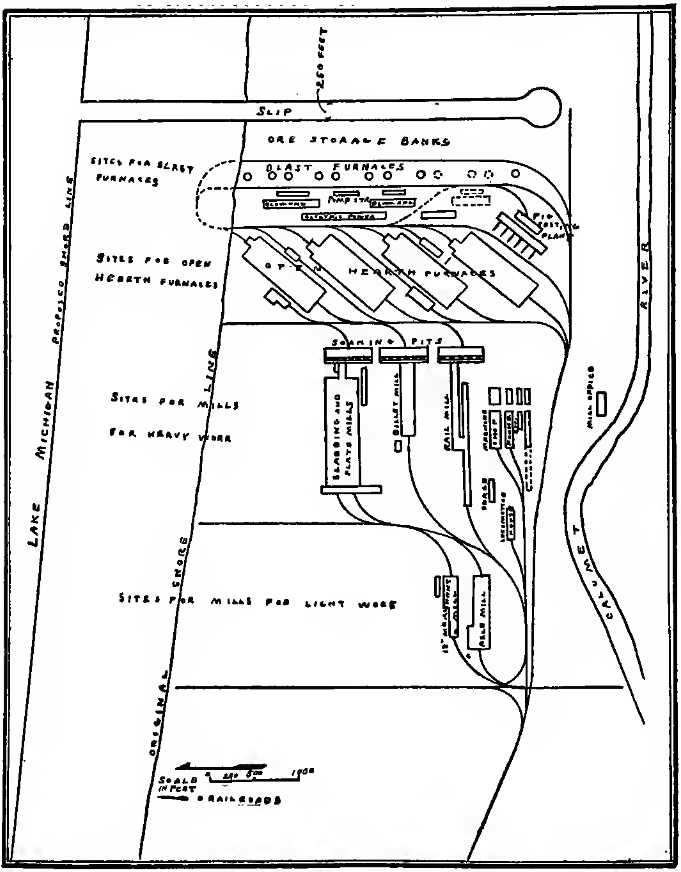
The manufacturing of steel goods from the raw materials is a continuous process; but a steel plant, unlike a textile establishment, is not handling light goods. The units handled weigh tons instead of pounds. The raw material has to be accumulated in great masses in order to keep sufficient stock for all seasons of the year. During the winter months, owing to the freezing of the lakes, ore transportation is largely suspended. Moreover, the forming processes of steel require many passages through fiery furnaces, making it impossible to use anything but the most stable and heat-resisting building material.

The first requisite demanded by the nature of the material and the character of the process is sufficient ground space to make provision for heavy foundations and ample room for machinery, furnaces, soaking pits, and all the subsidiary plants that are necessary parts of a plant.

The new plant of the United States Steel Corporation at Gary, Indiana, shows what present requirements are. The dimensions indicated on the map (Fig. 10) give one some idea of the gigantic proportions of its grounds. The engineers of this plant introduced every possible improvement that experience has demonstrated profitable. The ore is brought in by lake vessels and unloaded by machinery to the great stock piles and the charging bins. Railroad connections enable the coke and limestone to be unloaded from the cars into the respective receptacles without any unnecessary handling.

The blast furnaces are the apparatus which manufactures the iron ore into pig-iron. They are charged from the top by means of skip hoists, the buckets of which are filled by means of gravity with ore, limestone, and coke, from the bins above mentioned.

The blast furnace derives its name from the fact that it receives its air for fuel combustion under heavy pressure from powerful engines. This air is admitted into the bottom of the furnace at certain openings called tuyeres. In order to make it more efficient as an ironmaker the blast is highly heated by being passed through special devices called stoves, which are frequently as high as the furnace itself. The stoves are usually arranged in batteries of four to each furnace. While three of them are being heated by the waste gases from



Adapted from blue prints furnished by courtesy of U. S. Steel Corporation.

FIG. 10.—Plan of the Steel Plant at Gary, Indiana.

the furnace, the fourth stove is giving up its heat to the entering blast.

Three products come from the blast furnace:

1. Pig-iron, which goes onward for its final treatment, eventually becoming the steel rail or some other finished material. This is tapped out of the lower part of the furnace from time to time as the process goes on.

2. Gas, which is given off from the top of the furnace and is carried away by the downcomer. This gas contains sufficient combustible material in it to make it a very valuable by-product, and is now extensively used in heating the stoves of the furnace, and for power purposes.

3. Slag, which at one time was a source of expense to carry away, but is now made into cement.

The pig-iron, after it is tapped from the furnace, is carried onward in a molten state by great ladles to large mixing devices, where it is blended with the charges from other blast furnaces, and made sufficiently homogeneous to warrant its being taken to the steel furnaces. The steel furnaces may be one of two types—the open-hearth steel furnace which is now being more commonly used throughout the country because of the superior quality of the steel it produces, or the Bessemer converter, which was at one time mainly used in steel manufacture on account of the rapidity with which it converted pig-iron into steel. In either case the location of the plant, which does the changing of the pig-iron into steel, should be in a direct industrial line from the blast furnaces and mixing box, so that there will be no loss of time or waste of heat.

"Intra-works transportation plays a mighty part in this thrifty hurry. The switch track, indeed, is the vital factor in Gary's scheme. Other steel plants may adopt its gas engines, copy its enormous open-hearth units, duplicate its surpassing rail mill. But they would have to rebuild from the bare ground up to attain the economies secured at Gary by the arrangement of furnaces and mills. The placing of these was dictated by the speed a laboring locomotive can make on a curving switch track.

To relieve the locomotive, and achieve speed, the right angle was abolished in locating the various units. Instead of setting the blast furnaces parallel or at right angles to the tracks serving them, they were placed at an angle of 22 degrees, allowing a 200-foot radius for the entering switch. A train of 40-ton ladle cars can negotiate that swiftly, easily with little outlay of power and no danger of accident. Reversing on the main track, they will rush away to the open hearths on long, easy curves of 800 feet radius. What goes in at the near end of each unit goes out at the other, one step nearer finished product. There is no 'backing up,' except of empty ladles or cars.

From the casting floor of the open hearths, the ingots go to the mold-stripping houses, thence to the soaking pits and the ordeal of the rolls. Between blast furnaces and open hearths the angle to be overcome is only 57 degrees; between the latter and the soaking pits about 70 degrees. The shortest curve in the 175 miles of track, which will serve the mills, has a radius of 200 feet; nearly all are upwards of 400 feet. The elevated approaches to the furnaces and mills were planned with the same canny regard for speed where speed is vital; elsewhere they are a compromise between economy of space and of power. The company's locomotives will do the switching—the cost will depend on how fast they can move a load, how little coal and time they consume. Continuous gravity tracks at the shipping platforms allow the shifting of loaded cars without engines.

Analysis of the work's transportation can go no further than to say that it embodies the most advanced railway practice. Switch and service tracks, except those at the blast furnaces, are continuous; blockades are impossible, both ends being accessible and the forward movement of cars is uninterrupted. The same principle obtains in the 'Kirk' classification and storage yards, and in the locomotive house, through which tracks and pits run at an angle, abolishing the turn table. These individual savings, multiplied daily a thousand times, make tremendous economies."[1]

In the steel furnace, the molten pig-iron is brought into contact with air, and in this way the excess carbon in the iron is removed, to give the metal the properties of mild steel. When that stage is reached, the blast is turned off and the reducing process ceases. The furnace is then emptied of its steel contents into a great ladle, which is carried over to

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[1] *System*, January, 1909, pp. 10 and 11.

the molds. The molds are placed on trucks, set on an industrial railway, and after the steel is emptied from the ladle into these molds, it goes back for another ladleful, while the locomotive hauls away the steel-filled molds whose contents are soon to harden into ingots.

By the time the ingots arrive at the steel plant, they are ready to be taken from their molds. This removal is done by a device called the stripper, which automatically removes the casing and sets it on another car, by which it is returned, to be used in molding another lot of metal. The ingots, highly heated, remain standing on the trucks ready to be hauled to the soaking pits, into which they are placed in order to be kept hot until they are ready for the rolls. The waiting period is not long; some unseen power uncovers the top of one of the pits, a pair of giant tongs lifts the mass of dripping steel from the flaming cavity, and lightly waltzes it through the air to a little truck into which it is gently placed. The truck, as soon as loaded, automatically carries the great ingot on to the roll tables, which pass the mass of metal to and fro between two sets of rolls, one pair of which is placed horizontally and the other vertically. By a few passes the sizzling metal is reduced from ingot dimensions to bloom size. From these rolls, the bloom is taken automatically by rolling tables and carrying devices either to another soaking pit, where it is reheated before entering the rail mills, or it goes directly from the first pair of rolls to the rail mill.

The rail mill consists of three steel cylinders set horizontally one upon the other. The bloom is put between the two lower rolls and is drawn through. When it gets through, the roll table on the other side of the rapidly revolving shaping cylinders tips upward and carries with it the partly formed rail, and then automatically pushes the latter into the upper set of rolls, which now draw it back to the other side, and the other table tips up to receive the more nearly formed rail.

This process is repeated until seven or more passes are made, and the steel bloom becomes a great long steel rail.

After it makes its last pass it is carried on to the saws where the ends are trimmed off, and then the revolving gang saws, at a single sweep, cut several rails, thirty to thirty-three feet long from the still red-hot steel ribbon.

After that, automatic devices carry the rails to the cooling tables, where they remain until they attain the atmospheric temperature. When cooled they are ready to receive the fish-plate holes. These are put in by drilling machines. Three or more individual drills are grouped with a few inches intervening between centers, and then the two gangs of drills are distanced from each other by the length of the rail. The rail is placed in position, and the mere pulling of a lever starts all the drills in both gangs simultaneously, and the holes are cut in a few minutes, making the rail ready for shipment. Here, again, the ever-present carrying devices are ready to do their work. As soon as the holes are cut, a traveling chain slides the rail gently into a freight car, which is waiting to receive it to carry it to the consumer.

CHAPTER VIII

CONTINUOUS INDUSTRIES, ANALYTICAL

THE preceding chapter considered the kinds of plants suitable for carrying on synthetical processes. This chapter will discuss plant structures for another large group of continuous industries, which may be designated Analytical.

An analyst is one who separates a body of matter into its constituent parts, or breaks it down into its original elements. The process is not confined to the treatment of physical bodies. A judge is called a keen analyst when he takes a mass of data presented by contending lawyers, and separates it in such a manner as to reveal the true significance of the evidence. This is as truly an analytical process as is the filtration of water. The judge separates the true from the false in evidence, just as the filter extracts the impurities from the water.

Non-by-product and by-product industries may be in either the analytical group or in the synthetical class. The non-by-product group of analytical industries in 1905 contributed more than $2,500,000,000 to the wealth of the country, mainly in the form of food products (not including meat packing), liquors and beverages, and lumber products.[1] Liquors and beverages are properly placed in this group of industries because they are in the main extractive industries.

In the industries discussed in the preceding chapter, the materials handled in the process of manufacture were of such a nature that there had to be a considerable expenditure of time and labor or power in conveying the partly finished

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[1] *Census Bulletin*, No. 57, pp. 25 and 27.

goods from one machine or step in the process to another. In a textile establishment trucks and elevators are very extensively used, while in a steel mill the conveying machinery is unique for its elaborateness.

In the analytical group of industries, the larger number can utilize exceedingly cheap means to convey materials from step to step in the manufacturing process. Two conditions conspire to make this possible:

1. In many of those industries gravity can be extensively used in conveyance.

2. The processes are of such a nature that the goods, as a rule, are handled in bulk or in continuous, unbroken streams rather than in individual units.

Matter may be gaseous, liquid, or solid. The handling of the solid is the most difficult and expensive; but if the solids consist of very finely divided particles, the task is simplified. Such goods may, in fact, be handled as easily as liquids.

Liquids are very easily handled in bulk. They can be concentrated at a single point, as at the bottom of a building, and then, by means of pumps, be forced through pipes to the top of the structure. From this elevated position they can be passed by gravity through the various steps of the process from the beginning all the way to the shipping-room.

Sugar-refining affords an excellent illustration of an industry of the non-by-product type which handles solids and liquids. Raw sugar comes to the United States in large quantities from abroad. The large refineries are usually located at some seaport where it is possible to unload the sugar directly from the vessel into the storage house.

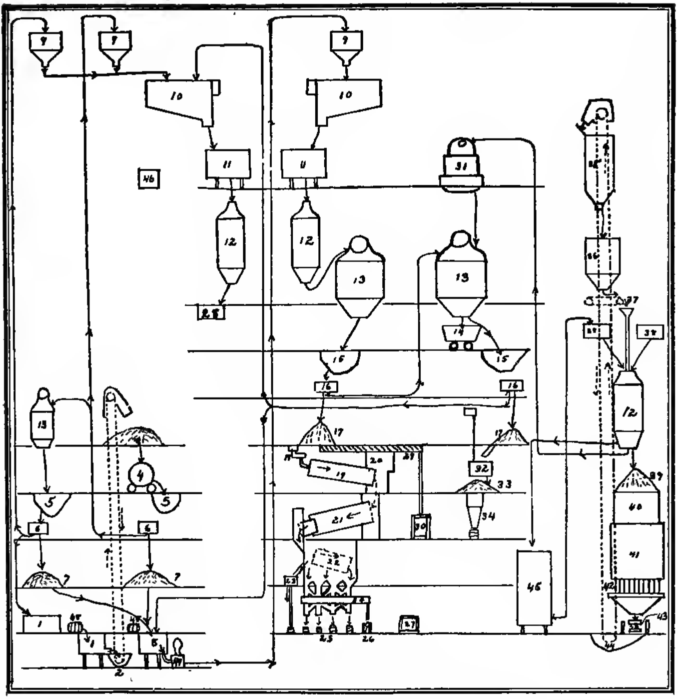
The raw sugar is carried in the hold of the vessels in bags of various descriptions, and is hoisted out by a steam windlass in lots of several hundred pounds at a time. From thence it is weighed in the presence of government inspectors who determine the duty charges. After it is weighed, it is carried to the storage house by means of rapidly moving traveling cranes. These cranes stack the sugar in immense piles away from the weather, where it is kept until ready for use.

In order to refine the raw sugar it is dissolved in crude molasses, which is then heated to the melting point. This is usually done on the first floor in close proximity to the storage sheds. (See Figs. 11 and 12.) From thence it is pumped to the top of the building and treated in the defecator with some reagents, which coagulate the various impurities and neutralize any vegetable acids in the sugar solution. When the coagulation is complete, the solution is run to the floor below, where it passes through coarse canvas bags, which strain out foreign substances.

The solution, although now freed from the grosser impurities, would still give a yield of rather unappetizing appearance if not further purified before crystallization. In order to remove all extraneous matter it passes another story downward through large bone black filters, from which it issues a clear, colorless liquid, occasionally slightly tinged with yellow. After it has passed through the bone black filters the solution is ready for crystallization. The crystallization is done on the next floor below.

Here are placed large enclosed vessels connected with an exhaust which reduces the pressure in the vessel to a very low point. These enclosed vessels are known as vacuum pans in which the solution is boiled in order to crystallize the sugar from it. The task of boiling the sugar until it reaches the proper point for crystallization is one that requires care and experience on the part of the operator, and as a rule he is one of the best paid men in the plant.

After the solution has been boiled until it has reached the proper condition, it is run into cooling and mixing tanks to crystallize. These tanks are situated on the floor below the vacuum pans and contain a semi-liquid paste of syrup and



By courtesy of Geo. M. Newhall Engineering Co. Ltd., Phila., Pa.

FIG. 11.—Sugar Refinery Scheme.

1. Sugar Breaker.
2. Elevator.
3. Raw Sugar.
4. Raw Sugar Heater.
5. Raw Sugar Mixer.
6. Centrifugals.
7. Machined Sugar.
8. Sugar Melting Pan.
9. Blow-Up.
10. Defecator.
11. Bag Filter.
12. Char Filter.
13. Vacuum Pan.
14. Sugar Wagon.
15. Mixer.
16. Centrifugal.
17. Sugar.
18. Air Drier Feed.
19. Air Drier.
20. Air Heater.
21. Granulator.
22. Screen.
23. Powdered Sugar Mill.
24. Conveyor.
25. Barrel Packers.
26. Bag Packers.
27. Scales.
28. Tank for Refined Molasses.
29. Conveyor.
30. Cube Sugar Machine.
31. Triple Effect Evaporator.
32. Mixer and Cooler.
33. Moist White Sugar.
34. Sugar Packer.
35. Water Cooler for Char.
36. Char Duster.
37. Conveyor.
38. Hot Water and Liquor Tanks.
39. Char.
40. Char Drier.
41. Char Kiln.
42. Char Cooler.
43. Char Conveyor.
44. Char Elevator.
45. Water Heater.
46. Bag Wash Tank.
47. Pump.
48. Raw Sugar.

granulated sugar. To make the complete separation of the crystals from the syrup the pasty mass is dropped into centrifugal machines located on another floor beneath. The centrifugal machines revolve at a high speed, and fling the liquid material through their porous sides, leaving behind the granulated sugar. At this point in the process, any yellowness which may tinge the sugar is removed by the slight addition of some ultramarine to the sugar as it is being whizzed in the machine.

From the centrifugal machines the sugar is passed to another floor, where it is placed in large drying and granulating cylinders heated by hot air. After it is dried and granulated it is run into bins, and from them, by gravity, into barrels and other containers, in which it is sold to the consumer. (See Figs. 11 and 12.)

Gravity is likewise used in cleaning the apparatus of the refinery. The bone black or char filters become clogged with impurities, so that it is necessary to clean them out at frequent intervals. This is accomplished in a very ingenious manner. The char contents of the clogged filter are dropped through a series of heated cylinders, which first dry the material and then heat the char to the point of incandescence, so that the impurities in the char become charred themselves, and as a consequence the impurities actually become the means of purifying succeeding lots of sugar. (See Fig. 11.)

It is evident that a sugar refinery must be a very high building if it is to take advantage of the gravity method of conveyance. This is usually the case; and, inasmuch as there are few steps in the process which require a great amount of light and observation on the part of the worker, one will usually find that sugar refineries are tall, somber-looking buildings. They must all have great storage-rooms in order to contain the raw sugar and also to hold their finished products, because the goods come from afar, and the manufacturer must keep on hand a great quantity of goods in

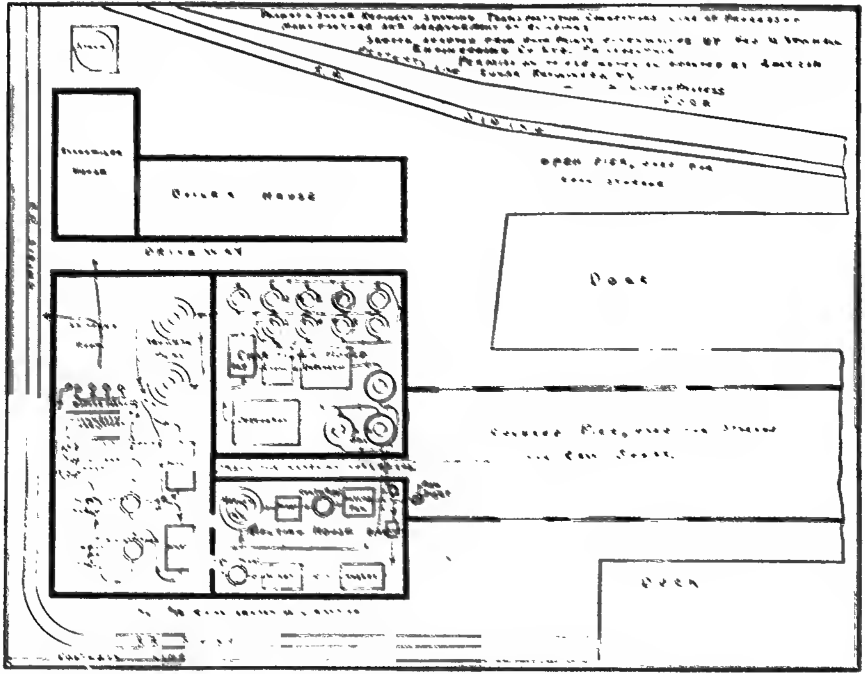


Fig. 12. Plan of a Sugar Refinery.

order to keep his plant running uniformly throughout the year.

The diagrams 11 and 12 show the layout and elevation of one of the largest sugar refineries in the United States. In connection with a great many refineries there are very frequently barrel factories and wooden box factories which manufacture the cases for the finished sugar.

The shipping room of the sugar refinery should be so placed that the finished sugar will come into the department with the least possible trucking cost. The room should also be so placed that the goods can be put into wagons or cars without any unnecessary handling. The diagram shows how closely the refinery has held to this ideal. The packing, storage, and shipping departments are located right on the corner of the public street and railroad, and goods can be put into the freight car with even less handling than it takes to load the wagons which distribute the products to the local grocers.

Another well-known industry of the analytical type which handles solids exclusively and uses the gravity means of conveyance is flour milling. The rapidity with which flour is made and the cheapness with which it is handled is a never-ending source of interest to the student of industrial management. One can go through a mill that manufactures thousands of barrels a day and find some few dozen men supplying all the necessary labor for the vast concern. The steps in flour-making are as follows:

1. *Cleaning.*—Here the grain is not only separated into good and bad lots, but has all foreign matter from dust to twigs and nails taken out of it.

2. *Grinding.*—At this stage the different qualities of flour are obtained by separating out of the grain its various envelopes of nutritive matter and grinding them between different series of rolls.

3. *Screening or Bolting.*—In this step the various grades

and sizes are separated after they have passed through the rolls.

4. *Purifying.*—The purifier extracts from the finely ground grain the light flaky cellulose technically known as "bees' wing." This bees' wing has become so intimately mixed with the flour that it cannot be taken out by the screens. The work is done by means of a gentle air blast, which is strong enough to remove the bees' wing but not the flour particles. This leaves the flour purified of all foreign matter.

5. *Packing.*—Here the flour is weighed into bags and barrels and sealed for shipment.

6. *Storage and Shipping.*

In order to take advantage of the gravity method, conveying buckets carry the grain to the top of a high, almost windowless structure, where it is cleaned of its impurities in preparation for the grinding. Several grinding processes take place, and after each grinding the grain is bolted. On account of these many grinding and bolting steps, it is uneconomical to build a mill so high that gravity will do all the conveying work from the beginning to the end of the process. Considerable saving in power and space is obtained by keeping the cleaning, grinding, screening, and purifying apparatus on different floors. This makes necessary some reconveying of the partly ground grain to upper floors, but the general line of passage is not broken. One great stream of grain starts from the top of the building, and after a few eddying currents on the downward flow, finally emerges from the last machine as white flour ready for the baker.

The by-product industries of the analytical type contribute by the meat packing and chemical industries, including oil refining, about $2,000,000,000 annually.[1] The meat-packing industry alone accounts for $914,000,000 of this

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[1] *Census Bulletin,* No. 57, pp. 25 and 27.

amount.[1] It offers one of the best examples of an industry of this type.

In meat packing, large units are handled. It would be an exceedingly difficult matter to handle the products of the packing house as grain is handled. The packing establishments have introduced such remarkable economies into their business that it is noted the world over for its perfection in organization; and the buildings have been made to fit the process in a most remarkable way.

The packing house, as in all industries, one of the important problems, is the passing of goods from department to department with the least possible outlay of power. It has been seen how some other industries solve the problem. The manager of the packing house does not handle goods that can be pumped or conveyed by belts and run through machines in bulk, as is done in cotton spinning or flour manufacturing. His task is to handle a delicate, but large and unwieldy body. A miscut will lower the value of the product, perhaps enough to destroy the profit in that step of the process, and even cause an absolute loss on the entire carcass.

It has been said that in the packing house everything about the animal is saved save his dying groan. A person can appreciate the full significance of this statement when he realizes the refinements of the savings. The first step in the process of meat packing is to drive the animal to the top floor of the building, where it is stunned. The succeeding steps in the process are as follows:

After the animal is knocked on the head it is dropped from the stunning platform to the floor. Here the animal is shackled and lifted by means of a power pulley to the bleeding rail, where its throat is opened and allowed to bleed for six minutes. At the end of that time the head is removed and the carcass allowed to bleed for ten minutes more. By

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[1] *Census Bulletin*, No. 57, p. 27.

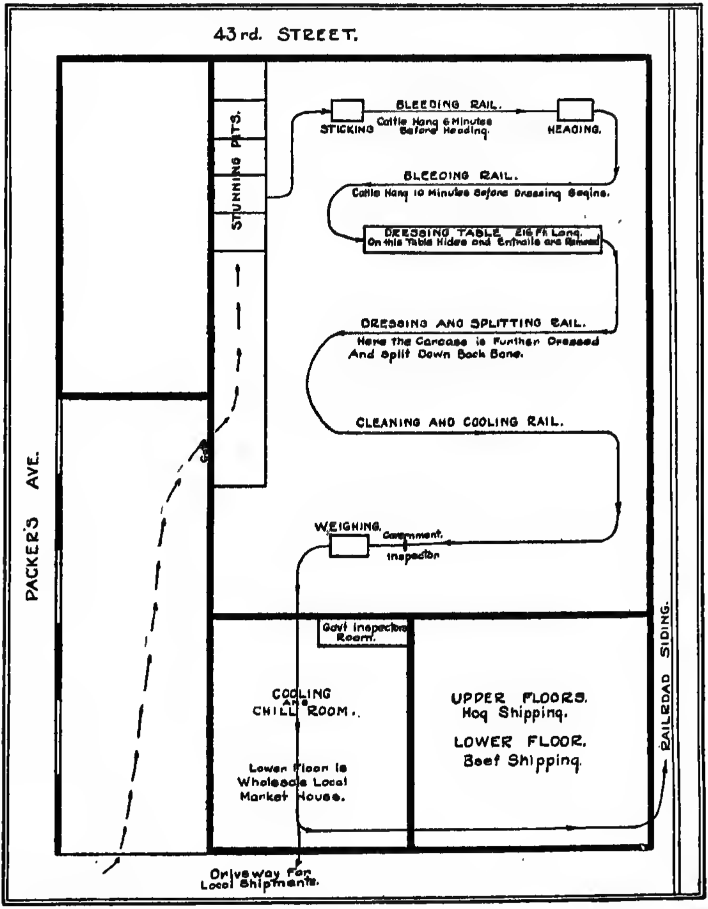
this time it is ready for further dissection. Formerly it was the universal practice to have this dissection carried on with the animal hung by its hind feet from an elevated rail. The rail was slightly inclined so that the mere weight of the carcass would move it onward.

With this arrangement the workman had to walk with the moving animal while he was working upon it. Moreover, the animal, being hung in this way, was somewhat inconveniently placed for some of the dressing steps. In order to place it equally conveniently for all dressing steps, and to eliminate the walking on the part of the operator, the Armour Company has installed a moving table, 216 feet in length, on which the animal is deftly dropped on its back after it is beheaded. The workmen stand on this moving table, make their cuts on the animal, and then move back to the new animal as it comes from the preceding worker. In this way while they are cutting the animal, they are stationary with respect to it, yet the animal is going on its onward course.

As each piece is taken from the body it is dropped into a chute or opening by which it is carried by gravity to the place where it will receive further treatment. The carcass itself moves onward. After all the trimming has been done on the tables it is lifted automatically from the table to overhead traveling hooks. These hooks are run on trolleys, and the track is inclined. Here the dressing is continued, and the animal is washed, cleaned, split, and eventually weighed. All the time these operations are going on it is gradually approaching the cooler.

Fig. No. 13 is taken from one of the large packing houses in Chicago, and shows graphically how well the firm has kept in mind the adaptation of the building to its purposes. The entrance for the animal is so placed that by the time its carcass is prepared no unnecessary traveling is required to enable it to have cheap shipment either for long distance by railroad, or for local trade by teams.

The photograph on the other page (Fig. 14) shows the tremendous extent of ground covered by one of the large establishments and the apparently heterogeneous arrangement of storehouses, power houses, laboratories, stables, and other



By courtesy of Armour & Co.

FIG. 13.—Plan of a Packing House.

departments.[1] The plants do not have the most economical layouts. The writer, in speaking to a number of the officials of the various concerns, has been told that there are hundreds of places where improvements could be made. Any concern having a clear spot of ground sufficiently large would rebuild its plant in quite a different way. The present grouping of buildings has resulted from meeting the needs of the moment. Idealism had to be sacrificed to present exigencies. However, the arrangement and grouping of the buildings with all of their defects indicate several noteworthy features:

1. The various killing departments have maintained the theoretical ideals of structure of buildings. In the cattle, sheep, and hog-killing establishments the animal supplies its own motive power to the plant from the unloading pens, and

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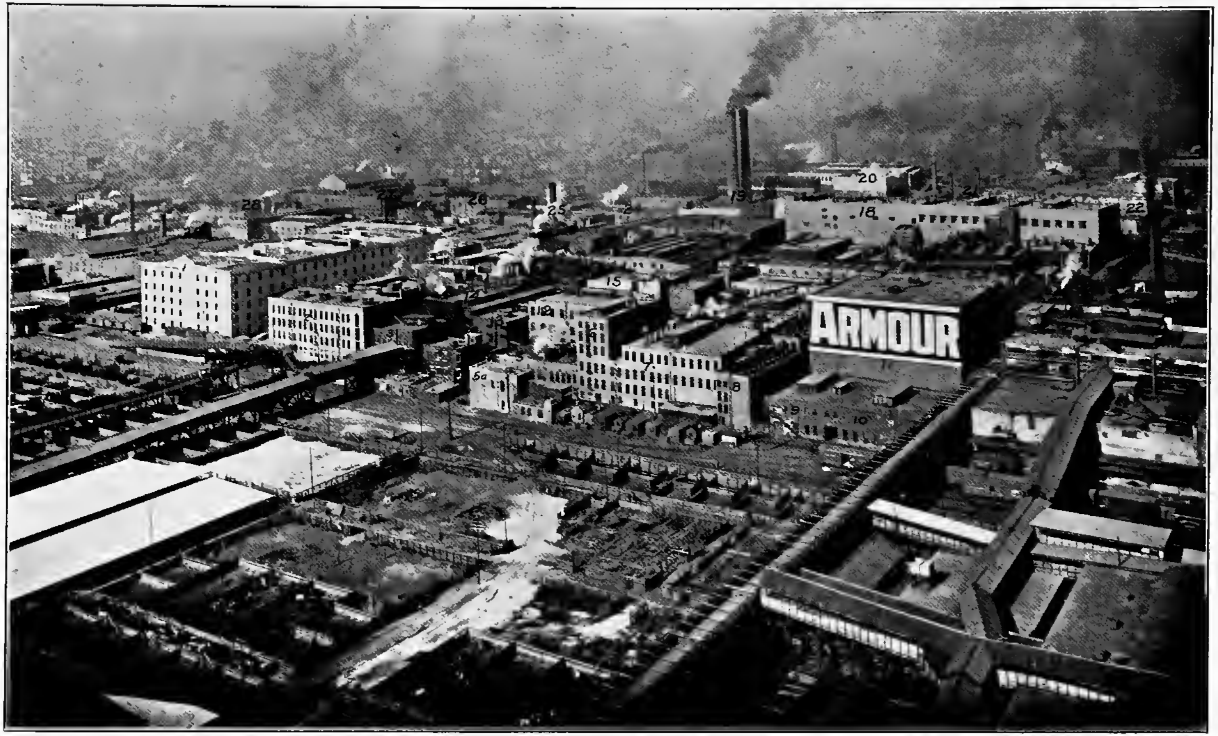
[1] The various departments numbered in Fig. 14 are as follows: 1. Lard and Oil Refinery, Butterine and Oleo Oil. 2. Tin Shop Lithograph Department. 3. Carpenter Shop. 4. Visitors' Entrance, Paymaster. 5. Timekeeper, Emergency Hospital. 5a. Fire Engine House, Watch Patrol. 6. Pepsin Laboratory, Digestive Ferments. 7. Vinegar, Pickled Goods. 8. Smoke House. 9. Scale Repair. 10. Employment Office. 11. Storage. 12. Printing Department, Labels, Stationery, Advertising. 13. Hog Killing. 14. Canning Department. 15. Beef Extract, Mince Meat, Soda Fountain Supplies. 16. Sausage. 17. Meat Curing. 17a. Pork Cutting Floor. 18. Butter, Egg, and Poultry Freezer. 19. Power House and Refrigerating Plant, Electrical Department, Machine Shop, Boiler Rooms. 20. Beef Freezer. 21. Cattle Killing, Sheep Killing. 22. Wholesale Market. 23. Ham and Bacon Department. 24. Shipping Department. 25. Bone Novelty Department. 26, 27. Fertilizing Factory. 28. Stables. 29. Wool House, Sheep Skins, Pelts, etc. A large number of the departments are not shown on the picture, for instance: Hide Cellars, Chemical Laboratory, Cooper Shop, Paint Shop, Police Station, Retail Market, Gas Plant, and Box Factory. The Glue, Gelatin, Soap, Curled Hair, Sandpaper, Anhydrous Ammonia, and Isinglass Departments are at Thirty-first and Benson Streets, one mile north of the Union Stock Yards.



By courtesy of Armour & Co.

FIG. 14.—Bird's-Eye View of the Plant of Armour & Co.

the buildings into which they run are well arranged to handle the cattle from the slaughtering to the shipping.

2. The various subsidiary plants, as the canning and smoked meats departments, that are most dependent upon these main sections, are situated in close proximity to main departments.

3. The auxiliary plants which manufacture the accessories necessary to carry on the main business are placed near the buildings, which use their output; the can manufacturing plant being placed conveniently between the lard, butterine, and oleo department and the canning department.

4. The departments which are not in such intimate contact with the more active business and yet which are absolutely dependent upon the main killing departments, are placed near the various killing departments, but not in any particular rotative order, as, for example, the pickling and storage departments.

5. The derivative industries, as, for example, the butterine and oleo plants, lard refineries, and the like are put as near the killing establishments as is possible without interfering with the other more important subsidiary industries.

6. The derivative industries, as the fertilizer plants, which create offensive odors, are placed on the outlying boundaries of the plant.

7. The power house is put in a central location. The ideal situation for the power house would be to place it as near the departments requiring the most steam, namely, the tanking house, bone house, and oil house, which, according to Mr. Wilder, are the largest consumers.[1]

A close inspection of the photograph will show, however, that in a number of cases there are deviations from the best practice, as recognized by modern managers. The printing

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[1] "The Modern Packing House," by F. W. Wilder, p. 28.

establishment, for instance, is backed by the house which manufactures digestive ferments. On its right side, is the beef extracting and soda fountain supply department, while on the other is the timekeeper's office and the emergency hospital. The various pickling and storage houses are scattered all over the plant, some of them quite a distance from either railroad siding or the plants which give them their material. Even the shipping department is open to some criticism. The beef and sheep shipping-room is located at one place, the hog shipping at another, while the products from the canning and curing departments must travel some distance before they reach a shipping platform. (See Nos. 22 and 24, Fig. 14.)

CHAPTER IX

ASSEMBLING INDUSTRIES

Besides those kinds of manufacturing wherein there is a continuous action upon the entire mass all the time the goods are being treated, there is the Assembling type. An assembling industry is one wherein the final product is made by first producing the various ingredients or parts, and then assembling them together. This type of an industry requires a manufacturing department, men or operators to make parts, and another set of producers who join these parts. Examples of these industries are shoe manufacturing, toy manufacturing, locomotive making, engine building, ship building, piano making, and clothing making.

According to the Census reports of 1905 this assembling class of industries in the United States yielded over $4,000,000,000 worth of products.[1] Four of the fourteen groups into which the census report classifies industries, including leather and its finished products, metal products, vehicles, and shipbuilding, had by far the larger part of their production made by this method. The miscellaneous group of industries, embracing agricultural implements, electrical machinery, and musical instruments, made a contribution of $350,000,000 to the assembling industries, while the lumber group gave $170,000,000 worth in furniture. Iron and steel added a total of nearly $800,000,000 of assembled goods in machinery products, and the textile group gave over $800,000,000 worth

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[1] *Census Bulletin*, No. 57, p. 25.

in men's and women's clothing, fur goods, hats and caps, millinery, men's furnishings, and corsets.[1]

These industries divide themselves into two typical classes, which in a measure correspond to the non-by-product plant and the by-product plant in the analytical industries, except that in the by-product plant the material is taken from the goods, while in the assembling process the subsidiary plants contribute to the main material. The assembling industries are here divided into these two groups which are considered separately:

1. Direct producing industries wherein the goods are received, worked upon, and assembled without the intervention or using of any intermediary steps which do not finally show in the finished goods. Examples of these are afforded by shoemaking, toy manufacturing, piano producing, and by many other industries.

2. Indirect industries wherein vast amounts of money must be spent in producing forms, patterns, molds, and other auxiliary supplies before the product can be obtained; as for example, machine and tool manufacturing, shipbuilding, locomotive making, general machine shops, and electrical supply plants.

One characteristic of the assembling industries of both classes is that the goods they produce are made up of a great number of parts, each one of which must be separately handled and treated, and adjusted to all the other parts of the completed article. A simple-looking instrument, like a piano, is made up of several hundred pieces, which must be carefully adjusted to each other to evolve the perfect instrument. The individual pieces are themselves made up of parts. The keyboard apparatus consists of a key and hammer. A key is made of about eight pieces. The hammer has seven pieces. A full piano has fifty-two white keys and

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[1] Cf. *Census Bulletin,* No. 57, Table 84, pp. 76–93.

thirty-six black. In addition, there are the strings, pivots, sounding boards, and a great many other parts which in themselves are made up of other parts. In order to get beauty in workmanship and a trustworthy article, all of these things must be handled with discriminating care and deftness. Machinery can cut the lumber, it can twist the strings, smooth the ivory, make the felt, it can plane the pieces, but it cannot assemble them without intelligent guidance.

Another characteristic common to both types of assembling manufacturing is that in these industries, more than in any others, a very large amount of the work must be done by human labor. Assembling industry plants, as a rule, have far more operatives to an establishment of a given size than does any other group of plants. This is due to the fact that, as a rule, the assembling plants manufacture direct consumption goods which are designed to give immediate personal satisfaction to the consumer. It is true that wheat grinding produces a consumable product in the form of flour, but the public does not get any immediate satisfaction from the flour. It must go through the bakery and be assembled with other ingredients, such as sugar, butter, lard, etc., before it becomes a consumable product. The manufacturing of pig-iron makes a consumable product for the foundryman, but the cast pig-iron in itself would be of little utility unless it passed through the foundry and machine shop to produce locomotives which can haul trains, or engines which can supply power to run looms.

The products of assembling industries are in themselves objects more or less complicated in their construction and essentially specialized in their nature. They have a great amount of individuality. They are complex and various in construction. In many cases it would be unprofitable in the first place to make machines to do much of the work; because the machines would have to be altered at frequent intervals on account of the changes in styles and of the rapid improvements which are constantly being made in the construction of these direct consumption goods. In the second place, machines to do the work would have to be so complicated that long periods of time would be required to evolve and develop a profitable machine.

The assembling industries, although having a very great deal of machinery, have machinery of a more or less general nature to do work of more than one kind or size. These machines of necessity require operatives who can adapt them to do new work, and who must guide and direct them while they are running.

These two characteristics at once bring up exceedingly important questions:

1. How shall the various manufacturing departments be arranged with respect to the assembling department so that there will be a minimum amount of handling of the pieces?

2. How shall the plant be built so that a comparatively large number of workers will find room and convenient facilities for doing their work?

It has been seen in the two preceding chapters that the straight-line method of moving material through plants is the theoretical ideal for cheap production; and it has been shown how various types of plants have adhered to the ideal and have adapted their structures accordingly. What is true of the continuous industries is also true of the assembling industries. The straight-line method of manufacture is, if considered from the absolute standpoint, the ideal. The buildings should be so constructed and the departments so arranged that there will be no retracing of steps or backward movement of the parts in their passage through the plant.

Fig. 8 shows how the straight-line ideal may apparently be varied and yet be rigidly adhered to in plant construction. The diagram likewise indicates in a similar manner how the straight-line method may be applied to the assembling processes. (See Nos. 4, 5, 6, 11, 12, and 13, Fig. 8.) The question of providing room for the employees will naturally modify the geometric line, and the figure shows how the straight industrial line is maintained in many plants and yet opportunity is given for the employees to carry on their work. If it comes to a question of deciding between departing from the straight industrial line and locating a certain department or set of machines so that they will be more convenient for the employees, it is usually better to depart from the industrial line rather than make conditions such that the output of the employees will be limited by external conditions.

Shoemaking is a good example of the direct producing industry. Factory shoes are usually made in two dozen lots, each company confining itself to a more or less limited number of styles and values of shoes. In some cases, the styles made by a concern will be a dozen or even less; and then, on the other hand, they may extend into the scores.

To produce a shoe requires:

1. *The Cutting of the Material for Uppers.*—The leather forming the upper portion of the shoe is cut to certain patterns which vary with the style of the shoe. The linings are likewise cut from special cloth.

2. *Skiving or Leveling.*—The edges of the leather are then put through a skiving machine, which levels them off so that they may be neatly turned, thus presenting a finished edge on all open parts.

3. *Turning.*—The skived leather is then passed over to a machine which applies cement to the inside of the beveled edge and deftly turns the leather over and gives it its finished appearance.

4. *Ornamenting.*—The small perforations seen in the tips and other parts, which are put in for ornamental purposes, are dyed in the leather at this stage by means of a Power Tip Press.

5. *Sewing.*—The different parts of the upper are sewn to-

gether on special sewing machines; and the cloth lining is likewise stitched to the leather.

6. *Eyeletting.*—The eyelets and hooks are next inserted, or buttons are attached at this stage of the process. The rapidity with which this is done is remarkable. One machine will place perfectly all the hooks and eyes in a pair of shoes within the space of five seconds.

7. *Stiffening Toe.*—This is done by cementing a piece of pulp board material between the under part of the tip and the lining to prevent the shoe from curling up on the end.

8. *Blocking Sole Leather.*—Dies are made for different sizes and shapes, and the outsole is cut from heavy hide by means of a powerful press.

9. *Blocking Insole.*—This is similar in process to blocking the outsole, but an inferior grade of leather is used.

10. *Rounding Soles.*—The roughly died out insole and the outsole are separately reduced to exactly the desired shape on a specially designed machine called the Planet Rounding Machine.

11. *Evening Insole.*—The insole is passed through a little machine which reduces it to an absolutely even thickness.

12. *Splitting Outsole.*—This is an operation similar to the evening, but the machine is heavier on account of the heavier leather that must be shaved and cut. Both machines make all soles uniform in thickness.

13. *Rolling Outsole.*—The outsole is passed through a heavy rolling machine where it is subjected to tons of pressure between heavy rolls. This brings the fibers very closely together, and greatly increases the wear of the shoe.

14. *Channeling Insole.*—In this operation a little slit is cut along the edge of the insole, extending about half an inch in toward its center. At the same time a little channel is cut in the leather so that it may receive the thread and permit the upper flap to be smoothly drawn over after the insole is attached to the welt and upper.

15. *Cutting Heels.*—The heel pieces are died out from small scraps of leather.

16. *Cementing Heels.*—The small pieces are firmly cemented together, and one piece especially selected is fastened to the top of the heel, thus giving a good base for nailing it to the shoe.

17. *Compressing Heel.*—The heel is put under great pressure to give it exact form, and to increase its wearing qualities.

18. *Inserting Insole.*—The insole is now attached to the last, and the last is put inside the upper, and a pulling over machine in the hands of a skilled operator is used to adjust the last to the upper.

19. *Lasting.*—When the last is properly adjusted, the shoe is taken to the lasting machine, where the upper is neatly stretched over the entire last. This operation is one of the most difficult and important in the shoemaking process. If it is incorrectly done, the appearance of the shoe is spoiled and its wearing qualities are greatly impaired. The machine works with almost human ingenuity. It has a set of fingers which grab the leather, pull it over the last, and then it inserts, at frequent intervals, tacks to hold the leather in shape.

20. *Welting.*—The welt is now sewed from the inside lip of the insole so that the needle passes through lip, upper, and welt. In this way all three are securely united, and the welt protrudes beyond the edge of the shoe. Just before the sewing has been done, the tacks, which were driven into the last to hold the upper in place, are withdrawn.

21. *Trimming.*—The surplus portions of the lip, upper, and welt, are now neatly trimmed off, and the welt is made to stand out evenly from the shoe. After this is done, the tacks which held the insole to the last are withdrawn.

22. *Attaching Outsole.*—The outsole is covered with ce-

ment, and is firmly pressed upon the insole and welt by means of a heavy machine.

23. *Trimming Sole.*—The portions of the sole extending beyond the welt are trimmed off so that both welt and sole make an even edge. At the same time a flap and channel are cut around the edge of the outsole, as was done in the insole.

24. *Opening Channel.*—The cut channel is opened out on a channel-opening machine, making it ready to receive the stitch.

25. *Stitching.*—The sole is firmly stitched to the welt on a powerful stitching machine.

26. *Closing Channel.*—The inside of the channel is coated with cement, and the flap is smoothly drawn over so that the stitches are entirely hidden.

27. *Leveling Sole.*—The sole is put under heavy pressure on a leveling machine, which subjects it to a rolling process, smoothing the bottom.

28. *Tacking Upper.*—The portion of the sole designed to receive the heel is not sewn to the welt. At this stage it is nailed to the upper and through the insole, the nails being turned by a steel plate on the heel of the last.

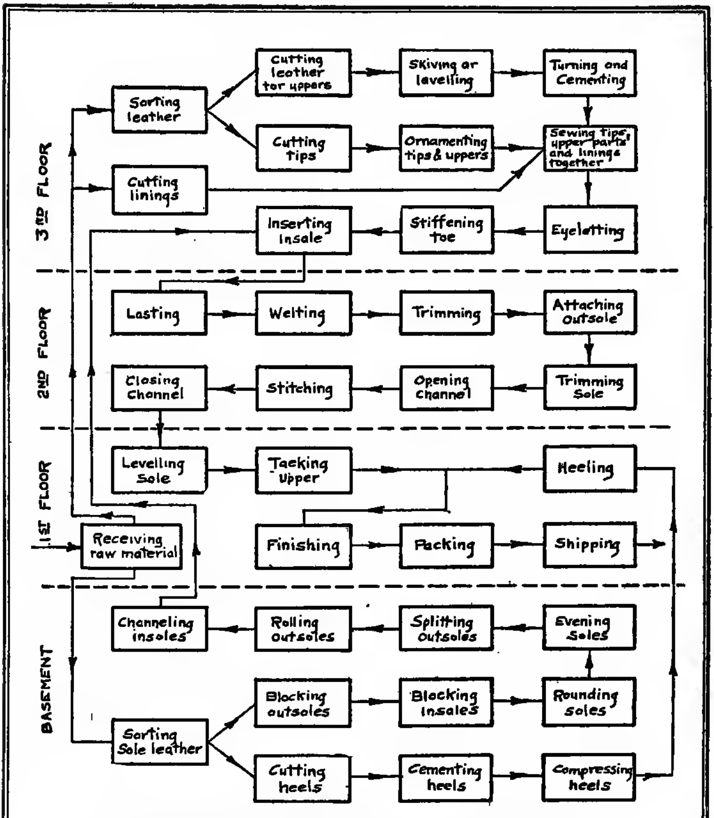
29. *Heeling.*—The heel is now nailed to the shoe and the bottom cap put on the heel.

30. *Finishing.*—This consists of several steps, all tending to give the shoe its final form and finish.

31. *Packing and Shipping.*

The diagram on page 123 (Fig. 15) shows graphically the relationship of these various steps to each other.

The great number of operations necessary to produce a shoe makes it important to order the processes in the most economical manner. The ideal order of arrangement is the straight, industrial line. The assembling industry may be regarded as a river fed from many sources, the shipping room corresponding to the mouth of the stream. The ideal plant is one which will make the rivulets flow into the main channel as soon as possible, and yet not flow in until all is ready



SKETCH SHOWING HOW LINE OF PROCESS IN DIRECT PRODUCING ASSEMBLING INDUSTRY IS MADE TO APPROACH THE CONTINUOUS TYPE OF INDUSTRY.

FIG. 15.—Shoe Manufacturing.

for their absorption, otherwise they will hinder progress. (See Fig. 17.)

Almost every part of a shoe factory should be well lighted; and since it is important that it be in the midst of a large labor supply and easily accessible to good markets, both local and distant, it is necessary to place the plant in either a city or suburban location. Consequently, the plant cannot be spread over too much territory, because not only would it unnecessarily increase the interest charges on the property, but would also increase the burdens of heating and power transmission.

The general form and structure of a shoe factory is characteristic of almost all of the plants of the direct producing group. The establishments are units in themselves, having few if any outbuildings.

The indirect assembling industries differ greatly in their plant construction from those just considered. Nearly all machinery-making plants require at least three comparatively large auxiliary divisions aside from the machine shop, namely, the drawing-room, pattern shop, and foundry. If the plant is very extensive, these auxiliary departments may increase until they include a carpenter shop, brass foundry, blacksmith shop, boiler shop, punch sheds, galvanizing departments, and perhaps several others. In addition to these directly contributing plants one will almost invariably find a pattern storage shed, a lumber shed, power house, boiler house, and possibly paint shed, drying kilns, and other departments of more or less importance.

The building of a vessel probably offers the most complete set of operations common to any assembling industry of the indirect type. To construct a ship it must, first of all, be designed in the engineers' offices and drawing-rooms. Here the shape, size, and specifications for the hull, machinery, and boilers are drawn up. The arrangement of the compartments in the vessel for carrying passengers, cargo, and coal, and for receiving the propelling equipment is shown. The furnishings and equipment of all the various departments of the vessel are specified, and detailed drawings are made of every part of the hull, machinery, and equipment.

The drawings are then sent into the three main divisions of the plant, each one of which carries out its assignments according to the drawings and specifications issued, the three parts being the Hull, the Boiler, and the Motive Power Divisions.

A. HULL DIVISION.

1. *Forms and Templets Making.*—In the mold loft of the yard are received the drawings of all hull parts, and in here are made all the forms and templets which are to be used as guides by the workmen in constructing the hull.

2. *Keel and Rib Cutting and Shaping.*—All the framework of the vessel is cut from the structural iron and bent into shape.

3. *Plate Shearing, Bending, and Punching.*—The plates which are to make the hull of the vessel are cut out in a machine called shears and shaped in bending rolls, and the rivet holes are put in by powerful punches.

4. *Keel Laying and Ribbing.*—The foundation framework for the ship is made by laying a heavy piece of structural iron the entire length of the vessel, and from it at right angles are set radiating ribs of varying shapes and lengths, so that when they are covered with the steel plates the vessel will have the designed shape and size.

5. *Fitting Plates.*—The plates which have been previously punched and shaped are now fitted to the ribs and to each other, the rivet holes are reamed out, and rivets inserted to bind the plates together. All plates that are to be below the water line are usually hand riveted, but above the water line machine riveters do the work.

6. *Piping.*—When the framework begins to be covered, the pipe and steam fitters put in all the piping necessary to

supply the complex organization of the vessel. In it are put sewage systems, steampipe lines for heating the compartments, and conveying steam from the boilers to the engines, the plumbing for carrying hot and cold water for the convenience of the passengers, and all piping necessary to supply the machinery with water inlets and exhaust outlets.

7. *Joinery Work.*—While the piping is going in and the hull is being still further completed, the wood work is introduced, and the carpenters and joiners put in all equipment like staircases, flooring, doors, window casings, paneling, and all other fittings specified by the contract.

8. *Wiring.*—While the fittings are being installed, electricians wire the vessel throughout.

9. *Caulking.*—At this stage all the seams are made water-tight by having a tool go over and swell the edges of the steel plates firmly against the side of the piece to which they are attached.

B. BOILER DIVISION.

1. *Laying Out.*—The plates are laid out on a floor and marked for the shaping operations necessary to make the boiler.

2. *Punching.*—The plates are punched for the rivets.

3. *Flanging and Bending.*—In order to make a boiler-shell, the two headpieces must be turned over like the lid of a baking-powder can, and slipped into a cylindrical piece of steel, thus making a complete cylindrical boiler after all the parts have been riveted together. The turning of the flange in an inch and a half steel, which is the thickness of some of the boiler shells, is a delicate and strength-requiring operation. The work is done on a boiler-head flanging machine. The steel is highly heated, firmly held between the two disks and then the edge is revolved against a roll. In a very few minutes a complete bend or flange is turned over.

4. *Fitting and Riveting.*—The plates, which have pre-

viously been punched, are now put in place, the holes are reamed out, and the rivets inserted.

5. *Inserting Tubes.*—In order to present a large heating surface to the water, the boilers are filled with a great multitude of tubes through which the hot gases flow in their course from the fire box to the stack.

6. *Caulking.*—Here all the seams are made steam-tight by a process similar to the one used on the hull of the vessel.

7. *Installing in Hull.*—The finished boiler is now installed in the hull, the fire boxes are attached, and non-conducting material is put around all exposed radiating surfaces to economize heat.

C. MOTIVE POWER DIVISION.

I. PATTERN MAKING.—In the pattern shop the drawings are received and models of the castings are made in wood so that the molder can have a form to which he can build his mold to construct the casting. The making of patterns is very exacting work, requiring highly skilled mechanics to read the drawings and interpret them accurately. As a result there is comparatively little division of labor and no elaborate equipment in the pattern shop.

II. FOUNDRY OR MOLDING DEPARTMENT.

1. *Making the Mold.*—In the foundry the conditions are much like those in the pattern shop, only here unskilled labor can be used to a much greater degree. Moreover, the units handled in the foundry are manifold heavier than those in the pattern shop, and there is very little assembling done in the foundry. The process briefly consists of inserting the pattern in proper supports and then tightly ramming sand around it. After the sand is fixed in shape the pattern is withdrawn and the mold is smoothed off and coated with some surfacing material, which will prevent the sand from caving in when the molten iron is poured into it.

2. *Core Making.*—If a casting is to be hollow, the mold

must be filled in with some solid material, the size of the hole desired in the casting. These fillers are technically known as cores, and the cores are made apart from the molds, dried in ovens, and then set into the molds after the pattern is withdrawn. The core is then anchored to prevent it from shifting when the metal is poured around it. The mold is then assembled and bolted together ready for the next step.

3. *Casting.*—After the mold is fixed the casting is made by pouring the molten metal into openings reserved for its reception at various parts of the mold. The filled mold is allowed to stand until the metal has solidified and cooled.

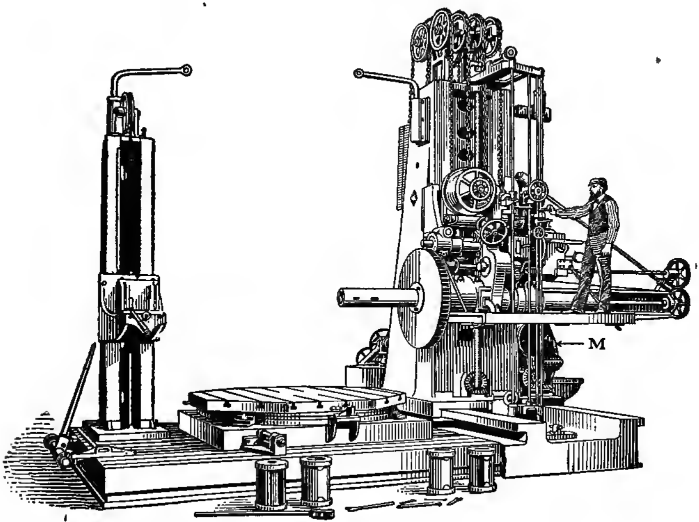
4. *Cleaning Castings.*—After the metal has cooled, the mold is withdrawn from around the casting and the adhering portions of sand are chipped off by means of air hammers in the hands of a rather unskilled class of workmen.

III. Machine Shop.—When the cleaned casting is received in the machine shop, it is slightly larger than the drawing calls for, and is covered with a scale which makes perfect joints impossible between the parts. Hence the pieces of iron must be cut, smoothed, and adjusted to each other until they make a perfect fit throughout the entire mechanism. The steps in the process are:

1. *Laying Out.*—Here the rough casting is picked up by a crane and carried to a large, smooth, level table where lines are accurately drawn, according to the drawings showing the exact amounts that must be trimmed off in order to make tight joints.

2. *Planing or Finishing Straight Surfaces.*—The castings have their straight surfaces cut and smoothed on a series of tools known as planers, milling machines, shapers, and the like. The usual practice is to smooth off one surface and use that as a basis for accurately cutting the other sides. The large pieces are cut off on planers (see *P*, Fig. 21) and large milling machines. Small pieces are handled on shapers, small boring and milling machines, millers, and others.

3. *Finishing the Round Pieces.*—Two kinds of round surfaces may be cut, convex surfaces which are represented by the forms of shafts and other similar pieces, and concave surfaces as represented by the inside of cylinders and the like. Shafts and such bodies are usually cut on machine tools, known as lathes. The piece to be cut is firmly held between two centers, and is revolved toward the cutting tool.



By courtesy of Niles, Bement, Pond Co., New York.

FIG. 16.—Horizontal Boring, Milling, and Drilling Machine.

This picture shows how general are the machines for large assembling industries, and also bow the individual motor drive is applied to machinery.

The concave surfaces are usually treated on a boring mill, either verticle (see *BM*, Fig. 21) or horizontal (Fig. 16), although much of this work may be done on lathes.

4. *Finishing Irregular Pieces.*—The cutting of gear teeth, the putting in of keyways, the drilling of holes and the making of slots, the finishing of surfaces having compound curves, and any number of incidental operations which must be done

in the shop, are performed on special machines designed for such purposes, as, for instance, gear-cutters, keyway cutters, drill presses, either ordinary, radial, multiple spindle or portable, slotters, and other special machines.

5. *Making of Bolts, Nuts, and Small Parts.*—Besides the main castings which must be finished off and fitted, there are hundreds of bolts and nuts, small rods, oil cups, tubes, piping, washers, keys, and other pieces of greater or less size necessary around the engine, in order to hold the pieces together, oil them properly, and to provide for the taking up of wear and other incidental work necessary to make the engine run, and keep it in condition while it is running. These things are made on special machines, the most important of which are the turret lathe, which is largely used to make nuts and bolts of large size, and an automatic screw-making machine which makes bolts and screws from the straight rod of steel. This latter machine does its work absolutely without the intervention of human labor after the bar of steel has been inserted.

6. *After All the Parts are Machined, They Must be Gathered Together on the Assembling Floor.*—When one realizes the thousands of pieces that go into a marine engine, when one knows that the weight of some of these parts is twenty tons or more, while the dimensions of others are less than that of a cent, one can appreciate the fact that ingenuity must be exercised in designing, building, and placing the tools so that the parts will make one direct line from the beginning to the end of their passage.

Machine-shop structure has long been a matter of grave consideration on the part of architects and engineers. At the present time the gallery type is the approved one for a machine-shop building. In this design there are three main divisions of the shop. (See Figs. 17 and 21.) Sections A and C have two stories. B is kept clear of a second floor to allow for the passage of one or more large cranes which handle heavy castings. In some plants two tracks are made for the cranes, one of which is superimposed above the other, the more powerful crane being put above and used only for handling the heaviest material in the shop. The lower track may have several cranes of smaller capacity.

The small parts are carried by means of elevators to the upper floors of the sides A and C. Here they are put through the various machines necessary to get them into the finished shape; and as each step is performed, they are moved forward in the direction of the erecting floor, so that by the time they are completed, they are ready to be lowered to the assembling or erecting floor.

The heavy parts are laid out on laying-off tables and then given over to the planers, millers, lathes, and other tools on the lower floor. The machines also are arranged so that every succeeding operation means bringing the large piece nearer to the assembling space.

The placing of the erecting floor in such relative position with regard to the remainder of the shop has several advantages:

1. It is in one of the best lighted parts of the shop.
2. There are no floors above to interfere with the erection of the tallest kind of machinery.
3. It is in a place where all parts of the floor are easily reached, so that one can get to any part of the work under construction.
4. It is under the heaviest cranes, so that all parts can be readily handled.
5. It is the converging point for all material that goes into the finished product.
6. It is accessible for shipping purposes.

In connection with a machine shop it is always necessary to reserve a considerable portion of space for tool and store rooms. The machines and workmen are hourly in need of supplies and tools for their various jobs. Good practice places

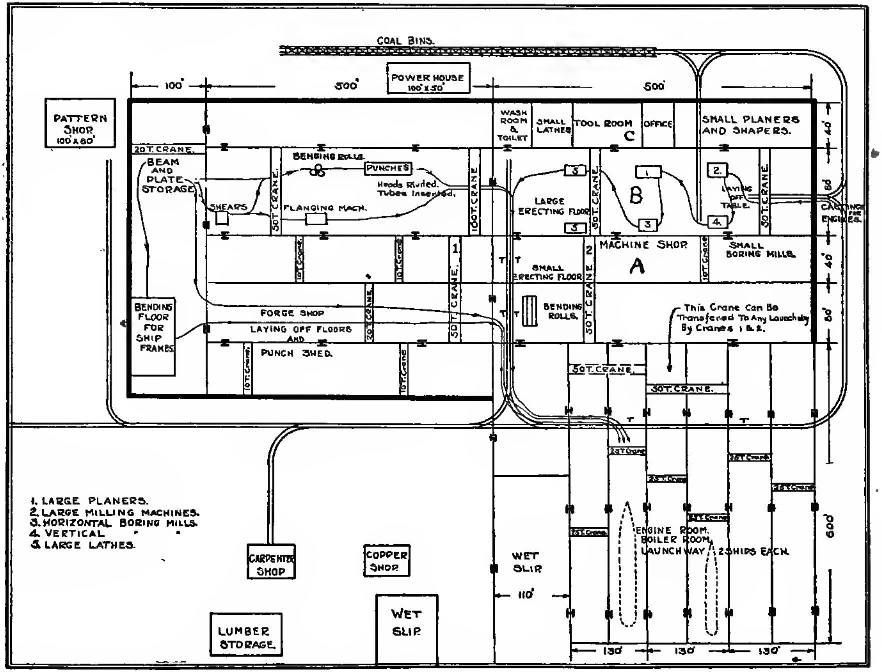


FIG. 17.—Plan of a Shipyard, showing Line of Process and Relationship of Departments.

those divisions in a portion of the shop where the space taken will not hamper the continuity of the process, and yet will be most accessible to those operatives whose duties require the greatest number of changes in tools.

In the shipbuilding plant under consideration there are two erecting floors, one for large work and the other for small work. The general course of the parts for both large and small engines is the same.

The crane arrangement of the plant is one worthy of careful consideration. If a small engine has been erected under space A, the heavy crane above this floor can pick up the entire engine and transfer it to the launchways without the necessity of taking any of the engine apart. (See Fig. 17.) If a big vessel is being built, the engines are erected on the large erecting floor, and when completed are separated into as large divisions as can conveniently be handled by the crane. They are then lifted to cars on the tracks *TT*, and hauled to the launchways, where another crane lifts them from the cars and carries them to the vessels.

Fig. 17 shows the arrangement of one of the most recently constructed shipyards in the United States. It does not possess a foundry, but otherwise its equipment is complete, and it is one of the best arranged plants in existence for inter-departmental communication. An overhead crane with a capacity of 100 tons can run the entire length of the combined boiler and machine shops, with the mere opening of the door between them. In other respects, too, it is well arranged. If, at any time, it should be desirable to add a foundry, it could be added to the right of the diagram as a continuation of the machine-shop building. For convenience of working it is ideal. All divisions, even the shipyard, are under cover, so that inclement weather need never hinder construction. The arrowed lines show the general course of work through the various departments to the launched ship. The short railway connection across the shops enables the ship cranes to handle anything that comes out of either of the two shops, so that from the time the goods are received from the outside world until the launched vessel is ready to steam down the river there is one straight continuous line of work with little if any retracing of steps.

The shipyard considered above is an example of an assembling industry. The plant, however, with its construction, excellent as it is, does not have many railway connections for handling its output. Elaborate railroad connections for such a purpose are unnecessary in shipbuilding, for the river is the avenue by which the finished commodity is distributed. If a plant is handling a product to be distributed by land, its railroad connections should be superior to those shown above. It is also true that if its product is of such a nature that it can be transported from department to department by means of railroads instead of cranes, the former is perhaps preferable.

The three preceding chapters have considered the kinds of industries and the ideal methods of adapting plants to meet their needs. The key to success in building a plant is to make it handle the work in the cheapest manner; and the cheapest manner is the one which will send the goods from the beginning to the end of the course with the least expenditure of time and labor. The architect, however, is foolish, indeed, if he does not recognize that there are conditions that may modify his ideal plans. Every manufacturer appreciates the fact that to erect the cheapest building possible he must spend large sums of money to provide for a contingency that may never occur. This subject will be reserved for the next chapter.

CHAPTER X

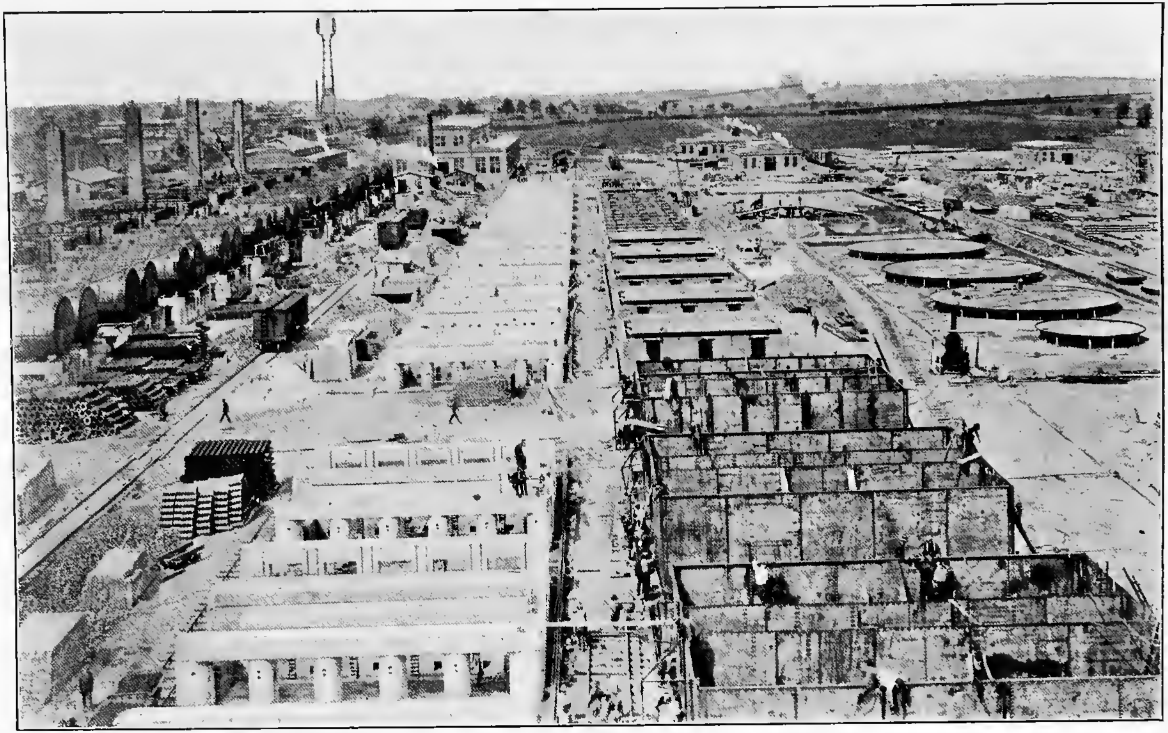
FIRE PRECAUTION, AND ITS EFFECT ON LAYOUT AND STRUCTURE

A WELL-DESIGNED establishment may deviate widely from the plans just considered, and yet be the best possible one that can be constructed to suit existing conditions, a fact amply illustrated by plants known the world over for their economy in production. Apparently these plants violate nearly every recognized principle that has been laid down for the industries of their class. The Standard Oil Company, for instance, has refineries erected at various points throughout the country, and their arrangement individually manifests a most scattered and ground-wasting design.

From the industrial and chemical standpoints, oil refining is a continuous analytical industry having to do with the handling of liquids. In many respects it is similar to sugar refining. The crude oil is received and heated, and from it are first driven off gas and the light oils. The residue is passed on to other stills and subjected to further heating and condensing operations until the crude petroleum eventually becomes gas, benzines, light, volatile illuminating oil known as "water white," a heavier grade called "standard white," another grade designated as "straw white," machinery or lubricating oil, paraffine oils, petrolatum, or vaseline, cylinder oil, refined paraffine, and coke. There are, of course, other products from the refineries made by further separation and treatment of the native petroleum, but they are all obtained by the same means—successive distillation, filter pressing, or sweating the crude oil and its derivatives. The ideal structure for an oil plant may appear to be one with the lines of a sugar refinery, a high building situated near waterways and railroad facilities. Why, then, do engineers of the oil-refining business so waste space and power? Because oil is so inflammable that it must be kept as far from flames as possible. One cannot be too careful, for in every plant there are occasional outbreaks of fire in some portions. So great is the fire danger in connection with oil refining that insurance companies cannot afford to assume the risk. Fire seems bound to break out somewhere in the establishment in the course of time, and if the departments are not isolated, an entire plant, worth millions of dollars, may become a heap of scrap metal and rubbish.. On account of the great danger, an oil refinery must be situated in some remote section apart from other valuable property. It must have a large area, its buildings must be widely separated, and every precaution taken against fire loss. Fig. 18 gives some idea of the scattered way in which the divisions of the distilling departments are situated, and shows, also, the way in which buildings are separated.

A gas-making establishment affords another illustration of a plant which can protect itself from fire only by building on large stretches of ground and in remote quarters. Gas is a product more inflammable than oil, but the raw material is not so susceptible to ignition. Let a fire once occur in a gas plant and the results may be calamitous. If a gas-holder leaks and air creeps into the tank, a rise in temperature or a carelessly struck match will give a vivid flash and a terrific explosion. The proof of a fire is not a mass of flame, but a lot of bent plates and twisted beams of iron.

For ordinary kinds of manufacturing the causes of fire may be divided into the common and the special hazards. The common hazards include those fires which may occur in any kind of a building, whether it be a department store or a machine shop, a slaughtering establishment, or a cotton



By courtesy of *The Standard Oil Company.*

FIG. 18.—Bird's-Eye View of an Oil Refinery.

This picture shows how far apart the various structures of an oil refinery are separated from each other; how the plant is placed within proximity to a large labor population and, at the same time, is isolated from all other properties. Note the large city in the distant background on the other side of the railroad.

mill. The special hazards include the fires which grow out of some risk peculiar to a plant of any particular type.

A good classification of the common and special hazards is found below, copied from an article by Henry A. Fiske, entitled "Causes of Fire."

"The Common Hazards may be divided into the following general classes and sub-classes:

- Lighting:
  - Electric (Arc).
  - " (Incandescent).
  - Gas (City or Town).
  - Gasolene Gas.
  - Acetylene Gas.
  - Kerosene Oil Lamps.
  - " " Lanterns.
  - " " Torches.
  - Candles.
- Heating:
  - Steam.
  - Hot Air.
  - Stove, Coal.
  - " Gasolene.
  - " Oil.
- Power:
  - Shafting and Bearings.
  - Steam Engines.
  - Gas Engines.
  - Gasolene Engines.
  - Electric Motors.
- Boiler (or Fuel):
  - Fuel, Coal.
  - " Waste Material or Refuse.
  - Overheated Woodwork.
  - Sparks from Stack.
  - Defective Chimney.
  - Ashes.
- Rubbish (or Sweepings).
- Oily Material:
  - Oily Waste.
  - Other Oily Material.
- Smoking.
- Lightning.
- Sparks from Locomotives.
- Miscellaneous.

The Special Hazards will vary according to the class of risk, but may be divided into the following general divisions:

1. Storage and Handling of Raw Stock.
2. Preparing Raw Stock.
3. Making, or General Manufacture.
4. Finishing.
5. Waste Material.

While some classes of manufacturing risks will have only one or two of the above groups, others will include all of the divisions.

Besides the two general classes of causes, i.e., Common and Special Hazards, may be noted the Exposure and Incendiary fires, which hardly admit of any general classification, and are not included in these tables."[1]

The relative importance of these classes in causing fires may be judged from this table:

AVERAGE PERCENTAGES BY GROUPS AND INDIVIDUAL HAZARDS, ALL THE CLASSES COMBINED:[2]

		Per Cent.
Common Hazards. Group I.	Light	6
	Heat	2
	Power	7
	Boiler and fuel	12
	Total	27
Common Hazards. Group II.	Rubbish and sweepings	4
	Oily material	3
	Smoking	2
	Lightning	2
	Locomotive sparks	3
	Miscellaneous	3
	Total	17
Special Hazards.	I. Storage raw stock	6
	II. Preparing	8
	III. Making	26
	IV. Finishing	7
	V. Waste materials	10
	Total	57

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[1] *Insurance Engineering*, "Causes of Fire," by Henry A. Fiske, July, 1907, Vol. XIV, pp. 5–7.

[2] Ibid., pp. 13, 14; the percentages are evidently not quite exact, as the total amounts to 101, J. C. D.

The main causes of fire are bad housekeeping and carelessness. Twenty per cent of all fires can be traced to the fact that the owners of plants permitted the accumulation of dirt, oily waste, and other easily inflammable material. From the above table no less than 7 per cent of the common hazard outbreaks are due directly to rubbish and sweepings and oily waste, while among the special hazards 10 per cent are the result of the improper disposition of waste materials.

Fires due to the lighting apparatus are to a very great extent caused by carelessness. On the whole, incandescent bulbs are safer than arc lamps; and, if the wiring and lights are properly installed, electric illumination is, from the insurance point of view, preferable to any other kind. An electric fire is almost invariably due to faulty installation, lack of care in maintenance, or the careless use of the electric lamp.

Power fires are commonly caused by poorly hung shaftings, by shaftings not being properly watched, by hot bearings, and loose pulleys. Belt holes running between the main floors of a building are very dangerous risks, because the friction of the belt is apt to start a fire, and the holes between the floors are ideal means to promote its spread.

Boiler and fuel fires can be almost completely eliminated by taking care to detach the boiler-room from the main building and to construct it of non-inflammable material throughout.

Among the special hazards the table shows that about 26 per cent of the fires have been caused in the making or actual manufacturing process. Few fires are the result of one cause, and usually the special hazard of a business acts in combination with some common oversight. For example, in a cotton mill the principal hazards are in the openers or scutchers, where foreign material, coming in contact with the steel teeth, causes sparks which ignite loose cotton. Place the scutcher on a clean floor and the fire will have little chance to spread before it is quenched. In the card-rooms the air is permeated with fine cotton, and the floors are apt to gather accumulations within a very short time. If here an electric short circuit takes place, or there is a badly installed electric light, a fire is almost inevitable.

Flour-mill records show the following: Fires due to spontaneous combustion of stock and dust explosions, 12 per cent, conveyers 4 per cent, grinding 8 per cent, cleaning machines 4 per cent, and special miscellaneous hazards 1 per cent. Contrasted with that, 71 per cent of the fires are due to common causes.[1]

In foundries special hazards total 82 per cent, in which the cupola causes 36 per cent, the melting furnaces 13 per cent, core ovens 9 per cent, molding and casting 12 per cent, miscellaneous special hazards 12 per cent, and the ordinary causes make up but 18 per cent.[2]

Shoe factories have 19 per cent of their fires caused in cementing, 6 per cent in bottoming, 3 per cent in waxing heels, 6 per cent in naphtha and naphtha blacking, 4 per cent in the waste chute, with 11 per cent due to miscellaneous accidents, and 51 per cent due to common causes.[3]

Although on many occasions fire would not occur were carelessness not evident, the object of the builder of a factory is to construct his plant in such a way that an occasional oversight will not result in the destruction of his property. At the present time there are two types of factory construction which succeed in limiting combustion—slow burning, and fire proof.

The slow-burning type received its highest development in New England among the textile factories, where it is

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[1] "Handbook of Fire Protection," by Everett W. Crosby and Henry A. Fiske, Fourth Edition, p. 114.

[2] Ibid.

[3] Ibid., p. 121.

generally known as mill construction. Mill construction is less costly than fireproof work, and when combined with the automatic sprinkler system, with reasonable care it makes a safe building. The principles of mill construction involve ten ideas.

1. There shall be no openings between floors, either to admit belts, stairways, elevator shafts, or for any purpose whatsoever.

2. There must be no concealed places in floors or walls which will permit of the hidden development of a fire. This necessitates the using of very heavy floor timbers, spaced from eight to twelve feet apart, and the floors must be constructed of three to four inch planks with single or double-top boarding. Thus all the joists are exposed and readily accessible to hose or sprinkler water.

3. The floors must not only be free from large openings, but they must be as nearly air and water tight as possible. This demands, besides the use of the heavy timber mentioned above, that the lumber must be well seasoned and laid down in a skilful manner.

4. The outside walls of the building should be so built of brick or concrete that there is no danger of fire breaking through, and division walls are to be carried at least three feet above the roof to prevent flames from leaping over. It is also desirable to have these walls winged on either side of the building to prevent a possible fire from leaping around the edges.

5. If there must be openings in walls between departments, they are to be protected with heavy fire doors or wire-glass windows, or fireproof shutters on the windows. These are designed to confine a fire to its place of origin.

6. The elevator shafts, stairways, and necessary passageways between the floors must be entirely enclosed in solid brick walls on all sides opening into the plant. The only exception to this is in the belt tower, where sufficient space

must be allowed in the wall to permit the shaft or belting to go through. The belting, however, does not pass from one floor to the other. Even in the belt tower there is no direct communication between floors.

7. The power house of the plant must be apart from the main building and not over one story in height. The height of the fabricating building must not exceed five stories, or sixty-five feet above the ground level.

8. Stacks, flues, and chimneys must be of brick or some approved fireproof material.

9. The roof must be flat and smooth, with just sufficient pitch to provide for proper drainage, and must be covered with metal, gravel, or approved composition. Cornices should be composed of incombustible material.

10. The building should be divided up into fire sections, each one not exceeding 5,000 square feet, unless adequately equipped with sprinklers.

Fig. 19 shows a sketch of the general protective schemes used in a slow-burning building.

Mill construction, while often effective, has, partly through lack of care and partly through the expensiveness of lumber, fallen into disfavor, and is beginning to yield place to fireproof construction. In the fireproof building, all the precautions taken in mill construction are employed, but instead of using timber in any part, it must use either brick, terra cotta, concrete, steel, iron, or some other fire-resisting material; and, moreover, all steel, iron, or other metallic material which is likely to bend or weaken in the presence of heat, must be adequately covered with non-conducting fireproof material, which will not permit these supports to bend or crumble in the presence of fire. The doors and windows of the fireproof building must be made of other than combustible material. Everything should be unburnable, and at the same time the structure should be so made that there will be no spaces or cavities to permit of the accumulation of material away from easy view. No section, however small, should be built in such a way that water or any other

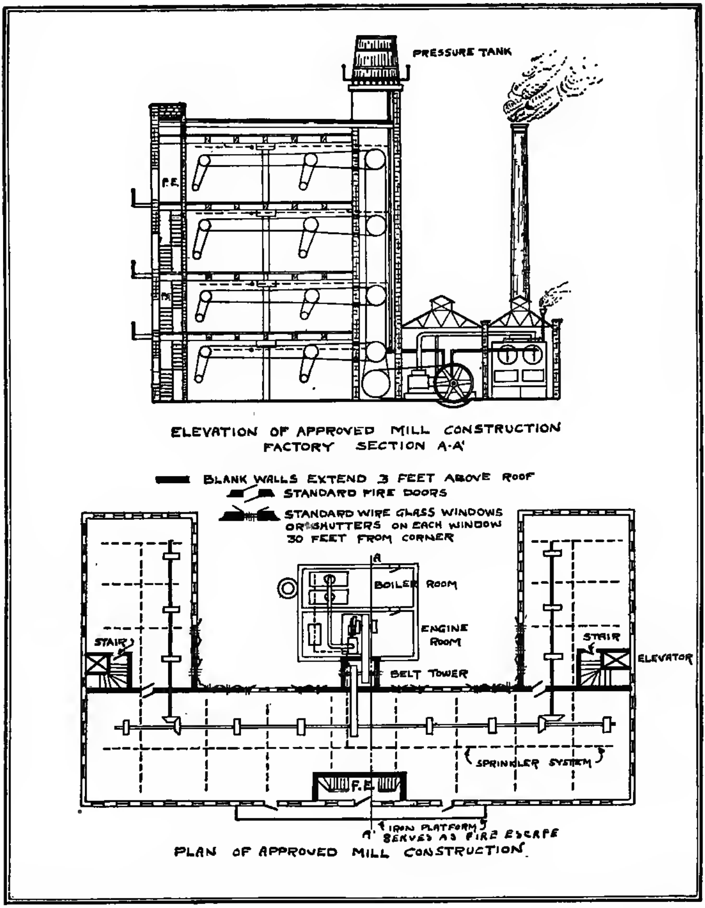

FIG. 19.—Elevation and Plan of Slow-Burning Construction.

extinguishing material cannot be quickly and accurately applied.

For a number of years there has been much discussion of the question of the best building material for factory purposes. At one time, brick-mill construction was considered by far the most acceptable. There seems to be a tendency, however, within recent years, to employ reinforced concrete to a great degree, as it is proving to have very satisfactory fireproof qualities, and is cheaper than structural steel properly reinforced and covered with insulation. The Turner Construction Company states of some structures it recently erected: "The cost of these buildings, according to estimates, made by the Bush Terminal Company, based upon authoritative sources, was something over 10 per cent less than what the same structure would have cost in first-class structural steel. The cost as compared to mill construction was found to be in excess of not over 5 per cent." The Robert Gair Company, a large paper goods concern, has two buildings which contrast the value of the older style of protection with the fireproof design. Across the street from the new building, erected by the Turner Construction Company, are two slow-burning, mill-construction buildings of large size. "Under the same conditions of ownership, occupancy, usage, sprinklers, installations, contents and exposure hazards, the rates on the mill-constructed buildings are 21.4 cents on the building and 65.6 on the contents. On the reinforced concrete building 12.2 cents on the building and 29.6 cents on the contents. Furthermore, the officials of the Gair Company are the authority for the statement that the building saves them probably $5,000 a year in eliminating vermin loss." With regard to the cost of construction, the mill buildings have about a 5 per cent difference in their favor, while the concrete cost 20 per cent less than structural steel properly guarded.

The photograph (Fig. 20) shows an interesting fire test which well contrasts the lasting powers of the two types of building in case of fire. The fire started on the fourth

By courtesy of Trussed Concrete Steel Co., Detroit, Mich

FIG. 20.—A Remarkable Fire Test.

This picture, besides contrasting the fire-resisting properties of a so-called fire-proof building with that of the mill-construction, also shows how much greater window space can be installed in the newer type of building.

floor of the reinforced concrete building, and burnt itself out without spreading to any of the other floors above or below. It did, however, break through a wall opening into the building next door and completely burned out the two upper floors and ruined the entire contents of the structure. According to the Trussed Concrete Steel Company, "special attention is called to the fact that in the Kahn System Building the sprinkler system was not completed, and was, therefore, not working, whereas in the mill-constructed building the sprinkler system was in good condition. . . . Had the fire doors been in place between the old and new structures, the fire would undoubtedly have burned itself out without getting into the mill constructed building."

For some time, concrete buildings were regarded with disfavor by insurance men because of their liability to collapse while in course of erection. *Insurance Engineering* reports a number of such disasters, but investigation has proved that the fault has been due to poor workmanship and inferior design rather than to any inherent weakness in the properly reinforced material. Until concrete, reinforced or not, has completely hardened or set, it must be supported in casings because of its more or less fluid condition. If careless inspectors and unscrupulous contractors neglect this necessary precaution, there is grave danger that their penny wisdom may cause the death of some workers and be the means of their own financial ruin.

Aside from the material which makes up the body of the building, manufacturers and others seek supplementary fire protectors. The automatic sprinkler system is the most effective protector. For twelve years, the National Fire Protective Association has a record of 6,064 fires in sprinkled risks where the heat was sufficient to operate the sprinklers. Sixty-seven per cent, or 4,039, of these fires were practically or entirely extinguished by the sprinklers. Twenty-seven per cent, or 1,647, were held in check so that additional help put them out at a small loss. Only 6 per cent, or 378, of the fires were uncontrolled by the sprinkler system. A careful study was made of the unsuccessful systems, and the following table shows the causes:[1]

	Number.	Per Cent.
Defective or partial equipment	87	23
Failure due to water being shut off	87	23
Hazard too severe for control	38	10
Faulty building construction and obstruction	35	9
Exposure or conflagration	29	8
Inadequate or light water supply	21	6
Water supplies crippled by explosion	12	3
Defective dry valve or dry system	10	3
Water supplies crippled by freezing	9	2
Unsatisfactory action of high test heads	7	2
Unaccounted for and miscellaneous	43	11
	378	100

The automatic sprinkler consists of a series of pipes arranged in a systematic manner under the ceilings of the rooms with valves placed at regular intervals which are closed with some easily fusible metal. In case of a fire the temperature of the room will soon rise to the point where the metal melts, opening the valve and causing it to throw out a spray of water.

In order to have an effective sprinkler protection, the following conditions should operate together.

1. The building should be so constructed and the sprinklers so distributed that there will be no parts either concealed or otherwise out of range of the quenching stream.

2. There must be a constant supply of water great in volume and sufficiently high in pressure to make it always possible to guarantee that the water will reach its designed range at any time.

3. The pipes must have adequate diameter to permit of

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[1] "Handbook of Fire Protection," by Crosby-Fiske, p. 236.

the passage of enough water to the valves, and the valves must be freely acting at all times.

4. Care must be taken that the water does not freeze in the pipes, and that acid fumes or chemicals do not affect the working of the valves. If either one of these things operate, the most expensive and elaborate system may prove utterly worthless.

The Crosby-Fiske Handbook contains diagrams of a number of distributing schemes showing both the approved and unapproved method of arranging the pipes. No less than 125 sprinkler valves are also pictured, and of that number only seven are approved by the Fire Underwriters' Association of the United States.

To provide for cases wherein the nature of the risk makes it impossible to prevent water from freezing in the danger zone, there has been devised the dry sprinkler system. In the dry sprinkler system air is pumped into the pipes in order to back the water into a non-freezing zone. In the presence of excessive heat the sealing metal on the valves will melt as in the ordinary system. In a few moments the air will escape through the resulting openings in the spraying devices followed by a stream of water.

In order to keep up the pressure in the sprinkler system two schemes can be used, the gravity tank and the pressure tank. The gravity tank is the older of the two ideas, and is ample for all ordinary cases. Such a tank, according to the underwriters' specifications, must have a capacity of at least 5,000 gallons. Ten thousand gallons is urged, and tanks with capacities of over one hundred thousand gallons are not uncommon. The minimum height requirement for the tank is not less than 25 feet above the highest sprinkler in the establishment. There are two methods of erecting the tank. In establishments which are all enclosed within the same set of walls, and in places where the ground is limited, a common scheme is to perch it on top of the main building itself.

This place is objectionable because it tends to weaken the building. Insurance companies are opposed to having buildings topped with much weight, unless extra precautions are taken to strengthen the holding walls. A later and more approved plan is to have special structural work provided for the gravity tanks. Where there are a number of buildings, or extensive grounds, a special tower is frequently constructed for the vessel.

The pressure tank is an automatic device consisting usually of a cylindrical tank placed horizontally and located in the upper stories of the building. Its capacity varies from 4,500 to 9,000 gallons of water or more, and it is kept two thirds full of water. The other third consists of air under pressure, always over 75 pounds to the square inch, and frequently reaching 150 and more. Connected with the pressure tank are two pumps, one for air and the other for water, so, whenever the pressure drops down or the water begins to flow out, the replenishing of both air and liquid can readily take place.

Many establishments do not have sprinkler systems, but nearly all do take the precaution to install fire hose. To make a hose system efficient there must be a constant supply of water under considerable pressure. This is usually maintained by either a gravity or pressure tank, as described above. There must also be installed a piping system, to which are fitted frequent outlets for hose connection. Good practice demands that the outlets shall be between 100 and 200 feet apart, and that the length of the hose shall be from 50 to 100 feet, neatly folded on swinging racks. The effectiveness of hose protection depends upon two things, a constant supply of water under pressure at the hose coupling and people with presence of mind around to use it when occasion arises.

Aside from the sprinkler system and the hose, there are two types of hand protection, chemical fire extinguishers, and the fire pail. There are several types of chemical fire extinguishers, namely, the liquid hand extinguisher enclosed in three-gallon upset tanks, the chemical tank on wheels, built usually in 40 to 60 gallon sizes, stationary chemical tanks, and dry powder extinguishers. The most effective chemical extinguisher is the small upset tank combination. It plays a jet of extinguishing fluid some forty feet for nearly one minute. The extinguishing material usually contains carbonic-acid gas and sulphate of soda in solution. When it comes in contact with the burning mass, soda salts are deposited forming a coat of material which tends to exclude air and retard combustion. While in operation a considerable pressure is generated in the extinguisher. At ordinary temperature a pressure of 125 pounds accumulates within the tank, and if for any cause whatever the nozzle becomes closed, 200 pounds and over may be reached. One can see how a cheap extinguisher may be a very dangerous instrument in the hands of an operator, because any concealed weakness makes it liable to explosion. The chemical tanks have not as yet been thoroughly approved by the fire underwriters, while the dry-powder extinguishers, according to the Crosby-Fiske handbook, have been the subject of the following circular of the National Fire Protective Association. "In view of the fact that several so-called fire extinguishers, consisting generally of sheet-metal tubes filled with mixtures of bicarbonate of soda and other materials in powdered form, have been widely advertised as suitable for use for fire extinguishing purposes, this committee has to report that in its opinion all forms of dry-powder fire extinguishers are inferior for general use, that attempts to extinguish fires with them may cause delay in the use of water and other approved extinguishing agents, and therefore their introduction should not be encouraged."[1]

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[1] "Handbook of Fire Protection," by Crosby-Fiske, pp. 185, 186.

No matter how well protected a plant is, it should always be so equipped that human beings can be informed at once when a fire is starting. Even if we have an automatic extinguisher, there should be some quick means of giving an alarm. In one case a sprinkler system operated so effectively that it flooded an entire building, destroying far more goods than the fire itself. It is also advisable to have a sprinkler alarm in order to notify people that a fire is in progress, because it is by no means impossible for a fire to get utterly beyond control of the sprinkler system within a very brief period of time. The sooner human aid is attracted, the better it is for all concerned, because other means can be taken to quench the fire, and after it is extinguished, all unnecessary water damage can be prevented by turning off the water. It is advisable to have a sprinkler alarm for another reason. Sometimes the sprinklers accidentally break or leak, causing water to flow when there is no fire at all.

Where there is no sprinkler system, automatic fire alarms are especially desirable. There are many kinds of such devices on the market. One common scheme of fire signalling is to place thermostats from ten to twelve feet apart at all portions of a risk. Fire alarms are used for all kinds of purposes. Some are put on the journals of shaftings to notify the engineer of a heated bearing, others are installed in coal bunkers which are liable to catch fire through spontaneous combustion. The general principle of the alarm is to have an electrical circuit, which is susceptible of being closed by the expansion of two pieces of metal in the presence of heat. To be effective they must work at all times of danger, and to keep them in working condition they have to be subjected to periodic inspection.

In large risks, it is not advisable to depend exclusively upon automatic signaling devices. Supplemental protection is afforded by human watchmen who, from the standpoint of efficiency, may prove of doubtful value. In one plant an old employee was given such a place. His conception of the duties of the position was to stroll around the building several times during the early evening. By ten or eleven o'clock he felt assured that no self-respecting fire would intrude any later, so, arranging for himself a comfortable couch he spent the remaining watching hours in sleep. His case was not an uncommon one, and insurance companies find that there is only one means of making watchmen service trustworthy, and that is to install time-recording devices at all portions of a risk where inspection should be made. The first time-recording clocks installed, were put in for the purpose of keeping accurate tab on the fire watchman. If a watchman is efficient and conscientious, he is one of the best fire protective devices known, but unless he is, his utility is uncertain.

The fire watchman usually visits both the inside and the outside of the risk, and makes a connecting link between the inside and outside fire protection. Outside fire protection may consist of automatic sprinklers located over windows or other openings. It may be a device which will send a curtain of water over an exposed wall. In general, however, the outside protection consists in placing water mains and fire plugs or hydrants in such places that they will adequately cover the entire risk. Good hose should be kept in the vicinity of all fire hydrants, enclosed in such a way that it will be safe from the weather and yet be quickly available in case of need. The watchman should be quick and intelligent. He should, on discovering a fire, immediately turn in the alarm and then try to extinguish the flame. The efficiency of the outside fire protection, aside from the automatic devices, depends upon three things: the water supply, the effectiveness of the watchman and firemen, and the efficiency of the hose.

Great care must be taken of fire hose, because cheap hose is likely to break at the most critical moment, and is never dependable. Fire underwriters and insurance companies inspect the various makes of hose on the market. On good tried material they set their stamp of approval, so that no one need unwittingly use defective material. The proper way to keep the hose is to place it in houses installed within the vicinity of the hydrants or fire plugs. Here also fire underwriters make it easy for one to use the best plans because they have drawn up careful specifications for hose houses

Many plants have well-drilled fire companies organized from among their employees. These bodies are encouraged by all underwriters. Some insurance companies insist upon frequent unannounced drills, because no matter how good and efficient the appliances are, they may prove utterly worthless in the hands of a nervous or incompetent crew.

Protection to property is important, but safety to life is vital. Fire escapes are installed for the purpose of providing sure exits to the employees in case a plant becomes ignited. Two types of devices are common, the exterior and interior enclosed fire escapes. The former is an iron stairway attached to the outside walls of the building, so arranged that easy and safe exit can be made through the windows and doors of every floor. The latter is a completely enclosed shaft running the entire height of the building. (See Fig. 19, *FE.*) In this shaft are placed the stairways, and frequently the passenger elevator, if the plant possesses one. Connection is made to each floor by means of an iron platform extending from a door on the outside wall of the shaft to another door some distance away, which opens into the floor of the building. In this way there is no direct connection between the enclosed shaft and the building, yet there is easy communication to the street from all parts of the structure.

CHAPTER XI

THE BUILDING AND THE WORKERS

MAN is like other animals—best results require pleasant, healthful surroundings. If compelled to work in a dark, cold, or repelling environment, his output will suffer. The comforts within the building and a spirit of hearty cooperation among all the departments influence the physical state and mental attitude of the employees.

Comforts can be provided when the building is being erected by providing for five things:

1. Abundant light.
2. Sufficient heat.
3. Good ventilation.
4. Adequate space for workers.
5. Convenient toilet and wash rooms.

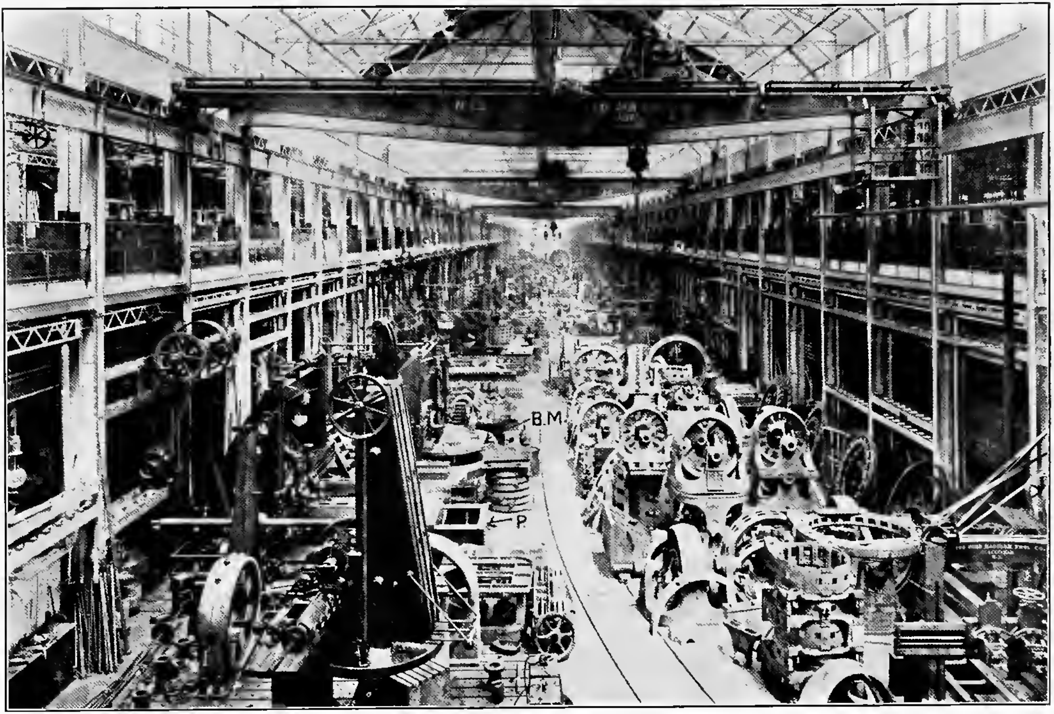
1. ABUNDANT LIGHT.—There are many operations in almost every line of manufacturing, for which abundant light is an imperative necessity. Without it the workmen are hampered in their activity and can produce neither good work nor a large quantity. If a plant must be erected on a site which will enclose parts of the building in more or less dark corners, the managers should so arrange their machinery that those which require the greater light will be in the more desirable sections.

Before the time of the steel frame, factory buildings had to be made with a comparatively small amount of window space in order to give proper strength to the structure; and the higher the building, the more massive had to be the masonry for the lower stories. Steel structural work overlaid with brick made possible better natural lighting. A brick, steel frame factory building can allow as much as 50 per cent window space without endangering the strength of the structure. Still more recently, reinforced concrete has been used quite extensively, and with increasing favor; because it is if anything cheaper than the steel structure, and likewise permits of quite as much window space. (See Fig. 20.)

The old style machine shops, like factory buildings, were very deficient in window space compared with their modern prototypes; but sometimes stupidity will do much to make a poorly constructed plant even worse. In a shop that was not by any means ideally lighted, the management decided that they needed some more storage room for iron plates and other heavy materials. They appealed to the city councils to have the street closed, which separated two of their departments. When that measure was put through they erected a shed against the wall of the machine shop covering nearly all of the windows of one side of the building. It is true that the shed was open on the street side, but its long slanting roof covered the windows, and darkened the machine shop.

The two methods of lighting a structure are by windows from the side or from the roof. Roof lighting has been used for many years. Fig. 21 illustrates a skylighted room. The objection to skylights is that shops thus lighted may be exceedingly warm on account of the direct rays of the sun. If the ceilings are high, however, the discomfort is less, although high ceilings will not obviate the unpleasant results of the direct rays of the sun completely.

A great many architects have adopted the scheme of lighting their buildings from the top by means of the saw-tooth roof. The saw-tooth light openings are usually faced to the north. In this way the light is admitted, but the direct rays of the sun are excluded for the greater portion of the day. The saw-tooth window is not strictly a skylight, but it has all the advantages of the skylight without its disadvantages.



By courtesy of Westinghouse Electric and Manufacturing Co., Pittsburg, Pa.

FIG. 21.—Interior of a Machine Shop.

This picture shows the inside of the gallery type of machine shop structure, the interior of a skylighted building, and the group drive method of arranging machines, G. D. At P. and B. M. are a large planer and a large vertical boring mill. In some plants another set of crane tracks are placed about the height, G. D., for an additional set of cranes.

Light should be provided for the plant by day, by night, and for such times of the day as outside light is inadequate for the work in hand. A great many methods of artificial lighting are advertised. The four common forms of electric lighting are the flaming arc light, the mercury lamp, the common incandescent bulb, and the ordinary electric arc. The flaming and mercury lamps give very good satisfaction, and are less expensive to maintain than the common incandescent and arc forms. They are, however, more expensive to install.

The artificial light in any plant should be so arranged that the worker will not be annoyed by any flickering or unevenness of the light nor disturbed by the casting of shadows. Two great objections to the arc light are its shadows and its flickering. The incandescent lamp gives a steady light, but it casts shadows, and in many cases is not powerful enough to give thorough satisfaction. The ideal light is one which most nearly approaches daylight in its intensity and diffuses the rays evenly during its entire time of running. The flaming arc light and the mercury light approach these ideals, and in general make a superior means of illumination.

2. SUFFICIENT HEAT.—The heating of buildings has tested the ingenuity of engineers and owners for many years. It depends of course very largely upon the type of manufacturing that goes on within the building, to what extent the various departments shall be heated. A foundry or blacksmith shop can get along with considerably less heat than a machine shop or textile mill. In any case, however, it is a short-sighted policy for the management of a plant to give its workers insufficient heat. The amount of money expended in heating a plant during cold weather is more than paid for by the increased capacity of the workers.

Several means of heating a plant may be installed:

(1) *Hot Air from Furnaces Direct.*—This method is little employed and is very expensive on account of its great

wasting of fuel, and is unsatisfactory because it is hard to distribute the heat. The writer knows of one instance where a plant was heated in this way with large furnaces. During cold weather it was almost impossible to get all of the rooms comfortably warm during the entire day. The workers in the poorly heated sections would sit with chilled hands trying to perform their tasks, but their best efforts were ineffective, and during and after cold spells the operatives would frequently be detained at home to nurse colds and other maladies resulting from their exposure.

(2) *Hot Water.*—Hot-water systems of heating are economical in small plants. They have objections in that they do not aid ventilation, and if the system is cooled down overnight, or for any period of time, it requires a great amount of heat and a considerable length of time to get the system working to its full efficiency.

(3) *Steam Heating.*—The most economical and generally used system of heating in plants and workshops is to utilize the exhaust steam from the engine, supplemented by live steam from the boiler, whenever necessary. Steam heat has the advantage of being easy to apply at any point by the mere insertion of a coil of pipe. The objection to it is that it does not actively aid ventilation; but under the best of conditions special means must be taken to properly ventilate a building which has a large number of occupants. Steam heating is much more quick in its action than any other system, and is easily handled.

Aside from the question of expense the ideal system of heating is one which works hand in hand with the ventilating system. Properly handled, the combination of the steam and hot-air systems succeeds in doing this. A scheme that is used in clubhouses, hospitals, and other institutions of a similar public character, is to have an arrangement something like the one shown in Fig. 22. The steam pipes are placed in front of the air port. The cool air from the outside enters

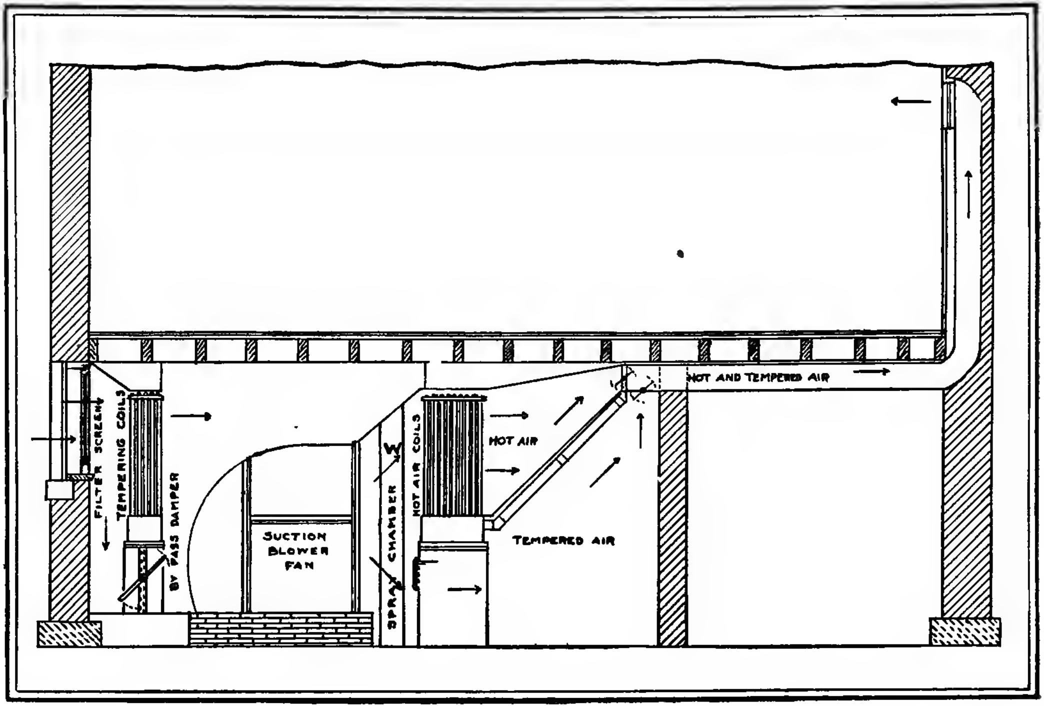


FIG. 22.—A Ventilation and Heating Plan.

the port, passes through the filter screen, between the steam pipes, and from thence to the rooms.

In certain plants, like textile establishments, it is necessary to have a considerable percentage of moisture in the air in order to get the best results in working the fiber. To do this humidifiers may be placed at the spray chamber, where water is sprayed through the air, giving it any degree of moisture required, and then the moist air is passed to the heating coils. This scheme heats the room with hot air by means of steam pipes. The air is conducted to the rooms by flues carefully covered to prevent the radiation of heat until it reaches the room. This scheme gives, when properly run, an ideal system. It is, however, expensive to install and to maintain, but once in operation, it provides not only for heating but also for air circulation.

A cheaper means of keeping the rooms moist in textile plants is to use the humidifiers directly. The humidifier is a spraying arrangement located at various parts of the rooms, which sends forth a fine, atomized spray of water or steam to the degree required by the conditions of the process.

3. Ventilation.—A well-ventilated room should be free from bad air, and flying particles of dust. A number of devices may be used, the most common of which is to open the windows at the top and bottom at various places throughout the mill or factory. This scheme is unsatisfactory; the change of air is too slow. If ordinary conditions of warmth are to be maintained during cold weather, certain portions of the room get too much air, others not enough, and drafts are liable to give the workers colds.

Proper ventilation in grinding rooms and in special places is of vital importance to the employees. A grinder's life is comparatively short, even under the best conditions, and various states have passed very rigid laws regarding the installation of blowers and other ventilating apparatus. The Illinois law for 1897 requires that hoods and hoppers shall be placed over grinding wheels in order to catch the dust and refuse, which must be drawn away by a current of air to the outside of the building. New York, Pennsylvania, Ohio, Massachusetts, and all of the industrial states have similar laws.

One cannot emphasize too much the advantage of abundant light, adequate heat, and good ventilation. It has a measurable influence, and has the psychological effect of making the place inviting. One can hardly appreciate the full significance of this until one has worked in different kinds of plants. Where conditions are unfavorable, extra effort must be made to do the work. The gloom and unpleasantness of the surroundings lowers vitality, and makes both men and officials irascible and displeased with conditions. Little annoyances in the work which would be passed over without any comment whatever, are just sufficient to cause loss of temper. The workmen do not know why they feel out of sorts, but they feel the effects of these surroundings.

4. Adequate Space for the Workers.—Workmen must have sufficient space in which to perform their operations. A floor crowded with machinery is a menace to their safety. Every machine should have abundant clearance space on all sides, so that the pieces can be handled readily and with safety, and no workman should be so placed that the passing to and fro of anyone will distract his attention. Everyone should have a convenient place to lay his tools where they will not be interfered with by his fellows, and will not annoy anyone in his vicinity. No exact rule can be established as to the amount of space that should be allotted to each man. There ought to be no undue crowding. No one likes to feel that he is in any way an annoyance to those around him. If one has room enough so that he cannot reasonably feel annoyed at the presence of those around him, and can perform his work with safety to himself and his neighbors, he has sufficient space in the true sense of the word.

5. Convenient Toilet and Wash Rooms.—Every plant, whether engaging women or men, should provide the employees with convenient facilities for washing their hands and faces, and for disposing of their clothing while they are at work. Personal experience proves that the actual amount of money saved by offering decent facilities more than makes up the interest on the capital expended in the installation of conveniences. No desirable workman, no self-respecting girl, cares to go through the streets laden with the dirt and grime of his or her occupation, or in shop clothing if there is any distance to go and the work is of an unpleasant nature. The manufacturer might as well recognize first as last that good employees are self-respecting ones, and that self-respecting people give attention to their personal appearance. If washing facilities are not provided, employees will provide substitutes, and will steal an unnecessary amount of time to complete their ablutions by stealth. Foremen very often quietly permit such breaches of discipline, if they are not too flagrant, because it is so exceedingly difficult to correct the abuse in the absence of any regularly provided place. If wash-rooms are provided for all, no one need take any minutes during the working day to secure water in his private bucket. If, in addition to wash-rooms, individual lockers for the employees' clothing are installed within those apartments set aside for washing, decisive action can be consistently taken to prevent time stealing; because foremen will have no excuse for permitting any laxness of discipline. If the wash-rooms are kept closed until quitting time, so that no one can get to his clothing until he is entitled to leave, there will be no object in stealing time.

To what extent should an employer interest himself in caring for his employees? Should a concern invest money to provide dinners and other comforts for the men at a low rate or at cost? In the writer's opinion, the question to what extent welfare work should be carried on depends entirely upon what the plant is manufacturing and its class of workers. A concern which manufactures a class of material requiring the employment of cheap labor will find it questionable economy to make investments of this character. Poorly paid workmen are, as a rule, ignorant. They cannot afford to pay a sufficient price for their meals to make restaurants profitable investments for employers. It is also a questionable policy to give things to workmen for less than they cost, because by so doing the firm is making an open confession that it is either overcharging the public for its goods, or underpaying the men, and there is distinct danger that the firm will undertake duties belonging to the community at large rather than to the company.

If a firm employs a class of labor whose patronage will make a restaurant and other activities a burdenless or profitable enterprise for the firm, the management might well consider the installation of such service.

There are concerns in this country which give themselves a great deal of free advertising by letting the public know how well they treat their employees. Certain health-food concerns are open for inspection the year round, and the interested spectator will be shown the generous favors that are showered upon the employees. Concerns of this character are in a distinctively different class than the ordinary competitive business. They can afford to carry on their philanthropies because the public pays for them. If one cares to do a little mental arithmetic he can prove it for himself. There are two very widely advertised articles on the market, one of which gives less than a pound—to be exact, 14 ounces—of wheat in a certain product which is sold retail at twelve cents per package. If we count 196 pounds of grain to the barrel and imagine that all the wheat ground goes into the flour, which is far from true, we find that a barrel of flour costs the consumers of that food about $25. Another concern gives seven ounces of grain for ten cents, making it on the flour basis worth about $50 per barrel. Selling their products at such famine prices, of course such concerns can afford to pose as philanthropists, but a machine shop, textile establishment, or other competitive business simply cannot do it. It neither pays as advertising nor in increased output on the part of the workers.

Intelligent workmen as a class are not unreasonable. They want fair treatment and like to be put into surroundings where they can respect themselves. They do not desire to be made objects of charity. They do appreciate efforts on the part of the management to get into close touch with them, they do like to work in pleasant surroundings, and are grateful to the firm that brings them into a better and closer understanding with fellow workers and employers. Man is a social animal, and prefers to work in a place where there is good fellowship; but there is a distinct line to be drawn between efforts which really cost the employer nothing and do not lower the workman's self-respect in accepting them, and the other kind which makes the employee conscious of a condescension on the part of the giver.

CHAPTER XII

THE POWER PROBLEM

Power is one of the prime causes determining the location of industries. Certain districts in the United States afford unusual manufacturing opportunities because of the presence of falling bodies of water. A waterfall is the cheapest known form of energy. That does not necessarily mean that it will give the cheapest power to a prospective manufacturer. A high drop and a great mass of water are merely the raw materials from which to obtain energy to turn the wheels of a factory. A thing is cheap only when a small expenditure of money puts it into consumable form.

To convert the wasting energy of a roaring cataract into productive income requires investments in several things.

1. *Land Around the Falls.*—The people who desire to use the waterfall must secure the land on both sides of the falls before they have a clear title to use the power; and, if the stream is navigable, further permission from the state and federal authorities must be obtained.

So far as purely engineering considerations are concerned, water-power equipment demands:

(a) Space for a dam or reservoir for storing the water, in almost every case. At Niagara Falls and some other places a dam is unnecessary, but such conditions are exceptions to the general rule.

(b) Power-house site.

(c) A canal or trench to conduct the water from the river above the falls through the turbine to the stream below the falls.

In many cases where a dam is necessary no land is needed for the site of the power house, the penstock, and flumes. It depends very largely upon the type of plant that is to be built and the nature of the falls as to how much land is actually necessary; but some must be purchased in any event, and it frequently happens that the amount is quite considerable.

2. The second item of investment is the *hydraulic machinery.*

The main parts of the water-power equipment for a water turbine usually consist of a dam which may cost thousands of dollars, a long tube called the penstock or down flume, which leads the water from the head race to the turbine, the turbine itself, and the draft tube or draw pipe which connects the turbine with the tail race. A penstock is not always a necessary part of the water-power plant, however, as it may be part of the dam; and, if instead of a turbine the hydraulic engine happens to be an impulse wheel, there is no draft tube.

After the power has been generated it must be transmitted. If the turbines cannot be directly connected to the machinery, the manufacturer must invest in expensive electrical equipment to carry the power to his plant.

In spite of these necessary investments water power has a number of advantages over any other form of energy. It is cheap to produce, because it requires neither the purchase nor handling of fuel. The mechanism is simple and can be kept in running order by a smaller number of people than is necessary in a steam plant. No space is taken up by boiler plants or by storage houses for fuel and ashes. Water power is naturally clean. There are no smoke ordinances to fear nor ashes to handle.

Its disadvantages, while few, are sometimes important. A heavy investment may be necessary before it is possible to utilize the falls. Frequently the manufacturer will require so little power that it is not worth his while to make an investment which will utilize even a small fraction of the cascade. Unless one wants to consume a fairly large amount of energy, the force of falling water is not cheap in spite of the fact that in large quantities it is possibly the least expensive power generated. This accounts for the fact that in the vicinity of a great many of the larger falls throughout the country, large power plants have been installed which manufacture power for sale. Small manufacturers may find it profitable to purchase power as needed. The advantages of purchasing power are considerable. Buyers are relieved of the necessity of securing the water rights, they need burden themselves neither with interest charges on the investments in power plant and transmitting equipment, nor with salaries to power-generating employees, nor with expenses for repairs or maintenance; and portions of the buildings which would otherwise be taken up by a private power plant can be devoted to manufacturing.

If a small manufacturer can agree not to call for a great amount of power during the time the power plant has its peak or heavy loads, very low terms may be obtained. The power houses find it highly advantageous to keep a constant load on their machinery, and in order to induce people to distribute their consumption, they will make considerable concessions to those who are willing to agree to use power when the burden on the power house would otherwise be light. Even if a plant cannot adjust its power consumption so that it can get these very low rates, it may still be profitable to purchase power. In such cases, however, the purchaser of power should take precautions to guarantee to himself a constant supply at all times.

Ordinarily, conditions are such that a manufacturer can neither use a waterfall nor purchase his motive force. He must transform the lowest known form of energy, heat, into power.

Two types of heat engines are known, the direct combustion, represented by gas, gasoline, and oil units, and the indirect combustion, or steam generator. The essential difference between the two great classes of energy transformers is that in the former case the fuel is directly introduced into the cylinder and there exploded by a spark or flame causing consequent expansion of the gases so generated and heated. In the latter, the fuel first converts water into gas under pressure, and then utilizes the expansive force of the steam to convert the heat units into mechanical energy.

If a plant is small, the gasoline engine is an exceedingly cheap power generator, and the probabilities are that this engine will become much more popular than it is even now. The gasoline engine is cheap to install and easy to run, although the fuel is somewhat dangerous to handle, and insurance companies are inclined to look upon it with disfavor.

Within recent years, the gas engine has become an exceedingly popular form of motive power. Two general kinds are in use, those which utilize the ordinary gas from street mains, and those which consume producer gas. The former engine was the first used, and is very popular with small manufacturers. It is easy to install, it being necessary only to mount the engine on a small base, and to make proper connections with the gas supply; no ground space is required for a boiler, no chimney is needed, nor is it necessary to store fuel. There are no boiler repairs, no handling of ashes, and the cost of maintenance and attendance is low. The objections to the engines are their noise, bad odor, and, if the price of gas is high, their excessive fuel cost.

At one time, all gas engines were run from the town lighting supply, and the owner of the engine had to pay the full domestic rate for his power fuel. This, of course, makes the gas engine an expensive apparatus if the amount of horse power consumed exceeds twenty or thirty horse power. In some sections of this country where natural gas is used, the old style gas engine is still the most profitable form of power for a moderate sized factory. The city of Columbus, Ohio, for instance, supplies natural gas for power purposes at a rate as low as ten cents per thousand cubic feet; and in that locality the gas engine is a very popular means of power generation. Cheap gas is hard to get from ordinary town supplies. If a manufacturer is to use more than twenty to thirty horse power his gas engine becomes an expensive instrument with such a source of fuel.

Chemists for a long time bent their energies toward the securing of a cheaper form of gas directly from the coal, and the results of their investigations developed that a cheap gas could be obtained in the form of producer gas. Engineers have also been able to design engines which can utilize this kind of fuel. Technically, producer gas is understood to mean the gas obtained by the partial combustion of fuel in a gas producer. The ordinary producer gas is usually made by driving air with or without the addition of steam or water vapor through a deep bed of incandescent fuel in a closed producer. Such gas is very poor for illuminating and heating purposes. According to one authority the calorific power of one cubic meter of an average sample of semi-water gas is 1,432 calories, while the same amount of ordinary sixteen candle-power illuminating gas is 5,693 calories.[1] Improvements have been carried on in making and using this producer gas so that at the present time the producer gas engine is a serious rival to the steam engine for both small and large units.

Wherever gas is produced as a by-product, the gas engine is superior to the steam engine. Within the past few years, steel plants and other establishments, which in the course of their work develop gas, have found the gas engine the cheapest form of power in existence. The Gary Steel plant in its

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[1] "Producer Gas," by J. Emerson Dowson and A. T. Larter, p. 99.

power houses has adopted the gas engine. Their electric power station is equipped entirely with gas engines as the prime movers. Their blowing engines are likewise gas driven.

Some of the recent gas engines are as large as 2,000 H. P., and on the continent of Europe there are twin tandem engines which develop over 4,000 H. P.[1] Although the large gas engine is in its infancy, it is demonstrating an efficiency which in the near future will give it first place among the economical heat engines. In the first place, by using the gas directly in its cylinders it saves a great deal more heat than does the most economical steam engine, because the latter must burn the gas under boilers and then utilize the steam. A gas-engine plant takes up about one half to two thirds the space necessary for a steam plant, which uses the most compact type of steam engine. The large unit gas engines, however, are economical only where the gas is developed as a by-product in some other part of the plant. Under these conditions, it is cheaper to burn the gas directly in the engine than it is to transform its heat energy into steam and thence into mechanical power. If, however, the plant does not produce gas incidentally to its other manufacturing work, or if the plant needs a boiler for heating, it is questionable whether steam power is not the more economical.

Two types of steam engines may be considered, the reciprocating steam engine and the turbine. The reciprocating steam engine attained a high stage of development years before the turbine engine was even regarded as a commercial possibility.

The steam turbine has, however, now demonstrated its efficiency, and in time it will probably displace the reciprocating engine. It may, for a while, dispute the field with

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[1] Cf. *Cassier's Magazine*, July, 1909, "Recent Developments in Large Gas-Engine Design."

the gas engine. The steam turbine possesses the following advantages:

1. It makes a great initial saving in foundation costs.

2. Compared with the reciprocating engine it requires small floor space.

3. Its oil consumption is very low, and as no oil is consumed in the cylinders, the condensing water may be used directly in the boiler.

Its disadvantages, as compared with the reciprocating engine, are as follows:

1. The first cost of engine is greater for equivalent horse power.

2. If it does not operate with a condensing plant, it is wasteful in power.

3. The condensing plant necessary for a turbine is more expensive than that required for a reciprocating engine.

4. Its high speed makes it disadvantageous for direct connection with certain electrical generators, and high speed seems as yet to be necessary to develop the greatest economy in the turbine.

An economical steam plant, whether it be reciprocating or turbine, has a large number of subsidiary appliances to reduce power cost. Three kinds of economies may be introduced into the steam plant.

1. Those which make the water more suitable for steam purposes.

2. Those which make the boiler and furnace more efficient.

3. Those which make the engine more efficient.

Water contains either organic or inorganic impurities held in suspension or in solution. If they are suspended impurities, they can be removed readily by a filtering process. If, however, the impurities are soluble, complications arise in handling the water question.

The common and most undesirable impurities found in water are inorganic, and may either corrode the inside shell of the boiler or cause a non-conducting scale to form over the tubes. In some cases the impurities will do both. The corroding impurities are sulphuric, hydrochloric, carbonic, acetic, and tannic acids. Those which corrode and form a scale are iron sulphate and magnesium chloride. The scale-forming impurities are the carbonates and sulphates of lime and magnesia and carbonate of iron. The third class of impurities is the most harmful to the boiler, because the scale formed within the boiler puts a sheet of non-conducting material between the plates of the boiler and the fire. This sheet shortens the life of the boiler, causing the insulated plates near the intense heat to become soft and bend and blister under the intense pressure on the inside of the boiler. In fact, it may happen that the scale may develop so great a weakness as to cause the boiler to explode.

Three methods may be taken to extract these impurities from the water. The first, the cheapest and a much used plan, which is probably at the same time the least effective, is to boil the water before it enters the boiler either by using the exhaust steam from the engine or by some other device. This will drive out carbonic acid and tends to precipitate the carbonates, but unfortunately the boiling process is not continued long enough, nor can it be conducted under the boiler pressure, hence the action is incomplete, and a small percentage of the impurities is removed.[1]

Another method is to introduce some precipitating compounds into the boiler. If tri-sodium phosphate or sodium fluoride be introduced, the heated water will have precipitated from it both the carbonates and the sulphates of lime and magnesia as phosphates or fluorides. These do not

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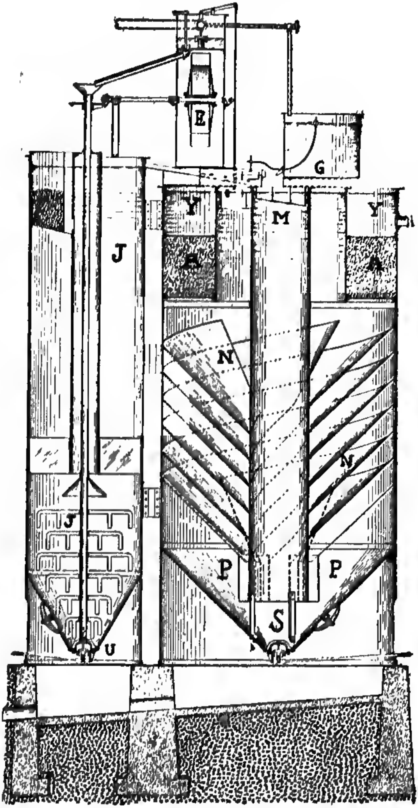
[1] Cf. *Cassier's Magazine*, April, 1904, Vol. XXV, p. 507, "Softening and Purifying Waters for Boilers," by J. C. W. Greth, pp. 506–514.

harden in the shell or fuse, but they are objectionable because the precipitation is expensive, and because heat is wasted in raising the temperature of the resulting sludge.[1]



By courtesy of Dodge Manufacturing Co., Mishawaka, Indiana.

FIG. 23.—Inside View of the Eureka Water Softener.

The third and most effective scheme is to remove the impurities from the water by precipitation before they enter

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[1] Cf. *Cassier's Magazine*, April, 1904, Vol. XXV, p. 508.

the boiler. The best precipitation agents known are lime and soda. The lime precipitates carbonates, the soda sulphates and chlorides. The soda also tends to neutralize any acids.[1]

The inside of an effective water softener is shown in Fig. 23. The raw water enters and falls on the wheel *E*, causing it to revolve, thus making all the power necessary to actuate the softener. A portion of the raw water is diverted from this first receiving tank to saturator *J*, where a clear lime solution of constant strength is manufactured. *U* shows the flush valve for the lime tank. *G* contains the soda. The water passes down through the center tube *M* after coming in contact with the chemicals, and gradually works up past the series of spiral plates *N*. These plates accelerate the separation of the precipitated impurities *P* as the water travels upwards. The impurities collect as a sludge in *S*, while the pure water, after it passes through the wood-fiber filter *A*, is collected in the reservoir *Y*, where it is drawn off to a storage tank or for use.

The *Engineering Magazine* gives a number of tables from which the following is quoted.[2]

"A 5,000 horse-power boiler plant located on the bank of a river and buying city water. The plant is a power station of a large street railway system. The statement is taken from the power house record for the month of March, 1905, and for the same month of the year 1906. The engines in this plant are run surface-condensing. When the boiler was fed with this condensed steam and city water for make-up, it was found necessary to use a high grade mineral oil for the cylinders, because the removal of oil by skimming devices from the condensed steam (in order to fit the latter for boiler feed) is more completely affected with pure mineral oil than with an emulsifying mixture containing animal or vegetable oil. This will explain the decided drop in the cost of oil per month.

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[1] Cf. *Cassier's Magazine*, April, 1904, Vol. XXV, p. 509.

[2] *Engineering Magazine*, March, 1908, "Water for Economical Steam Generation," by J. C. William Greth, pp. 945, 946.

SAVINGS EFFECTED OPERATING WITH WATER-SOFTENING SYSTEM

Boiler Room Labor Saving		$ 9.30
Boiler Repairs Saving		24.21
Oil and Grease		204.87
Water		59.46
Fuel, 154 tons at $1.59 per ton		244.86
		$542.70
Cost of purifying water	$35.25	
Depreciation charge per month at rate of 10 per cent on $7,000	58.33	
Interest charge per month at rate of 6 per cent on $7,000	35.00	128.58
Savings effected per month		$414.12
Savings effected per year		4,969.44

Or almost 71 per cent on an investment of $7,000."

After the water has been purified, the boiler plant uses other schemes to increase economies. One is to heat the water before it enters the boiler. It is a well-known fact in engineering practice that the more heat the water contains before it enters the boiler, up to about the boiling temperature, the greater will be the saving in fuel to raise the water to the boiling temperature.

"There is no great advantage in the introduction of feed water at the steam temperature, because such a temperature cannot be gained without an economic loss, either in flue gases or in steam used for the purpose; and, second, a moderate difference in temperature increases the effectiveness of heat transfer and promotes circulation." [1]

To introduce water at the economic temperature, several schemes are used. One practice is to introduce coils of pipe into the flues and chimney of the boiler plant and to have

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[1] *Engineering Magazine*, March, 1908, Vol. XXXIV, p. 955, "The Argument for the Open Feed Heater," by Reginald Pelham Bolton.

the water heated on its way to the boiler by waste gases of the furnace. This scheme is called the Economizer System. In installing an economizer, care must be taken not to introduce too many coils of pipe in order to get all of the heat out of the gases, because if the economy is carried too far, there will not be sufficient heat left in the gases to make a draft for the furnace. On this account, the economizer can be used with profit only in very highly organized plants, which have the most expensive engines and all the accompanying refinements.

A more common and more profitable scheme for heating the feed water for the boiler is to utilize the exhaust steam from the engine as a heating agent. There are many varieties of exhaust heaters on the market, but the general principle is the same.

Within recent years much attention has been devoted to the heating of the steam after it leaves the boiler, in order to extract all the moisture from it, thus making it more expansive and effective in the cylinder of the engine. The heating of the steam, after it leaves the boiler and before it enters the cylinder, is called superheating. Superheated steam makes a saving, because in passing through the cylinder it does not leave any moisture in the walls of the cylinder to reduce the temperature of the incoming live steam.

In considering the adoption of superheating, the added interest on investment, the repair costs, and depreciation must be balanced against the coal saving resulting from the superheater.

An incidental objection to the superheater is that the intense heat of the steam destroys the lubricating qualities of the oil introduced into the cylinder, but that difficulty may be overcome to some extent by using a dry lubricant.

Another boiler-room saving device is the automatic stoker, of which there are many types and forms. Three main types may be noted: the chain, the plunger, and the rocking grate.

The chain stoker consists of a revolving chain grate on which coal is dropped and consumed as it passes under the boiler. By the time it gets to the end of its journey, the fuel is ash, and is dropped into the ash pit. In the plunger type the coal is forced by means of a plunger gradually across the grate bars, until it is pushed over the end of the fire box in the form of consumed fuel. In the rocking grate stoker, coal is dropped on a series of grate bars which are inclined toward the ash pit and have an oscillating motion. The coal soon becomes ignited and the moving bars gradually work it toward the ash pit, so that by the time the fuel has exhausted its heat-giving qualities its ashes are ready to be carried away.

The automatic stoker makes several very important savings. It reduces the boiler-room labor, gives greater uniformity in firing, and makes combustion more complete. The automatic stoker often makes it possible for one to use an inferior grade of fuel under the boilers. With the automatic stoker have been introduced great improvements in the handling of coal and ashes by machinery. Large plants have for a number of years found these innovations decidedly paying investments, and now small plants are also finding them profitable. They are tried and tested devices, and have gained for themselves assured standing in boiler equipment.

All the economizers for the steam engine above noted, however, give place in importance to the oldest saving apparatus known, the condenser, a device designed to enable the engine to utilize all the steam pressure generated in the boiler. The atmosphere exerts a fifteen-pound pressure to the square inch. If steam exhausts from the cylinder into the open air, this pressure will be exerted on every inch of the side of the piston, which is pushing out the expanded steam. To eliminate this back pressure, which may retard the efficiency of the engine from eight to fifteen or more per cent, the steam is exhausted into a space which is kept as nearly vacuum as possible. The partial vacuum is obtained by attaching the exhaust to an enclosed cooling apparatus which turns the exhaust steam into a few drops of water. The condenser reduces the back pressure, and also accomplishes other results. The water contains considerable heat on leaving the condenser, and for many years engineers worked on the problem of utilizing this waste. At first it was pumped into the boiler directly, but the lubricating oil in the cylinder being united with the water caused much trouble in the boiler by adhering to the tubes and plates, thus impeding the flow of heat and likewise causing the water to foam. Devices were invented to extract the oil from the water before it was pumped back into the boiler. There are now scores of oil separators on the market. Some are more or less effective and some are very good. A good separator both enables the boiler plant to save the heat and reduces the water bills, and in some sections of the country this is a very important item. Many plants find the water bills so considerable that they make it a practice to use the surface rather than the jet condenser, because the former keeps the original boiler water free from contact with the cooling liquid, which may be full of impurities, either suspended or in solution. In it the exhaust is transformed into water by permitting a cold stream to play on the outside of the pipes which carry the steam from the cylinder. The cold water in time becomes highly heated on account of its contact with so many hot pipes. In order to use it over and over indefinitely, cooling towers or sometimes ponds are constructed. In the former the water is pumped to the top of a high elevation, whence it falls over a series of plates, so that by the time the bottom is reached, it is again cool enough to condense the steam. The jet condenser accomplishes its task by spraying a fine stream of water on the steam as it comes from the cylinder.

After the power has been developed in the cheapest possible way within the limitations of the environment, the question of carrying the power to the machines in the most economical way arises. The writer knows of one plant where tests showed that more than 43 per cent of the power was lost between the fly-wheel of the steam engine and the machinery. There are five ways of distributing power from the power house to the plant:

1. *Pipe Steam from Boiler House to Engines.*—One of the oldest schemes is to have the boiler house located at some central point and pipe the steam to the various departments where the machinery is located. This scheme is used where fuel is cheap. It occasionally may be seen in steel plants of the older type and in the vicinity of coal mines.

2. *Taking Power from Fly-Wheel by Belts.*—Another uneconomical scheme, but one still frequently observed, is to have the power taken from the fly-wheel of the engine by a large belt to main shafts which run the entire length of the various departments which utilize the power. From these main shafts are run other belts to countershafts from which the power is distributed again by belts to the individual machines. This scheme has two objections—it wastes much power through the turning of useless shafting, especially if the plant is one which uses its power intermittently, and it is condemned by insurance companies because it is liable to facilitate the spread of fire. The latter objection is overcome to a great extent by a rearrangement of the main driving belt. The belts are enclosed in a belt tower and are not permitted to pass through the floors of the building. The main belt runs small shafts within the tower. These small shafts have other shafts connected with them by means of belts by which are run the various machines. (See Fig. 19.)

There are two classes of belt drives, the older form consisting of a wide band of leather or rubber composition, which transfers the power from the generator to the departments, and the more recent form consisting of rope belts or drives as they are usually called. The old style is for large powers rather more expensive and difficult to handle than the rope drive. It requires greater care and skill in aligning the shafts and pulleys. Since the belt tension is not self-adjustable, it is necessary to tighten the bands so that they can carry the heaviest loads without slippage. Thus there is more wear on the journals than is necessary with the rope drive. The rope drive claims several other advantages. With it one can transmit power over long distances across spaces exposed to the weather. It can transmit at any angle, and the same pulley may drive two line shafts. The rope drive is more economical in transmitting, and for large units is cheaper to install and less expensive to maintain. It needs less space to carry a given horse power, has a more steady pull, is less noisy, is free from static electrical disturbances, and it can provide for future extensions in power more readily than the old style belt drive.

The rope drive, however, is for small units more expensive to install because it requires special sheave wheels and a trained man to get it running. Where the units are large and one has an employee familiar with the rope drive, the latter is more economical; but in small places where the amount to be carried is not great, and is limited to small distances within doors, the old style belt drive is a little cheaper.

3. *Electrical Transmission.*—Electrical power can be transmitted in two ways:

(a) By having large motors located at various parts of the plant, arranged so that they can run a number of machines. This plan is known as the group drive. (See *GD*, Fig. 21.) The group drive is a little less economical in transmitting power, but it requires a smaller initial expenditure to install than do the individual motors.

(b) The individual motor drive. (See Fig. 16.) The individual motor drive is expensive to install, but it is economical of energy. Moreover, the separate motors make it easy to determine the exact amount of power each machine is using. It is economical in power utilization in that there is no power lost when a machine is not running.

If, however, the motor drive rested its claims only upon economy in power transmission, it would hardly deserve the vogue it has obtained; because, if the extra cost of investment is matched against the power saving instituted, there is question as to whether there would be net gain by its installation. The motor drive has a fair claim to recognition in that it makes possible other savings besides preventing waste in power transmission. In the first place, it makes a larger output possible, because it gives the operators such perfect control of their machines. With that system of power distribution the work-rooms become more pleasant to the employees, there is more light, less dust, and usually less danger. Where these conditions obtain, a concern gets so much greater output that the extra investment necessary for electrical power can well be afforded.

4. *Air Pressure.*—Air pressure is more convenient than economical, but all things being considered, it is probably the cheapest kind of power available for the driving of small tools like chipping machines, riveters, and almost all kinds of portable labor-saving devices used around a plant. It is neither so cheap nor so convenient as electricity and belting for stationary machines, and hence is seldom used for such purposes.

5. *Hydraulic Power.*—Another scheme of transmitting power is by means of water. Hydraulic pressure is convenient for use in elevator service, or in any place where it is desirable to exert great pressure. It is, however, for general service somewhat slow working, and is also rather expensive.

This chapter has not mentioned all kinds of power generators nor all the various transmitting devices. To do so would require a special volume. The important factors in both classes have been considered. No one can state absolutely for either generators or transmitters which is the best, all things considered, because conditions vary to such a degree that one scheme may be very economical in one place and in another be an unnecessary extravagance.

PART THREE

ORGANIZATION AND MANAGEMENT

CHAPTER XIII

THE THREE TYPES OF ORGANIZATION

In Parts I and II the questions which the business executive must consider have been discussed. The creation of an ideal equipment solves about one half of the problem of industrial management. The plant must yet be put under a satisfactory organization before it can be well managed. The works manager must so combine the equipment which has been given him with labor and material that the product of the plant will be the cheapest and best that can be manufactured. The sales department must put the goods on the market efficiently.

The works manager's field in the concern is limited to the production department of business. His work begins with the receipt of the order and ends with its shipment. He has nothing to do with the soliciting of orders, he is not concerned with the finances of the firm nor with its legal difficulties. His work begins and ends with production. To perform his duties ideally:

1. He must get the work performed rapidly.
2. He must get the work performed accurately.
3. He must get the maximum result from the machinery.
4. He must get the maximum product from the raw material.
5. He must see that improvements in methods are introduced.

In order to get this work performed, there have been evolved three kinds of industrial organization—the military, functional, and departmental types.

The Military System of Organization.—This is the oldest and was almost the only one until very recent years. According to the military scheme, all power and authority for directing the work emanate from one man, who is held responsible for everything that is done in any part of the division under his control. With his plan the leader does not give general directions and then look for results. He keeps control of all details that arise within his sphere of command. The armies of former ages were run according to this plan. The general-in-chief gave directions concerning the health of the men, the way they should march; he saw to the provisioning of the troops, and in fact Cæsar, Napoleon, Frederick, and many other great military leaders, directed the affairs of the state as well. Curiously enough the modern army is no longer run according to the old style military system. The health of the troops is under the care of a distinct body of men, the provisioning and supplying of the troops is attended to by another group of officials. The commander-in-chief now decides upon the general plan of the campaign. He plans where and how battles shall be fought, but modern warfare no longer makes it possible for him to lead his men as did the youthful Alexander, the great Napoleon, or as did Scott, Lee, or Grant in American history. The army now has a staff organization which corresponds very closely to the departmental system used in the progressive firms of to-day.

With the military system of industrial organization every officer in each division or subdivision is held responsible for all that happens within his province. No matter what mistakes are made, he is the one who must stand the consequences. If a foreman has charge of a shop and that shop runs behind in orders, is extravagant in the consumption of supplies or power, or is deficient in the quality of work turned out, the foreman in charge is responsible. He is given a division presumably sufficiently small to make it possible for a reasonably good man to look after details, and everything is considered distinctly within the scope of his duties. He is expected to keep his men always supplied with work. He must see that the machines are in working order. He must be able to select good men and keep them. If any question arises concerning how things should be done, he should be able to give explicit directions. He must detect work that is not properly done, know on whom to saddle the blame, and must also remedy the faults. In a word, he must be a thorough, all-round man to fill his place properly.

A trained man of ordinary ability can efficiently direct from fifty to one hundred and fifty people in simple, ordinary tasks which require little mechanical ability. It is only the exceptional man of considerable experience and familiarity with the work who can profitably direct more than one hundred and fifty or two hundred workmen. In continuous industries, of both the synthetical and analytical types, a large number of processes are simply and easily directed. The work is almost entirely routine. The machinery is nearly if not quite automatic. There are no great calls upon the intelligence of the foreman, because there is very little to be done outside of seeing that the workers are at their posts and are turning out an adequate amount of material. In such industries, the military organization is ideal, because the task should be quite within the limits of the foreman's ability, and the responsibility can be constantly fixed upon him. If he fails to prove equal to his position, there is no great difficulty in obtaining another man. Generally speaking, the executives of these types of industries do not find their labor management problems difficult of solution in the production departments. Their energies can be directed toward the distributive department, and to finding a corps of workers who will develop the mechanical efficiency of the machinery, look to the economies of the processes and power-saving possibilities and to other similar questions.

In industries which depend to a greater extent upon the ingenuity and efforts of the laborer who cannot be so greatly aided by machinery, the military organization shows its weakness.

The machine shops in the assembling industries were the first to feel the limitations of the military system. For many years, no one noticed its deficiencies, because the shops were small and one man could attend to all the details and give a fair degree of satisfaction. When, however, the departments grew to more than two hundred workmen, the scheme began to break down. No one could look after all the details of so large a shop. It was useless to discharge the overseers, because no one could be found equal to the task. It is a dictum in management that if punishment by discharge does not eliminate failures and mistakes in an organization the scheme in itself is vitally wrong.

Works managers gradually came to appreciate that the defects were due to the system, so they sought to eliminate the weaknesses of too highly concentrated authority by dividing the leadership among several men, each being equally responsible to the superintendent. This solved the problem of giving the foreman a reasonable number of people to look after, but it increased the unproductive labor expenses and tended to make a conflict in authority and interests. For example, the foreman of the machines in order to make a good showing would be apt at times to have his men rush the work through in a hasty manner, expecting the erecting gang or bench hands to make good his deficiencies. The bench foreman would also slight his work. If heavy castings were to be moved by the cranes, two foremen, equal in authority, would put the riggers and crane men in an exceedingly unpleasant situation because both would insist upon immediate attention. There was but one outcome. The riggers served whomsoever they pleased. The writer is familiar with a shop where the riggers were bribed by an ambitious gang boss to attend to his requests. He needed the services of the crane for a considerable length of time. However, there were intervening periods of a half hour or so in which the crane could be used to fill machines and move other castings. Instead of using this time and making the favored man wait an occasional quarter or half hour, the riggers stood by the job, holding up the machines and erectors the better part of the day. Of course this is an exceptional and most glaring example of the weakness of this scheme, but it is nevertheless a weakness which grows out of too extended a spreading of the military system.

Briefly summarized, the advantages of the military system of management are:

1. It unifies the work, putting it all in the hands of one individual.

2. It fixes the responsibility for the performance of tasks in a definite manner upon certain individuals.

Its disadvantages are:

1. When a plant becomes too large the foremen are held responsible for too many things, and cannot justly be held accountable for blunders or for smallness of productivity in machines and men.

2. The foremen have so much to do that they cannot see to the introduction of improvements as rapidly as is desirable.

The military system of works organization in a large concern leads to chaos in management, because it fails to prevent bad work and to stop the nursing of jobs. It has no means of rewarding the efficient man or of punishing the poor worker or loafer. Managers of plants who worked with the military system in their younger days were puzzled as to why the later generation developed so few good foremen and why it brought forth so many poor workmen. They did not recognize the fact that it was due not to a degeneration in the younger members of the community but to an inherent fault in the system. Thoughtful students felt the need of something, but hardly knew what. Some plants tried varying schemes of running their work. Several concerns hit upon the plan of piece wage payment and careful inspection of material by independent inspectors who were held responsible. This scheme has worked with a reasonable degree of success, but there are so many ways of fooling the inspector and of getting bad work passed, and there are so many possible evasions of the piece wage scheme that it was soon realized that another change was necessary before this method would prove efficient. The piece wage payment and inspection scheme did lead to something better.

Piece workers, on account of the fact that they are working for themselves, are insistent upon allowances being made for all kinds of contingencies. The manufacturer finds it more profitable to lighten their duties, and to limit as little as possible the movement of the workers. He soon begins to study how the work can be divided and men assigned to certain parts. From this development arose the functional system of organization.

The Functional System.—The greatest exponent in America of the functional system of organization is Mr. Frederic W. Taylor, a past president of the American Society of Mechanical Engineers. Mr. Taylor has held a great number of responsible positions in various sections of the country, and has made an enviable reputation in the engineering world. His paper entitled "Shop Management," delivered before the Society of Mechanical Engineers, is a memorable contribution. In that paper he discussed the management of a shop under the functional system of organization.

"Functional organization consists in so dividing the work of management that each man from the assistant superintendent down shall have as few functions as possible to perform."[1]

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[1] Cf. *Transactions American Society of Mechanical Engineers,* Vol. XXIV, Paper No. 1003, p. 1391.

The scheme is based upon the theory of the division of labor as applied to management. A workman in a machine shop according to this plan is not under one but several foremen. Mr. Taylor advocates four shop bosses: gang boss, speed boss, inspector, and repair boss. The gang boss has charge of preparing the work up to the time that the piece is set in the machine. He must show his men how to set the work on the machine in the quickest possible time and in the best possible way. The speed boss has the function of providing the proper tools for the workman on the machine. He must see that the cuts are started at the right place and that the machine is speeded up to its proper limit. The inspector is responsible for the quality of the work, and both workmen and speed bosses must finish the work to suit him. The repair boss sees that each machine is kept in working condition, is clean, free from rust and scratches, and is properly oiled.

In addition to these four shop overseers the workmen come into contact with the representatives of the planning department, whose function is to relieve the shop foremen of all thought of how the work should be arranged and distributed to the machines. Four representatives of the planning-room also come in contact with the workmen, the order of work or route clerk, instruction card man, time and cost clerk, and the shop disciplinarian. The route clerk writes a daily list, instructing the workmen and all shop bosses as to the exact order in which the work is to be done by each class of machines or men. The instruction card man states in writing the general and detailed drawing to refer to, the piece number and cost order number to charge the work to, the special jigs to use, the depth of cut to be made, the number of cuts to make, and the time in which the job should be finished. He also sets the piece rate. The time and cost clerk sends to the men through the instruction card all the information they need for recording their time and cost of work, and he secures the proper returns from the men.

> "In case of insubordination or impudence, repeated failure to do their duty, lateness or unexcused absence, the shop disciplinarian takes the workman or bosses in hand and applies the proper remedy, and sees that a complete record of each man's virtues and defects is kept. This man should also have much to do with readjusting the wages of the workmen. At the very least, he should invariably be consulted before any change is made. One of his important functions should be that of peacemaker."[1]

To quote Mr. Taylor again:

> "The greatest good resulting from this change is that it becomes possible in a comparatively short time to train bosses who can really and fully perform the functions demanded of them, while under the old system it took years to train men who were after all able to thoroughly perform only a portion of their duties. . . . Another great advantage resulting from divided foremanship is that it becomes entirely practicable to apply the four leading principles of management to the bosses as well as to the workmen."[2]

The four leading principles of management to which Mr. Taylor refers in this last statement are:

1. A large daily task should be given to the men.
2. The men should be given standard conditions, making it possible to perform the task.
3. They should be given a high pay for success.
4. They should lose in case they fail to reach the requirements of the daily task.[3]

Viewing the subject from a broader point of view, there are other advantages to be gained from the functional organization.

1. The work is divided so that one man need attend to only one thing. It enables complete specialization of labor.
2. It definitely fixes the responsibility for the performance of each function upon one man.

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[1] *Transactions American Society of Mechanical Engineers*, Vol. XXIV, pp. 1393, 1394.

[2] Ibid., p. 1394. [3] Ibid., p. 1368.

3. It allows the workman opportunity to think out improvements by enabling him to make an intensive study of his work.

Notwithstanding all of these advantages the functional system of organization has not proven popular or successful in a number of plants where it has been tried. It causes men to lose initiative. It has a tendency to shift and divide the responsibility in spite of the contrary intention. This has been found to be true in several places where the plan has been tried. The difficulties that have been encountered in carrying the scheme through are:

1. It requires a great amount of clerical work to fill out instruction cards and write out all orders and minute instructions necessary for the complete enforcement of the scheme.

2. It is exceedingly hard at times to define clearly to whom certain functions belong and on whom the responsibility rests when things go wrong. For instance, no less than eight bosses outside of the shop disciplinarian come into direct contact with the workmen. Four of these men make out instructions, and four others say how they should be carried out. It not infrequently happens that the man who makes out the instructions is somewhat vague in his directions, in the hope that the speed boss or gang boss will make up deficiencies. If a mistake occurs under these conditions, it becomes a difficult matter to determine who is to blame, because the instructions man will plead that they were not interpreted correctly and the other bosses will assert that such interpretations could be made. Sometimes the instruction card man will give instructions and the gang bosses may see a better method. If they do, the chances are that they will want to put their scheme into operation. Hence there will be a conflict of authority. If a boss adheres to the system and doesn't follow the best method possible under the circumstances, the firm is paying for a system of man-

agement which is failing in its purpose of getting the goods out in the cheapest possible manner.

3. It is cumbersome and expensive to operate. In every shop the jobs must be assigned to men at all kinds of odd times during the day. If a workman desires to start on his job he must come into contact with at least three of those bosses before he can do anything. There are usually several men desiring jobs at one time. Under a system where the workman is supposed to know how to set up a job and interpret instructions, he merely needs to find out what he is supposed to do, and do it, calling on the boss only when there are complications. With this functional scheme he is not supposed to act on his own initiative. As a matter of fact, so many bosses really hinder the work. They irritate the men and are expensive to keep up, because in a large shop they must have a number of sets of bosses to carry out the scheme as laid down.

The Departmental System.—In advocating the functional system of works organization, Mr. Taylor made a valuable contribution in that he brought out the idea of dividing the work in such a way that it could be looked after by functions rather than by complete units. No plan of organization can be successful unless it is workable. The military type fails to be workable in large organizations, because it is impossible to get men who are capable of filling the leading positions. With the functional plan it is possible to train a sufficient number of men to carry out the functional duties, but it is only under the most exceptional conditions that these various functions can be clearly defined and the scheme worked without conflict and irritation. If there is a remarkable man at the head who can smooth all points and be everywhere present whenever a difficulty arises with conflicting ideas and authorities, the system has a chance of working; but in this every-day world a highly sensitive organization of that character, no matter how perfect on paper, is bound to be disrupted by the bumps and collisions of daily strife. A finely adjusted, compensated astronomical chronometer will keep perfect time, provided it is wound up at certain stated intervals, and is kept from jars and vibrations and extremes of temperature, but for ordinary day use to carry around in the pocket, a dollar watch may prove more satisfactory. Works managers need the dollar-watch combination, and they have found it in combining the good features of both the military and functional systems of organization. Hundreds of plants at the present time use the departmental system without being fully aware of what they are doing. The departmental system does the following things:

It divides the plant up into a number of clearly defined departments, and puts each under the control of a gang boss, who is given general directions to work to and is held responsible for results and not for servile attention to detailed instructions. Thus in a machine shop there is a man to look after the large machine tools, such as lathes, planers, and milling machines. Another foreman will be appointed to look after the erection of the large parts of the engine, another will be given a valve-setting gang, and still another may be given charge of the tool-room, and another will look after the stores. The riggers or crane men will be under a sub-foreman, who will have to keep all the machines supplied with work. In addition to these, the repair department will be in the hands of one man, a tool-making and grinding department in the hands of another, and the stores department in the hands of another. All of these men will be under a head foreman or superintendent. Each man is held responsible for the output of his machines. When a set of drawings of an order comes into the shop, the head foreman will examine the drawings and call in the various gang bosses. He will tell them the things they are to look after. Each man clearly understands, from either written or oral instructions, his particular province. It is then his duty to keep his machines going and his men employed on their particular tasks. The work, when performed and inspected, is passed on to the other departmental boss. If the succeeding gang boss finds any defects in the work, he must at once report the mistakes, or he will be held responsible for all defects uncovered by his immediate successor.

The departmental system divides the work up into small departments, each under the absolute control of a man, and the departments are so related to each other that no individual workman will have to obey two bosses. The riggers, for instance, in the military system served any man upon request. In the functional system, the riggers obey a rigging boss who is at the beck and call of a half dozen functional foremen. In the departmental system, the rigging boss learns from the head foreman the conditions of the large castings, and about when they are to be moved, and adjusts his gangs in such a way that there will be a minimum of waiting throughout the entire shop. If the head foreman finds any men idle due to the fact that they cannot work because castings are not moved, he can at once ascertain whether the boss rigger has arranged the movements correctly, or whether there is insufficient crane service. Whatever the reason, there is one man from whom an explanation can be demanded and readjustments promptly made. If the machines are not turning out sufficient work or are giving poor service, the departmental boss cannot blame the speed boss or an instruction-card boss. He has the machines to look after. If his men are not efficient, he is to blame, because he should report and discharge the delinquents. If the machines are in bad condition, he is at fault, because it is his duty to report defects and breaks at once, and insist that they be repaired. A machine boss should never let a machine get into general bad repair. The erecting boss is to blame if the erecting is progressing slowly or is poorly done. The great advantage of this departmental system is that the responsibility can be fixed; it is possible to train men to fill the jobs, and it is impossible to have any shifting of responsibility, because the men must show results in output, and not prove that they have given or followed instructions.

CHAPTER XIV

THE LABOR FORCE

BEFORE the employer can decide how he is going to run his labor force he must determine what kind of labor he is going to use, because his treatment of employees will be influenced to a very great extent by the labor personnel. The labor force may be men, women, or children. Adult male labor is for the greater majority of the important industries the most profitable kind of labor. There are, however, a great number of industries wherein women and children may be employed with profit, because they work for less wages and have their natural aptitudes for the work. The industries that can employ women and children are the textiles, shoe factories, and other concerns which produce either light materials or goods which require deftness in handling. We may compare male and female labor in the following way:

1. COMPARISON OF MALE AND FEMALE LABOR.—Male labor is stronger and has greater physical endurance. Men alone are able to stand long-continued heavy work, such as is required in a shipyard, steel plant, or locomotive shop.

2. Men are more apt to be permanent employees. The home is woman's ultimate sphere. A woman's maximum working period in industrial occupation is usually limited to the time she leaves the grammar or high schools until she reaches the age of thirty. In that time, she may serve an apprenticeship to a trade, and become a capable, conscientious employee. She is, however, apt at any time to marry and leave work. Marriage increases a man's value to the firm, because he now has new responsibilities to shoulder, and is more desirous of giving satisfaction to his employer.

3. In general, men have more initiative than women.

Man's initiative is not due to superior brains, but is the result of greater opportunity. In the city, night schools, Young Men's Christian Associations, correspondence schools, and public schools offer inducements in the way of courses of study which men can pursue during their evening hours. These courses of study are designed primarily for men's needs in industry. A great number of the evening schools inform the employers of the progress their hands are making in the courses, and the employer is consequently apt to give such persons greater opportunities. Women in the same lines of occupation do not have the same encouragement, they are less able physically to work all day in the mill, and then to carry on technical studies after working hours. There is a lack of incentive to attend these courses, because they do not in most cases regard their work as a life's career. Moreover, thousands of women and girls, after they leave their factory at the close of the day, have household duties to perform for parents or for the male members of the household, who are also engaged, perhaps in the same mill or factory. Even if they do not engage in those duties, a girl invariably has a great deal more to do than a man; she usually makes much of her clothing, often trims her hats, repairs her garments, and looks after a thousand and one things which a man turns over to some one else and pays for having done. All these things combine to make man possess more initiative. He has more opportunity to learn how to do harder things, has a better physique, a greater incentive to make an effort to learn, and less of other things to do.

4. Woman's clothing is a hindrance to her, and she can be employed only in places where the machinery is of such a nature that her clothing will make employment safe. In places where she could otherwise be more serviceable than a man, firms take the trouble to design the work-room and machinery in such a manner that she can be employed with safety.

5. Women's hours of labor are more closely restricted by law. Our labor laws justly seek to throw more protection around women and children than around men. The manager of a plant, however, cannot afford to overlook the fact that these are disadvantages when he considers women as prospective employees, although it is only a question of time when the law will place greater restrictions upon male labor. Legislation and common justice require conveniences for women in wash-rooms, and a supply of chairs for resting during the working period. Their hours of daily and weekly labor are shortened, and they may not be permitted to work overtime except in rare and carefully guarded instances.

6. Men are more disposed to form permanent labor unions; and, in this respect men may be more difficult to deal with than women as regards wage increases. Women do not lack organizing capacity, but they are apt to regard their industrial grievances as a temporary inconvenience not worth the effort to remedy.

In the long run, powerful labor unions are better for society than unorganized labor. If the laborers of all industries are united in their demands, no hardship is imposed upon any manager, because all are on the same basis. If, however, one concern is compelled to yield to certain demands which involve an outlay of money, and its rivals are not also put to the same trouble and expense, it is working under disadvantageous conditions.

Although women do not readily organize into permanent labor bodies, in some respects they are harder to manage than men. Many a successful foreman of men would wreck his reputation if he applied his methods to women. Tact is required to get good results from the girl in the factory, mill, or office.

7. Women have an aptitude for certain classes of work. In hosiery mills, silk spinning establishments, and a great

many operations in textile works which require painstaking care and deftness, women are better employees. In pottery works her lighter touch and more appreciative sense of beauty are valuable assets.

8. Women work for less money than men. Manufacturers and managers of establishments which employ women, agree that in the lines in which they employ the women, they do so because the same grade of men would demand a larger wage.

Under these conditions, the manager of the concern must study carefully his industry and the parts of his industry to see where he can introduce female labor. In lines of work where it is a question of deftness of fingers and lightness of touch or skill in running small machines, women can be employed to advantage. Anyone who has visited the National Cash Register works will be impressed with the proportion of women and girls employed on drilling machines and machinery, which finishes and prepares the small iron and steel parts of the register for the assembler's hands. Some electrical manufacturing companies employ women exclusively in a number of their departments. In commercial lines, large firms employ several hundred women in their bookkeeping departments. In one concern the entire bookkeeping staff is composed of women who are under the direction of a man head accountant. Whether women or men shall be employed depends upon whether the work can be adjusted so as to suit the peculiar aptitudes of women.

Child Labor.—In some classes of industries children may be employed. The child can be used in a great number of operations in textile plants, glass factories, coal breakers, and other establishments. Society pays a high price for child labor in decreased vitality and efficiency of its adults, and is now restricting the liberty of the manufacturer to use children. The child as a laborer has only one advantage to the manufacturer, that of being cheap. Against this advantage the manager may well weigh the disadvantages of child labor.

1. Their hours of labor are limited by law in most states, and in those industries where children are employed they are apt to limit the hours of the adults, or to compel the management to make disproportionate equipment for the child, as compared with the adult, departments. The adults are dependent upon the children for their material, and when the child department shuts down, the adult department may have to discontinue.

2. Children require more careful overseeing. They are more apt to destroy or spoil material than their elders, are harder to keep at work, and require a greater degree of attention and direction. Unless constantly watched, their little minds wander from their tasks. They are full of animal spirits, and when not under observation will play pranks, which cause production to cease, and even frequently destroy goods.

3. Children are more careless about machinery than are adults, and more likely to be injured. They are not safe workers in a plant.

The casualty insurance companies do not as a rule care to insure children. Some companies refuse to accept risks upon any child under fourteen years of age.[1]

Nearly every firm employs boys of seventeen and under for messengers, elevator attendants, and similar workers. The only reason for employing boys for such positions is their willingness to accept low wages. In spite of his small remuneration, the boy is not cheap when one considers his unreliability. Some firms have had so much trouble with

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[1] This rule, if not already adopted by almost all casualty companies, soon will be on account of the general tendency of states to raise the minimum working age of children to fourteen years or over.

boys in filing rooms, as messengers, and as office assistants that they are now employing for such places men who are well past middle life and are getting better results. Such men ask for more wages, but they are well worth the extra pay, for they are much more careful, reliable, and faithful in fulfilling their duties than the youngsters, and far less apt to leave.

From the broad, social point of view it is a question whether boys ought to be engaged in such occupations as messengers, elevator attendants, and office assistants. From fourteen to eighteen a boy should be preparing for his future career; if he cannot attend school or college he should be serving an apprenticeship to some trade, or be working at something which will enable him to fill a place of usefulness in some office, store, bank, or similar place in later years. Being an office, elevator, or messenger boy, is not giving him this preparation; and he should not be so occupied unless it is merely a temporary expedient to obtain a position which will give him a chance to develop his faculties for greater things. The engaging of men past middle life for such places, on the other hand, confers a social benefit, and is more satisfactory to the employer, all things being considered. Besides making his selections of laborers along the lines of sex and age considerations, the manufacturer must consider the educational qualifications of his employees.

Classes of Laborers.—All industries require one or more of three classes of laborers as regards mental caliber, education, and training.

I. *Unskilled Workers.*—In the continuous industry of the synthetic type these men are used to a very great degree. Large numbers of them are required in steel plants as laborers around blast furnaces, coke ovens, the steel furnaces, and other departments. In previous years they were more widely used than at the present time. Some years ago they were employed in great numbers around paper mills, textile establishments of all kinds, and other plants of a similar nature, but this type of laborer is being largely eliminated from the steel plant, and he is gradually passing away from all plants as a type of worker. Conveying machinery is now so extensively used and is so efficient that the unskilled laborer is no longer profitable. In the steel plants, he is still needed to some extent to look after coke, slag, and other materials, to shovel dirt and to attend to cinders, but his days are numbered, not only for steel making and continuous industries, but for every other type of industry wherein the only qualifications are strength and willingness.

In the analytical continuous industries, great numbers of these laborers are required to perform the unpleasant work of unloading raw sugar, of cleaning out apparatus around the sugar, oil, gas, and meat-packing establishments. They are also necessary as attendants in firing boilers and, before the introduction of conveying machinery, were required to carry the material from department to department. Conveying machinery has eliminated the laborer as a draft animal, but machinery has not made it possible to remove him from doing a number of other unpleasant duties. In time it will, and it is distinctly to the management's interest, as well as society's, to take him away as soon as possible.

In the assembling industries, the unskilled worker was formerly employed to transport the material from the foundry to the machine shop and between departments in the shop. He was a necessary adjunct around the shop to pull on the ratchet for drilling holes, to sledge, to chip the rough castings and set the material up on the machines for the machinist to finally adjust, but now the new factory has the overhead crane which reaches every part of the shop. A hydraulic lift or chain block can be placed at every machine, so the laborer is no longer helpful there. Likewise, the air drill, air hammer, riveting machine, and air-chipping machine take away his job in chipping, riveting, and sledging.

In a word, this laborer is being eliminated to such a degree that he will soon become extinct.

II. The *intermediate grade of laborer* whose qualifications in addition to regularity and good health must be:

1. Ability to learn to handle machinery of a more or less semi-automatic type without injury to himself.

2. A willingness to attend closely to such machinery, seeing that it is constantly running properly, and is always supplied with material to keep it producing.

3. Ability to keep the machinery in his charge in good running order.

There are three types of machines:

(1.) The machine which needs an attendant merely to keep it filled. Examples of this type of machine are:

(a) The endless screw-conveying device, which mixes the various grades of raw sugar and molasses so that they become semi-liquid, capable of being pumped from a tank to the top of the building, from whence they are started on their refining process.

(b) Shears, punches, and other cutting devices used around iron works, shipyards, and such establishments to cut up scrap iron, plates, punch rivet holes, etc.

(c) The filter presses in oil works, potteries, and plants which have straining or filtering processes.

(d) A great many automatic screw-making machines and nail cutters. These machines merely need a rod shoved in at one end from time to time, or a roll of steel wire occasionally started going through the apparatus. Everything else is done completely by machinery.

(2.) The machine that does most of the work but requires an attendant to be present to make occasional adjustments and to see that the machine is running in such a way that the material going through is not being spoiled. Examples:

(a) The modern turret lathe, wherein the attendant need only put the bolt or nut blanks in and see that as each step is completed on the machine the succeeding tool is applied to do the next step at the proper time.

(b) The modern drill press. In some cases the drill press has a great number of spindles, so that the one machine turns out a number of pieces of work at the same time. Here the attendant must be constantly on the alert to see that the various spindles are supplied with material in order to keep the entire machine productive.

(c) The modern loom—an excellent illustration of this type of machine. The more recent loom will stop whenever a thread breaks in either direction in the cloth. The attendant must be capable of tying the broken threads and starting the loom at any time. He must be deft in handling the material and must not mix threads or get them tangled in the weaving process.

(d) The modern spinning frames or spinning mules. These do not require very great skill on the part of the attendant, but do need adeptness in handling the fine threads.

(e) The slotting and modern key-way cutting machines of the machine shop. The attendant must adjust the feed or rate of cutting to suit the requirements of the material or the machines, and must be able to select the proper tools for the various cuts. The tools are readily learned and do not vary with the same material and cut, so that after once learned such machines can be run by an ordinary person.

(3.) The third type of machines requires great skill to run because such machines are designed either to handle a large variety of work which must be performed with exacting accuracy or they require unusual steadiness of nerve and skill to operate. Examples of these machines are:

(a) The large lathes and milling machines in general machine shops. These machines get a great variety of work every day; sometimes they are used to bore out cylinders, again to turn shafting, and in fact one never can tell just what they may be called upon to do.

(b) Large planers and shapers are another variety of the same class of machines. They may be used to cut grooves, smooth off the top of plane surfaces, finish the sides of castings, and the variety of castings they may be required to handle is indefinite.

(c) Steam hammers in forges, such as make ship work and other heavy forgings.

(d) The roll sets which make steel rails, structural iron, ship plates, and other work of a similar type.

This third class of machines requires the services of the third class of workers discussed below.

III. *A high grade of skilled labor.*—The worker need not be of powerful physique, but he must be in good health, and possess the following qualifications:

1. Ability to interpret accurately complicated instructions either from blue prints, drawings, or from written or oral communication.

2. Ability to concentrate attention on details, to use skill and patience in accurately carrying out, in the concrete reality, the pictured idea of the inventor or engineer.

This class of laborer is the most highly skilled non-professional group of people in existence, and must be well paid. Indeed, they frequently obtain wages which compare favorably with the salaries of teachers and the incomes of lawyers, doctors, and other professional men. They are needed in foundries to make complicated castings, in the pattern shop to produce the patterns for the foundry, in the machine shops to run the large lathes and machines to which jobs of varied dimensions are assigned. Such a man is entrusted with valuable material, and if he makes a mistake its results are far-reaching. A pattern-maker once misread a drawing, making the inlet into the condenser on the wrong side of the condensing apparatus. The pattern went through the foundry. The casting came into the machine shop and was machined in many parts before the mistake was discovered, and it cost the firm some $800 to rectify the error. In another case, a man in charge of one of the large lathes misinterpreted a drawing and turned a certain piece of material one thirty-second of an inch smaller than it should have been. The casting was some forty inches in diameter and seventy-odd inches in length. The mistake was discovered when it was attempted to fit it into the other parts, and it was utterly worthless—a loss of several hundred dollars to the firm. It is absolutely necessary for men holding such places to be thoroughly equipped. To train a man for this rank, he must first of all be intelligent, naturally resourceful, and possess the innate ability to visualize a described idea. To obtain the development of these latent qualities the workman must have:

1. A preliminary education of such a degree that he can readily acquire an accuracy in interpreting instructions. In a word, he must have a receptive, active mind.

2. He must serve an apprenticeship. This preparation must be in shops, night schools, and other places where he can learn more than the mere routine of his tasks. He must attain the attitude of mind that we look for in the professional man, the ability to depend on himself for carrying out work, and an unwillingness to jump at conclusions.

The great problem of a manager in any place is to introduce machinery and so to arrange the work that the unskilled worker will be unnecessary, and the call for the highly skilled man will be small. Unskilled exhausting toil is so monotonous that the employee can take little or no interest in his duties, and the work itself is so unprofitable that a concern cannot afford to give a wage that will encourage men to be alert and faithful. The man reasons rightly that if he gets discharged he can get as good a job in another place; and if he doesn't find an opening, society will give him a living at least, which is little, if any, less than he is now getting out of all his exertion.

An organization which must have a large number of the third class of workman, the highly skilled man, is likewise undesirable, not because his services are not valuable, but because so much depends on him. His grade is so high that it is difficult to obtain him. He is well worth his wages in any organization if he is efficient and does not make mistakes; but if he does err, even occasionally, considerable loss may be entailed. Therefore it is highly desirable to get machinery to do as much of his work as possible.

The second class of worker is the most desirable. The advantages of this class are:

1. A short apprenticeship makes the man valuable to the employer.

2. The employee with his limited capacity feels his dependence on the employer, and is likely to be a faithful and attentive workman because he receives a larger income than the ordinary laborer, and could in most cases obtain employment only as a less valuable man in another place.

3. The employee becomes very dexterous in doing one thing, and is thus able to turn out a large product.

It is possible to run but few plants without using more of the third class than are readily available. They are necessary as bosses and leaders of the first and second groups, and unfortunately they cannot be developed rapidly from either one of them. Shop managers find themselves seriously handicapped, from time to time, in getting men who can take charge of departments, who can become gang bosses and foremen in the various divisions of the organizations. So important has the specialization of labor become that the old style apprentice in the shop has almost completely vanished. A few weeks of practice enables a man to run a loom, but to get a good loom foreman a man should come through an apprenticeship which has taught him every part of the loom and its running mechanism. It takes a very short time to learn to run a drill press or milling machine, but it is an exceedingly hard proposition to get a man who can tell what classes of work should go on the machines, how they should be attached, how the tools should be adjusted, and a hundred and one other such matters. It requires little intelligence to scrape in a valve seat, but it requires skill to set the valves of the variety of engines that come into some of the large general shops. So pressing has the need of this highly skilled class of mechanic become that in spite of the profitableness of the second class, corporations now make every effort possible to encourage young men to advance past the mere routine of making goods. A number of large concerns are devoting a great deal of attention to the development and teaching of apprentices.

APPRENTICESHIP.—The General Electric Company of Lynn, Massachusetts, about 1902 put into operation an apprenticeship system which has proven to be beneficial both to the firm and the employees. They organized a special department devoted entirely to the training of apprentices. This department was put under the direct control of a superintendent, who was especially qualified to teach young men the principles of their trades. The company also established class rooms in the factory in which the boys are taught drawing, and are given instruction in engineering science. The training received by a student at Lynn is so broad "that the graduate apprentice is prepared to fill a position as a skilled journeyman or as industrial foreman in any mechanical establishment."[1]

The Baldwin Locomotive Works of Philadelphia is another well-known firm which has established an apprenticeship system. They have not, however, set apart a separate school or department for the training of the young men. A learner goes into the various shops and departments and

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[1] *The Annals of the American Academy of Political and Social Science*, Vol. XXXIII, No. 1, January, 1909, p. 143.

gathers knowledge and experience from things as they actually go on in the usual course of events in the works. In order to provide for several classes of apprentices they have made provision for three classes of applicants.

Apprentices of the First Class.—The first class includes boys of seventeen years of age who have had a good common school education, and who bind themselves by indentures (with the consent of a parent or guardian in each case) to serve four years; to be regular at their work; to obey all orders given them by the foreman or others in authority; to recognize the supervision of the firm over their conduct out of the shop as well as in it; and to attend such night schools during the first three years of their apprenticeship as will teach them, in the first year, elementary algebra and geometry; and in the remaining two years, the rudiments of mechanical drawing.

Apprentices of the Second Class.—The second-class indenture is similar to that of the first class, except that the apprentice must have had an advanced grammar school or high-school training, including the mathematical courses usual in such schools. He must bind himself to serve for three years, and to attend night schools for the study of mechanical drawing, at least two years, unless he has already sufficiently acquired the art.

Apprentices of the Third Class.—The third-class indenture is in the form of an agreement made with persons twenty-one years of age or over, who are graduates of colleges, technical schools, or scientific institutions, having taken courses covering the higher mathematics and the natural sciences, and who desire to secure instruction in practical shop work.

The indenture or agreement in each case obligates the company to teach the apprentice his art thoroughly and to furnish him opportunity to acquire a practical knowledge of mechanical business. The firm is also bound to retain the apprentice in service until he has completed the terms of the indenture or agreement, provided his services and conduct are satisfactory. In all cases the firm reserves the right to dismiss the apprentice for cause.

The rates of pay in the different classes are as follows:

	1st year per hr.	2d year per hr.	3d year per hr.	4th year per hr.
Apprentices of the First Class	7c.	9c.	11c.	13c.
Apprentices of the Second Class....	9c.	11c.	13c.	
Apprentices of the Third Class.....	16c.	20c.		

In addition to the rates mentioned above, apprentices of the first class each receive an additional sum of $125, and apprentices of the second class an additional sum of $100, at the expiration of their full term of apprenticeship.

By the course of training provided for in this system, it is believed that a great benefit will accrue to the mechanic as well as to the employer. To young men who have received a thorough technical education, the two years' course in shop work is especially recommended.[1]

Mr. N. W. Sample, superintendent of apprentices in the Baldwin Locomotive Works, states that the system has proven quite satisfactory.

> "Three years after the first indentured apprentice completed his term, there were employed over two hundred graduated, first-class, all-round mechanics capable of assignment to any shop, and of this number fifty occupied places of responsibility as heads of departments, foremen, assistant foremen, contractors, and leading workmen. It is no longer necessary to go outside of the works for any talent desired."[2]

The Westinghouse Electric and Manufacturing Company is another firm which is laying much stress upon the proper

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[1] *Circular No. 3, Apprenticeship System,* Baldwin Locomotive Works.

[2] *The Annals of the American Academy of Political and Social Science,* Vol. XXXIII, No. 1, January, 1909, p. 177.

development and training of young men for their works. They have two apprenticeship systems, that of the Trades and that of the Engineering. The former is designed for young men who have not had a technical education. The latter is intended for graduates of technical schools and colleges. The Trades Apprentices are recruited from young men between the ages of 16 and 23 years. All under 21 years must have their parents' or guardians' consent embodied in the agreement which is made with the company. The term of service for the Trades Apprentice is four years, while that of the engineering class is two.

The company is generous in its treatment of the men. They are given very fair remuneration during their term of service, and are promoted from task to task as their capabilities develop. The promotions are accompanied by graded increases in wages. The trades apprentices are started at 9 cents per hour, and at the end of each year receive an increase of 3 cents per hour until they complete their term. The engineering men are started at 18 cents per hour, for which sum they work one year of the time, or 2,740 hours. After this first year of service, they are remunerated at the rate of 20 and 22 cents per hour, the former rate being granted for the first six months of the second year, and the latter being for the next six months.

The firm takes care that the young men to whom they grant the privileges of apprenticeship have the fundamental training and native ability to make proper use of the opportunities. Those who desire to become enrolled in the work are obliged to make application in their own handwriting, and must tell their father's name, state his business, they must give their name, age, height, weight, educational and other training, the foreign languages they speak, the degrees they have received, and the schools or colleges they have attended, and no one is considered who does not submit a recent photograph.

While they are serving their time an exact record is kept of their conduct and performance within the plant; and, if they are trade apprentices, their outside night school work is carefully graded and recorded. They are marked for workmanship, personality, and outside class work. A young man has an incentive to do his best in every department; because, if at any time he becomes incompetent through neglecting his work or studies, or is insubordinate, he is liable to dismissal. Dismissal means he loses both a job and a chance to better his future condition. If he honorably completes the term of service, the firm in the case of trade apprentices presents a substantial reward in the form of $100 and a diploma, which tells the world that he is competent to follow some definite line of work. The engineering apprentices receive no gratuity, but obtain certificates.

Nothing so clearly indicates our progress both in the industrial and educational fields as do these highly organized apprenticeship systems. This development has taken place within the last ten years. Indeed it is not that long since apprentices in some places were started in at $2 per week, and raised a dollar or so every year until they were earning a weekly wage of $6 by the time their terms expired. In the older shops, his training depended very largely upon the caprice of his foreman and his own assertiveness. If he were wide awake and insistent upon getting acquainted with all classes of work which went on in the shop, he would get a good training. If, however, he were not a favorite or a forward kind of youngster he would frequently secure a poor training for a future career.

The writer knows of one plant which still has the old style of apprenticeship contract, and the trouble it has had to find competent foremen, gang bosses, and workmen is evidence that a far-sighted, generous policy is the most profitable.

Individual Ability.—No firm can hope to be successful if it is dependent upon unusual ability of any considerable portion of its workers. A large number of firms whose work is of such a nature that a formal system of indenture is inadvisable or impossible have adopted the policy of supplying an understudy of some kind to every man who has charge of a department containing a number of men. This assistant or helper is expected to acquaint himself with all the duties of his chief, and is supposed to act in his absence. In this way the plant is never at a loss to fill any position which may be vacated in any department. One large organization engaging some 40,000 employees will not promote one from a lower to a higher position unless that same man has trained a subordinate to fill his position. This insures to the firm available workers for every possible position, and it also has a tendency to develop a very friendly feeling between the heads of departments and their assistants, because the departmental head sees that it is to his distinct interest to have capable subordinates.

Another firm takes the attitude of fearing the coming man. Every foreman or division head likes to impress all of the superior officers with the idea that, if he leaves, the department will suffer. In a measure he speaks the truth, because those individuals take care to have subordinates who possess few of the larger qualities needed by men of initiative. The firm as a consequence is terribly handicapped, and as is to be expected, the work in the departments is so unsatisfactorily performed that every few years there is a general "shake-up" in the plant, entailing the resignation and dismissal of a large number of the departmental heads. Thus the short-sighted policy pursued by every one in the plant to hold his job is the very thing that is hindering his personal advancement and the general prosperity of the firm. This concern has not paid a dividend on its stock for more than a half dozen years, while the former company's stock has averaged 7 per cent for a generation.

CHAPTER XV

THE PAYMENT OF THE WORKMAN

In order to get the maximum product from any set of employees, the manager must consider:

1. The best methods of keeping the men employed at their maximum limit while within the plant.
2. The best methods of making their work accurate.

When one establishes a wage scale he should have those two objects in mind.

The greatest incentive a man can have to work faithfully is to be paid according to some scheme whereby his remuneration is directly proportional to his output. How to establish a wage scale which will yield this maximum output for a minimum wage cost is a problem that has troubled managers for years.

The oldest scheme of wage payment is to pay the worker a certain fixed sum for the time he is employed in the plant. In the hands of a vigorous overseer thoroughly conversant with all the work in the plant, the time system proves satisfactory provided the plant is so small that the foreman in charge can keep in constant touch with all that is going on. From the employer's point of view it might appear that nothing can be more perfect than the time system of wage payment; because every increase in output that the man makes means an absolute gain to the owner of the plant. The curves *A A′* in Fig. 24 show how increased exertion contributes to the profits of the firm; the employee gets the same compensation whether he does one piece or a hundred, while the employer can see with glowing satisfaction his wage cost per unit dropping downward. There is but one difficulty with which the employer must contend in this remunerative scheme. The employee will not give his best efforts so long as added exertions do not bring immediate returns. The only tangible encouragement a man has in the time system is that his rate of pay will be increased from time to time as he demonstrates his worth. In a large shop it is impossible for a foreman to be in such intimate contact with all the men that he can make wage adjustments that will be strictly fair to each individual. It is hard to measure the efficiency of a man by his general attitude or by his talk. Some of the best talkers and apparently most industrious workers may be confirmed loafers and the least efficient men in the firm's employ.

The only practicable way of establishing a satisfactory time-rate system is to divide the men into groups or classes and fix a maximum and minimum rate for these classes. If a man is valuable he may get his wages raised to the maximum within the class, or he may be advanced to another class. The wages are fixed by bargain between the men and the employer. This bargaining may be done either collectively at the dictation of a labor union, which fixes minimum wage rates, or it may be done by the individual workmen fixing their wages with the foreman. At best, the wage adjustment is largely guesswork so far as rewarding individual men for what they do.

Unless there is some means of measuring what a man does, it is unsafe to depend upon personal likes and dislikes. Here lies the inherent weakness of the time-rate system. A foreman will often raise wages not because a man actually produces more, but because he thinks the man more efficient. Managers in plants have long appreciated the fact that there should be a different method of fixing standards of wage payment than on the basis of personal conjecture.

The average man is not inclined to overexertion. Frequently his chief aim seems to be to do the least amount of work necessary to keep from getting discharged or being reduced in pay. Foremen are much annoyed and firms lose thousands of dollars through the idleness of men from one cause or another. A great deal of this lack of energy on the part of the men is not due to wilful idleness but to oversight on the part of the foremen. Men will frequently get a job completed and wait with perfect complacency until the foreman comes to them with another task. In some poorly run shops men waste as much as half a day waiting for the foreman to find out that they are ready for a new job. There are also other kinds of time losses. Men will frequently wilfully kill time in order to make work last. Machines will not be run to their maximum capacity because to do so will finish a job so long before quitting time that it will be necessary to lift off the piece and adjust another about the time the whistle blows. One will sometimes see men in day-rate shops actually make their machines run without doing anything at all in order to appear to be working and so do away with the necessity of changing a job at some inconvenient time. Managers of plants are not ignorant of these conditions. The wilful dishonesty and lack of willing cooperation on the part of the employees have made the daily wage system a poor means of remuneration for many kinds of work. Wide-awake men rightly reason that if a scheme could be devised by which workmen lose money for idle time, they would not be so inclined to sit with bovine patience until their foreman finds them out of work and starts them on another task, neither would they be apt to waste time wilfully in order to start new work at a more convenient season or to save a job when work is getting low in the shop.

It is rational to assume that the remuneration for labor should be on the basis of all ordinary commercial transactions, that the man should be paid for what he does, that compensation should be by the piece-rate system. There can be no more effective way to prevent idleness, because the

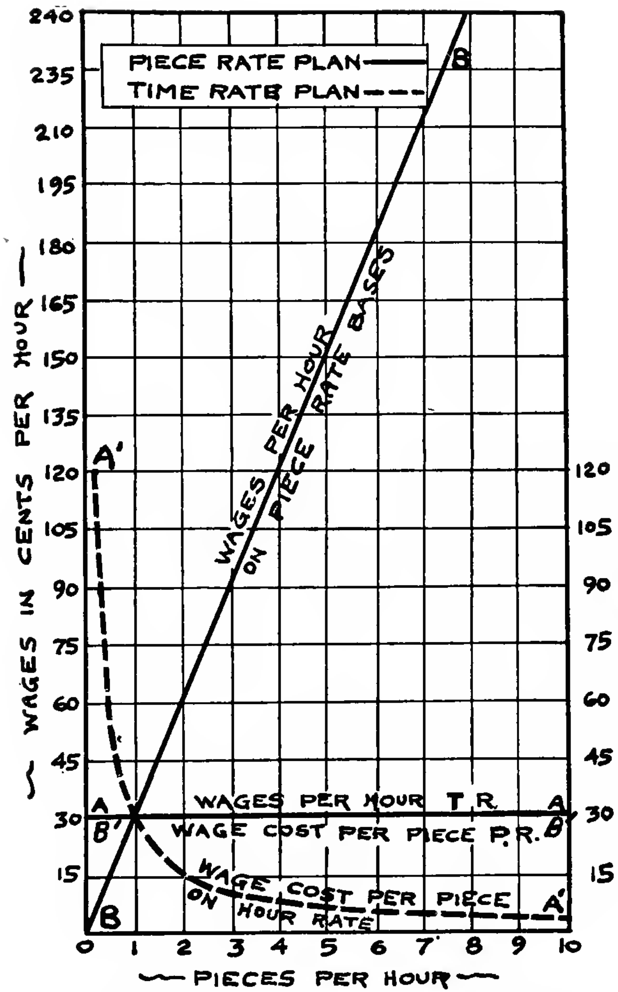

FIG. 24.—Comparison of the Time-Rate and Piece-Rate Systems.

idler is fully as much a loser as the firm. Viewed from the workman's standpoint, there can be no more profitable means of remuneration. Fig. 24, on lines *BB*, shows that on the piece-rate system of wage payment a man automatically raises his hourly rate by increasing the output. The firm apparently does not gain directly from the increased effort, as is shown by the fact that the wage cost per piece is a constant quantity. (See lines *B′ B′*, Fig. 24.) From the diagram one would conclude that the piece-rate system of wage payment would be a system strongly advocated by the workman. The opponents of the piece-rate system are not the employers, but the men. Their opposition is based upon good reason, and yet, from the employer's point of view, it is almost impossible to eliminate the objection. To fix piece rates one must be guided by the capabilities of the employees. When managers introduce the scheme they try to be fair to the men and estimate the time it will take to perform certain tasks on the basis of previous time records made by men employed on the day-rate system. These records are from the very nature of the case inaccurate, and it is found invariably that nearly every one underestimates the workman's efficiency when he has an incentive so great as that offered by the piece-rate system. In some cases the output of the workman will increase seven and eight times his estimated maximum.

Under these conditions the manufacturer finds he is often paying extravagant prices for labor which is either unskilled or semi-skilled in type. In these competitive days, he cannot afford to pay exorbitant daily wages to men whose training is of a low order, because his competitors will soon adopt a daily wage or a piece-rate schedule of a very much lower wage standard. The result is that the piece-rate system of wage payment in industries, which have not been thoroughly standardized and developed, has been found exceedingly unsatisfactory, because the workmen consider it unfair to cut their rates, and the managers find it almost impossible to establish a rating which will be satisfactory to themselves and to the employees without considerable adjustment.

The breakdown of the piece-rate system is due to the fact that it is impossible to adjust rates without friction. The men consider every reduction of the piece rate an illustration of the employers' greed, while the employers feel that the increased output is another example of how grossly employees have deceived them in the past in order to mislead them into paying excessive wages. Both sides feel disgruntled.

Employers who have experimented with this system and have discovered the skill a laborer possesses, have endeavored to apply the theory of giving a large incentive to some one who can guide and direct the men and yet pay these workers a day rate. There are plants in this country which apply this scheme, and call it the Contract System. The foremen in charge are given a certain price for the work they do, they hire and direct the men, usually paying them on a day basis, and fixing their wages at the lowest possible point the men will agree to take. Under the contract system of working, the foremen have their income based upon the work they can get from these men. The scheme has a tendency to develop a body of alert overseers who are always after the men to see that they are not wasting time either through laziness or by incompetence. The system when it operates makes men work, but it has the unpleasant disadvantage of developing slave-driving habits. Many men will not stand for such treatment; and unless the work is of such a nature that a rather low type of worker can be employed and taught the tasks to be done, the company is liable to have a great deal of trouble with its labor under this contract system, although in some plants it has worked successfully for many years.

Mr. Henry R. Towne, a number of years ago, conceived a scheme which has had a profound influence upon pay systems, because he introduced an incentive rather than a coercive process to get men to increase their exertions.[1] His scheme is briefly this—find out what has been the average cost for a given amount of output in the best year before he introduced the system. With this as a unit he determines what the labor cost for the same quantity has been for each succeeding year. The difference in labor cost between the two gives him the savings made for the firm by the extra effort of the labor force. This saving he distributes in the following way: 50 per cent is retained by the firm, 10 per cent is given to the foremen in charge of the work as an inducement to them to get men to increase output, 40 per cent he distributes to the gang bosses and workmen throughout the plant on the basis of their annual wages. The remuneration is given at the end of the year or at the end of some considerable length of time shorter than a year.

This sharing of the gain with the men has in it a number of defects, the most important of which are:

1. The reward is remote.
2. The method of division is not likely to encourage great activity because the men do not receive shares in proportion to their individual efforts.

Some writers have criticised the system, because it makes the men share gains which they say may be due to improved methods of work or to better management. There may be some basis for this statement, but Mr. Towne's paper distinctly stipulates that the books shall be so kept that any improvements in management will not be shared by the workmen save in so far as they actively assist in the work. The paper specifically notes that it is only fair to share with the operatives the savings which their activity makes for the firm.

The remoteness of the reward and the method of division

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[1] *Transactions American Society of Mechanical Engineers,* Vol. X, p. 600, No. 341, "Gain Sharing," by Henry R. Towne.

are, however, serious objections, and these Mr. F. A. Halsey circumvented when he presented the premium plan of remunerating labor.[1] Mr. Halsey believed with Mr. Towne that the workman should be rewarded only in so far as his actions lower production costs. He, however, appreciates the fact that a much better incentive will be given to men if they are paid at once their exact share of all the profit they make. His scheme is briefly this:

A man is given a certain rate per hour. A piece of work is assigned to him which will be allowed a certain number of hours time in which to be done. If the man performs the work in a shorter time, he will be given a fixed percentage of the value of the time saved. This extra sum will be paid to him as a premium to his wages, and on that account the Halsey scheme is called the Premium Plan of Remunerating Labor. The idea of the scheme is to establish the shop on a piece-rate system, in which the men will be guaranteed a certain daily wage. If the management has fixed the price of the unit of work performed at too high a figure the workman will share his extra productive value with the manufacturer in a manner that will not require the cutting of the rate. In a word, by dividing the gains due to his extra productivity, both the manufacturer and the worker profit, and the worker will have no reason to limit his output because there will be no rate cutting.

The lines *AA*, Fig. 25, show how by this system a man increases his hourly wage in a very material way by increasing his productivity. At the same time he cuts the unit price per piece considerably for the firm. (See lines *A′A′*, Fig. 25.) The figure shows just how Mr. Halsey manages to make unnecessary any cuts in the unit rate. By his sys-

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[1] *Transactions American Society of Mechanical Engineers*, Vol. XII, p. 755, "Premium Plan of Paying for Labor," by F. A. Halsey.

tem, the workman by increasing his wages actually cuts the cost of production. His only method of obtaining a big reward is to cut the unit cost. Thus the employer has a decided advantage. If we look at the other term of the contract we find that the workman is guaranteed a standard daily wage, so that he can feel that he is not on the piece-rate system. If the price per unit has been set too low, he is not compelled to overexert himself in order to make a fair daily wage.

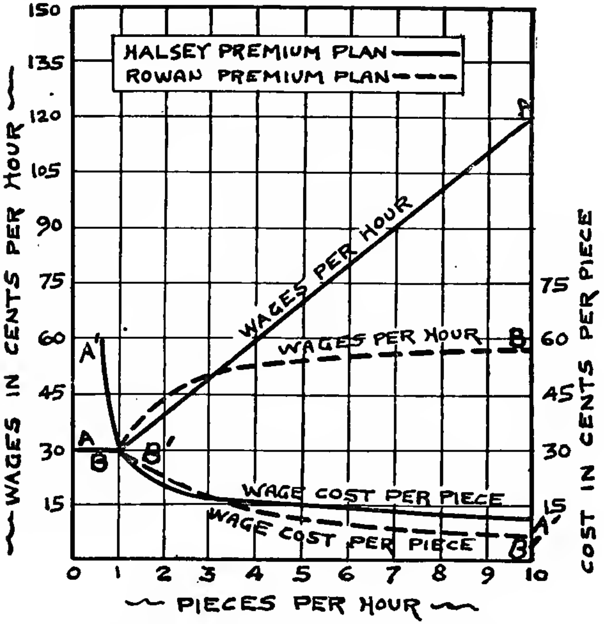

FIG. 25.—Comparison of Halsey and Rowan Premium Plans.

The advantages of the Halsey system are:

1. The men are encouraged to produce more by being rewarded in proportion to what they do.

2. The reward is immediate and substantial.

3. The employer, in sharing the gains of the extra exertion on the part of the worker, does not have the necessity of cutting the rate in an arbitrary manner, hence the workman's mind is relieved of the fear of having his wages reduced arbitrarily.

A British modification of the system was put into operation by David Rowan & Company. Mr. Rowan's wage curve is plotted *B B* on the same diagram (Fig. 25), which shows Mr. Halsey's premium plan, while the Rowan piece cost is shown as line *B' B'* on the same diagram. According to Mr. Rowan's idea, if a job has been allotted too much time, even with the Halsey system, a man may get a remuneration out of all proportion to the value of the work. For example, if a man should be allotted one hour to do a piece of work worth 30 cents, and if he should increase his productivity ten times, with the Halsey system he would get $1.20 an hour. This is considerably better for the firm than his hourly rate would be with straight piece work. The latter cost would be $3 an hour. (See Fig. 25.) Mr. Rowan believes, however, that even Mr. Halsey's scheme is too extravagant in its reward, so he devised a plan of so adjusting the premium that every increase in wages should be equal to the percentage the operator saves on the time. For example, if a job is allotted one hundred hours and the man's rate is 30 cents per hour, the cost of the work would be $30. If he does the job in ninety hours, with his hour rate 30 cents, the time wages on the job would be $27. He has saved, however, 10 per cent of the time, and gets a 10-per-cent increase in wages on the actual time cost. Should he do the work in eighty hours, the time rate would be $24. Twenty per cent time saved on $24, the time cost, would be $4.80. A comparison of the two tables will show the wage scale (wages rate 30 cents per hour) as worked out by the Halsey and the Rowan methods.

COMPARISON OF DIFFERENT METHODS OF CALCULATING PREMIUMS.[1]

Halsey's Method.

Hours Allowed.	Hours Taken.	Time Wages on Job.	Premium Earned on Job.	Total Labor Cost.	Workman's Rate per Hour.
100	100	$30.00	$0.00	$30.00	$0.30
100	90	27.00	1.00	28.00	.311
100	80	24.00	2.00	26.00	.325
100	70	21.00	3.00	24.00	.343
100	60	18.00	4.00	22.00	.366
100	50	15.00	5.00	20.00	.40
100	40	12.00	6.00	18.00	.45
100	30	9.00	7.00	16.00	.533
100	20	6.00	8.00	14.00	.70
100	10	3.00	9.00	12.00	1.20
100	1	.30	9.90	10.20	10.20

Rowan's Method.

Hours Allowed.	Hours Taken.	Time Wages on Job.	Premium Earned on Job.	Total Labor Cost.	Workman's Rate per Hour.
100	100	$30.00	$0.00	$30.00	$0.30
100	90	27.00	2.70	29.70	.33
100	80	24.00	4.80	28.80	.36
100	70	21.00	6.30	27.30	.39
100	60	18.00	7.20	25.20	.42
100	50	15.00	7.50	22.50	.45
100	40	12.00	7.20	19.20	.48
100	30	9.00	6.30	15.30	.51
100	20	6.00	4.80	10.80	.54
100	10	3.00	2.70	5.70	.57
100	1	.30	.297	.597	.597

The reader will observe that while the Rowan plan compared with the Halsey method does prevent excessive earnings on the part of the employee when he multiplies his output many times, it on the other hand gives a decidedly

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[1] "Trade Unionism and Labor Problems," by John R. Commons, p. 287.

greater reward to the workman until he more than doubles his productive capacity. Is this a desirable characteristic of a wage system? Does not the Rowan Premium tend to encourage the workmen to remain at a lower level of efficiency than the Halsey Premium? To be perfectly fair to Mr. Rowan, it should be stated that his rate is adjusted for the purpose of making special cuts unnecessary. If a man loiters about his work when the rate is being set, he cannot reap too great a harvest by "rushing." The scheme certainly does act automatically in reducing output cost, but it seems highly probable to the writer that men who work under it would be somewhat inclined to "nurse" their jobs when they found that their added exertions increased their wages so slightly as the system does in the later stages.

In 1895, Mr. Fred W. Taylor read a paper before the American Society of Mechanical Engineers, in which he recognized the advantages of the Halsey system and its superiority over any previously proposed scheme, but pointed out that it has one very grave defect—while it encourages the workman to do good work, it gives only a passive incentive by not punishing him for not doing his best. In other words, the Halsey system permits men to gather premium for work done, but it does not necessarily stimulate a man to produce his utmost. In order to introduce this element, Mr. Taylor proposed a scheme of wage payment which both punishes and rewards, and which he calls the differential piece-rate system. According to this plan, a man is rewarded only after he attains a certain fixed standard of work. If he does not accomplish the job in a given time, instead of being paid an ordinary piece-rate price, he is paid a piece-rate price considerably lower than the one paid if he does the work within the stipulated period.

If the usual output of a 30-cent-an-hour man in an ordinary shop is one piece in an hour, Mr. Taylor would by his timing process find that an individual working at his maximum rate on every part of the job could accomplish three pieces in an hour. He would then fix his rate as follows: Three pieces in an hour would be made the standard. If a man could perform three pieces an hour he would get, not as he would get in the day-rate shop, thirty cents an hour, or ten cents a piece, but fifteen cents a piece, or some similar amount, for each piece performed, so that his hourly rate, if he reached three pieces in an hour, would be forty-five cents. If he performed more than three pieces in an hour, say four or five, he would still get 15 cents a piece for every one performed, so that the workman, as shown by Fig. 26, would raise his wages by a fixed amount for every piece finished. If, however, he could not make three pieces within the allotted time, he would not get 15 cents a piece, or even 10 cents a piece. He may be given but 8 cents for every piece made

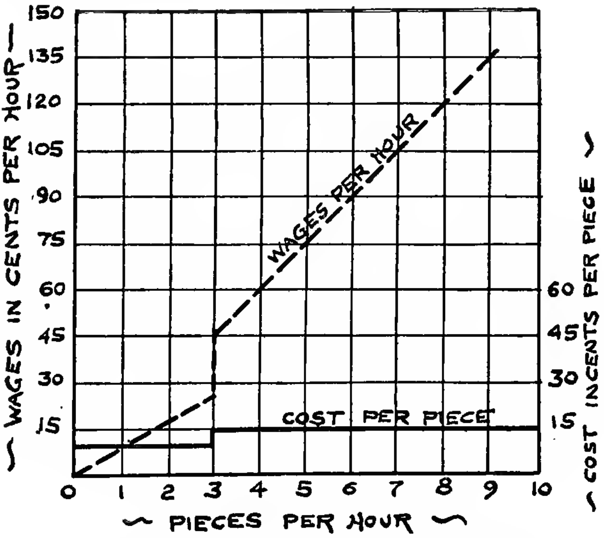

FIG. 26.—Taylor Differential Piece-Rate System.

below three pieces. With such a scheme one can easily see that it is very important indeed, from the workman's point of view, to perform a large amount of work in a day.

This plan of reward differs from any of the others in another essential, aside from the differential piece-rate idea, viz.: The time allowed to do the job is very accurately determined. The superintendents of the works make a careful study of the exact time it needs to take to do the jobs, working in the quickest known way, and the workmen are allowed a period just sufficient to permit them to perform the task in the most approved fashion in which it can be done. Thus there are two ideas involved in Mr. Taylor's differential piece-rate system: (1) a punishment for one who does not perform the task, and a reward for the one who does, which is the method of payment idea; and (2) the workman has accurately determined for him by his superiors the time it should take to do the work. In a subsequent paper entitled "Shop Management,"[1] Mr. Taylor discusses in detail his method of ascertaining the time it should take a workman to perform his task. Every job is divided into its elementary operations; and an attendant, by means of a stop watch, observes the time in minutes and seconds it takes a good workman to perform each part. The total time of the job is then fixed by adding together the time it takes to accomplish all of these elementary steps. With the time thus determined, a task is given which will keep a good man busy in performing, and yet which is within his possibilities. Mr. Taylor emphasizes the idea that the task must be so hard that only a first-class man can perform it. He gives high wages and secures a low labor cost by accurately determining the maximum possible output of a workman, and compelling him to reach that standard. He utilizes the hitherto unre-

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[1] *Transactions American Society of Mechanical Engineers*, Vol. XXIV, pp. 1337–1480.

alized possibilities of the laborer by learning what those possibilities are, and giving the reward only if they are attained.

The Halsey system, as criticised by Mr. Taylor, is defective, because it does not give the workman a definite goal to reach, hence the high wage paid does not reduce the output cost as it should.

In the *American Engineer and Railroad Journal* for February and December, 1906, there appeared two articles descriptive of the Santa Fe's shop-management scheme. The first article is entitled, "Shop Betterment and the Industrial Method of Profit Sharing," by Harrington Emerson. The second article is entitled, "Betterment Work on the Santa Fe," written by the staff writers of the *Journal*. These two articles have been the source of much comment, and of articles in other magazines. Mr. Emerson has devised a piece-

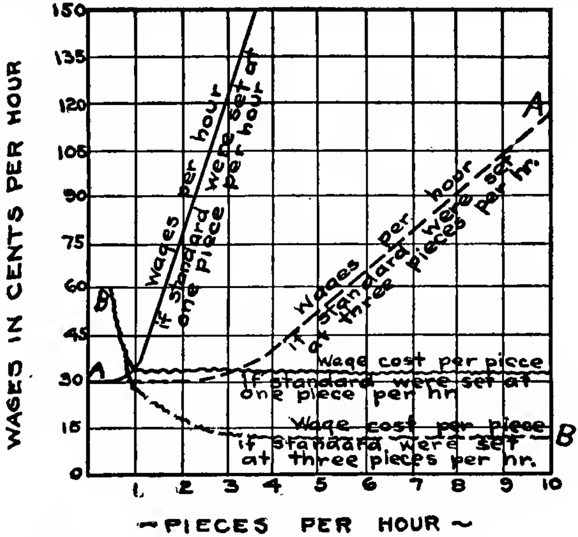

FIG. 27.—Emerson Differential Piece-Rate System.

rate system, which in many respects is analogous to the Taylor plan. He determines from previous shop records, and by a careful study of the best possible ways of performing the work, how long it should take to do each task as it comes into the shop. His scheme of remuneration is, however, different from Mr. Taylor's as regards the basis of payment. After determining the minimum time it takes to perform a task, a man is paid a fixed daily rate of say 30 cents an hour until he performs two thirds of the standard task. If he performs the standard task, or 100 per cent, which in our illustration would be three pieces in the hour, he is given an extra reward of one fifth of the regular wages for the operation. If he performs more than two thirds of the work, but less than the standard, he is likewise paid a gradually increasing bonus, as shown by curve *A A* on Fig. 27. If the workman can perform more than three pieces in an hour, he is paid the high price per piece for every piece he makes over the standard. The Emerson system differs from that of Mr. Taylor in one respect. It is not a piece-rate system until the man performs at least two thirds of the standard task.

Between the Halsey system and the differential piece-rate system, as developed by Messrs. Taylor and Emerson, there is another plan proposed by Mr. H. L. Gantt, called the "Bonus System for Rewarding Labor."[1] Mr. Gantt's scheme differs from the differential system in that it is not a piece-rate system, yet it is like the Taylor system, in that it does set a definite task for the person to perform. If the individual performs the task within the given time, he is paid his regular hourly rate and a certain stipulated bonus. Every job is allotted a certain amount of time; if the man performs the task within this time, he is given the bonus, and as soon as he finishes one job he is given another, to which he is like-

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[1] *Transactions American Society of Mechanical Engineers*, Vol. XXIII, 1902, p. 341.

wise allotted a definite amount of time. The result is that if a man in the course of a day doubles his output, he will get a day's wage plus the bonuses, which are attached to the separate jobs he has performed. If he fails to do the work within the allotted time, he gets only his day's wage.

As a matter of fact, it makes very little difference which system of wage payment is used. There is no reason why the Halsey system need be a ''drifting'' system, as termed by Taylor. The thing that makes the differential piece-rate system effective is that the manager of the shop determines the time that should be taken to do the work, and fixes his differential rate accordingly. Should the manager of the plant, where the premium system is applied, take the same means to determine the minimum working time, the premium system could be adjusted equally well. There are shops which have tried both the premium and the differential piece-rate systems; and, after giving both a fair trial extending over many months, found the premium plan considerably more satisfactory. On the other hand, there are shops which have ultimately decided upon the differential piece-rate system. Indeed, the method of payment is not so important, if the concern can find a scheme that will justly determine the possibilities of a worker. The system of wage payment for this purpose is a secondary matter. The method of obtaining the possible speed at which a worker can produce is the real problem of management, and the real object of all wage-payment systems should be to reward him in such a manner that he will produce this maximum.

Mr. Taylor suggests his unit-time study method to obtain the speed possibilities of the man; Mr. Halsey gets his data by studying shop records and carefully observing the men. Both schemes have produced good results under different conditions. Generally speaking, the unit-time study system is successful in shops which handle contracts of a more or less unvarying character, and are not compelled to follow exacting requirements. In one shop of a miscellaneous type which handled work that had to be exceedingly accurate, the unit-time study system, after a fair trial extending over many months, proved a most dismal failure. When men tried to make the calculated time, they spoiled the work. In another shop it has proven successful, yet the same man who made it a success in the one shop, failed to make it a success in the other, and he had the cooperation of the management in both cases. The cause of the failure in the one shop was the exacting type of the work, and in the other the success was due to the rather crude character of the output.

In the shop where the differential system failed the premium system was next tried, the time being predetermined by previous shop records, and by keeping after the men; and the scheme was successful, the very scheme which Mr. Taylor so severely condemns.

In his paper, Mr. Taylor emphasizes one thing which should not be passed over without some comment. He does not advocate the paying of high wages so much as he urges the paying of wages which are considered high by the average workman of the grade he employs. His plan is to teach a low-grade man to do work which would otherwise be given to a highly skilled man. "The writer" (Mr. Taylor) "goes so far as to say that almost any job that is repeated over and over again, however great skill and dexterity it may require, providing there is enough of it to occupy a man throughout a considerable part of the year, should be done by a trained laborer and not by a mechanic. A man with only the intelligence of an average laborer can be taught to do the most difficult and delicate work if it is repeated often enough, and his lower mental caliber renders him more fit than the mechanic to stand the monotony of repetition."[1]

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[1] *Transactions American Society of Mechanical Engineers*, Vol. XXIV, p. 1347.

Care must be taken not to carry that policy too far. There are concerns in this country employing this means to have their work performed. One plant has advertisements in papers every once in a while for men. They employ a high-salaried man, who is nominally in charge of a large department, but whose work is delegated to an assistant. The chief of this department spends so much time getting people that he is not in touch with the work as he should be. He gets men at a low price, and just about the time they are trained they leave. The plant is in a state of unrest and irritation at all times, due to the fact that about one third of the working force is always just learning, and is making mistakes that cause the gang bosses and foremen to be blamed for not looking after the men. These, in turn, vent their spleen on the man who ignorantly makes mistakes. This concern, however, looks with pride upon its average wage rate per man, and fully believes that it is carrying out a sound labor policy. On the contrary, the low average per man being paid for work regarded elsewhere as safe only in the hands of skilled men is costing the firm dearly in spoiled work.

In order to determine the best way to carry on a plant, one should not be guided by any set of opinions or by any one system. The manager should know the men's records, the amount of material that is used and wasted, the amount of defective products returned by purchasers, and the performances of the machinery. These are the things which his shop accounting system should tell, as the following chapters will explain.

CHAPTER XVI

RECORD OF THE WORKERS

If the management establishes a fair wage scale, it can enforce the performance of good work by discharging incompetent workers, because well-paid men want to do good work in order to hold their jobs. If the wage scale is unfairly low the workmen will be able to find better, or at least as good, employment elsewhere, so that discharge is no threat to compel good work under these conditions. Assuming a fair wage scale, how can the management enforce the performance of accurate work? Obviously, there is but one way, and that is to punish the workmen who turn out poor work. Good management dictates more than a policy of finding out what each man does. To have good work turned out as a matter of course, is the goal for which all concerns should strive, and this can be done only by getting rid of the poor men and by seeing that no incompetent men are re-employed. To keep good men, rewards must be given either by promotion or advances in wages from time to time. To reward the right employees, there must be an accurate record kept of the men from the time they enter the plant until they leave it.

For a small shop, a foreman can be secured who may be entrusted with determining the efficiency of the employees, because if he is in the habit of being easily deceived by incompetent assistants, the defect soon manifests itself to the management. In large plants, however, good foremen are frequently embarrassed by poor workmen; and, many times, poor workmen, after being discharged from one department, find employment in other departments until their delinquencies are again discovered. If insufficient record is kept of their service in the plant, they may, after a time, be re-employed in the department in which they first demonstrated their inefficiency, and even under the original foreman.

No ordinary person, having under his constant guidance three hundred to four hundred men, can keep in mind all past employees. It is not hard to discharge a man if he displays inefficiency, but by the time he has proven his incapacity, the firm loses money, and the man himself is being done an unkindness by being given even passive encouragement to work in a field for which he is unfitted. It is better for him to be compelled to discover a place where he will be serviceable, or to find an occupation more suited to his ability.

Some few years ago, there was a plant which did not believe in keeping records of its employees. The foreman hired men whenever he needed help. In one instance, an employee was caught idling and was discharged. He lost half a day, was re-employed in another department the next morning, and at the end of the week, in spite of the lost time, he received more money for the same work than he would have had with his old job under the other foreman. The second time he "soldiered" as much if not more than the time before, but was circumspect enough to be employed very assiduously whenever the officials approached his vicinity.

Another organization transferred men from one department to another without ever recording such changes in the main office. A vacancy once occurred in a department wherein a man desired to be located, and he asked permission to change. The boss signified his consent by saying, "All right, I'll send your time to the main office." A week later the pay envelope showed that the man was paid for working in two departments at the same time. To cap the climax, when he reported the overpay, he was reprimanded by his former boss, who said, "You might have kept quiet and not have gotten me into trouble. It didn't do you any good to squeal.'' And it surely did not, for the man was now compelled to wait two weeks for his next week's wage, the paymaster remarking that it took so much time to make the correction.

In order to make the foreman responsible for good work, both in quality and in quantity, the manager should take pains to supply him with efficient men, and to do this he should have a working scheme that will keep proper record of the employees. In a large concern, this can be done to best advantage by establishing a labor bureau. A small concern can safely let the time department keep a card-index record of the men.

The problem of the labor-employing bureau may be divided into several parts:

1. To select and employ the proper laborers for different duties.

2. To keep record of the employees who are still employed, with their status as workers.

3. To keep record of all people who have been employed at any time with reasons for their dismissal and their record as employees.

The best basis for good judgment is accurate knowledge. If an employer secures accurate knowledge of an applicant for a place before he hires him, he can save himself much trouble and some expense. There are several things a manufacturer should know at once about an employee.

1. Has he any constitutional weaknesses or injuries?
2. His approximate age.
3. His educational qualifications.
4. His experience.

The first three can be gotten pretty accurately by combining answers on the part of the applicant with personal observation. The fourth one is not so easily determined by asking questions, especially if the applicant is inclined to be untruthful. Many men apply for jobs for which they are unfitted or have had a very meager preparation. In one shop an ex-weaver secured a position as a steamfitter by merely stating to the hiring clerk a lot of hypothetical experience. As a matter of fact the young man did not know the difference between a pipe-wrench and a pipe-cutter, but he held the job for six months before he made too many blunders.

The safest way to determine a man's experience is to have him state the names of his former employers and people to whom one can be referred who can tell about his efficiency and conduct from actual experimental knowledge.

Considerable thought should be put upon the framing of the questions on the application blank. For instance, in asking for the practical experience the applicant should be requested to state the trade or occupation learned, the length of time in service, and what was done while in service. In this way the applicant will give definite information concerning his work and will not have a chance to branch off into meaningless generalities. Every question should be so framed that the answer to it must be brief and give definite information about one thing.

Some firms require the applicant to state age, whether married or single, whether he uses drugs, liquor, or tobacco, whether he belongs to a union or not, whether he is a citizen of the country, if he knows anyone in the plant, why he left his former place, the number of people depending on his wages, whether he speaks English and can read and write, what wages he expects, what he previously earned, does he look for further advancement, why he wants to be employed by that particular plant, and sometimes even other questions. One large concern asks no less than forty questions of every prospective employee. When one goes to that extent he is getting data which even if truthfully given would be unnecessary for any but the most unusual conditions. The data, however, cannot be depended upon after it is obtained.

Men, especially those in middle life, are very apt to misstate their ages. Several years ago a large concern determined to find out the ages of all of its employees, both those who had been long in service and those who were just being engaged. In hardly any case did the men state their exact age. The younger men overstated their age from one to five years, and the older men understated their age five years and more. In one case a man of more than sixty years told the clerk, "I am forty-three, and if you come around thirty years from now I'll still be forty-three."

Men resent questions of an inquisitorial nature. They rarely object to stating whether married or single; but when asked why they want to be employed in the plant or whether they expect any advances in wages, they feel they are being asked what a workman once called "fool questions anyway."

Much more information can be obtained about the man by looking up references. Some firms make it a point to send out blank forms to previous employers of an applicant whom they contemplate hiring. Others look up the references of every man who applies, so that they will have a trustworthy list of available candidates. The letter seeking information about the employee should be framed in such a way that the former employer can answer very briefly and definitely questions which will give one a very good idea of the capabilities and personality of a man. One form of a letter of this character is shown below.

DEAR SIR:

.... has applied for a place as .... and has given your name as reference. Will you kindly answer the following questions regarding ...., and if there is any other information relating to him which is of interest, we shall be indebted to you for it.

1. How long was the above man employed by you?...............
2. In what capacity?...
3. What was his rate per hour?...............................
4. What advances did he get, if any?......................... ......

5. Is he a good mechanic?..............................
6. Are his habits good?................................
7. Is he regular in attendance and industrious?.................
8. Why did he leave?...................................

Any information you give us will be treated as strictly confidential, and we shall be glad to answer requests of a similar nature regarding men who give our name as reference.

Very truly yours,

....

This letter embodies questions which can be accurately answered with little trouble on the part of the individual who receives it. Some officials object to telling the public or business rivals what wages they pay their workmen. If experience shows that firms are unwilling to state the wages they have paid to past employees it is well to omit the question, and in fact all questions which they believe another company would not care to answer. The reason for leaving out such questions is that if there are too many objectionable requests there is a strong probability of the letter being ignored.

After one has obtained full information concerning the man, the next step is to keep a record of him as a worker. No recording scheme is of value unless it records actions as well as opinions. By this is meant that one of the most unsafe bases for judgment of a man's ability is what some individual thinks of him, unless the estimate is supported by evidence which shows the basis for the opinion.

The scheme which keeps record of the employees should do two things. In the first place, it should keep accurate record of what each person is doing so as to enable the foreman and other officials to place the men to the best advantage in the plant, and in the second place it should make it impossible for men to be put on the pay-roll who are not doing the work they are expected to do, or who may not be in existence at all.

A good employee must at least:

1. Be regular in his attendance, prompt in his appearance at starting, and faithful in his stay in the plant.

2. He must be diligent while within the plant.

3. He must be efficient.

It was shown in the previous chapter how the plan of wage payment develops the diligence and efficiency of the employee, but no matter what the wage scheme is, unless it has back of it some recording device to keep track of what a person is doing, it is impossible to gather data for the establishment of a good wage system, or to determine the cost of the article; and it is likewise impossible for the management to ascertain who are the good and who are the poor employees. A man is a good man for the firm if his average record is good, and a poor man for the firm if his average record is poor. The basis for determining his standing should be, "What has he done?"

Foremen are very apt to make wrong estimates of men, because they do not know their averages of efficiency. For example, in one place there is a bright, capable man who has on numerous occasions, in face of considerable difficulty, erected engines. His work has always been done with few men, and these not of the best, yet he has not made a serious mistake in the erecting of several engines. There is another man who on two separate occasions was likewise given some engines to erect. On these two occasions it happened, through laxity on the part of the shop management, that he was able to borrow men from other gang bosses, and the engines he had to erect were of such a nature that he could use nearly all the temporary bolts and other material which the other gang boss had been compelled to collect in order to erect some previous machines. The first man's ingenuity in gathering material enabled the second man to take advantage of these conditions, and in addition he used some laborers who were not properly charged to the job. In the course of the erection he made a great many mistakes, had holes drilled in the wrong places, which made it necessary to have them tapped out and filled with plugs, he did nearly twice as much actual work in getting the cylinders and housings in the proper place, and his work all through was decidedly that of an amateur. Nevertheless his engines were done in a week's less time than were the other man's. He had established for himself a record in the plant, and when there was an opening for advancement he was given precedence over his rival. Workmen in the humbler positions are sometimes compelled to submit to such conditions. The foremen do not mean to be unjust. They cannot be altogether blamed for advancing the wrong man, when that person makes a spectacular showing. In the case above cited, if there had been exact time records kept of all the time expended on each engine, there would have been a considerable showing in favor of the first man who did not get the reward.

There is nothing so fatal to the discipline of a plant nor so disastrous to its smooth and profitable working as to have a body of men irregular in their appearance, who come late and go out at odd times.

Efficiency is, to a great extent, a matter of faithfulness; and, if a firm insists upon regular and prompt appearance, it is paving the way for good work. There is only one way to stop irregularity—make it unprofitable. If a firm weeds out the non-dependable individuals, it will, before long, develop a good working organization. To weed out these undesirables one should have an accurate record of the entering and leaving time of all the workers in the concern.

One of the most effective devices of time recording, and the one first adopted, is the time check. This is used in a variety of forms.

1. The in-board out-board form. At the entrance of the works are placed two boards, one marked "out-board," placed near the gate, and the other marked "in-board,"

placed farther toward the work rooms. Every man is assigned a numbered check, which hangs with the corresponding number on one or the other board according as he is in or out of the works. While the men are filing in, taking their checks off the out-board and hanging them on the in-board, a watchman stands near by to see that no one takes other than his own check. The gate is closed as soon as the signal for starting work is given, so that no one can get to his check after starting time without calling the timekeeper's attention to the fact.

2. A modification of the above scheme is to give the men actual possession of the check, which they drop in a box on entering the works. Obtaining the time record by either method is a simple matter. After the plant is started, all the checks are in, and the timekeeper makes a record of the numbers. In the second plan he takes the checks into the work-rooms and returns them to the men. In this way he comes into actual contact with each workman, so that there is no possible means by which one man can drop another's check into the box without being detected.

3. The third plan dispenses with the check. The workman is given a number, which he must announce as he enters a specified gate. A clerk at the entrance crosses off the number as the employee calls it out. With this scheme, it is impossible for a man to give more than one number, and the clerk has an immediate record of the men who are in the plant.

4. While these schemes are effective for plants of moderate size, or where the work-rooms are close to the entrance, they fail to be thoroughly satisfactory when the departments become scattered over a large area. Unless there be some kind of a check on the men after they enter the main gate, those disposed to shirk will take advantage of the opportunity to waste time in getting to their places after they have recorded their entrance. To prevent these losses the large

firms have been forced to adopt some plan which would record the employee's entrance into the department in which he is due. A check plan of surmounting the difficulty is to have a clerk distribute the checks at some main entrance, and then require each man to hang his check upon a board within the department in which he is working. This scheme proves effective in insuring the prompt appearance of the men in their departments, but it involves more clerical work than is necessary, because it requires a set of clerks at the entrance gates as well as another set who make record of the checks as they are hung in the departments. In order to reduce clerical work to a minimum and at the same time record the time accurately, mechanical devices have been perfected.

5. The recording clock. The greatest improvement that has been made in timekeeping devices is the introduction of the recording time-clock. There are a number of styles and varieties on the market, but all aim to:

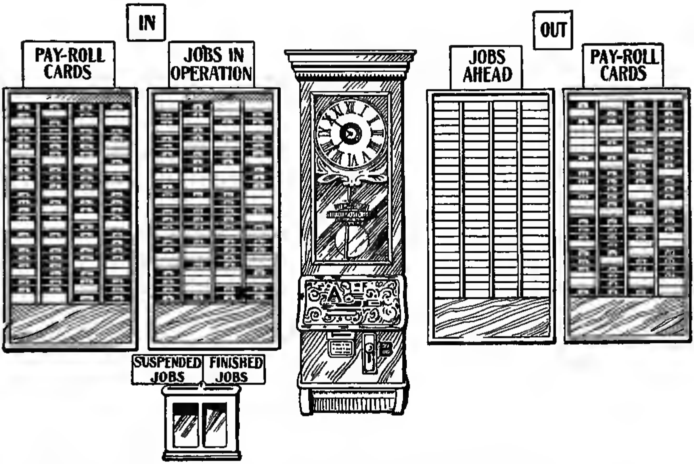
1. Enable the employee to record his own time of entering and leaving the plant, thus preventing errors on the part of timekeepers.

2. Enable the timekeeper to compute readily the number of hours each employee has to his credit, thus saving clerical work in making up the pay-rolls.

3. Prevent employees from entering the departments after starting time and leaving before quitting time.

These clocks are often used in connection with a shop cost system, and have proven very satisfactory. (See Fig. 28.)

According to this scheme a card is made out once every week or two weeks for each man. The man gets a numbered card, which is placed in the rack "out" before he enters the plant. When he goes to his department he inserts the card into the slot *A*, depresses the knob *B*, which records his time of entering. The card is then placed on the "in" rack. When he leaves the plant he takes the card from the "in" rack, goes through a similar process, and records his leaving time, after which he places it in the "out" rack. This card at the end of the week, two weeks, or half month, records the total number of hours he was within the plant, and all latenesses or irregular leaving are stamped in red ink, thus calling attention at once to his delinquencies. At the end of every day, the timekeeper enters the daily hours in the total column, so that at the end of the period the cards can readily be made up and each man given his wages from the record. In many cases the back of the card is used as a check, so that the payment is made by merely having the paymaster and foreman sign and countersign the back of it. In any case, the cards for each man are kept and filed under his name, thus giving a truthful record of his regularity as a worker, truthful because it shows him by his own actions and not by a report of opinions.



By courtesy of International Time Recording Co., Endicott, N. Y.

FIG. 28.—Recording Clock with Cost Equipment. Each clock can conveniently keep record of two hundred people.

The recording clocks help in making out the pay-rolls, and in keeping accurate record of the men passing in and out of the plant; but if the time scheme does only this, the firm has a very poor system. Good accounting demands that no plan is complete unless it can be verified automatically from independent sources. Moreover, one should know not only that a man has been present during a certain period, but also that he was an efficient worker while he was present. His efficiency can be determined by knowing what he has done with the time recorded on his time card.

Several schemes may be cited by which a record is kept of a man's actions while within the plant.

1. Send a timekeeper around every day to get from the workmen the time they expend on each job or contract.

2. Have the man list on a card his tasks from the beginning to the end of the day.

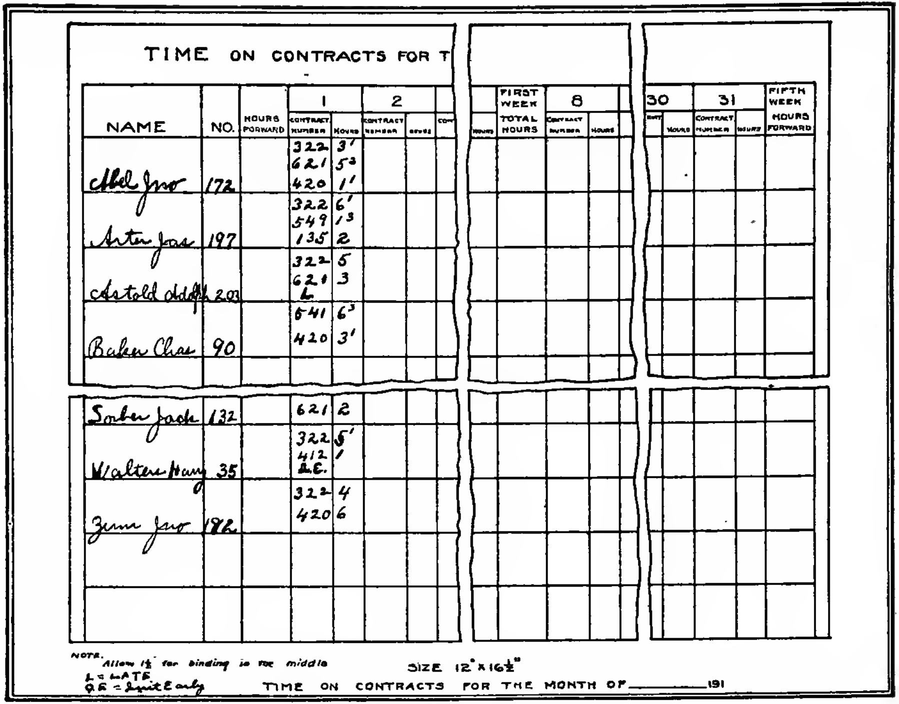
3. Have the man record on separate slips of paper for each contract the hours he spent on each particular job.

4. Have the office attach to each job, or piece of material, a tag on which the workman records his name or number and the time for his operation.

5. Have a multiple part tag attached by the office, so made that as each operation is completed, the workman tears off a portion on which is stated his operation, number, and time elapsed.

6. Have the office make out a slip for each operation to be performed on every piece of work for every contract. In this case the man is allotted the work, and the time is stamped when he is given the paper. When he returns it, it is again stamped, and the elapsed hours and minutes will show his time on the job. Another slip is immediately given him, so that he has mapped out for him his entire work.

In the first scheme, the timekeeper is sent around to enter in a book the time each man spends on each contract. (See Fig. 29.) The time allotted to each contract may be quite



TIME ON CONTRACTS FOR T

NAME	NO.	HOURS FORWARD	1 CONTRACT NUMBER	1 HOURS	2 CONTRACT NUMBER	2 HOURS	CON	HOURS	FIRST WEEK TOTAL HOURS	8 CONTRACT NUMBER	8 HOURS		30	30 HOURS	31 CONTRACT NUMBER	31 HOURS	FIFTH WEEK HOURS FORWARD
Abel Jno	172		322 621 420	3^{1} 5^{3} 1^{1}													
Arter Jas	197		322 549 135	6^{1} 1^{3} 2													
Astold Adolph	203		322 621 L	5 3													
Baker Chas	90		641 420	6^{3} 3^{1}													
Sorber Jack	132		621	2													
Walters Harry	35		322 412 Q.E.	5^{1} 1													
Zimm Jno	186		322 420	4 6													

NOTE. Allow 1½" for binding in the middle

L = LATE

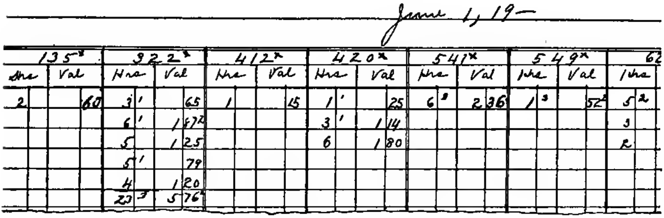
Q.E. = Quit Early

SIZE 12" × 16½"

TIME ON CONTRACTS FOR THE MONTH OF ________ 191

FIG. 29.—Workmen's Monthly Time Book.

inaccurate, especially if the shop has several contracts or different classes of orders. In one plant where this scheme was in operation, the men would give the wildest kind of guesses as to the time they spent on each job. Their only care was to see that the amounts they apportioned around equalled the total time they spent within the plant. Coupled with its inaccuracy, such a plan entails an unnecessary amount of clerical labor; because the time of each contract must be summarized on an analysis sheet (see Fig. 30) before it can be finally allotted to the individual contracts. (See Fig. 32.) This labor has been reduced to a very great extent, however, by having the time-book ruled in columns for each contract, and by inserting in their respective columns the time that the workmen expended. The footings of these columns equal the time expended on the different contracts by the end of the week. However, in places where the shop has a great many contracts the time-book increases to such large proportions, and the ruling becomes so elaborate that the columnar books become cumbersome and expensive.



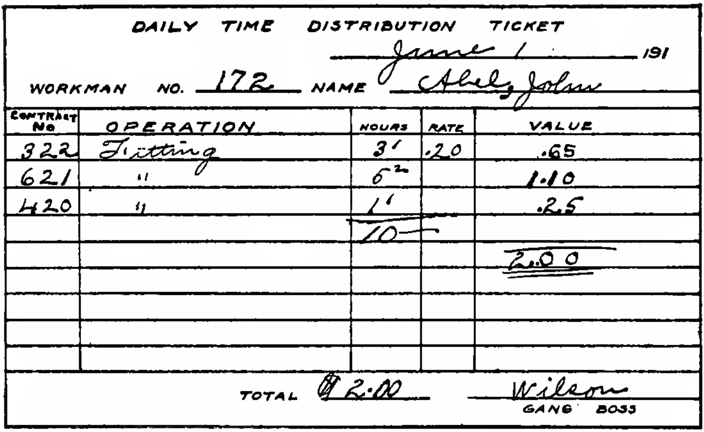
June 1, 19—

135x				322x				412x				420x				541x				549x				62	
Hrs		Val		Hrs		Val		Hrs		Val		Hrs		Val		Hrs		Val		Hrs		Val		Hrs	
2			60	3	'		65	1			15	1	'		25	6	^{3}	2	36	1	^{3}		52^{2}	5	^{2}
				6	'	1	87^{2}					3	'	1	14									3	
				5		1	25					6		1	80									2	
				5	'		79																		
				4		1	20																		
				23	^{3}	5	76^{1}																		

x Contract numbers.

FIG. 30.—Daily Analysis Sheet showing Method of Distributing Time.

The second scheme of having the men list their tasks on a card (see Fig. 31) was introduced for the purpose of making the men more careful in apportioning their time, the assumption being that if they could record their time as they completed each job they would find it just as easy to be accurate as to be inaccurate in distributing their labor by contracts. The scheme is weak in that it is almost impossible to make men record their hours as they complete their tasks. In about eight cases out of ten the men have their pencils and cards securely locked in their tool boxes during the time they are working. Toward the end of the day they make out their time, apportioning the hours very largely according to their fancy. The result of this scheme is that it is no more accurate than the first, nor does it save clerical labor, because the cards must be sorted by contracts and then totaled on separate contract sheets (see Fig. 32) before they can be recapitulated. In one respect, the card system does save time. It dispenses with the services of the timekeeper, who goes around quizzing the men.



DAILY TIME DISTRIBUTION TICKET

June 1 191

WORKMAN NO. 172 NAME Abel, John

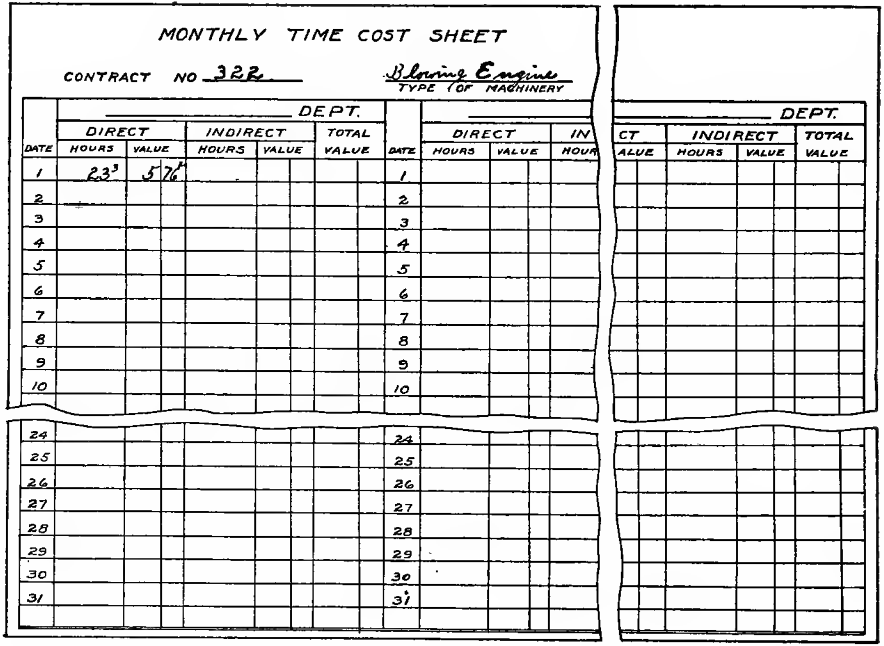
CONTRACT No	OPERATION	HOURS	RATE	VALUE
322	Fitting	3'	.20	.65
621	"	6^2		1.10
420	"	1'		.25
		10		
				2.00

TOTAL $2.00 Wilson
GANG BOSS

Size 3″ x 5″.

FIG. 31.

In the third scheme, the man makes out a separate slip of paper for each contract on which he works. (See Fig. 33.) Here the time is not apportioned any more accurately to the



MONTHLY TIME COST SHEET

CONTRACT NO 322

Blowing Engine
TYPE OF MACHINERY

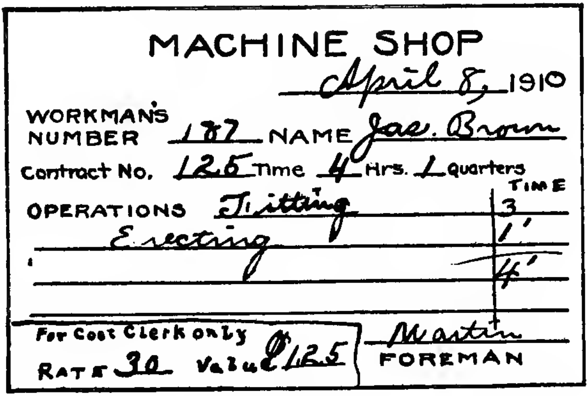
	DEPT.						DEPT.				
	DIRECT		INDIRECT		TOTAL		DIRECT		INDIRECT		TOTAL
DATE	HOURS	VALUE	HOURS	VALUE	VALUE	DATE	HOURS	VALUE	HOURS	VALUE	VALUE
1	23^{3}	5 76				1					
2						2					
3						3					
4						4					
5						5					
6						6					
7						7					
8						8					
9						9					
10						10					
24						24					
25						25					
26						26					
27						27					
28						28					
29						29					
30						30					
31						31					

NOTE
Allow 1½" for binding in the middle

SIZE 9½" x 29"

FIG. 32.

contracts. The men, as a rule, do not make any more effort to be exact in their statements because of these contract slips. The pads of slips, like the cards, are either locked in the tool boxes or are in the hands of gang bosses, who give them to the men at the end of the day. The separate slip system, however, has the advantage of saving the clerks the trouble of resorting the papers to charge properly the time to the contracts. With this scheme, the total time for each contract each day can be obtained at once by one sorting, and then by listing on the adding machine the time cost of the various operations.



MACHINE SHOP

April 8, 1910

WORKMAN'S NUMBER 187 NAME Jas. Brown

Contract No. 125 Time 4 Hrs. 1 Quarters

	TIME
OPERATIONS Fitting	3
Erecting	1'
	4'

For Cost Clerk only

RATE 30 Value $1.25

Martin
FOREMAN

Size 3″ x 5″.

FIG. 33.—Individual Contract Time Slip.

The fourth method. There are two ways in which the tag can be used, viz., not as a production order, or as a production order. According to the first scheme, as the workman gives the piece to the next person in line he puts on the tag (Fig. 34) his number and the number of hours he worked, stating the operations which he performed. This scheme tends to make the man more accurate in his statements because the tag is always with the job, and must be filled out before being handed to the next worker. It saves labor for the clerks in analyzing the time by contracts, because each tag stands for one contract only, and the total time on the tag represents the total direct labor cost of the contract up to the last operation performed. The scheme does not, however, necessarily make the men more accurate, if they desire to deceive; because with a number of contracts on their hands at the same time, some being worked upon and some awaiting their efforts, the men, especially if they are working under a premium plan or any kind of piece-rate scheme, will be tempted to allot time in such a way that the contracts do

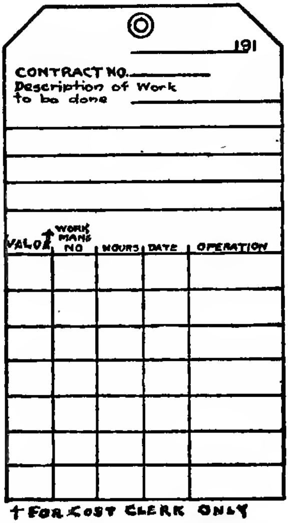
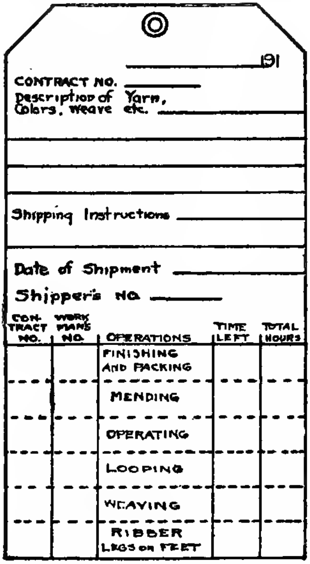


FIG. 34.—This tag is not detachable. It shows the length of time and wage cost of each operation. By sorting these tags by workman's number one can check the correctness of the recording clock or time book.

not really get charged with their proper shares of time. For instance, in one place men were paid a certain price for reaming out holes on a certain class of work. They were paid another price for reaming under other conditions. It happened that the time allotted for the first job was so very generous that in spite of the fact that the second one was actually unfair, the men never complained because both kinds of holes invariably went together, and instead of stating the exact time it took to do each class of holes they understated their actual time where they had the meager allowance, and overstated it where they had the generous one. In the long run they obtained unusually high wages, and the cost was exceedingly unfairly distributed on the work.

The multiple part tag used as a production order is arranged as in Fig. 35. Every piece of work must go through a certain number of steps or processes. If the work is standardized, regularly printed tags may be attached to each piece of material, as, for example, in a stocking factory. If the shop manufactures things which vary, the multiple part tag may be printed in blank and the steps filled in on the blank as they are performed. When a man performs his part of the task, he merely tears off the step which he performed, and then affixes his number with the hours worked. In this way the time department receives a record by contract, and likewise by men by first arranging all the slips by contracts, and summarizing them on the contract sheet (see Fig. 32), and then rearranging them by men and carrying the wages to each man's personal account. This form of tag is very good for continuous process industries or for work of a machine order. When, however, it is a question of the erecting of engines where several people work on the job at once, and where it takes some time to finish the job, the tags do not fill all the requirements, because it is difficult to enter more than one man's number on a space. For work of such a character a good scheme is to put the task under the immediate control of a gang boss who will be held responsible for carrying out the details. It is well in connection with this plan to use Scheme No. 6, wherein the workman secures from the time clerk a slip of paper indicating the task his gang boss gave him and the time when he began it. As soon as he completes the task he should be required to return the paper to the clerk, who will stamp the time returned, and the elapsed period of duration will show the length of time it took to perform the work. (See Fig. 36.)



191

CONTRACT NO.

Description of Yarn, Colors, Weave etc.

Shipping Instructions

Date of Shipment

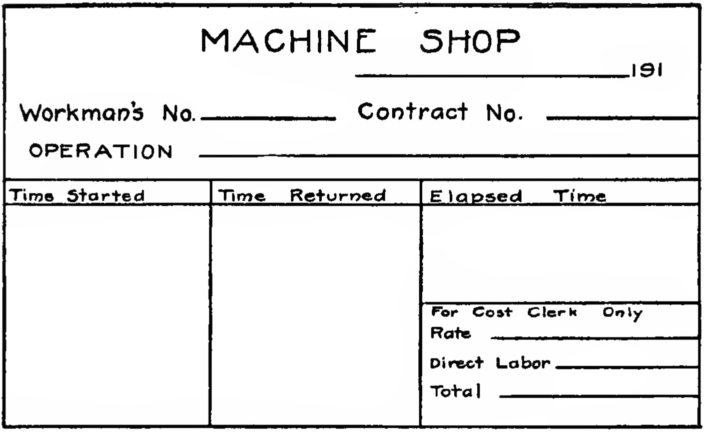
Shipper's NO.

CON-TRACT NO.	WORK MAN'S NO.	OPERATIONS	TIME LEFT	TOTAL HOURS
		FINISHING AND PACKING		
		MENDING		
		OPERATING		
		LOOPING		
		WEAVING		
		RIBBER LEGS ON FEET		

FIG. 35.—Tag detachable along dotted lines. It serves as a production order, besides showing time of each operation.

In this way, the gang boss need not keep the time nor be held responsible for its keeping. The workman cannot apportion the hours as he fancies, because he can start no task without his order slip, on which must be stamped, as he gets it, the time he received it.

In order to use any of these devices to determine the efficiency of the men it is necessary to make a record of the men. Two schemes may be used. If the work is paid on the piece basis, one of the best records of a man's efficiency is the amount of wages he draws. This record can be kept in a wage-record book (Fig. 37), where the names of all the men in each class are grouped, or an output record may be made on a separate monthly memorandum output card. (See Fig. 38.)



MACHINE SHOP

____________ 191

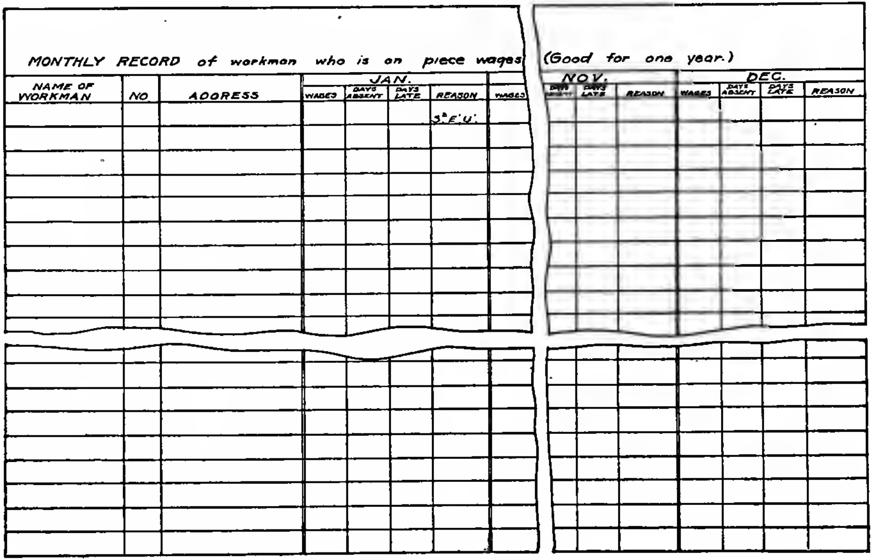
Workman's No. ________ Contract No. ________

OPERATION ________________

Time Started	Time Returned	Elapsed Time
		For Cost Clerk Only Rate ________ Direct Labor ________ Total ________

FIG. 36.—Individual Operation Time Slip for each Contract.

If, however, the man is paid on the day plan, it is necessary to standardize the tasks and compare workmen who do similar classes of work. If it is hard to standardize the tasks, as it is in the erecting of large machines, the gang bosses in charge of the erection may be charged with their labor costs (see Fig. 32), and comparative records made with other men who have worked, or are working, on similar con-



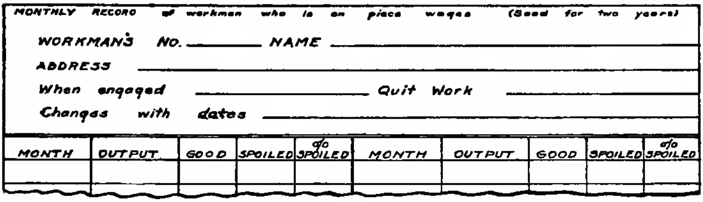
MONTHLY RECORD of workman who is on piece wages (Good for one year.)

NAME OF WORKMAN	NO	ADDRESS	JAN.					NOV.			DEC.			
			WAGES	DAYS ABSENT	DAYS LATE	REASON	WAGES	DAYS ABSENT	DAYS LATE	REASON	WAGES	DAYS ABSENT	DAYS LATE	REASON
						S²E'U'								

NOTE. S². Sickness 2 days. E'. Excused 1 day. U'. Unexcused 1 day.
Allow 1½" for binding in middle of page

SIZE 12" x 28"

tracts. The gang boss can be held responsible for too high a cost; and if an exact and definite record is kept, he can at once be notified when his costs are running high, and be asked to give the reasons for it. If there is any complaint to make against any particular men, the foreman can shift the men reported delinquent to other gang bosses; and if through several trials the labor costs increase with these workmen, proper means can then be taken to improve the labor force. This method of comparison, sometimes termed the deadly parallel, does away with elaborate records and obviates the necessity of marking systems for the individual men.



MONTHLY RECORD of workmen who is on piece wages (Good for two years)

WORKMAN'S NO. ________ NAME ____________________

ADDRESS ____________________

When engaged ____________ Quit Work ____________

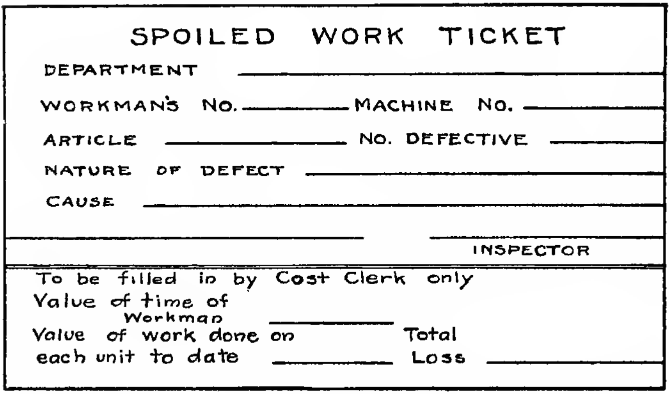
Changes with dates ____________________

MONTH	OUTPUT	GOOD	SPOILED	% SPOILED	MONTH	OUTPUT	GOOD	SPOILED	% SPOILED

FIG. 38.—Monthly Memorandum Card showing Efficiency of Piece Worker.

Some firms adopt a system of grades and marks based upon an estimate more or less accurate of what each man does, and the number of mistakes he makes. While this scheme may have some advantages, it is, for industrial enterprises, cumbersome and expensive to keep up, and it is really less satisfactory than the report system above outlined. Of course, in connection with the scheme suggested, there is an individual card kept for the workman or foreman; and if he is responsible for any destruction of material or breakage of tools it is recorded against him. (See Fig. 38.)

A good way to know accurately of a man's spoiled work and mistakes is to have a spoiled work slip made out for his work as it is spoiled. (See Fig. 39.) This should be signed by the workman and the inspector with the reasons for the rejection and the slip filed as an original record. At the end of the month the slips can be summarized, and a record made on his individual report card. (See Fig. 38.) These individual cards soon indicate to the foremen the inefficient subordinates, who should gradually be weeded out of their departments, and deserving ones promoted as opportunity occurs. Every time a change is made in relation to any man's position, it should be entered on his permanent file card. (See Fig. 40.) At the end of each year the general average of the man, as shown by his output record (Fig. 38), should be entered on the back of his Permanent Record Card filed in the Employment Bureau's office. (See Fig. 40.) This last card should not be destroyed, unless the employee is known to be dead. While he is retained in the plant, it should be filed in one drawer, and when he is released it should be taken out of the employed file and entered in the unemployed file, so that whenever a man seeks reemployment he can be at once investigated. Some firms obviate the ne-



SPOILED WORK TICKET

DEPARTMENT ______

WORKMAN'S NO. ______ MACHINE NO. ______

ARTICLE ______ NO. DEFECTIVE ______

NATURE OF DEFECT ______

CAUSE ______

______ ______

INSPECTOR

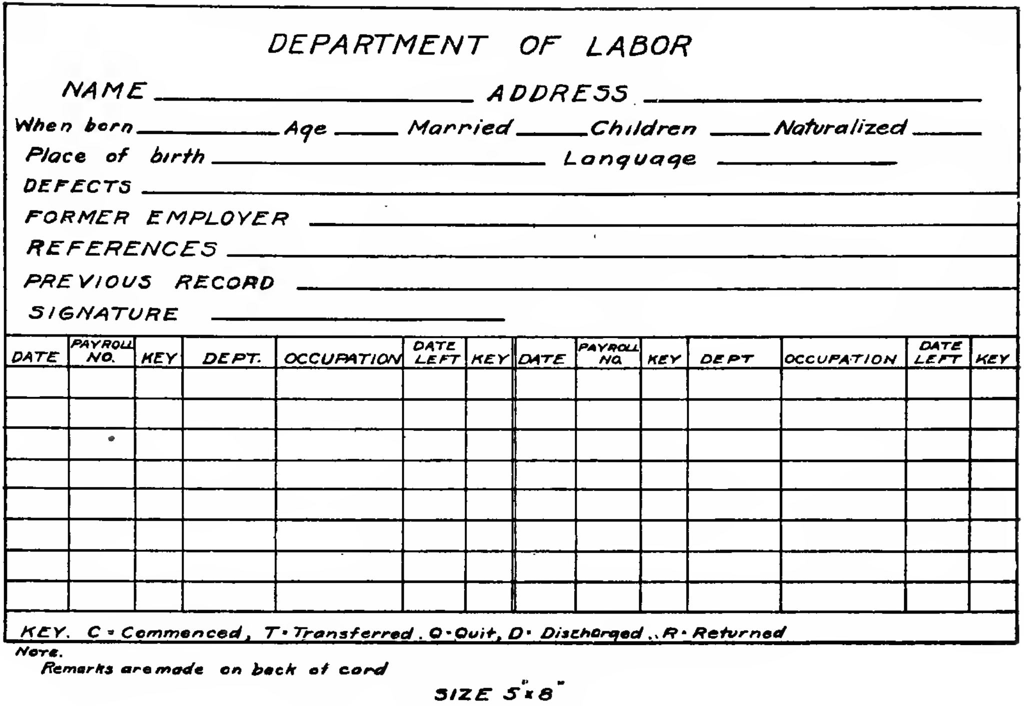
To be filled in by Cost Clerk only

Value of time of Workman ______

Value of work done on each unit to date ______ Total Loss ______

SIZE 3"x5"

FIG. 39.



DEPARTMENT OF LABOR

NAME ______ ADDRESS ______

When born ______ Age ______ Married ______ Children ______ Naturalized ______

Place of birth ______ Language ______

DEFECTS ______

FORMER EMPLOYER ______

REFERENCES ______

PREVIOUS RECORD ______

SIGNATURE ______

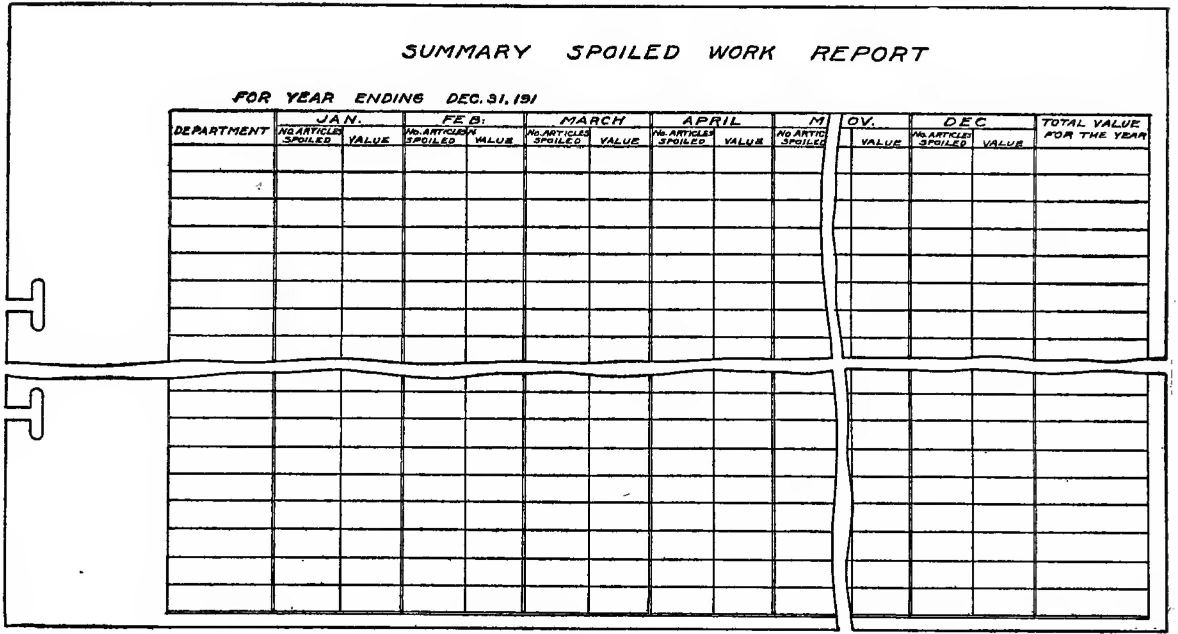
DATE	PAYROLL NO.	KEY	DEPT.	OCCUPATION	DATE LEFT	KEY	DATE	PAYROLL NO.	KEY	DEPT	OCCUPATION	DATE LEFT	KEY

KEY. C = Commenced, T = Transferred. Q = Quit, D = Discharged., R = Returned

NOTE.
Remarks are made on back of card

SIZE 5" x 8"

FIG. 40.—Permanent Record Card of Employees.



SUMMARY SPOILED WORK REPORT

FOR YEAR ENDING DEC. 31, 191

DEPARTMENT	JAN.		FEB.		MARCH		APRIL		M	OV.	DEC		TOTAL VALUE FOR THE YEAR
	No. ARTICLES SPOILED	VALUE	No. ARTICLES SPOILED	VALUE	No. ARTICLES SPOILED	VALUE	No. ARTICLES SPOILED	VALUE	No. ARTIC SPOILED	VALUE	No. ARTICLES SPOILED	VALUE	

FIG. 41.—Report summarizing Spoiled Work of Entire Plant by Departments.

cessity of copying the workman's record twice by combining the essential features of the two cards shown in Figs. 38 and 40, and filing them in the foreman's or manager's office while the men are engaged; and in event of discharge or quitting they are sent to the employment office. In this way the employment office has on file only the former employees, while the managers keep in touch with the present help. This method of handling cards has its advantages and disadvantages. It is cheaper in cards, filing space, and copying, but the cards are apt to become soiled, torn, mislaid, and even permanently lost in the general handling and passage between departments. If the employment office retains its copy at all times, then the loss of the output card in the shop is not so serious as it is when only one card is kept.

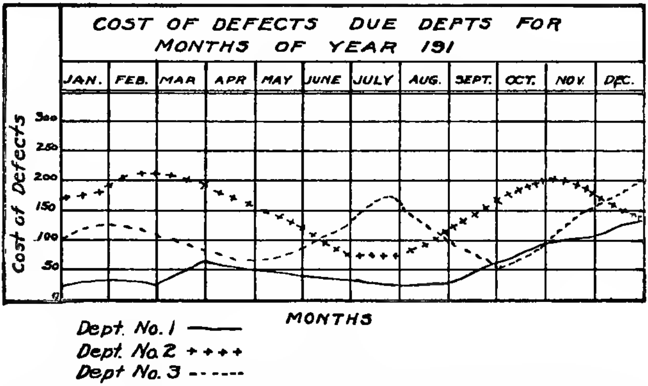
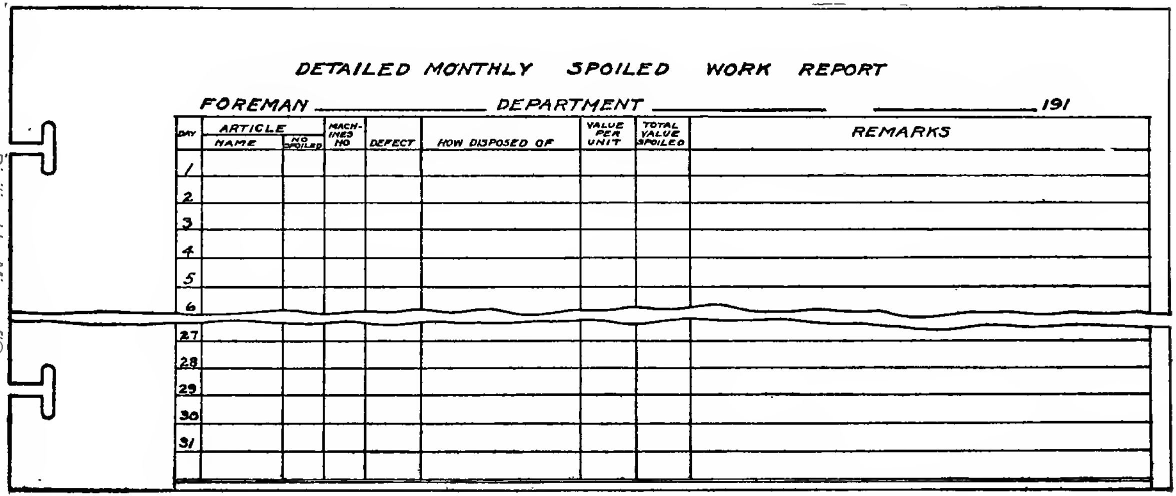


FIG. 42.—Chart of Errors showing Monthly Efficiencies of Departments.

While the manager should have a record of the efficiency of each man in the plant, that is not sufficient. He should know just how much each department wastes and loses, and what have been the causes for all losses. A foreman's efficiency is determined by his ability to prevent men from wasting time and spoiling material.



DETAILED MONTHLY SPOILED WORK REPORT

FOREMAN ____________ DEPARTMENT ____________ ____________ 191

DAY	ARTICLE		MACHINES NO	DEFECT	HOW DISPOSED OF	VALUE PER UNIT	TOTAL VALUE SPOILED	REMARKS
	NAME	NO SPOILED						
1								
2								
3								
4								
5								
6								
27								
28								
29								
30								
31								

FIG. 43.—Detailed Monthly Spoiled Work Report for each Department.

Two plans of recording defects can be used, either summarize the errors in tables (see Fig. 41), or make a chart of the defects chargeable to each department according to their number or cost, or both number and cost. (See Fig. 42.) To make the charts involves but slightly added expense above the cost of tabulation, because the information must be tabulated before it can be charted. The added advantage, however, is worth more than the increased cost; because a chart shows, at a glance, tendencies over periods of months, while the table compares for only one month at a time.

If a manager keeps these general comparative records, and if, in addition, he has a detailed record of why the losses occurred in each department (see Fig. 43), he can intelligently criticise the work of his lieutenants and can make changes which will be improvements and not mere "shake-ups."

CHAPTER XVII

RECORD OF RAW MATERIALS

In the process of manufacturing goods, two classes of material are used, direct and indirect materials. The direct are those which go into the manufacturing of a product, and stay with it when it is in its marketable form. The indirect are goods used in the process of manufacturing, but which never become a part of the product. In making a desk, for instance, lumber, nails, varnish, rotten stone, sand paper, polishing cloth, and other materials are used. The lumber, nails, and locks are part of the desk when finished; while the rotten stone, sand paper, and polishing cloths though necessary in order to put a beautiful finish on the desk, do not appear as part of it when ready for the consumer.

In making an engine it is necessary to use iron, steel, brass, and other metals, and also molds, oils, waste, and other materials which are quite as necessary as are the steel, iron, and brass, although they appear nowhere in the make-up of the engine.

Good management insists upon two things regarding raw materials:

1. The greatest care possible should be exercised in preventing waste and losses on direct material.

2. The greatest possible economy to prevent undue expenditures for the indirect materials.

To secure maximum economy in materials it is necessary to:

1. Purchase them from the lowest-priced firms when goods are at their lowest prices.

2. See that the material comes up to the contracted standard of excellence in quality.
3. See that the quantity purchased is obtained.
4. See that the goods are delivered at the specified time.
5. See that they are properly housed and stored.
6. See that there is no unnecessary waste in the plant.
7. See that no losses can occur, except through waste.

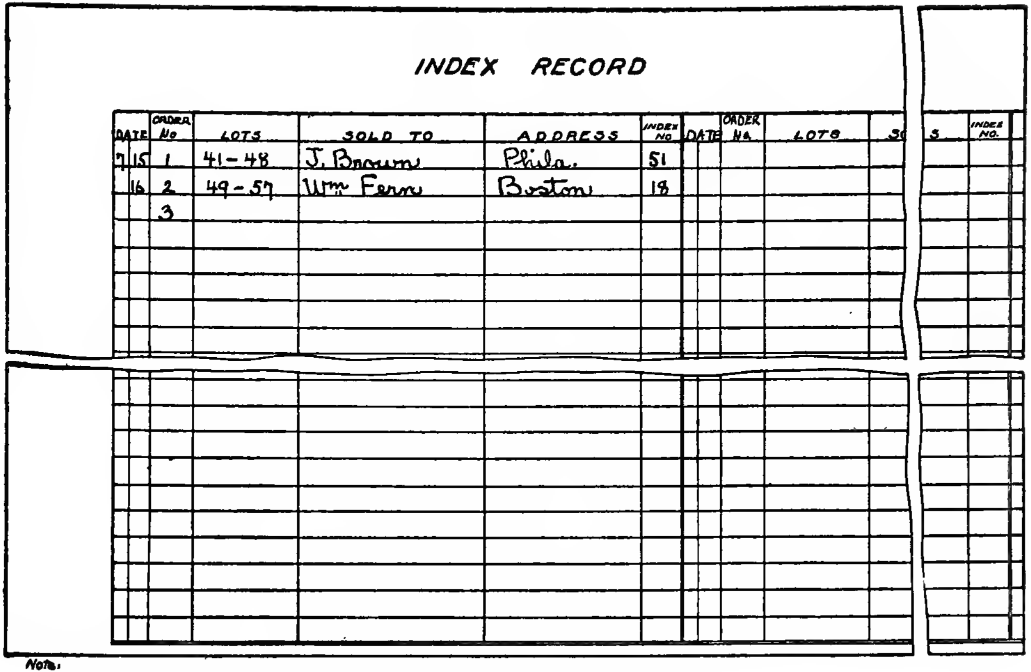
In order to accomplish these seven ends it is necessary to have a complete record of the most reasonable supply firms, to know the best time to purchase goods, and to have an exact checking system.

1. To attain the first aim, the purchasing department should be in constant touch with the market from which the raw materials are obtained. In small concerns, some member should gather information as to the causes that influence the prices of raw materials. He should find out the seasons when they are cheapest, should know the prices of the various usable qualities, and keep himself informed as to weather conditions, crop failures, and other causes likely to affect prices. The firm should also take advantage of the market, e.g., if a cotton manufacturer finds that he can purchase his cotton most advantageously during a certain month in the year, he should arrange his finances so that he can acquire his cotton at that time, but he should probably not purchase an entire year's stock of raw material during a single month or so, and then pay storage on his purchased goods and interest on the money used to secure them.

Most companies have a regular purchasing agent or purchasing department to look after securing supplies. In some concerns, a very strict account is kept of the price quotations for every day in the year; and in some cases, the price changes are charted on squared paper, and curves are plotted showing price movements for each day of the year. For most lines of material, and for all ordinary businesses, such a scheme is unnecessary. Some goods have higher prices during some seasons than others, and the management of the plant should endeavor to buy during the favorable time, although if he must borrow funds, the price he pays for his goods will be the market price plus interest, as well as storage and insurance.

2. Quite as important as purchasing the material at the right time and at the lowest possible price is to have some scheme by which one can be certain of purchasing the most useful quality of material. The common plan is for the purchasing department to establish standards for all of the materials to be purchased, and then have all goods tested before acceptance. Many large concerns have well-equipped laboratories that establish standards and test all purchased materials in order to see that they fulfil the terms of the specifications. In many branches of work it is not only desirable to make a preliminary test of the material, but also to keep track of the material while it is going through the plant, and to test the finished product of which it becomes a part. This is especially important for plants having no special department for testing materials and such goods as are hard to standardize.

It is not difficult to keep track of materials. A continuous industry plant, which manufactures several styles and grades of some textile material, can keep record of the raw material which goes into the various lots of goods by numbering the lots and recording specifically the material charged to these lots. Whoever buys the finished product will have the lot number recorded against his name. If the finished product from this raw material should turn out to be bad, or to be unsatisfactory to the customers either in wearing qualities or in other respects, they will report to the manufacturer who is able to tell, by turning to the Index Record (Fig. 44), which shows the customer's name and lot number, what raw goods proved to be unsatisfactory, and, as he keeps a record of his purchases, he is able to tell from



INDEX RECORD

DATE	ORDER No	LOTS	SOLD TO	ADDRESS	INDEX No	DATE	ORDER No.	LOTS	SO	S	INDEX No.
7 15	1	41-48	J. Brown	Phila.	51						
16	2	49-57	Wm Fern	Boston	18						
	3										

Note: If customer finds goods defective, he reports Order No., then the Index No. corresponding to the Order No. will show on the purchase record (Fig 45) the firm which supplied the raw material.

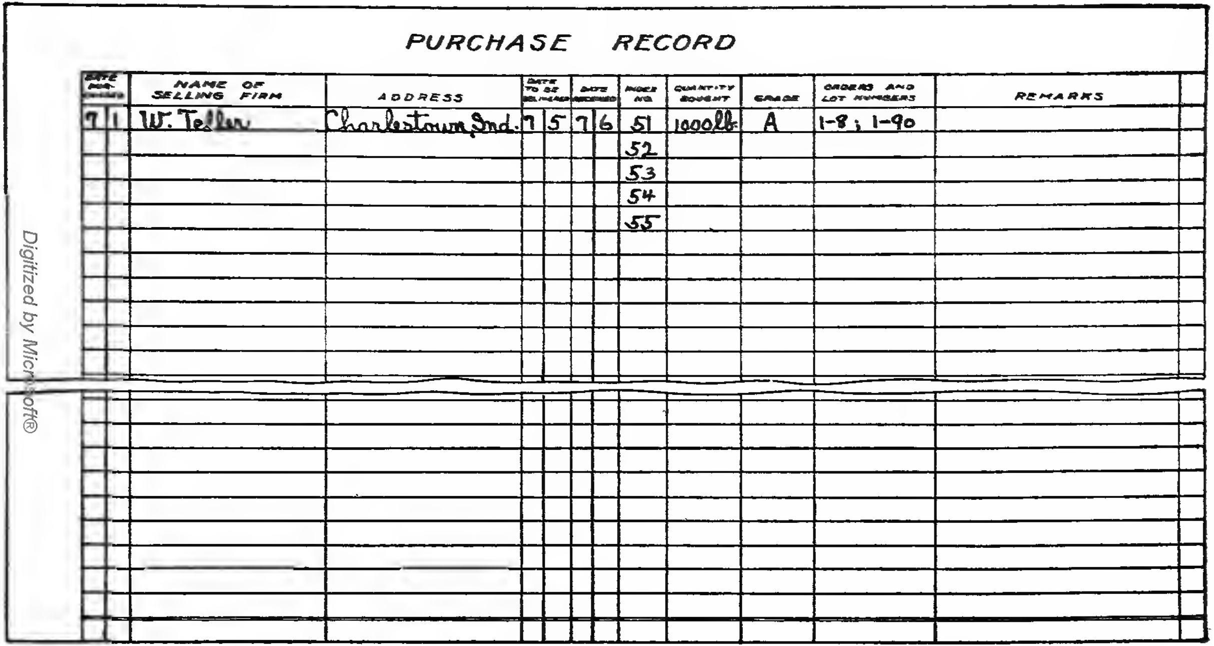
Size 15"x 12"

FIG. 44.—Index Record for keeping track of Customers and Wearing Qualities of Raw Materials.

whom he bought the unsatisfactory raw material. (See Fig. 45.)

To illustrate the records needed for an assembling industry an automobile plant may be selected. The parts of an automobile are purchased from widely different sources. If the product should prove unsatisfactory, the manager will hear specific complaints in the form of objections about some particular parts of the machine. If the defect is real, investigation will soon show whether it is due to faulty material or to workmanship, and if proper records are kept of the source of the former, it is not hard to discover where the fault lies. The fact that the material is bought from widely different sources does not offer any serious objection, because the firm, as a rule, buys the same parts from a very limited number of firms, e.g., the engines and engine parts will come from one or two firms, and their products have characteristics which soon betray their origin.

3. See that the quantity purchased is obtained. One of the most fruitful causes of losses in large concerns which do not have a good receiving system is shortness in weight or amount due either to mistakes or open dishonesty on the part of their employees and others. In order to see that the firm gets all the goods for which it pays, the usual plan is to establish a store-room and to let the order go through the following routine: Have the purchasing department make out the items in triplicate on a special blank, sending one copy to the firm from which they order, one to the receiving department, and retaining one on their own files. When the consignment arrives, the man in the store-room should be compelled to take his copy of the order, compare it with the invoice, and then check the actual items of the invoice against the goods received, sign the two slips, and send them up to the purchasing department, where they are checked against the purchasing department's copy, and approved. The invoice will be sent to the accounting department, which



PURCHASE RECORD

DATE PURCHASED		NAME OF SELLING FIRM	ADDRESS	DATE TO BE DELIVERED		DATE RECEIVED		INDEX NO.	QUANTITY BOUGHT	GRADE	ORDERS AND LOT NUMBERS	REMARKS	
7	1	W. Teller	Charlestown Ind.	7	5	7	6	51	1000 lb.	A	1-8; 1-90		
								52					
								53					
								54					
								55					

FIG. 45.—Purchase Record used to determine Source of Defective Raw Material.

will select the paying day and credit the firm for the amount, while the other slip will be returned to the store-room, where it will be kept on file. The store-room records should be kept in the form of some kind of perpetual inventory.

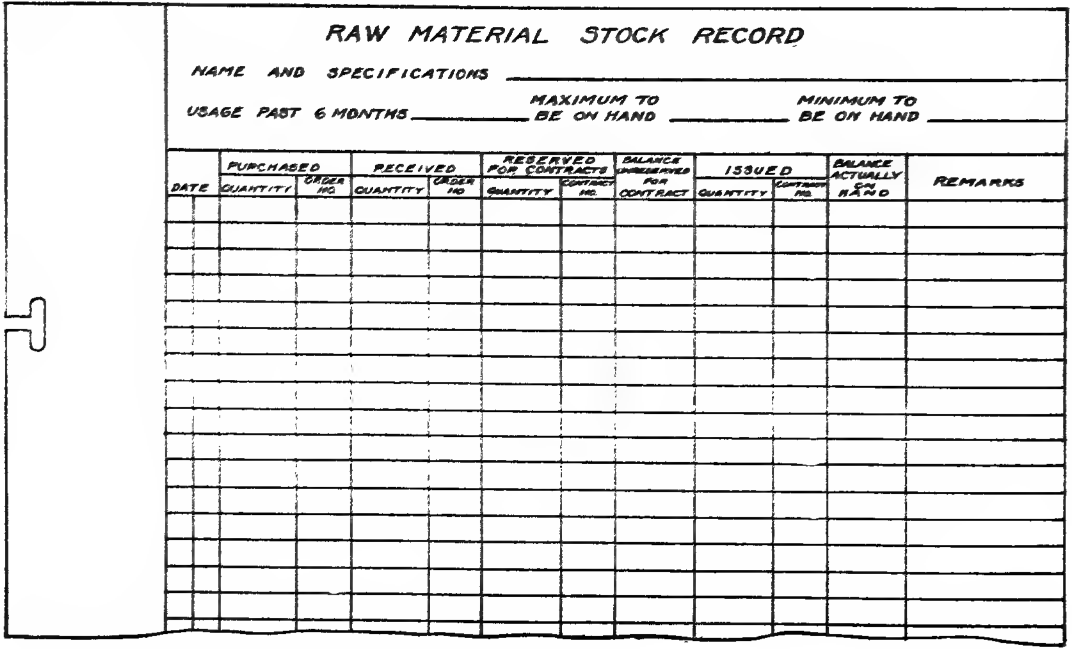
A perpetual inventory is a record which shows at once the amount and value or the amount or value of goods on hand at any time. (See Fig. 46.) To have these perpetual inventories correct, there must be kept for each class of goods:

(a) A statement of all the goods received.
(b) A statement of all goods issued.
(c) A balance of goods on hand.

The accuracy of the book inventory is tested from time to time by an actual counting and valuing of the stock on hand, and a comparison of the results obtained by this means with the balances shown on the books.

There are two methods of keeping an inventory. One is, to have all the material arranged in bins and racks, and to have in front of every bin and rack a card or tag on which is placed the amounts of materials received, with dates and the amounts taken out with their dates. Two bins are often used to simplify the keeping track of the material, one bin being used to receive goods while they are being taken from the other. When the delivering bin is emptied, it is used to receive material, while the now emptied one becomes the receiving bin. The double bin idea is good, if there is sufficient space available in the stock-room, because it lessens the accumulation of shop-worn stock.

The record tag, however, is objectionable from two standpoints. In the first place, the tags are so widely distributed that it is inconvenient to see just how the stock stands, as shown by the records. It is inadvisable to remove the tags from the bins in order to ascertain the situation, because in the meantime someone may withdraw things; and, having no slip on which to enter withdrawals, fails to make any record, with a consequent inaccuracy in the records. It also



RAW MATERIAL STOCK RECORD

NAME AND SPECIFICATIONS ____________

USAGE PAST 6 MONTHS ________ MAXIMUM TO BE ON HAND ________ MINIMUM TO BE ON HAND ________

DATE	PURCHASED		RECEIVED		RESERVED FOR CONTRACTS		BALANCE UNRESERVED FOR CONTRACT	ISSUED		BALANCE ACTUALLY ON HAND	REMARKS
	QUANTITY	ORDER NO.	QUANTITY	ORDER NO.	QUANTITY	CONTRACT NO.		QUANTITY	CONTRACT NO.		

PERPETUAL INVENTORY STOCK RECORD

SIZE 15"x10"

FIG. 46.

frequently happens that the amounts are put down on the slips carelessly, and sometimes even by unauthorized persons. Of course, this latter difficulty could be overcome by not giving access to the store-rooms to anyone who has not proper authority, or who is not responsible for goods.

An inventory without these objections is a book ruled somewhat according to the form of Fig. 46. The book is put in charge of a storekeeper or a clerk, and no irresponsible person is permitted to take anything from the store-room. Everything received is entered in the book from the invoices, and everything given out must have a properly written requisition. Both the purchasing agent's authority checked against the invoices, and the requisitions are kept until the books are audited. The difference between these two shows the book balance, and should always be represented by the actual amount of goods on hand in the stock-room. The balance can be verified by inspection; and if, for any reason, there is a discrepancy, an investigation is in order.

4. While a firm may lose much on the value of the goods purchased if it does not have a well-planned receiving department, it may lose the profit of an entire contract if the raw material does not arrive in time for use when wanted. In order to get material delivered in time, the purchasing department should be notified long enough in advance to be able to anticipate all needs. With an inventory ledger of the type shown in Fig. 46, the storekeeper has little difficulty in keeping the purchasing department informed as to when it should go into the market for more goods. Whenever the storekeeper finds his balance to be below the minimum limit, he must at once report the approaching deficiency, thus giving the buyer ample time to replenish the stock. The purchasing agent should see that the minimum limit is set sufficiently high so that the store-room will never be completely out of anything that may be needed. The usual practice is

to have the storekeeper fill out a blank, telling the kind of stock needed and the maximum and minimum amounts carried. These reports are made out in duplicate, one for the information of the purchasing department, and one to be retained by the storekeeper for his own protection. The maximum point for the stock is fixed in order to prevent overbuying.

5. After adequate provision has been made for receiving goods and reporting deficiencies in deliveries and lowness in stock, there arises the problem of the care of the material. Losses in material may be from three sources:

(a) Bad storage, which causes actual deterioration in the goods.

(b) Storage which makes it possible for unauthorized people to have access to the store-room, and to steal or pilfer materials.

(c) Losses through waste.

If goods are properly stored, the first and second of these difficulties will be reduced to a minimum. If judgment is exercised in storing material, it will be found unnecessary to exercise the same precautions over all materials. It is unnecessary in a machine shop to store the rough castings with the same care that one should exercise in storing heavy machinery, and no one would exercise the same care in storing heavy machinery that he would exhibit in storing more valuable articles, like brass ware, oil cups, electric-light bulbs, and various other similar supplies. The latter stock should be kept strictly under control, and it should be impossible for one to get any of these things without proper authority, unless by actually breaking into some room or compartment.

While rough castings may very frequently be stored out in the open, it is inadvisable to do so unless absolutely necessary. There is an instance of a concern which had made several expensive castings of hollow wheel segments and arms, which it stored in the open in such a way that the hollow arms were turned upwards. In the course of a severe winter, which had many changes in temperature, the arms became filled with water which froze solid, and split them beyond all possibility of repair, entailing a complete loss to the company. Had the foreman in charge taken the precaution to cover the openings with boards, it would have prevented the water from getting in at all.

There are certain fabric goods, such as raw wool, cotton, and yarn, which must be kept from the weather, and yet which are of such a nature that there is no necessity for taking special precautions to prevent petty thieving. Workmen have little use for these things in small quantities, because they cannot sell small lots to advantage; and, it is hard for them to dispose of large amounts, because they usually have to establish relations with people who will dispose of such materials for them. Silk, however, must be very carefully watched because of its value.

The material on hand should be studied with reference to the liability of pilfering. The storage-rooms should be so arranged with shelving and racks that the material is at all times easily accessible for inventory, and is at the same time kept from contact with vermin, overheat, dampness, or anything that will hasten the deterioration of the goods.

Besides arranging the goods so as to be available, safe from the weather and secure from theft, the storekeepers should so arrange the material that it can be found by a comparative stranger. There are two methods of doing this. One is to arrange the materials according to some alphabetical plan, as for example putting all brass work, bolts, buckets, brooms, etc., in one section; the next section following with articles beginning with C, and so on. For a small shop, where the variety of goods is not large, this scheme is sufficient. If, however, the amount of stores is large, or the variety extensive, of which some are being called for constantly while others are not so much in demand, it is wise economy for the storekeeper to put the former material close at hand, and the less used in the more remote places. When this scheme is adopted, the best plan is to number the bins in some well-recognized order, and to have an index book, which lists all the material according to name, size, and quality or other relations, and states, opposite the description, the number of the bin or section in which the listed material is to be found. Such a scheme saves much space in storing, and the goods are convenient to find and easy to handle.

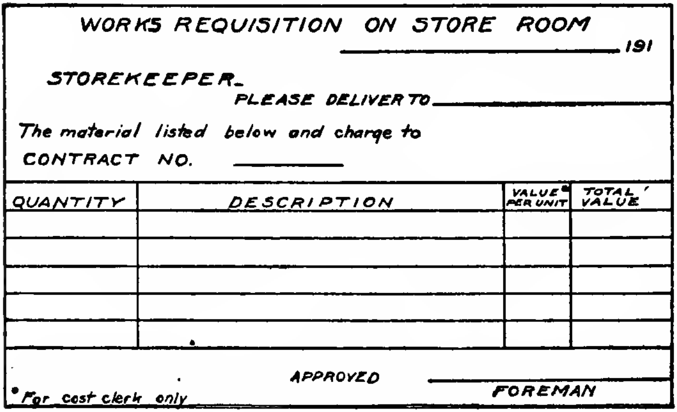
6 and 7. After the goods have been properly stored, care must be taken to prevent loss of material by unnecessary waste and theft. Both ends can be accomplished by the same method, provided precautions are taken to keep everything under the absolute control of the storekeeper, and to hold him responsible for the proper issuance of goods.

A complete record of materials taken from a store-room may be kept in two ways. One is the voucher or requisition plan, by which the person receives the goods upon the presentation of a properly authorized voucher. The other scheme, the budget system, does not permit the issuance of materials on vouchers. The two plans require explanation.

Formerly foremen and workmen found all supplies open to them for the mere asking. Many shops and mills at the present time may be found wherein the workmen need only to make an oral request, and stock will be given out without further ceremony. In such plants, the storekeeper attempts to make a record by charging the value of the material to the contract on which the workman says he is employed. The scheme is so loose that men frequently obtain many things which they do not use for their work at all. In one instance there were men working on some things which were exceedingly grimy and oily. Their hands became ingrained with the dirt. A happy accident revealed to them that the grime could readily be removed by the application of lard oil.

At some time every day, while they worked on that job, the storekeeper issued to each man about a half pint of the oil, presumably for the contract, but which they actually used to clean their hands. At that time lard oil of that quality cost about $1 a gallon.

No one who has tried the plan of unrestricted issues has found it satisfactory where the raw products possess any exchangeable or usable value, outside of the shop. Losses in stores were found to be inevitable, and it became customary to give out stores only to workmen having authority from the foreman in charge of the department, or from some other authorized agent. In order to carry out this scheme, shop accountants devised the plan of putting in the hands of the foremen regularly printed requisitions ruled much like Fig. 47.



WORKS REQUISITION ON STORE ROOM

______ 191

STOREKEEPER

PLEASE DELIVER TO ______

The material listed below and charge to

CONTRACT NO. ______

QUANTITY	DESCRIPTION	VALUE* PER UNIT	TOTAL VALUE

APPROVED ______

FOREMAN

*For cost clerk only

Size 3″ x 5″

FIG. 47.

A workman desiring anything for his job, applies to the foreman or his clerk, who fills out a blank, stating the material, with the amount which he wants given to the man, and then signs the slip. The storekeeper with this authority issues the requested goods. In small shops, where the foreman has comparatively few things to look after, this scheme can be used with excellent results. Men will not call for goods or supplies which they do not need, since the foreman, being held responsible for all goods given out over his signature, is not likely to authorize the order without good reason. When, however, a shop becomes large, the foremen are apt merely to sign their initials in approval of requisitions made out by the men. There are shops which use the requisition system with very poor results. In one plant where this scheme was in operation, the men were building some machinery which required the use of candles. One or two of the workmen found after a few trials that the foreman gave his approval without trying to remember whether the materials had been duplicated in a previous voucher, and without giving much attention to the items in the list. The O.K. mark was given in a perfunctory way, thus the workmen could get the goods by going through a mere formality. Two men every day made a regular practice of getting some half dozen candles each, which they put in their dinner pails and took home. Others obtained brass by the same method, others incandescent lamps, and the storekeeper, who would ordinarily have been able to check these losses, was unable to do so because there were, on an average, several hundred requisitions daily. It kept all the store's clerks busy delivering the amounts authorized without doing anything more, even had they felt so inclined.

In a large shop it is asking too much of the foreman to expect him to look after such leaks. His main work should be to see that the men are supplied with the equipment to do the work, that everybody is being properly employed, and that the work is going along with the least possible friction. If he is asked to do anything else, these important matters must suffer. The storekeeper can hardly be asked to pass a judicial decision as to whether or not a man should have the supplies called for on a properly authorized voucher. If he is expected to go back of the voucher, then it is he and not the foreman who really has the authority to issue goods. This would entail endless friction and needless waste of time, and would cost more than the saving would be worth. The fault is not with the men, but with the system.

Since the requisition system fails in checking losses, a number of shops have sought for some other device. The requisition system would have succeeded had it been possible to prevent orders being made out for more than the requirements of any job; because the storekeeper can be held responsible for all over-issues, though the foreman cannot. The problem was to introduce a system that could utilize the storekeeper's possibilities and obviate the need of depending upon the foreman.

In order to construct a large engine or electrical generator, engineers must carefully draw up plans months in advance, and must show to the utmost detail everything which enters into the firm's product. In these plants the great losses have occurred through the requisition system. In textile plants and continuous industry plants the voucher system has been very successful in stopping all unnecessary waste and losses. In other concerns, however, where it has not proven a success, the managers can use the very disadvantages of the work to aid their purpose. In the drawing-room after the drawings and plans are all completed, clerks go over the drawings and make lists of the material which goes into the finished product. This must be done in order to let the purchasing department or agent know just what to buy. Copies of these lists of materials are sent to the foremen of the various departments so that they may know what to prepare for in the forthcoming new work. Someone hit upon the happy device of having several copies made of the lists of materials. One of these was given to the storekeeper. The list for each contract is ruled as in Fig. 48, and is given to the store clerk with the following instructions: "Issue material to any responsible workman who calls for it, provided the goods are listed on the sheet, but take precautions to get the workman's number against every amount of goods he takes out. When the list has all those items checked off, issue no more goods unless spoiled material is returned, or some satisfactory explanation comes from the foreman over his signature as to why the extra material is needed."

This is the budget system, and it has a number of advantages.

1. It absolutely prevents stealing, because no one gets goods unless he is responsible for them.

2. It lessens waste to a remarkable degree, because any unnecessary calls for material are at once noted, and require much careful explanation as to why they are required, and men are not apt to be careless when they find their actions subjected to such close scrutiny.

3. It inevitably brings scrutiny and questioning when the loss occurs. A man cannot shift his responsibility.

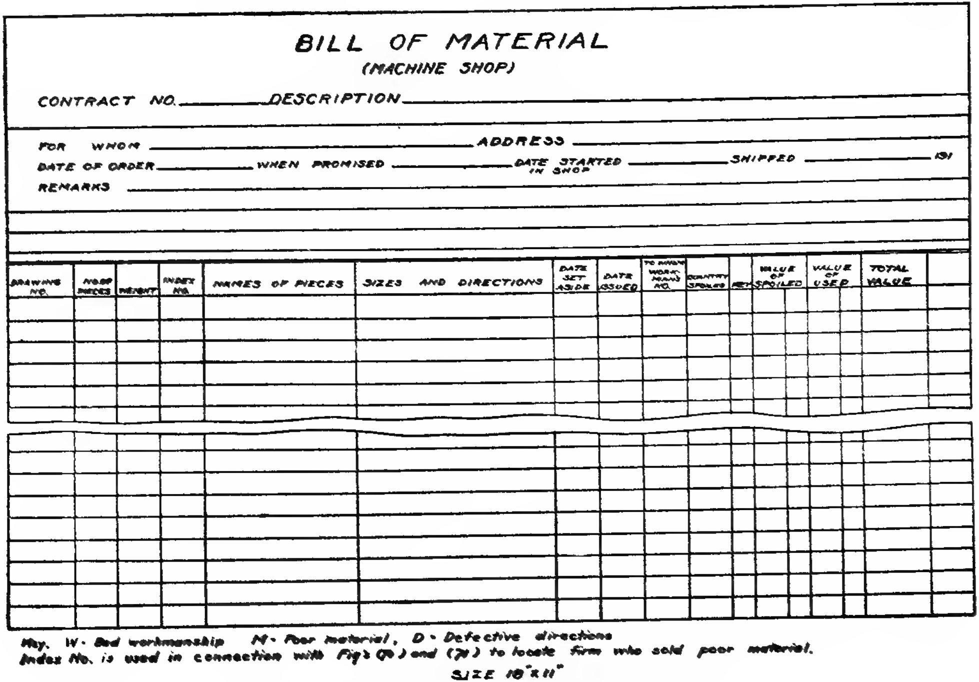
4. It enables the storekeeper to tell well in advance just what materials he needs, so he can get ready for the demands.

5. It lessens the accounting, because it eliminates the handling of the vouchers, their listing and adding at the end of every day. In fact, the storekeeper can make up his books days in advance if he so desires.

6. It enables the people in charge to keep close watch on all material, because by it one can predict what should be the condition of the stock at any time; and, if it is not in that condition on the appointed day, explanations must be made for shortage in stock or for delay in completing the contract.

To be sure, it has some disadvantages.

1. It cannot be operated successfully unless the actual



BILL OF MATERIAL
(MACHINE SHOP)

CONTRACT NO. ______ DESCRIPTION ______

FOR WHOM ______ ADDRESS ______

DATE OF ORDER ______ WHEN PROMISED ______ DATE STARTED IN SHOP ______ SHIPPED ______ 191

REMARKS ______

DRAWING NO.	NO. OF PIECES	WEIGHT	INDEX NO.	NAMES OF PIECES	SIZES AND DIRECTIONS	DATE SET ASIDE	DATE ISSUED	TO WHOM WORKMAN NO.	QUANTITY SPOILED	KEY	VALUE OF SPOILED	VALUE OF USED	TOTAL VALUE	

Key, W - Bad workmanship M - Poor material, D - Defective directions
Index No. is used in connection with Figs ([illegible]) and ([illegible]) to locate firm who sold poor material.

SIZE 10" x 11"

FIG. 48.—Budget Blank for a Machine Shop.

amounts of material needed for any undertaking can be closely estimated.

2. In special emergencies it does not work fast enough.

On account of the former defect, shop managers use a modification of the budget plan to keep a watch on materials like oil, waste, and things which cannot be definitely allotted to jobs. An approved plan in use to prevent extravagance is to issue to each man a certain amount of these materials every week, and give him no more until the next distribution day. One firm adopts the scheme of giving the floor hands a couple of pounds of waste every Saturday, and permits them to have their oil cans filled on certain scheduled days. Those who have charge of the machines are given different allotments, and are permitted to get oil at any time they desire.

In a shop where large work, made up of many parts, is being handled, or where there is a great number of regular orders going through daily, the budget system is without question the most efficient material record that can be devised. There are conditions, however, when the system becomes an annoyance and expense if literally carried out. Suppose, for an extreme instance, that an urgent repair job is brought into the shop about Saturday noon, after all the clerks and draftsmen have left until Monday morning. To wait until the complete lists of materials are made out for such a case would be stupid folly, for the plant which needs the repairs will want to be running by the time the clerks would ordinarily have the budget ready to send into the shop.

For repairs or special rush orders of any kind, a good plan to prevent loss of material and at the same time get the work out in a hurry is to give the foreman or some responsible official in charge of the departments the privilege of making special requisitions for such emergencies. After the contingency has been taken care of, the special requisitions can be assembled and the amount of used material accurately determined and priced. If, on comparing the issues and costs, as shown by these special vouchers with similar repair jobs or ordinary output, it is found that the issues have been unusually large, an investigation should be made and explanations sought. While such inquiry does not of course prevent loss or waste on a contract that has left the shops, it tells the management who is responsible for losses, and if the man at fault does not prevent future overissues, he should be discharged.

These unexpected difficulties are apt to arise at any time, and no system can be devised to take care of them all in the ordinary routine, without either delay or friction, or both. For such instances every system should provide some short cut, as above outlined. It is under these conditions that the manager proves his worth. In fact, he is not really capable of filling his position unless he knows how to make short cuts at the proper time, and just when he should modify his standard system, whatever it may be, to take care of unexpected events.

CHAPTER XVIII

RECORD OF FINISHED AND UNFINISHED GOODS

After providing for keeping track of the labor force and of the raw materials, there still remain the partly finished goods, the finished goods, and the machinery, including equipment. It is necessary to keep track of the partly finished goods for several reasons:

1. To keep the management informed as to the probable time when various goods will be ready for delivery.

2. To keep track of the approximate value of the goods at any time.

3. To determine whether departments are over or under equipped with men and machinery.

4. To enable the management to determine the value of a new contract and to localize waste in production.

First, it is necessary to know the approximate time when deliveries can be made, in order that the company may be able to satisfy customers as to its ability to deliver goods.

Second, it is highly desirable to know the value of any goods up to their particular state of completion, because it enables the management to determine what are the most expensive steps in the process, and makes it possible to determine in case of fire what his losses have been in partly finished goods.

Third, it is well to know which are the undermanned and equipped and overmanned and equipped departments with relation to each other. One cannot be too careful as to the way in which money is spent to balance the plant. If a concern does not know its strong and weak points in production, it is in danger of spending money uselessly or of giving appropriations to some well-equipped department for further improvements, which it really does not need and cannot use because of the condition of the rest of the plant. True economy does not consist in buying the latest improvements in machinery unless the whole plant is fully capable of utilizing the improvement to the best advantage.

Partly finished products give rise to a complicated problem of accounting. Goods bought at a certain price as raw material have their value constantly increased by the addition of labor, power, and of certain costs in the form of overhead expenses, insurance, reserves for depreciation, interest, and the like. One day the goods are worth little more than the raw material. A week later they may be completed. If a particular kind of product is being manufactured, various amounts of a large order are worth different values at the same time, because the material is going through in lots, so that it is not in the same state of completion at any given period.

From the standpoint of the nature of orders sent into plants, there are two kinds of manufacturing possible:

1. For a general stock from which the goods are taken as the sales are reported. Examples of this type are furnished in the making of hats, shoes, textiles, furniture, pianos, and almost all ordinary goods consumed in a community.

2. For a specific contract, as illustrated in the production of locomotives, large machinery, steamboats, and in building operations.

If it be desired to keep close watch on all the goods in the partly finished state with their degrees of completion, there must be a perpetual inventory or record of unfinished work. To accomplish this, it is necessary to carry into effect two ideas that have been found imperative elsewhere for the attainment of successful management:

1. Divide the plant into departments.

2. Use the production order and have each finished operation reported by departments to the accounting division.

The departmental method of running an organization is to divide the establishment into a number of sections. Each division is under a foreman, who is held responsible for a certain number of steps in the process of manufacture.

The production order is an instrument, or a series of instruments (see Figs. 85 and 86), made out by the central authority, presenting in written form the instructions to be followed in various departments of a plant in order to produce a given commodity. It may or may not be a part of a voucher or budget system. The production order, in its strictest sense, only tells what things shall be done; it does not necessarily keep track of material used. However, wherever a production order plan is used, it almost always combines with it some kind of a material record, and whenever the budget system is put into operation, it invariably uses some form of the production order. This instrument follows the goods through all the departments in the manufacturing process; and as they pass from one to the other, the order can be made the basis for keeping record of the work as it progresses through the plant. To do this, one need only require each manufacturing division to notify the accounting office of the number of production orders received and the amount of work expended on each order during the day. This can be done in connection with the material budget and time-check system, and in fact is usually a part of the time-record scheme.[1] In this way the officials of the concern have a constant exact record of the value of goods in the process of manufacture.

The simplest type of plant is one which manufactures a product like sugar or refined oil. The product comes into the plant in a bulk that can easily be measured, and is

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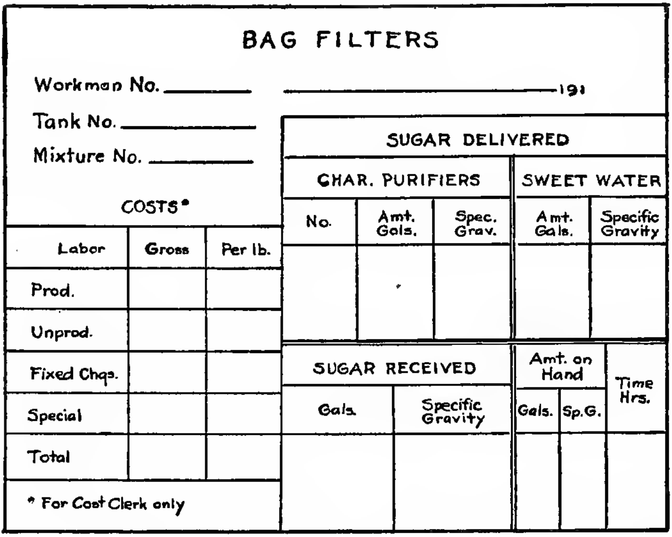
[1] See Chapter XVI.

passed from one department to the other, either by pumps or gravity. The quantities can be definitely measured, almost if not quite automatically, at the end of each step in the process by simple registering devices on the tanks, conveying tubes, or receptacles. Nothing need be handled. The only attention required is to see that the machinery is in condition. Of course, there may be wastes in the chemistry of the process; but, if these are once revealed by the scientist, the measuring gauges can be made to show their importance.



BAG FILTERS

Workman No. ________ ____________________191

Tank No. ________

Mixture No. ________

COSTS*

Labor	Gross	Per lb.
Prod.		
Unprod.		
Fixed Chgs.		
Special		
Total		

* For Cost Clerk only

SUGAR DELIVERED

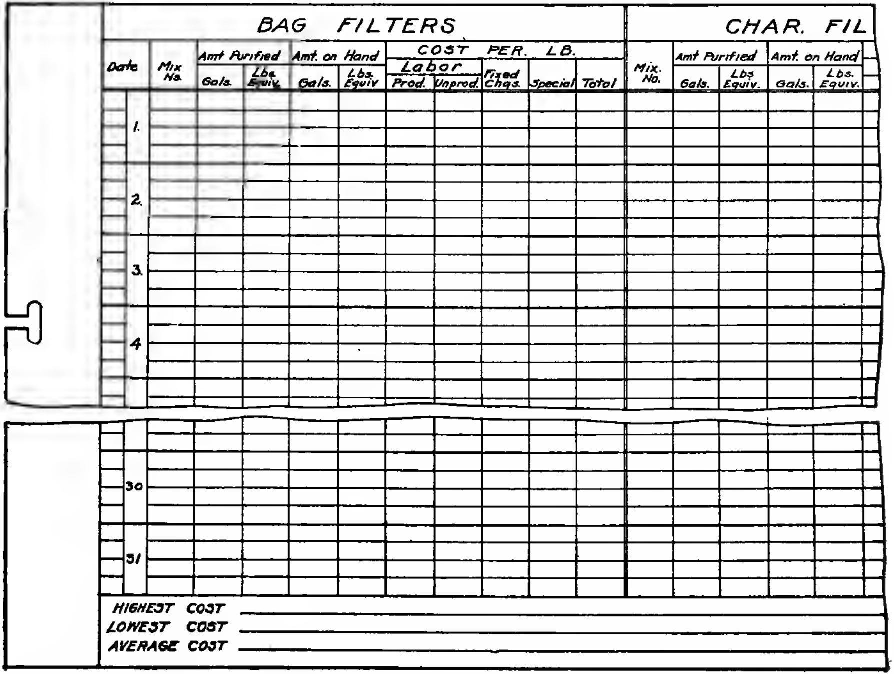
CHAR. PURIFIERS			SWEET WATER	
No.	Amt. Gals.	Spec. Grav.	Amt. Gals.	Specific Gravity

SUGAR RECEIVED		Amt. on Hand		Time Hrs.
Gals.	Specific Gravity	Gals.	Sp.G.	

FIG. 49.—Record Slip showing Amount of Goods which passed through a Department in Bulk.

In such a plant, the task resolves itself into making a permanent record of the product of each department, as shown by the weighing of the solids and the readings of the registers on the tanks, stills, boilers, and other holders of the liquids, and the length of time each amount took to pass through every particular step in the process. If these slips (see Fig. 49) for each day's work are sent to the cost clerk, he can add the direct labor cost on each portion of the product; and can apportion the percentage that the said department carries of the managerial expenses—rent, taxes, interest, depreciation, repairs, and the like, and thus determine unit costs. Each department can be required to fill out forms like Fig. 49, and, at the end of the day, send them to the cost clerk, who can enter them on a cost ledger sheet, ruled something like Fig. 50.

In a plant of this character, where nothing is sold except from general stock, it is desirable to know what has been the amount of waste in different mixtures, as well as their stage of completion within the plant. The former can be determined very readily by making note of the total amount of the various ingredients of the mixture, and noting at the end of the process the total amount of the different kinds of finished products obtained from this mixture. If accurate ledger record is kept of the material as it passes from one step of the process to the other, one can tell, by merely looking on this summary page, the amount that has been received, the amount that has passed through, and the balance on hand. One can also tell the extent of the loss that has been entailed in purifying the product to any particular degree. If, at any time, a new order should come in for a lot of material, or if a cargo of new raw material should be delivered, the manager of the plant can turn to the ledger sheets and ascertain just what is the condition of the orders under way, and how soon he can utilize the raw material awaiting his disposal, or how soon he can deliver any unusual orders. The ledger can also tell him whether or not one department is smaller in capacity than it should be to bring about the best results for the firm. In fact, the ledger, if well kept, affords just as accurate an inventory of goods in process of manufacture as of the raw materials.



BAG FILTERS											CHAR. FIL				
Date	Mix No.	Amt Purified		Amt. on Hand		COST PER LB.					Mix. No.	Amt Purified		Amt. on Hand	
						Labor									
		Gals.	Lbs. Equiv.	Gals.	Lbs. Equiv	Prod.	Unprod.	Fixed Chgs.	Special	Total		Gals.	Lbs Equiv.	Gals.	Lbs. Equiv.
1.															
2.															
3.															
4															
30															
31															

HIGHEST COST

LOWEST COST

AVERAGE COST

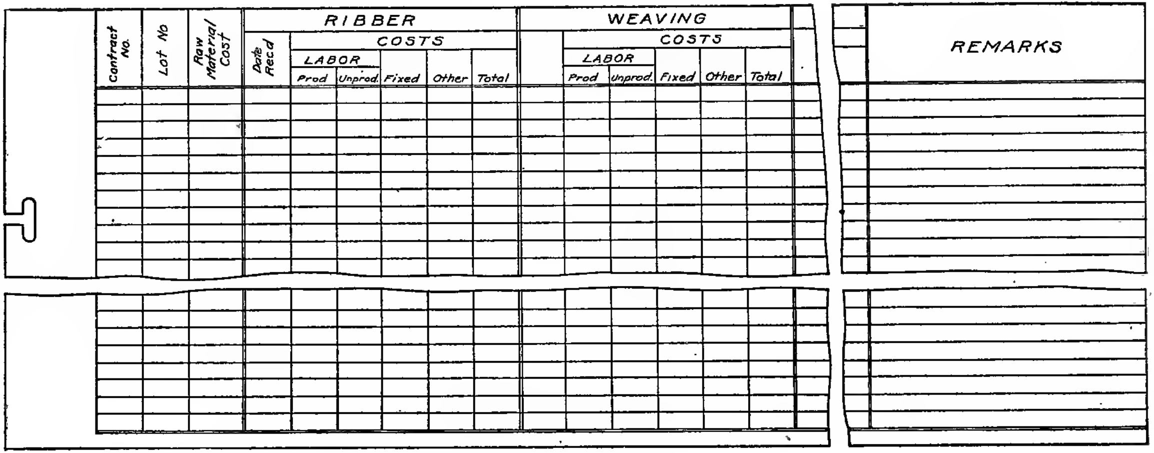
FIG. 50.—Combined Cost Ledger and Partly Finished Goods Record for Goods which pass through Departments in Bulk.

In the manufacture of hats, shoes, furniture, and similar materials, there is a more difficult problem. The product cannot be measured in bulk, and the time taken to manufacture cannot be recorded for each lot in a group way. The commodities are made up of pieces which must be handled as units, and the steps in fabrication are such that each product must be acted upon separately by the attendant at each machine.

A good way to keep account of products of this type is to pass them through the factory in small quantities. Hat factories, shoe establishments, and textile mills divide their products into lots which may include pieces of so many yards, or comprise one, two, three, or more dozens units or pairs. A production order is written out for each lot of goods, and two methods may be used to record the exact condition of the lot in the process.

1. The production order may be arranged in the form of a tag having detachable slips. (See Fig. 35.) As each operator finishes his step in the process, he detaches his portion of the tag, and sends it to the accounting department, where all tags are summarized on a partly finished goods record sheet for goods which pass through departments in lots. (See Fig. 51.) To determine what is in each department by Fig. 51, one need only note the number of lots which have been received, but which have not been passed on to another machine or step. If one of the departments has received a great number of lots and does not seem to be delivering them as rapidly as they are turned in to them, the management can at once search out the reasons, which may be lack of men, insufficient machinery, or may need more ability on the part of the foreman to get the work out.

2. According to the other scheme, a tag or slip is made out for each operation (see Fig. 36), and every day the foreman of each division makes a list of the jobs he finishes and then gives this record to the accounting department. In the



Contract No.	Lot No	Raw Material Cost	RIBBER						WEAVING								REMARKS
			Date Rec'd	COSTS						COSTS							
				LABOR						LABOR							
				Prod	Unprod.	Fixed	Other	Total		Prod	Unprod.	Fixed	Other	Total			

PARTLY FINISHED GOODS RECORD
Also used as a Cost Record

SIZE 24" x 18

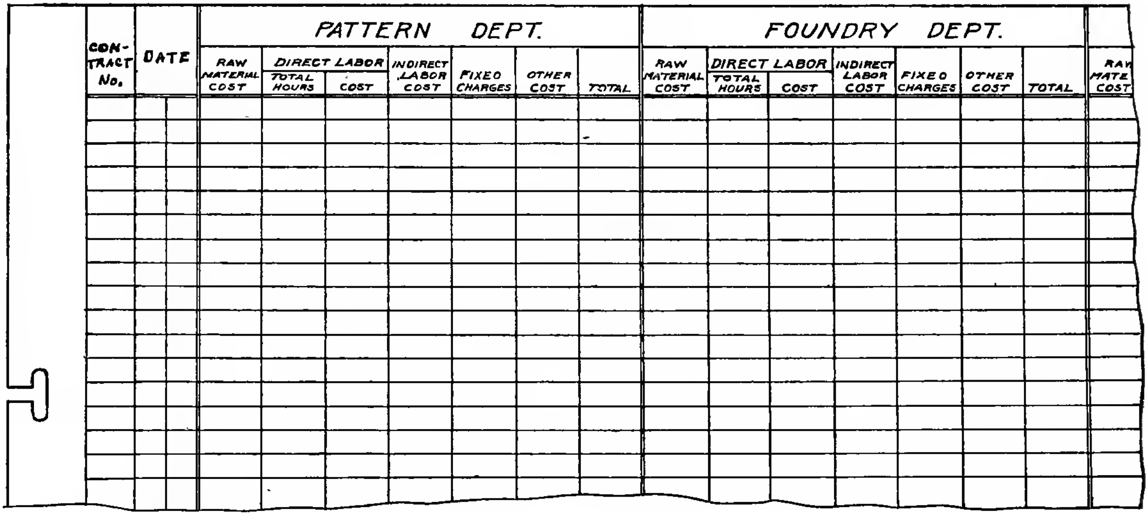
FIG. 51.—Partly Finished Goods Record. As the sheet is ruled, it can be used to keep track of special orders. If the plant does not manufacture for special orders, the column headed "Contract No." should be omitted.

accounting department these totals may be summarized on a sheet like Fig. 52. This sheet gives the head of the plant a good idea of what is going on. Some firms use this balance scheme to very good purpose. A certain large wagon manufacturer calls together all of his foremen every day, and has them list on a big blackboard their receipts from and deliveries to every other department, with their balances on hand. If any foreman is short of goods or runs below his standard amount of receipts, he records his deficiencies in red chalk. If his receipts and balances of goods are unusually large, he records them in blue chalk. The result is that each foreman knows what every one else is doing; and the manager of the plant having all the foremen together, can discuss with them why they are deficient. If anyone is to blame, the difficulty can be located at once, and remedied with remarkable lack of friction. This latter scheme of handling material can be used very effectively in assembling processes.

This chapter has advocated the use of the production order form of tag or slip, to gather the time of each contract on the summary books. (See Figs. 35 and 36.) While this is in most cases the best scheme to employ in machine shops and similar plants, these ledgers can be used in connection with other kinds of time-slips like those illustrated in Figs. 31, 33, and 34, or even with the daily contract time-book (Fig. 29).

The work of gathering the material on the ledger sheet is practically the same in each case. A ledger sheet of this character shows the length of time the work has been in each stage of the process, and gives the management some idea when it should be finished.

The general question of cost accounting is not under discussion here, but if records are kept in the manner indicated by the chapters on keeping track of the labor and keeping track of the raw material, it requires little or no added expense to fill in the column shown on these ledger sheets for



CON-TRACT No.	DATE	PATTERN DEPT.							FOUNDRY DEPT.							
		RAW MATERIAL COST	DIRECT LABOR		INDIRECT LABOR COST	FIXED CHARGES	OTHER COST	TOTAL	RAW MATERIAL COST	DIRECT LABOR		INDIRECT LABOR COST	FIXED CHARGES	OTHER COST	TOTAL	RAW MATE COST
			TOTAL HOURS	COST						TOTAL HOURS	COST					

Allow 3 inches for Remarks Column at extreme right.

FIG. 52.—Combined Partly Finished Goods Record and Cost Ledger. This sheet is for use in plants which manufacture engines and other kinds of machines for special contracts.

determining exact labor and material costs. Indirect expenses and power costs will have to be apportioned from the general books to the plant's output.

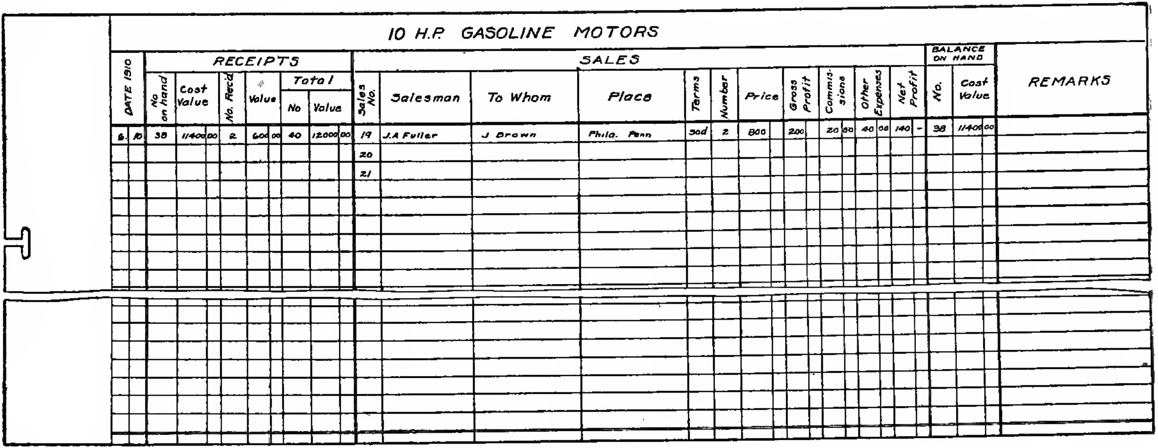
To keep track of the finished product, little need be done. In ordinary enterprises the shipping department receives all its finished goods from its own factory. Some businesses are of such a nature that the product is shipped as soon as it is completed; but where stock is kept on hand, the keeping of an inventory is quite as important. The following formula suggests an efficient method of keeping such an inventory:

[Amounts received from factory (both quantity and value) + Balance already on hand (quantity and value) + Returns (quantity and value)] — [Sales (quantity and value) + Amounts given out, but not sales, as gifts, etc. (quantity and value)] = Inventory on hand (quantity and value) or $(A + B + R) - (S + G) = I$. (See Fig. 53.)

To make any inventory thoroughly reliable, an adequate system of original records should be provided in addition to a proper summary record in the ledger. A very good plan is to have the shipping department give a receipt for every consignment of goods received from the factory. The receipt should be made out in triplicate, one copy being retained by the foreman of the factory, one by the shipping department, and the third sent to the accounting department, to be used as a basis for the ledger entries, and to be filed away for reference.

When the shipping department receives goods returned from dissatisfied customers, or from any other source than the factory, another form of receipt should be made out in triplicate, one to be sent to the customer or source from which return comes, one to be retained by the shipping department, and one to be sent to the accounting department.

The shipping department should send goods out only on receipt of an order from the sales department. The sales or-



10 H.P. GASOLINE MOTORS

DATE 1910	RECEIPTS						SALES											BALANCE ON HAND		REMARKS
	No on hand	Cost Value	No. Rec'd	Value	Total		Sales No.	Salesman	To Whom	Place	Terms	Number	Price	Gross Profit	Commis-sions	Other Expenses	Net Profit	No.	Cost Value	
					No	Value														
6. 10	38	11400 00	2	600 00	40	12000 00	19	J.A Fuller	J Brown	Phila. Penn	30d	2	800	200	20 00	40 00	140 -	38	11400 00	
							20													
							21													

SIZE 16"x18"

FIG. 53.—Combined Sales Record and Finished Goods Inventory.

ders should be made out in triplicate, the original to be retained in the sales department, duplicate and triplicate sent to the shipping clerk. The shipping clerk will fill out the order so far as possible, checking off all the items he has been able to deliver. He will file the duplicate for his own reference, taking care to notify the sales department of any inability to fill out all the requirements of any order, and will send the corrected triplicate to the accounting department, where it will be used as an original record for the ledger credits.

Ledgers of this character can be used for every kind of work. They give the management an accurate statement of the various kinds of finished product on hand at any time, and are an aid in determining future policies in manufacture. If goods are not being sold rapidly, the reasons can be investigated to ascertain whether slow sales are due to laxity on the part of the sales department, or to inferiority in manufacture. Ordinarily, a large percentage of returns indicates the latter cause, and a careful investigation will reveal the true cause of the plant's deficiency.

CHAPTER XIX

RECORD OF EQUIPMENT

THE equipment of a plant may be separated into four divisions:

1. Hand tools and machine attachments used by the workmen in the course of their work throughout the day.
2. Patterns, templets, and other forms used for special classes of work or for special occasions.
3. Drawings, records, and plans.
4. The power machinery which makes goods under the direction of the workmen.

In keeping track of each of these four classes of material, a different principle is involved. The tools of the first class are used constantly, and to keep track of them, they must be put in a place convenient for the workmen. The tools should be so arranged in the tool-room that anyone can find them at once, even if he is a comparative stranger to the room, and the system of accounting for stock must enable the storekeeper at any time to tell who has a tool out.

As has already been stated, the best situation for the tool-room is near the center of the shop. If, however, there is any great difference in the rate of wages paid to the men, it will be cheaper to place the tool-room nearer to the machines at the section of the shop where the most skilful and expensive labor is situated. Frequently, however, the highly paid workers have one or more helpers, so our rule will again have to be modified. It is the workmen who have no helpers, and yet are highly paid that should be nearest the tool-room.

1. To keep track of the tools within a tool-room in such a way that anyone can find them is not so difficult a task as

it might seem. In a plant like a textile establishment which has really little if any need for hand tools, the tool-room is small and unimportant, and almost any system suffices that makes it possible to know who have possession of the tools; but in a machine shop where there are a great many small tools and attachments for machines, hammers, chisels, drills, wrenches, taps, dies, gauges, and a hundred other different kinds of instruments constantly in greater or less demand, a convenient system must not depend upon the memory of any one or of several individuals.

Two systems are in general use to keep track of materials in machine shops:

(a) The tools may be arranged in classes and groups. By this scheme, all cutting tools are kept together in the cutting class, the machine cutters being put in a group by themselves, while the hand-cutting tools are grouped separately. Within these groups the tools are arranged according to their use. If they bore holes, they go under boring cutters; if they cut grooves or flat surfaces, they are plane-cutters. They are also arranged in order of sizes. One firm carries out this scheme to a very elaborate extent.

The tools in the tool-room should be kept in good condition by the tool-shop. The workmen should be relieved of the necessity of grinding or caring for them. There should always be a large supply of the more commonly used tools, and at no time should a workman fail to obtain a tool when wanted. There should be no red tape necessary to get a tool. The workman should be held responsible for a tool after he has received it, but should not be put to any unnecessary trouble to get it.

According to the plan outlined, accuracy in record and availability for use can be achieved by stamping on the tools their proper letters, so that one, even a stranger, need only look for the drawer or compartment bearing the same letters, in order to put them away in their proper place.

(b) The other scheme is to classify tools by numbers instead of by letters or any mnemonic sign. According to this plan, every tool is indexed, and a person desiring a particular one, turns to the index, finds its number, and goes to the corresponding case or drawer. There is little difference in the principles of the two schemes. Both permit the tools most generally used to be stored in convenient places, and they also keep all tools of the same class together.

Quite as important as being able to find the tools in the tool-room is the ability to tell where the tool is in the shop. Many tools are used intermittently, and numerous duplicates are unnecessary. Large wrenches are required on big jobs, but even the largest shops do not need to have many duplicates, provided the tool-room clerk is able to tell where a tool is at any time. A good device is to give the workman a set of brass checks stamped with his number, so that the tool clerk may put a check in place of the tool which the workman has secured. This check acts as a receipt for the tool, and is not to be returned to the workman unless he delivers the tool to the clerk. If a workman calls for a tool not on hand, the tool clerk can promptly tell who in the shop has it. The workman may then borrow the tool, or leave his check with the toolkeeper, get the other man's check and exchange it for the tool. The second workman might also go directly to the first man and exchange a check for the tool. The next time the first workman goes to the tool-room he can exchange this check for his own.

By this simple scheme shops can keep track of all tools while out of the tool-room. With the check system, workmen can be made to deliver all borrowed tools before they permanently leave the plant, because they can be compelled to return a full complement of checks before they will be given a clearance paper from the tool-room.

The system indicates who has any particular tool out at any time, but it does not show how many tools any particular workman has. If it is desirable to keep track of this, the tool clerk can have a list of the workmen's numbers, and enter therein the numbers of the tools each workman takes out. There are so few advantages, however, in having this information that it is seldom, if ever, recorded. In some cases expensive or special tools, as a diamond-cutter, may require a special receipt from the workman, but otherwise the tool-room clerk can keep sufficiently close watch on the tools a man has out by keeping record of the checks a workman has lost, and by noting his calls for any tools which would be unusual for his particular work in the shop. If the man is about to leave and has lost checks, the clerk need merely refer to his memorandum, and insist that all other checks be accounted for by tools. This may seem a free and easy method for one to keep track of thousands of tools and hundreds of workmen; but, as a matter of fact, the fine that is attached to the loss of checks makes it unprofitable for a man to take tools which are not extremely valuable in their nature, and in those cases the special receipt is ample protection.

Besides keeping the tools convenient to the men and keeping track of them in the tool-room and in the shop, the tool department should be able to report to the management the kinds and makes of the most serviceable and profitable tools. A convenient and reliable scheme is to have stamped on the shank of the tool, or in some inconspicuous part, the date of its purchase and the cost mark; and, if it is not already there, the name of the firm which made it. If this plan is followed and care is taken to issue the tools under comparison, an equal number of times, the management can soon tell which makes are proving the most efficient and economical. It can also determine from this record what is still more important: the actual expenses connected with the tool department and what classes of work are the most expensive users of tools.

2. The second class of equipment—patterns, jigs, templets, and other forms and guides for the workmen—are not important in many lines of manufacturing. In many others, however, they are used almost continuously. In some classes of production the forms or patterns must be renewed every year or so, not because they are worn out, nor because the firm ceases to manufacture goods of a similar grade, but simply because the whim of fashion has called for something else a little different in shape or form. In the shoe industry the question of lasts is troublesome. Some factories sell their lasts to concerns that manufacture a cheaper or lower grade of shoe, and hence do not cater to the more fastidious public. Even when lasts are sold, they are sold at a loss to the concern. Eventually every shoe manufacturer must sacrifice a great deal of money yearly through the discontinuance of certain styles and the introduction of others. Great as this loss is in total amount, it does not put a heavy burden on any one pair of shoes, because a concern manufactures thousands of pairs in a year, and the money expended upon the lasts is distributed through so many pairs of shoes, that it adds but little to the cost price of the shoe.

Other industries find patterns and forms just as essential as does the shoe industry. An engine cannot be built without using many expensive patterns and forms of various kinds, and general machine shops rapidly accumulate a large number of patterns. The drawing-room receives the specifications for all contracts, and it can make possible heavy savings in using old forms and patterns if they happen to know of previous jobs whose patterns can be adapted to the new undertaking.

It is important for the drawing-room to know just what patterns it has at any particular time. Few engines made at different times are exactly alike, yet every new engine must have a complete set of patterns, which will in all probability never be duplicated. The patterns may represent several thousands of dollars in labor and materials, and be useful for only one contract. It is not to be assumed that these patterns represent a dead loss, for, although they may never be used again as they stand, they can frequently be utilized for other orders by making alterations. Because they may be adapted to other work, manufacturing firms always keep patterns, whether the work is likely to be duplicated or not. If a plant has been in operation for some time, these patterns may accumulate to embarrassing proportions, and unless there is some system of registration for them and the drawings which they represent, duplications and partial duplications of these forms will constantly occur and occasion large losses. Companies early began to develop plans for cataloguing drawings and patterns.

3. One scheme was to classify the drawings by the number of the contract, and to list the name of each by the part of the engine it represented. Thus, a drawing of a high-pressure cylinder of the 121st contract would be entitled "high-pressure cylinder," and in some less prominent place on the sheet would be printed "Contract No. 121." The patterns would be numbered in a corresponding manner. The system is faulty, because the contract number gives no intimation as to the kind of job represented. Should it happen that the shop turns out water turbines, steam pumps, hoisting engines, blowing engines, and marine engines, Contract No. 121 might be anyone; and since patterns and drawings were filed and stored in order of the number, the disadvantages were many, but the system had in it suggestions for a better one.

Few, if any, contracts go through a drawing-room without the chief engineer and the draftsmen knowing for whom they are intended. Involuntarily the number of the contract becomes associated with the purchasing firm; and the said firm is, in nine cases out of ten, engaged in a particular business. If the company orders a blowing engine, it is in the iron business, and not likely to call for marine engines. The contract numbers become attached to the firm's work, and the firms become associated with certain classes of machinery. To the men in the drawing-room, a new order for a blowing engine calls to mind the firms which have ordered similar engines in the past, and they recall the contract numbers which have been attached to those firms. This coincidence gave rise to another system of tabulating drawings and patterns, viz.:

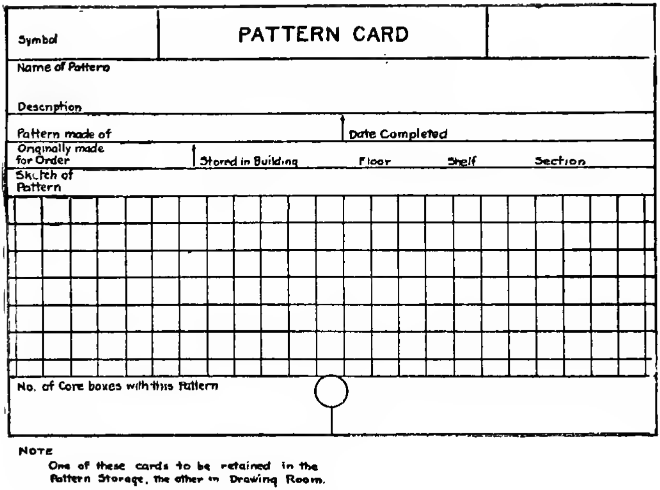
To classify alphabetically according to the names of the firms who order. This system is superior to the previous one in that it simplifies the search for drawings of machinery of a similar type, and reduces the probability of drawings being overlooked. To the older men in the office a firm's name suggests the kind of machinery it is in the habit of securing, and they involuntarily start to hunt them up when machinery of that type is reordered. Although in a moderate-sized plant the system is quite satisfactory, in a very large one it fails because new men are constantly coming in who do not know all the ordering firms, nor remember their characteristics. Besides, ordering firms at times radically change their work and call for other things, so that important drawings may be forgotten, especially if there has been any change in the administration of the engine-building company. The system tends to fail because men are compelled to remember too many names, and too much about past orders.

An effective system is to classify the machinery into groups, and give each group a distinctive number. Engines of the reciprocating marine type might all come under 500, if simple engines their number will be 510, if compound 520, triple expansion 530, and so on. Should the steam expansion of the simple engine occur in two cylinders, its number would be 512; by letting the units represent the number of cylinders, a triple expansion engine with five cylinders would be 535. The arrangement of the cylinders over each other determines the number of connecting-rods, piston-rods, cranks, housings, and the like, which the engine will require. Frequently a five-cylinder engine will have four of the cylinders arranged in pairs tandem, while the fifth will be single. An engine of that character will have three connecting-rods, three cranks, three sets of housings or their equivalent, three sets of eccentric rods; in brief, the engine will be built on a triple basis throughout. These kinds of arrangements could readily be indicated by the addition of decimals. Thus, if a quadruple expansion marine engine had six cylinders arranged—two tandem, two single, two tandem—it could be expressed 546.2112. Should there be any other characteristics that were desired to be shown, it could be done by the insertion of letters, or some other simple device. Thus, suppose the above quadruple expansion engine had surface condensers, they could be indicated by a letter "S" substituted for the decimal, thus 546S2112. A jet condenser would be shown by the substitution of a letter "J" instead of the letter "S."

A system of classification based upon this general outline possesses the advantage of giving easy accessibility to all kinds of machinery of any class made at any time. In addition to its application in the drawing-room, it can be used in the pattern storage houses.

A convenient scheme for the arrangement of the patterns is to apply the drawing-room classification to the placement of the patterns in the storage shed. The drawings above have been numbered according to a certain grouping system, which gives characteristic numbers to each class of engines or machinery manufactured, so that one can tell at once by the number what an engine is like, and much about it. If we divide up the pattern storage room on a basis of that classification, all the patterns for the engines and engine parts would be readily accessible. All engines, although they may differ widely in their design, structure, and size, have certain parts which are in the main common, as cylinders, steam chests, engine frames, bed plates, shafts, fly-wheels. The patterns may be grouped either by contracts as a whole, or by like parts of different contracts.

The first scheme has the disadvantage that patterns of small and large parts and of dissimilar pieces are likely to be piled together at the expense of good order and of storage space. If all the similar parts of the various machines are grouped together, it is easier to find the same kinds of pieces; and if the system of arrangement is made to correspond to the drawing numbers, the particular patterns can easily be located.



Symbol

PATTERN CARD

Name of Pattern

Description

Pattern made of

Date Completed

Originally made for Order

Stored in Building

Floor

Shelf

Section

Sketch of Pattern

No. of Core boxes with this Pattern

NOTE

One of these cards to be retained in the Pattern Storage, the other in Drawing Room.

FIG. 54.—Pattern Record Card. (Front.)

In addition to having the patterns accessible, it is highly desirable that the drawing-room should know the exact condition of each pattern, and where it is at any time. This can be accomplished by having filed in the drawing-room cards which give the number and complete history of each pattern, showing all alterations. Copies of the card may be kept on file in the office of the pattern storage rooms. When the pattern is taken from storage, its card may be removed from the usual filing drawer to another one, so that all the patterns in the storage shed may be in one compartment, while those in the foundry or pattern shop may be in another. (See Fig. 54.)

If, in addition to the scheme of segregating the pattern cards, to show those out of storage the plan to be adopted of requiring everyone who secures a pattern to leave a receipt countersigned by the foreman of the department to which it goes, and of filing that receipt with the pattern card, it becomes a very simple matter, indeed, to trace the pattern at any time. If any alterations have been made on the pattern, the nature of these changes may be entered on the back of the card, so that one will have a complete record of the pattern from the time it was first constructed until it is destroyed.

The principles outlined for keeping track of patterns may be carried out for keeping track of any other kind of material. Some concerns have adopted a filing scheme based on the Dewey Decimal system for their technical literature. The Engineering Experiment Station of the University of Illinois has published several pamphlets showing how the Dewey Decimal System of classification may be applied to Engineering and Architectural work.[1]

According to the Dewey system, all knowledge is sepa-

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[1] *Bulletins*, Nos. 9 and 13, University of Illinois Engineering Experiment Station, "An Extension of the Dewey Decimal System of Classification Applied to Engineering Industries," and "An Extension of the Dewey Decimal System of Classification Applied to Architecture and Building."

rated into ten classes, and each class is given one of the hundreds for a number, viz.:

000, General, including Astrology, Palmistry, and Works of a similar character.
100, Philosophy.
200, Religion.
300, Sociology and Economics, the Social Sciences.
400, Philology.
500, Natural Science.
600, Useful Arts.
700, Fine Arts.
800, Literature.
900, History.

Each of these classes is broken into nine divisions with a tenth division for general matter in the class, and each division is in turn separated into nine sections. The sections are again subdivided, and the process may be carried on indefinitely.

"To show clearly the working of the system the divisions of Class 6 (useful arts) and the sections of Division 2 of this class (engineering) are given.

600, Useful Arts.
610, Medicine.
620, Engineering.
630, Agriculture.
640, Domestic Economy.
650, Communication and Commerce.
660, Chemical Technology.
670, Manufactures.
680, Mechanic Trades.
690, Building.

620, Engineering.
621, Mechanical.
622, Mining.
623, Military.
624, Bridge and Roof.
625, Road and Railroad.
626, Canal.
627, River and Harbor.
628, Sanitary: Water Works.
629, Other Branches.

"It will be seen that the first digit gives the class; the second, the division; and the third, the section. Thus 625 indicates Section 5 (railroad engineering) of Division 2 (engineering) of Class 6 (useful arts). For convenience a decimal point is inserted after the section digit. Further subdivision is indicated by digits following the decimal point. For example, 625.2 is the number indicating rolling stock; 625.23 passenger cars; 625.24 freight cars, etc.

"*Uses and Advantages of the Classification and Index.*—The decimal classification may be used to advantage in the indexing and filing of notes and memoranda, clippings, general information, articles in technical journals, drawings, catalogues, or books. For this purpose the decimal system possesses certain important advantages over the alphabetical system.

"(1) It groups allied subjects. For example, suppose the alphabetical arrangement to be applied to a case of catalogues. The catalogues of the various machine tools, as planers, lathes, drills, hammers, etc., would be scattered throughout the case. With the decimal system, on the other hand, all these catalogues would be grouped together under the class number 621.9.

"(2) Unless an elaborate system of cross reference is used, the alphabetical scheme is ambiguous; in many cases there is doubt as to what letter should be given a subject. For example, take the item "Automatic pneumatic block signals." This might almost equally well be indexed under A, P, B or S. With the decimal system this item has its one number 656.256.4.

"(3) The decimal system has the advantage of flexibility and an indefinite capacity for extension. For the indexing of books and catalogues only the main division and sections will, in general, be found necessary; but for card indexes of technical literature the most minute subdivisions must ordinarily be used. In individual cases, the user may find that still further division is required. An extension may then be made by adding another decimal place, and if still further subdivision is required still another digit may be used.

"The average engineer, for example, can easily index all matter relating to traveling cranes under the single class number 621.872. The designer or builder of cranes may, however, have so much matter relating to this special subject that further subdivision is needed. By the addition of a digit, this matter may be divided into nine groups, designated by 621.872.1, 621.872.2, etc.; and, if necessary, each of these may be divided into nine new groups."[1]

While this system works well for the filing of books, clippings, and drawings, it has its limitations when used to ar-

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[1] *Bulletin*, No. 9, University of Illinois, Engineering Experiment Station, pp. 2 to 4.

range contracts and patterns. Manufacturing firms, as a rule, have specialized their work to such an extent that it is unnecessary for them to have any general class number like 621, to let them know their contract deals with mechanical or electrical engineering machinery. For locating patterns, such numbers are not only unnecessary in the average shop, but are confusing; hence, while the Dewey system of classification is excellent for filing all information which the firm may gather from outside sources, a simple modification like the one above suggested, may be used to advantage in cataloguing patterns and contracts.

4. In order to keep a sufficient record of machines, the management should know the following:

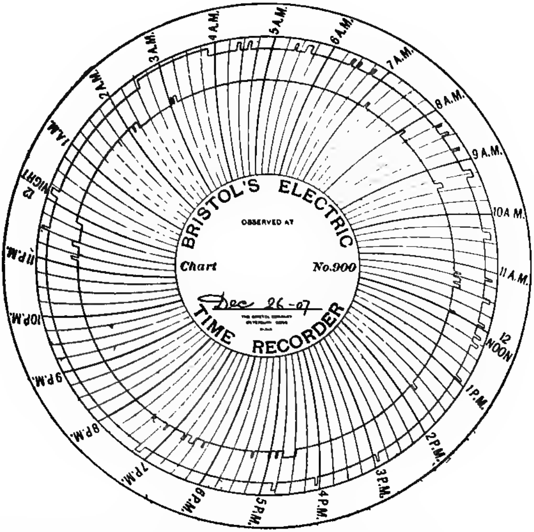
(a) Are the machines running to their full capacity all the time the workmen are attending to them?

(b) Are there sufficient machines to do the class of work required by the shop?

(c) What is the up-keep cost of the machines in repairs, lost time, etc., and the reasons for these expenses?

(d) What is the rated and real capacity of the machines?

When a company purchases a machine, the salesman is quite apt to make extravagant statements concerning the performance of the device, and the apparatus often proves to be far less efficient than one would conclude from the salesman's representation. Manufacturers have frequently been inclined to discredit salesmen's promises fifty to one hundred per cent. In many instances such action is unfair to the salesman and to themselves, because they may not have gotten the possibilities from the machine, and may blame the salesman for misrepresentation while their own workmen are at fault. The lack of output may be due to prejudice against the device on the part of the workmen, who, to prevent changes in wage rates, will not make the machine produce to its utmost. Sometimes they feel that the output from previous machines is sufficient, and that the new machine is to be considered a labor-saver, in the sense that it will save them from exerting themselves, as formerly, in order to make the old standard output. The old way of managing a shop compelled the foreman to be alert to prevent machine hands from soldiering. If the boss is familiar with all the machines in operation, he can prevent idleness to a very great extent; but it is possible to loaf on machine work, even with the best and most knowing overseers. A number of ingenious devices have been put on the market to eliminate dependence upon the foreman's knowledge. These automatic-recording devices keep track of the power used per hour, of temperatures, and of pressures at all times. In fact, one can have almost anything recorded. With them one can tell from



By courtesy of The Bristol Company, Waterbury, Conn.

Fig. 55.—Record Card of a Bristol Automatic Time Recorder Applied to Two Paper Machines, Showing All Idle Time in Twenty-four Hours.

the power and time records whether the machine is using up all the power demanded by its maximum capacity, and what is the extent of its idle time during any period.

The following figures and illustrations give an idea of the application of recording instruments to industrial conditions. Fig. 55 shows an application of it to two paper machines. Every time either of the machines stopped, the recording pen for the machine dropped toward the periphery of the card, and the duration of the idleness is shown by the length of the notch. Figs. 56 and 57 show the temperature records, "the chart No. 661, of December 15, 1908, was drawn shortly after the installation of this thermometer on our feed-water system. That of April 13, 1909, is from the same instrument. A comparison of these two will give you an idea of the improvement it is possible to affect in feed-water temperature, with the aid of a sensitive, accurate recorder."[1]

One great advantage of all these recording instruments is that no matter where the operations are carried on, the recording apparatus can be concentrated at any point. In this way it is possible to have all the records in the office of the foreman or superintendents while they are being made. Many plants, however, do not have the instruments so placed, because if they are going to get the greatest efficiency out of their men, it is well to let the workers see just what kind of a record they are making while on duty. The foremen should be around to see the men from time to time, so there is no great advantage gained by having the gauges gathered together in his office, or that of some superior official. The superintendent of a large plant has other duties than watching gauges in operation. His clerk should gather the records and call his notice to any bad reports or unusual showings which need attention. He will thus know what to investigate, and should not be troubled with the records when

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[1] *Bulletin*, No. 111, The Bristol Company, September, 1909.

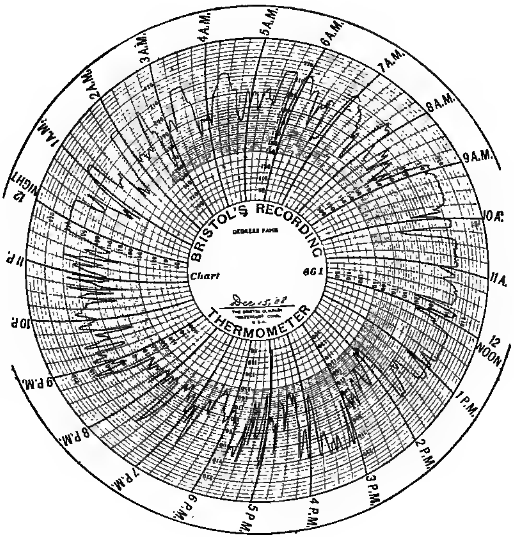


Fig. 56.

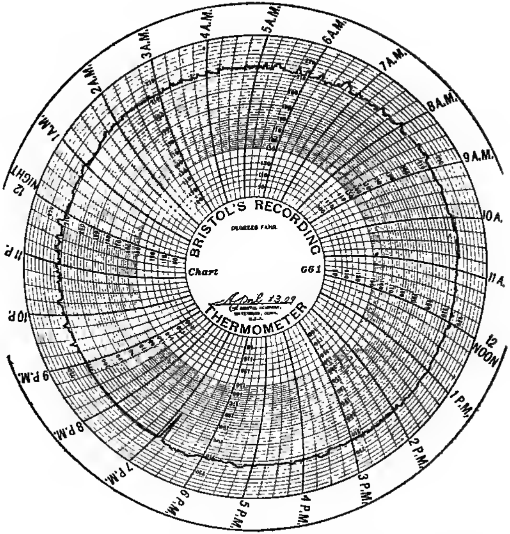


Fig. 57.

Chart of a Bristol Recording Thermometer in a Heating Plant. Fig. 56 is a record a few days after installation; Fig. 57, a record several months later. *By courtesy of The Bristol Company, Waterbury, Conn.*

everything is going as well as present methods make possible. His time under those conditions can be better employed in improving the methods in operation.

If the records kept show that machines are always running at their full capacity, it is fair to expect them to make their promised output. Not only is it necessary to see that machines are making their promised outputs, but care should be taken to see that they make it consistently throughout long lapses of time. Many firms keep daily records of machine outputs in such a way that a person can tell at a glance how the department is running. These records are frequently used in connection with other data. Mr. H. L. Gantt in 1903 published a paper, entitled "A Graphical Daily Balance in Manufacture," to show how a daily balance scheme can be used to facilitate getting work turned out by a department. The advantages of his daily balance scheme, as he presented it, are that it aids the foreman by showing him at a glance what is to be done, and what he has already done on any particular lot. In order to show this he presents some tables indicating his balance sheet scheme, which are here reproduced. (See Fig. 58.)

One will observe that this is merely a plan for keeping track of unfinished material, not unlike some previously described, but the scheme can be used to determine whether the plant is over or under supplied with any kind of machines. Indeed, Mr. Gantt, in his note at the bottom of the right of Fig. 58, calls attention to the fact that it can be so used: "This table shows the way Fig. 58 would look if the works were short of frame-drilling capacity." Any one of the schemes used to keep track of partly finished goods would likewise show any deficiencies in machine equipment, provided the foreman could prove it was not due to lack of labor or to his own insufficiency.

After a firm is satisfied that its machinery is working to its full promised capacity, and has demonstrated that it has sufficient machinery on hand to do the work required, the next question, and an exceedingly important one, is to determine which machines are really the most economical to

H. L. GANTT
Order No. 77
16 Engines, N. Y. C.

A. L. CO. PRODUCTION SHEET
Schenectady Works, Machine Shop No. 1

PART.	FRAMES.										RAILS.											
Pur. Ord.: Sketch; Pat. or Card Dr. No.																						
OPERATION	Rec'd.		Planed		Slotted.		Drilled		Assem'd		Rec'd.		Planed.		Slotted.		Re-Pl. Top.		Re-Pl. Bot.		Drilled.	
To Be Begun.																						
To Be Finished.																						
No. Wanted.	15		15		15		15		15		30		30		30		15		15		30	
No. Finished.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.	Daily.	Total.
1903.																						
Jan. 20	2	2	2	2	..	..	..	..	..	..	6	6	..	..	..	..	..	..	..	..	..	..
" 21	2	4	.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
" 22	.	.	2	4	..	..	..	..	..	..	6	12	6	6	..	..	..	..	..	..	..	..
" 23	1	5	.	..	..	..	..	..	..	..	..	..	4	10	..	..	..	..	..	..	..	..
" 24	2	7	1	5	3	3	..	..	..	..	..	..	2	12	4	4	..	..	..	..	..	..
" 26	4	11	2	7	1	4	..	..	..	..	6	18	4	16	..	..	1	1	1	1	..	..
" 27	1	12	.	..	..	.	..	..	..	..	..	..	.	..	4	8	3	4	3	4	..	..
" 28	2	14	2	9	3	7	..	..	..	..	4	22	4	20	2	10	..	..	..	..	..	..
" 29	1	15	1	10	1	8	..	..	..	..	4	26	4	24	4	14	2	6	2	6	4	4
" 30	..	..	1	11	2	10	..	..	..	..	..	..	.	..	..	..	1	7	1	7	4	8
" 31	..	..	3	14	1	11	..	..	..	..	4	30	2	26	4	18	2	9	2	9	..	..
Feb. 2	..	..	..	..	1	12	..	..	..	..	..	..	2	28	4	22	1	10	1	10	..	..
" 3	..	..	1	15	1	13	..	..	..	..	..	..	2	30	6	28	3	13	3	13	2	10
" 4	..	..	..	..	..	..	..	..	..	..	.	..	..	..	2	30	2	15	2	15	4	14
" 5	..	..	..	..	2	15		..	..	..	..	..	..	..	..	..	..	..	..	..	4	18
" 6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	24
" 7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	28
" 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
" 10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	30
" 11	..	..	..	..	..	..	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
" 12	..	..	..	..	..	..	1	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..
" 13	..	..	..	..	..	..	1	4	1	1	..	..	..	..	..	..	..	..	..	..	..	..
" 14	..	..	..	..	..	..	1	5	1	2	..	..	..	..	..	..	..	..	..	..	..	..
" 16	..	..	..	..	..	..	1	6	1	3	..	..	..	..	..	..	..	..	..	..	..	..
" 17	..	..	..	..	..	..	2	8	1	4	..	..	..	..	..	..	..	..	..	..	..	..
" 18	..	..	..	..	..	..	1	9	1	5	..	..	..	..	..	..	..	..	..	..	..	..
" 19	..	..	..	..	..	..	1	10	2	7	..	..	..	..	..	..	..	..	..	..	..	..
" 20	..	..	..	..	..	..	2	12	1	8	..	..	..	..	..	..	..	..	..	..	..	..
" 21	..	..	..	..	..	..	1	13	1	9	..	..	..	..	..	..	..	..	..	..	..	..
" 23	..	..	..	..	..	..	2	15	1	10	..	..	..	..	..	..	..	..	..	..	..	..
" 24	..	..	..	..	..	..	..	..	2	12												
" 25	..	..	..	..	..	..	..	..	1	13												
" 26	..	..	..	..	..	..	..	..	2	15												

This side shows how the table would look if the works were short of frame drilling capacity.

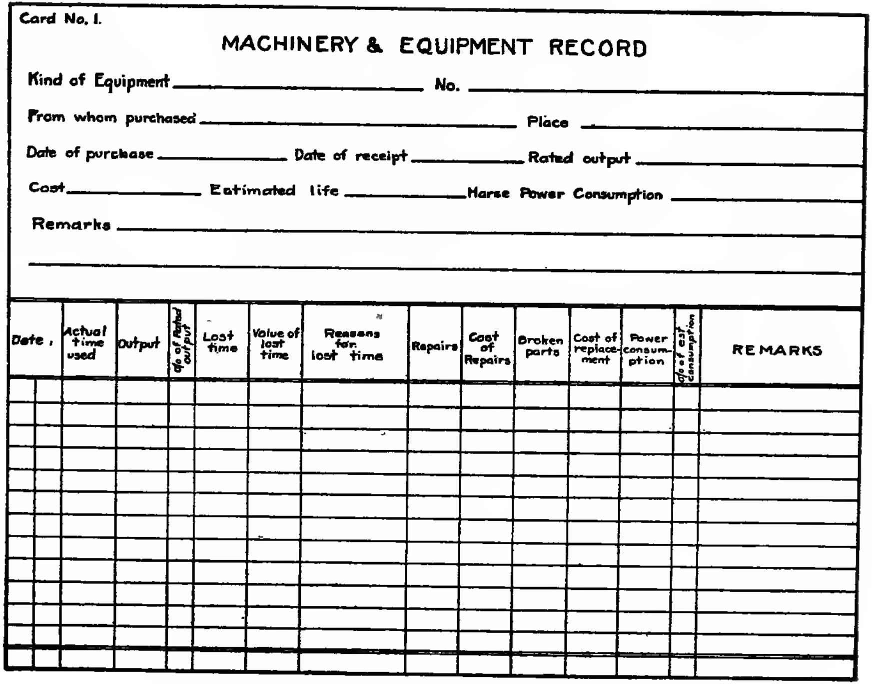
This side shows a record as actually kept.

FIG. 58.—Records Showing Output of Machines. Adapted from a Paper Given by H. L. Gantt, "A Graphical Daily Balance in Manufacture," *Transactions American Society Mechanical Engineers*, vol. xxiv, pp. 1322–36, Figs. 290, 291.

have. A large textile establishment once introduced a number of costly looms which were guaranteed to turn out a certain quantity of cloth within a given period. In testing the looms it was found that they made the output with little apparent effort, but when it came to examining the output records of the departments, it was found that the looms were not nearly so efficient as they were expected to be. It was found on investigation that the loss in output was due to lost time taken in repairing and looking after the machinery. The manager then kept a record of the amount of repairs and of lost time on the looms, and found to his amazement that they were not nearly so efficient as the ones that had been discarded. Upon further investigation he found that the operators were unfamiliar with the electrical starting devices, and through their ignorance were causing the firm a loss of hundreds of dollars. Many concerns keep records of this type for every machine in their plant, and they find the records are helpful in determining what machines are best suited to their purposes, as well as being useful in determining the repair and depreciation charges. (See Fig. 59.)

Within recent years, some important textile concerns have adopted an effective inventory scheme. A plan is made of every department of the establishment, and on it is indicated every machine or piece of equipment within the section of the plant represented. All pieces in the department are numbered, no matter how small, and are shown in the drawing. (See Fig. 60.) In addition a separate record is kept containing an accurate description of the machines, and also information relating to their prices, dates of purchases, rates of depreciation, from whom purchased, by what power driven, when and how disposed of, and the amount realized on their disposal. (See Fig. 59.)

The drawings alone present considerable information. They show the dimensions of the plant or department, and indicate the exact position of every piece of equipment, while on the same sheet with the drawing is tabulated a brief description of the machines, the number of each, the methods of driving them, and a description of the motive power. A more detailed statement of these items is entered on type-



Card No. 1.

MACHINERY & EQUIPMENT RECORD

Kind of Equipment ______ No. ______

From whom purchased ______ Place ______

Date of purchase ______ Date of receipt ______ Rated output ______

Cost ______ Estimated life ______ Horse Power Consumption ______

Remarks ______

Date ,	Actual time used	Output	% of Rated output	Lost time	Value of lost time	Reasons for lost time	Repairs	Cost of Repairs	Broken parts	Cost of replacement	Power consumption	% of est. consumption	REMARKS

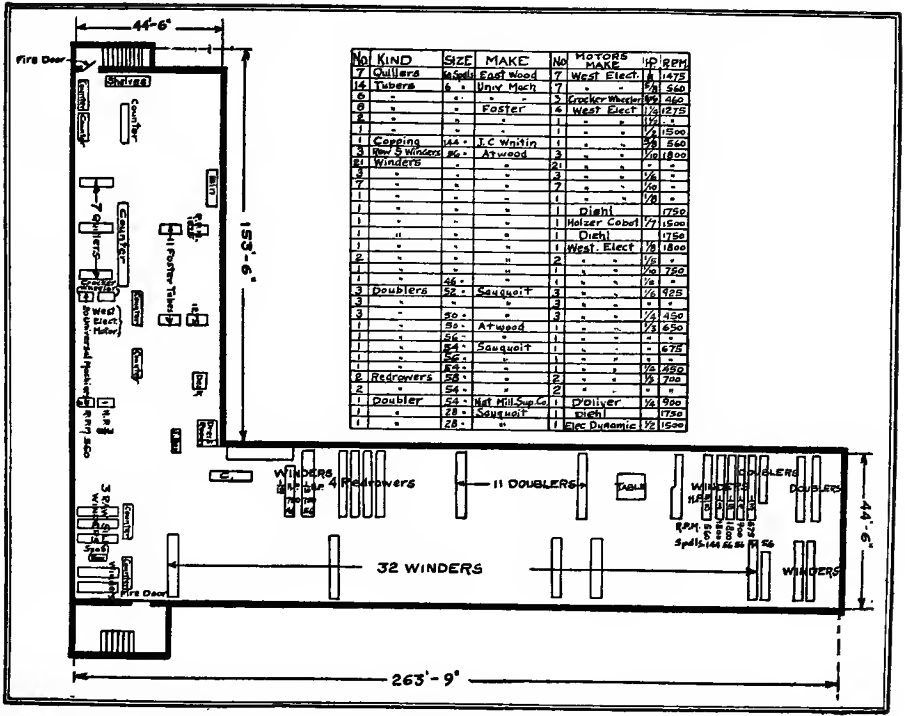
SIZE 6"×8"

FIG. 59.—Machinery and Equipment Record Card.

written sheets, which give full descriptions of the inventory. Whenever a change is made in the equipment, the drawing is altered, the table is corrected to correspond with the change, and the descriptive part of the record is corrected in order to give accurate indication of the new conditions within the plant.

Accuracy and fairness in keeping these inventory records are essential. Insurance companies prefer, at times may even insist, that they be kept by disinterested appraising firms in order to guarantee absolute trustworthiness. It is not, however, an imperative necessity for an outsider to keep such records; because fallacies may be detected from internal evidence. Save in unusual cases, machinery is acquired by purchase, a bill of sale is always given with such transactions, and the machine-manufacturing companies keep their sales records. In case of any dispute the insurance companies can refer to these records; and thus, by making proper depreciation allowances, obtain a close approximation of the value of the machinery from an independent source.

This inventory record possesses a number of advantages. Aside from its importance in case of fire, it keeps the firm thoroughly informed as to the exact status of all its possessions within the plant. The true value of the equipment, both in total and in individual items, is never obscured. Even if the records are not accurately kept they serve as a convenient basis for tracing out the original value. It frequently happens that the assured will, unless he possesses such a record, be unable after a fire to tell just what his losses are. Many times he overlooks important items in his loss statements to the insurance companies, and does not recover amounts to which he is justly entitled. Insurance companies feel quite justified in paring down claims whenever their validity is in any doubt, and there are often possibilities for disagreement where no such record is kept. Seldom, indeed, after large conflagrations, are adjustments



No	KIND	SIZE	MAKE	No	MOTORS MAKE	HP	RPM
7	Quillers	16 Spdls	East Wood	7	West Elect.	[illegible]	1475
14	Tubers	6 "	Univ Mach	7	" "	5/8	560
6	"	"	" "	3	Crocker Wheeler	[illegible]	460
8	"	"	Foster	6	West Elect	1 1/4	1275
2	"	"	"	1	" "	1 1/2	"
1	"	"	"	1	" "	1/2	1500
1	Copping	144 "	J. C Whitin	1	" "	5/8	560
3	Raw S Winders	86 "	Atwood	3	" "	1/10	1800
21	Winders	"	"	21	" "	"	"
3	"	"	"	3	" "	1/6	"
7	"	"	"	7	" "	1/10	"
1	"	"	"	1	" "	1/8	"
1	"	"	"	1	Diehl		1750
1	"	"	"	1	Holzer Cobot	1/7	1500
1	"	"	"	1	Diehl		1750
1	"	"	"	1	West. Elect	1/8	1800
2	"	"	"	2	" "	1/5	"
1	"	"	"	1	" "	1/10	750
1	"	46 "	"	1	" "	1/8	"
3	Doublers	52 "	Sauquoit	3	" "	1/6	925
3	"	"	"	3	" "	"	"
3	"	50 "	"	3	" "	1/4	450
1	"	50 "	Atwood	1	" "	1/3	650
1	"	56 "	"	1	" "	"	"
1	"	54 "	Sauquoit	1	" "	"	675
1	"	56 "	"	1	" "	"	"
1	"	54 "	"	1	" "	1/8	450
2	Redrowers	58 "	"	2	" "	1/3	700
2	"	54 "	"	2	" "	"	"
1	Doubler	54 "	Nat Mill Sup. Co.	1	D'Oliver	1/4	900
1	"	28 "	Sauquoit	1	Diehl		1750
1	"	28 "	"	1	Elec Dynamic	1/2	1500

By courtesy of Sanquoit Silk Mills Co., Phila., Pa.

FIG. 60.—Plat Record of Machinery and Equipment.

made without friction, and always at the expenditure of considerable sums of money. These sums far exceed the cost of installing a proper fire inventory system, while the after-expenditures are never satisfactory.

If fire never occurs in the plant, the additional work required to keep this type of inventory is so small compared with the advantages gained by having a chart of the equipment constantly in view that it is well worth the trouble to have it, if only to help keep the other records, as shown in Fig. 59, which refers to output and repairs on machines. The plat record shows at a glance all the things that the firm owns, while the other figure gives the details of each individual item. It is an ideal inventory record for machinery.

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