UNIVERSITY OF PENNSYLVANIA

# MACHINERY AND ITS BENEFITS TO LABOR IN THE CRUDE IRON AND STEEL INDUSTRIES



BY
CHARLES REITELL

A THESIS
PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

The Collegiate Press
GEORGE BANTA PUBLISHING COMPANY
MENASHA WISCONSIN
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## MACHINERY AND ITS BENEFITS TO LABOR IN THE CRUDE IRON AND STEEL INDUSTRIES

Civilization may well be measured by the progress made in mechanical processes. From the simple and crude tools of earlier ages to the colossal machines and complex implements of today there is observed an ascending series of greater mechanical production which registers itself in a greater number of useful things which go to satisfy our ever increasing wants.

Coupled with and as a part of this long range of changes in machine processes are seen changes in the type and kind of human effort required to operate the new machinery. The man with the flail is replaced by the man of the threshing machine. The green-groomed cabby and the hostler give way to the trim chauffeur and the auto machinist. The dull and stupid driver of the horse-car has long since found the electric motorman his replacer. Even the strong and robust Slav, with pick and shovel witnesses at the ditch the mechanical digger which by the guidance of the skillful engineer constructs more trench in a day than fifty laborers could accomplish in a week.

Everywhere, on all sides, we see this advent of new machinery; and everywhere, on all sides, we see this machinery making different demands upon labor effort.

What, then, have been the effects of this industrial evolution upon man? Does the newer kind of work call for a higher or a lower type of employee as measured by physical and mental requirements? For instance, does that gigantic charging machine, which carries tons of iron and scrap into the open hearth furnace demand higher or lower standards of its operator than were required of the men who put in the iron by hand?

The effects of this growth of machinery upon man have been both commended and denounced, approved and condemned, regretted and indorsed. On one side we find marked enmity to the machine. As William Morris writes: "Machinery has made of man a mere automaton—a thing without soul and without spirit—an insignificant cog in a mammoth wheel." The poet is not alone in his condemnation of machinery. Herbert Spencer takes a similar attitude.

"Clearly these adjustments brought in on account of mechanical inventions make the motions of the workman himself relatively automatic. At the same time the monotonous attention required, taxing special parts of the nervous system and leaving others inactive, entails positive as well as negative injury. And while the mental nature becomes deformed, the physical nature, too, undergoes degradations, caused by breathing vitiated air at a temperature now in excess, now in defect, and by standing for many hours in a way which unduly taxes the muscular system."[1]

In contrast, machinery has been just as ardently praised and appreciated. Possibly one of the best positions on this side is stated by Dr. Carrol D. Wright: "Machinery necessitates not only the greatest care in preservation, but also in operation; so a man who is intelligent enough to run one machine is usually intelligent enough to learn quickly how to operate another in some other industry. Unskilled and ignorant labor cannot make such sudden turns. . . . The man who makes the small parts or the small articles, and is thus subjected to what is called the 'terrible monotony of machine occupation,' is not the man who is capable of making whole things, but is a man who has been lifted out of some more monotonous calling, and by machinery promoted to labour which calls for the exercise of some intellect. The use of machinery compels sobriety on the part of the operative; there has been no more powerful or effective temperance worker than the machine. The life and limb of a man with a muddled brain are in danger in the presence of machinery, while the damage done to the works by habitual drunkards undertaking to manage them of necessity compels the employer to engage men who come to their employment with clear heads. Machinery does not degrade labor but elevates it."[2] An appreciative attitude is also maintained by one who has observed the problem from a practical side—Mr. Harry H. Campbell, former General Manager of the Pennsylvania Steel Company, and at present a scientific writer on iron and steel.

Quoting Mr. Campbell: "While machinery may decrease the number of men, it demands a higher grade of workman, so that the man who operates a machine will get a higher wage than the workman who carried on the operation by hand."[3]

Thus we have reiterated time and again these different and antagonistic views regarding the effects of machinery upon the operatives.

[1] "Principles of Sociology," by Herbert Spencer. Vol. IV. p. 253.

[2] "Outline of Practical Sociology," by Carrol D. Wright. p. 256. Longmans, Green and Company.

[3] "The Manufacture and Properties of Iron and Steel"—Campbell, pp. 618-619. The Engineering and Mining Journal.

Where one sees the development of inventions as "extremely detrimental to the worker," another views the same situation as "elevating labor." But wherever such views are expressed we find them appraisals or mere opinions, a collection of attitudes rather than a collection of data. In other words, actual facts are lacking.

As a step toward finding what the actual effect of machines upon men has been, this study covers the conditions and changes found in the crude iron and steel industries. Two industries, the blast furnace and open hearth have been considered. The first of these produces all the pig iron and the latter 74% of the steel of the United States.[1] The investigation covers 25 blast furnaces and 38 open hearth furnaces located in eastern Pennsylvania and in Maryland.

In carrying out the study careful observation was made of each mechanical invention introduced from time to time, and the corresponding changes in labor such inventions demanded. Four definite factors were considered throughout the investigation:

First. The nature of the mechanical processes introduced.

Second. The number of employees added or displaced by the new invention.

Third. The machine as regards the problem of safety.

Fourth. The higher or lower type of worker demanded as measured by (a) physical requirements, (b) mental control and intellectual skill, (c) incomes received.

The results found portray (1) that in both industries mechanical methods have come in to an almost amazing extent; (2) that they call for fewer workers; (3) that where modern machinery has been put in the work has proven safer to the employees; (4) that to a great extent unskilled labor has been displaced, and that a call for higher types of workers has been made.

Let us now trace the processes of these two industries, giving especial attention to those positions and jobs where mechanical changes have been made. The blast furnace and open hearth operations will be considered in turn. To familiarize the reader with the details of making pig iron and crude steel a general description of the blast furnace and open hearth is given.

[1] In 1915, 29,916,000 tons of pig iron were made in blast furnaces. During this same year 23,679,000 tons of steel were made in open hearths. The pig represents total production and the steel 74% of total production. U. S. Rept. Mineral Resources of U. S., 1915, pp. 327 and 335.

## THE BLAST FURNACE (CRUDE IRON)

The purpose of a blast furnace is to make crude iron (i.e. pig iron) from iron-ore. The modern blast furnace is an egg shaped chamber one hundred feet high and twenty-five feet wide, with the broadest part of the furnace toward the ground. See photograph I at (x) and II at (a). This massive chamber is lined with fire-brick and is usually covered on the outside with plates of steel bound by heavy iron hoops. Piercing the furnace a few feet from the bottom are from eight to twenty small holes one to one and one-half inches in diameter, called tuyeres. It is through these tuyeres that strong blasts of heated air are blown so as to feed the fire that melts the material that stocks the furnace clear to the top. From these air blasts we get the name "blast furnace." At the top of the furnace there is a round trap door of iron called "the bell," through which the material is introduced which is to be burned and melted. Such material (i.e. stock) consists of iron-ore, coke and limestone.

The iron-ore is a combination of iron and oxygen, so that the chemical reaction needed is to free oxygen from the ore, thus leaving iron. Coke does this. But more than this is necessary. The iron must be melted and the earthy parts of the iron-ore and coke must be separated from the iron. This need is supplied by the limestone which unites these impurities and is tapped off in a red-hot liquid state about ten feet from the bottom of the furnace. This material is called slag. Molten slag is much lighter than the molten iron, and therefore floats on the top of the liquid mass, which comprises about a tenth of the total height of the furnace.

The blast of air when entering the tuyeres is already red-hot. The high temperature is obtained by the air passing through stack-like cylindrical "ovens," or "stoves," which are seventy to a hundred feet high and twenty feet in diameter. The inside of these ovens contains porous bricks so laid that open spaces exist between them. The gas from the top of the blast furnace is for a time channeled into these stoves and ignited. After the bricks become sufficiently heated the gas is turned off and the blast air in turn is pumped into ovens. When the air has circulated through the bricks it attains a heat sufficient to be blown in at the furnace tuyeres.

The spectacular part of blast-furnace operation is the casting time —the time when the molten metal is drawn from the furnace and is cast into molds in order to harden. The pure iron is taken from the bottom


PHOTO 1—OLD TYPE BLAST FURNACE

(x) Top of furnace, also top fillers' cabin.
(y) Gas ovens.
(z) Stock piles. Note same are dumped on ground.

of the furnaces and belches forth through a three-inch "tap-hole," lighting up the whole casting shed with brilliant glow.

Near this tap-hole at a distance of about 45 degrees is the "cinder notch" through which the slag is tapped. The cinder notch is about ten feet from the furnace bottom. The molten iron quickly flows through a runner or channelway, into large ladle-trucks (hot pots), and is immediately sent to the open hearth to be turned into steel. If the blast furnace is not working in conjunction with steel plants the iron is cast into molds, and, when hardened, is the common commercial pig-iron traded on the iron and steel market.

With this brief and general description let us draw nearer to our theme by considering each specific type of work carried on in a blast furnace.

All the occupations may be conveniently classified in three large groups:

First. Those occupations whose activity is centered in conveying the raw material from the stock-bins or railway cars into the furnace.

Second. Those occupations which have to do with the actual operation of the furnace.

Third. Those occupations concerned with the handling of the iron after it has left the furnace.

In order to show the changing conditions in these groups it is necessary to subdivide each of these main groups into its specialized occupations, and then in turn trace the development of each of these specific occupations.

## Group I. Stocking the Furnace

This group of occupations covers the work of conveying the ore from cars and ore-bins to the furnace bell, and comprises unloaders, barrow-men, or bottom-fillers, larrymen, top-fillers, cagers, weighers, and sweepers.

In the twenty-five blast furnaces visited, several distinct methods in stocking, or filling, the furnaces were carried on. These different processes were in vogue according to the degree of modern inventions introduced.

### *Unloaders and Barrow Men*

Unloaders are the pick and shovel men who unload the coke, iron-ore, and limestone from the cars. Up until 1894 or 1895 there were from 16 to 20 unloaders connected with every blast furnace. The work was very hard physically, and usually the unloading was contracted out by the furnace company to some individual who, in turn, hired common day labor to do the work. In the furnaces visited at Steelton, Pa., this work was seen to be of a very disagreeable nature, both on account of the dust and exposure to the extremely cold weather. The wages of unloaders at Steelton in 1890-94 were 12 cents an hour, and each gang had a foreman receiving 15 cents an hour. The entire labor force, including foreman, were negroes or foreigners. At six of the furnaces visited this old method of unloading is still in vogue. The work is done at present by common labor at 20 cents an hour.

In the more modern furnaces the raw materials are now handled by car-dumpers. The stock is handled by having the trestles and stock piles above the bins, and having chutes to convey the iron-ore, coke, etc., into the barrows. This change is clearly seen in comparing Photo I with Photo II. At Photo I (z) will be noticed the old stock-pile method. At Photo II (b) the cars dump the stock into bins. This dumping process requires but one man, who has general charge of the stock. At most furnaces the stock man was an American of moderate intelligence. No one observing the unloading processes of today would deny that a higher type of man was doing the unloading compared with the earlier days and earlier methods. One or two men per furnace, who show a higher degree of intellectual power, are now doing the work formerly carried on by twelve to twenty unskilled laborers.

*Bottom-fillers, Weighers and Cagers*

Their work consists in filling the cars or cages located at the bottom of the furnaces, weighing it, and then hoisting it up to the furnace bell. From the coming in of the anthracite blast furnace (1851)—that is, the blast furnace using anthracite instead of charcoal for fuel—until 1895, bottom-fillers loaded large two-wheel barrows by hand from the various stock piles of ore, limestone and coke, moving them when loaded to the scales to be weighed, and then placing them on an elevator to go to the furnace top. (See Photo I x) With the ordinary furnace producing 150 to 250 tons per 24 hours, 12 to 14 bottom-fillers are required per turn. The wage paid is the common, ordinary labor wage.

Note the revolution made by machinery! Where 14 men are needed in order to load sufficient stock for making 200 tons of pig-iron per turn under the old method, the work at improved furnaces is carried on by two men who load sufficient stock to make 250 to 300 tons per turn.

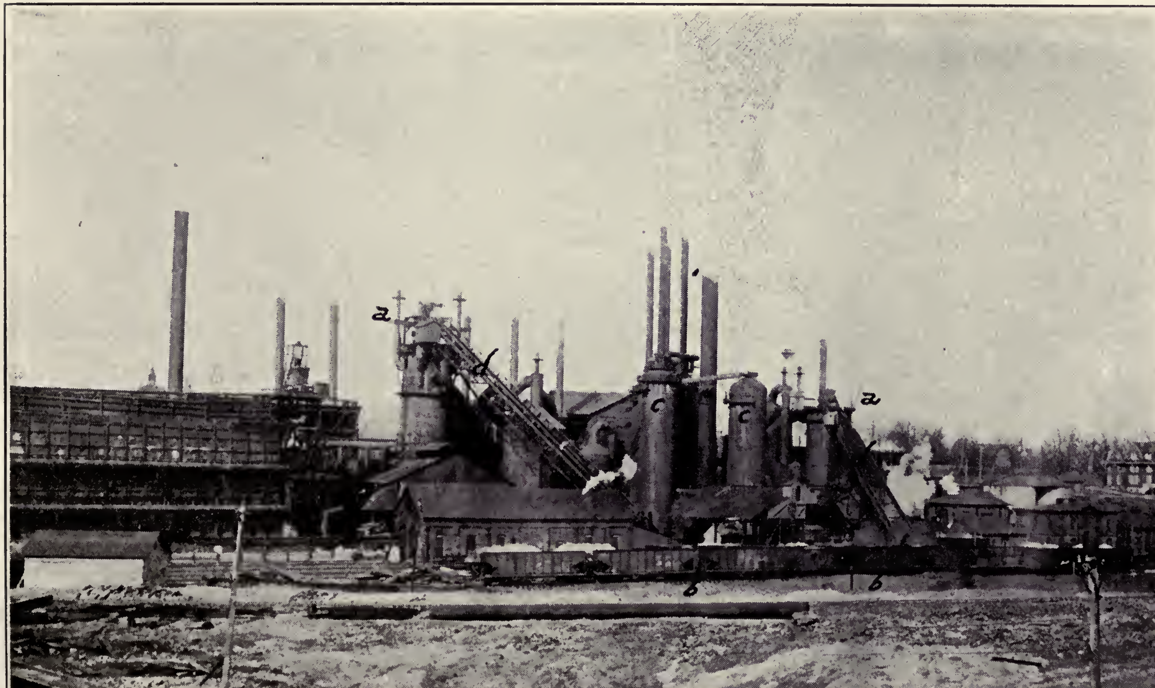



Photo II—Modern Blast Furnace

(a) Tops of furnaces.
(b) Trestles where stock is dumped into bins.
(c) Gas ovens.
(d) Skip hoists.

The three mechanical inventions ushering in this change are, first, the skip-hoist, which replaces the elevator and top-fillers; second, the larry-car, which replaces the barrowmen; and third, the automatic weigher, which replaces the weigher of earlier days.

The old method of getting stock to the bell was to have the barrowmen wheel the ore, coke, etc., from the bins to the elevator, then to have it lifted to the top of the furnace where two or three men called top-fillers took the two-wheeled barrows and dumped their contents upon the bell.

The skip-hoist removes all this. This apparatus is operated on one endless belt plan. From the ground to furnace top at a 45 degree slant is a narrow tramway, upon which runs the skip-hoist cars. When these cars reach the top of the tramway they automatically dump their stock upon the furnace bell, and immediately return to the bottom for refilling. At the bottom, in lieu of having the many bottom-fillers haul the material to the hoist, an electric car, called after its inventor a larry-car, does all the work. This car runs under the bins containing the stock and automatically weighs the material as it drops from the bins. The larry-car then runs by electric power out over the skip-hoist cars, into which it dumps the material which is to go to the furnace bell. (For picture of skip-hoist see Photo II at (d).)

One has no difficulty in comparing the operators of these mechanical devices with the old bottom-fillers. Under the older methods the work is purely of a heavy physical nature, and, as Mr. Francis Dutton, Superintendent of the North Lebanon furnace, states, "no brains were required of these workers—only big bodies with lots of endurance." Today we see that the larryman must be about as skillful as our trolley motorman. Larrymen at several of the newer furnaces received from 25 cents to 30 cents an hour. At most of the furnaces they employ a larry helper, who ranks as a common day laborer.

### *The Top-fillers*

Top-fillers, as their name suggests, work at the top of the furnace. (See Photo I (x).) Their duty is to take the stock in the barrows from the elevator, haul them twenty to twenty-five feet to the bell, where they dump the contents into the furnace. They also operate the mechanism which lowers the bell and drops the charge into the furnace proper. This latter operation permits the escape of large quantities of gas, which makes it both disagreeable, and often dangerous, to the workers. Top-fillers are common, unskilled laborers, and receive ordinary laboring wages. Their work demands tremendous physical endurance. No training or skill is needed. Usually 4 or 6 top-fillers are needed for the daily operation. With the use of the skip-hoist no top-fillers whatsoever are needed, for, as before mentioned, the material is dumped automatically upon the bell. This is a clear instance where a complete displacal of men has been made by machines.

Acrelius narrates in his "History of New Sweden"[1] that "the Cornwall charcoal furnace, which started operation in 1743, had in all eight individuals who put the stock into the furnace. (See Photo of Cornwall Furnace.) The ore and limestone were carried to the furnace top with bags, and to make the journey an easy one, the furnace was lodged by a mountainside, or in a ravine, so as to save the furnace fillers any uphill journey with the stock."

When one observes the modern method of stocking a blast furnace, such as the skip-hoist method at No. 5 furnace, Steelton, or at Sparrows Point, Md., with these older methods cited by Acrelius, or with the 1860 or 1890 wheelbarrow methods still in vogue at the Miley furnaces at Lebanon, one is forced to admit that the larryman is a higher type of man, both in the amount of mental control and intelligence demanded, and in wages received. As to physical requirements, he has but to work levers instead of hauling heavy wheelbarrows.

The above observed changes are corroborated in the United States report on the Conditions of Employment in the Iron and Steel Industry. Quoting from the report: "In 1895 fourteen men were needed per turn who loaded large two-wheel barrow by hand from the stock piles. This stock was taken from the top of the cage (elevator) by the top-fillers, who dump the barrows into the open furnace. They had to distribute the loads regularly around the furnace and when they had to dump the stock on the lee side, with a high wind prevailing, it was exceedingly dangerous. . . . In 1910 the raw materials are unloaded by car dumpers into bins and are brought by means of electrically operated cars, which automatically weigh the materials, dump them into the skip-hoist, which automatically distributes the materials. No hand labor is connected with the operation and no men are required at the top of the furnace."[2]

The following table taken from an older furnace and from one of the modern type shows from a cost basis the changing conditions. The

[1] "History of New Sweden," by Israel Acrelius, 1756.

[2] "United States Report on Conditions of Employment in the Iron and Steel Industry," Vol. III, p. 510 (1913).

Old Cornwall Furnace at Cornwall, Pa.

One of the first blast furnaces in the United States. It was built in 1742 by Peter Grubb, whose descendants to this day have been prominent ironmasters. Cannon were cast at this furnace for the Revolutionary War.

Toward the upper left of photograph may be seen the stack extending from the furnace.

To the left is the casting house containing pig beds.

older furnace is the costs as of November 6th, 1916, and of the modern furnace for October 28, 1916. Both furnaces are typical, and as blast furnaces are to a great extent similar in general operation, this table gives us some general idea as to the nature of the replacement.

COMPARATIVE LABOR COSTS IN CONVEYING STOCK IN BOTH OLD TYPE AND MODERN FURNACE ALSO NUMBER OF MEN—WAGE RATES

| | Top-fillers | | Weighers | | Bottom-fillers | | Barrow Men | | Sweepers | | Larrymen | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | Rate | No. | Rate | No. | Rate | No. | Rate | No. | Rate | No. | Rate |
| Old type furnace | 6 | .23 | 2 | .22½ | 18 | .21 | 16 | .20½ | 2 | .20 | None | ........ |
| Modern furnace | None | ........ | None | ........ | None | ........ | None | ........ | 2 | .20 | 2 | .26½ |

(TABLE CONTINUED)

| | Larry-helper | | Unloaders | | Stock Foremen | | Total Number | Average Rate | Total Labor Cost |
|---|---|---|---|---|---|---|---|---|---|
| | No. | Rate | No. | Rate | No. | Rate | | | |
| Old type furnace | None | ........ | 6 | .25 | 1 | .24 | 51 | .223 | $132.36 |
| Modern furnace | 2 | .21 | 2 | .25 | 2 | .24 | 10 | .233 | 33.72 |

## Group II. Occupations Connected with Actual Furnace Operation

In blast-furnace operation we can distinguish as a class those men who handle the molten metal. Their work is hot, dangerous, and demands constant vigilance and care. It is the occupations connected with the molten metal, then, that will be treated in this second grouping which arbitrarily has been titled "actual furnace operation."

This class of workers comprises one blower or foreman, one furnace keeper, four keepers' helpers, one monkey boss, two slagmen or cinder snappers, and one craneman.

### *The Blower*

The prime duties of a blower are those of foreman and leading man in charge of the furnace—superintending the routine work. The position is one which requires high skill and ability to quickly arrange activities in times of emergency. For in casting, the molten metal acts at times very oddly and mysteriously. I was told by Mr. Frank Stewart, Chief Timekeeper at Steelton, Pa., that the income ranges from $90 to $100 per month. With the growth of mechanical appliances more difficult tasks fall upon the blower, but no distinct change in type is observed.

### *Furnace Keeper and Helpers*

The keeper has charge of getting the iron from the furnace, of making the sand-runners leading to the sand molds, and has charge of opening and closing of the "tap-hole." The opening of the "tap-hole" is a very prolonged, hot, and laborious job. Through three to four feet of hardened clay, and then through semi-molten iron into the molten iron, a hole must be drilled before each casting. Very often the opening must be made by driving large drills by means of sledge-hammers. The invention of the oxygen drill removes to a great extent the great amount of physical effort sometimes necessary to open the tap-hole.

Worse, however, than opening the tap-hole was its closing, until the coming in of the mud-gun in 1895. This invention removed the work of two men and greatly eased the work of the keeper. When a cast is about completed the blast of the furnace blows out through the tap-hole particles of hot iron and also slag and hot gases. Sparks of iron fly helter-skelter, exposing the men to great danger. Before the shot-gun was invented the keeper and his helpers put balls of clay on long poles and stuffed them into the tap-hole. This plugging, which in many attempts failed, had to be continued until the hole was completely filled. The shot-gun worked miracles. The keeper himself operates the gun. It is swung into place by a crane in front of the tap-hole, and then by steam or compressed air the clay balls are shot into the opening. In less than five minutes the work is completed. One superintendent states: "The mud-gun, like the skip-hoist, has removed one more of the dangerous occupations in furnace operation, and, in addition, has removed the need of two workers. I remember how the keepers accepted the mud-gun with a decided welcome, for it made their jobs cooler, easier, and much safer."

### *Keepers' Helpers*

The keepers' helpers make up the runners, or channels, through which the iron is to flow, help the keeper to open and close the "tap-hole," watch the operation of the tuyeres, and work into any other jobs that emergencies create about the furnaces. In most of the furnaces investigated the keepers' helpers were common laborers and received laborers' wages. At some of the furnaces all the helpers were on a tonnage basis, and in conjunction with the sand-bed men received 12 cents a ton for all pig-iron cast. With the pig-men they comprised ten men per turn, or twenty for a complete twenty four-hour day. If the daily tonnage was 500 tons, it would mean $3 a turn for each worker.

An invention of no small benefit to the helpers is the patent skimmer. The hot iron flowing from the furnace carries with it some molten slag. This, floating on top of the iron in the runners, must be skimmed off before the iron reaches the ladles. To do this the older method was to build a dam of sand, and then at the bottom of this dam a sluiceway carried off the pure iron, while from the top the slag was tapped off in a different direction. If the iron flowed especially fast, the dam overflowed its banks, which always meant danger and decided inconvenience to the workers. The patent skimmer, which came in about 1898, is an iron dam which is placed in the runner or runway. Its great benefit rests in the ability to adjust the size of the sluiceway by the raising or the lowering of a lever. This invention saves the need of one helper, and lessens very materially the danger to all at work in the casting process.

### *Monkey-Boss and Cinder-Snappers*

The monkey-boss has complete charge of the slag, a charge of no small magnitude, as in volume almost as much slag flows from a furnace as does iron. Under his direction are usually two cinder-snappers, who break up the slag which happens to remain and become cold in the channelways. No marked changes were to be noted in the work connected with the handling of slag, due to the entrace of machinery, save that the steam crane removed the heavy lifting which was formerly necessary.

In summing up the occupations connected with the handling of molten metal we find the work has become much safer and also less fatiguing, due to machinery. Inventions have done away with two or three helpers, but have done little which calls for any increase of skill or ability.

## Group III. Occupation Covering Work after Iron Leaves the Furnace

We now turn to Group III, covering the occupations of pig-bed men, piggery men, gas-oven operatives, and power-house men. In this group mechanical progress has wrought many changes in the kinds of jobs and the kinds of workers needed to fill them.

Of the 25 blast furnaces studied, 10 had special machines for casting pig-iron, called piggeries, 11 others used sand pig-beds, while 4 delivered the molten iron directly to open hearths. Formerly all the casting was done by use of pig-beds.

Pig-beds are the molding beds for pig-iron. On flat, level ground is placed a two-foot layer of sand. In this sand are several hundred molds shaped by the pig-men—molds about four feet long, six inches wide, and six inches deep.

The men working on pig-beds rank very often with the keepers' helpers. At the Steelton furnaces negroes and Hungarians made up the pig-bed force. At the Lackawanna Iron and Steel Company furnace at North Cornwall, American whites with a few Hungarians completed the force. The number of pig-men differs with the casting capacity of the furnace—usually from 6 to 15 pig-men are employed. Besides making the molds, these men guide the flow of the hot iron into the molds, also gather up the pig iron when cold and place it upon cars. The work calls for great physical strength and endurance. The intellectual demands are nil. "It's lift pig iron and that's about all," as the Chief Timekeeper of the Cornwall furnaces, stated it. "Gorilla men are what we need," is the way one employer put it. Wage rates range from 18 cents to 21 cents per hour. At the Cornwall furnaces 18 cents was being paid; at North Lebanon, 20 cents. In quite a number of instances the flat rate of 12 cents a ton is paid to the pig-bed force for every ton of iron cast. That is, if 20 pig-bed men cast 500 tons, they would receive $3.00 each. At several of the Steelton furnaces this method of payment was in vogue. All the workers on pig-beds are young or middle-aged; no elderly person could endure the strain demanded for this kind of work.

Piggeries drive out pig-beds and pig-men, and in the driving demand an entirely new coterie of workers. Like the skip-hoist and larry-car, the piggery has played havoc with the need of brute force and unskilled labor in blast furnaces. In lieu of 24 to 60 unskilled pig-bed-men necessary for operating four furnaces, one piggery with 7 workers handles the iron of the same furnaces with ease.

The piggery is a mechanical arrangement whereby the pig-molds, which are made of metal and are attached to an endless chain, operate on a horizontal plane with a length of 75 feet to 100 feet. This long chain of molds moves very slowly. The molds are filled with hot iron at one end and by the time they reach the other end of the chainway the pig iron has reached a sufficient coolness to be dropped into a car for shipment.

The labor force of the piggery at Lebanon consisted of one hot-pot dumper, one flow regulator, one molder, two clay-mixers, two laborers, and one foreman. At another furnace the piggery uses but six men, having but one clay-mixer and but one laborer. The foreman and molder are skilled workers, the flow-regulator and clay-mixers are semi-skilled; while the ladle-dumper and the laborers are practically unskilled. Their wages average—foreman, 30 cents per hour; clay-mixers, 24 cents; flow-regulator, 23 cents; and laborers, 20 cents.

Under this third group are also included gas-oven operatives and power-house men. In each blast furnace visited there were found one engineer, one oiler, one machinist, one machinist helper, one hot-oven keeper, and one hot-oven laborer. The machinist and engineer are skilled workers, and the oiler and machinist helper, semi-skilled. There are few changes demanded in the types of these workers due to the coming in of machinery. The positions in this group which have passed through a radical change are the pig-bed men and the piggery-men.

Comparative labor costs show, under pig-bed operation, a charge of $48.00 for a 400-ton cast. The pig-casting machine to cast the above 400 tons of iron would cost per day:

| | |
|---|---|
| Foreman | $ 7.20 |
| Clay-mixers | 11.04 |
| Flow-regulator | 5.28 |
| Labor | 10.08 |
| TOTAL | $33.60 |

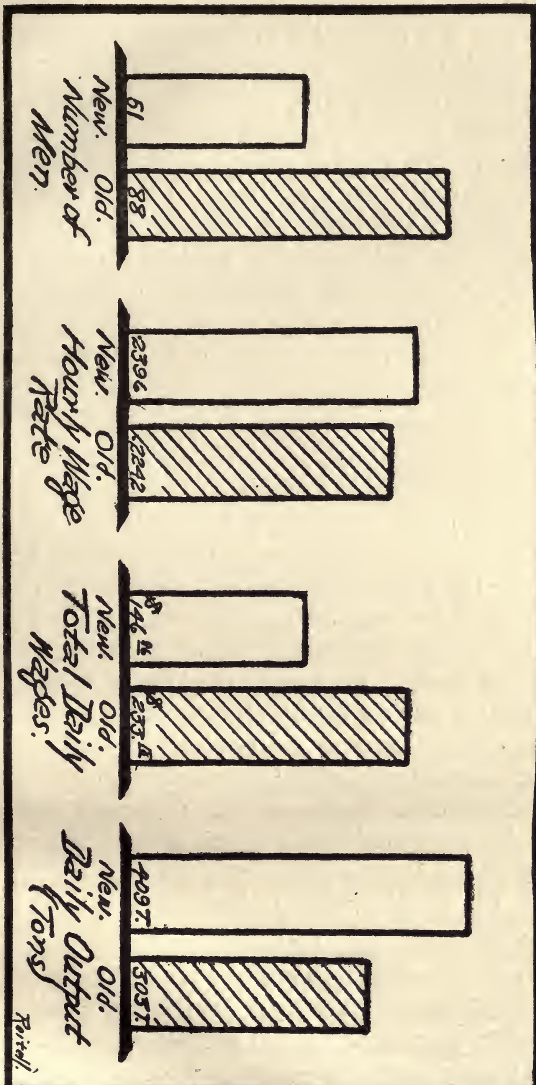
This is a saving of $14.40 per 400-ton day, due to the coming in of the casting machine.

Summing up the following tabulation of comparative labor costs taken from an old type of furnace for November 6th, 1916, and from a furnace of the modern type for October 28th, 1916, portrays vividly the change of jobs that has taken place in total operation, and also the change of labor supply. Furnace A represents the older type of furnace, while B is a modern one. It should be noted that the output of the modern furnace is about one-third larger than that of the older type furnace. Also the reader should observe that no casting costs are included in the older type of furnace. This would amount to approximately $36.00 additional and also would require 12 more workers.

| Job | BLAST FURNACE A November 6, 1916 OUTPUT 303 TONS | | | | BLAST FURNACE B October 28, 1916 OUTPUT 409 TONS | | | |
|---|---|---|---|---|---|---|---|---|
| | No. of Workers | Hours | Rate | Amount | No. of Workers | Hours | Rate | Amount |
| Top-fillers | 6 | 72 | 23 | $16.56 | (None) | | | |
| Weighers | 2 | 24 | 22½ | 5.40 | (None) | See L | arrym | en and |
| Bottom Fillers | 18 | 216 | 21 | 45.36 | (None) | Lar | ry Hel | pers |
| Barrowmen | 16 | 192 | 20½ | 39.36 | (None) | | | |
| Sweepers | 2 | 24 | 20 | 4.80 | 2 | 24 | 21 | 5.04 |
| Larrymen | 0 | 0 | | | 2 | 24 | 26½ | 6.36 |
| Larry Helpers | 0 | 0 | | | 2 | 24 | 21 | 5.04 |
| Scrap Loaders | 4 | 48 | 20 | 9.60 | 3 | 36 | 21 | 7.56 |
| Stockhouse Foremen | 1 | 12 | 24 | 2.88 | 2 | 48 | 22 | 10.56 |
| Car Unloaders | 6 | 72 | 25 | 18.00 | 2 | 24 | 23 | 5.52 |
| Furnace Keepers | 2 | 24 | 24½ | 5.88 | 2 | 24 | 26 | 6.24 |
| Helpers, first | 2 | 24 | 22 | 5.28 | 2 | 24 | 23 | 5.52 |
| Helpers, second | 4 | 48 | 21 | 10.48 | 4 | 48 | 20 | 9.60 |
| Cinder Snapper | 2 | 24 | 21 | 5.04 | 2 | 24 | 21 | 5.04 |
| Clay-mixer | 1 | 10 | 20 | 2.00 | 2 | 24 | 21 | 5.04 |
| Hot Oven Tender | 2 | 24 | 21½ | 5.16 | 2 | 24 | 24 | 5.76 |
| Hot Oven Labor | 1 | 10 | 20½ | 2.05 | 2 | 24 | 21 | 5.04 |
| Flue Dust Wheeler | 1 | 10 | 20 | 2.00 | 2 | 24 | 21 | 5.04 |
| Engineers | 2 | 24 | 26 | 6.24 | 2 | 24 | 20½ | 6.84 |
| Oilers | 2 | 24 | 21 | 5.04 | 2 | 24 | 22 | 5.28 |
| Machinists | 1 | 11 | 32 | 3.52 | 1 | 10 | 35 | 3.50 |
| Machinists'Helper | 1 | 11 | 23 | 2.53 | 1 | 10 | 26 | 2.60 |
| Piggery Foremen | 0 | 0 | | | 2 | 24 | 30 | 7.20 |
| Moulder | 0 | 0 | | | 2 | 24 | 32 | 7.68 |
| Piggery Clay Mixer | 0 | 0 | | | 4 | 48 | 23 | 11.04 |
| Flow Regulator (Flowman) | 0 | 0 | | | 2 | 24 | 22 | 5.28 |
| Piggery Labor | 0 | 0 | | | 4 | 48 | 21 | 10.08 |
| TOTALS | 76 | 904 | .2242 | $197.18 | 51 | 722 | .2396 | $146.86 |
| Casting Costs | 12 | | | 36.00 | | | | |
| (Approx.) | 88 | | | $233.18 | | | | |

Adding in the costs of casting in Furnace A (under the older sand-bed method), we would have a total of 88 workers and a total labor cost of $233.18. This transfer from the older to the newer methods shows an elimination of 39 men and a reduction of the total daily labor costs of $86.32. And furthermore, of these 39 men displaced, we notice them going from the lower-type jobs—bottom-fillers, barrow-men and top-fillers. This tendency toward higher types registers itself in the average rates of $.239 for a modern furnace in contrast with $.224 in an older type of furnace. In contrast to this lowering of labor costs and in the number of employees, we find a decided increase in output—303 tons to 409 tons.

The above may take clearer form in the following chart:




CHART—Comparison of Labor in Old and Modern Blast Furnace.

From the twenty-five blast furnaces investigated the facts warrant the following:

First. That the mechanical invention is coming into every part of blast-furnace operation, as is shown by some of the principal inventions—the larry-car, skip-hoist, mud-gun, skimmer, and piggery.

Second. There is a diminution in the number of workers required. The average amount of labor to operate under the older method was 50 laborers per turn, or 100 per day. Where new processes are in vogue 30 men are needed per turn, or about 60 per day. In spite of this reduction of laborers the product has increased considerably in amount. The older form of furnace turns out from 150 to 200 tons per day, while a modern furnace casts from 400 to 500 tons per day. Some conception of the tremendous increases in producive power, and the low increase of the labor force, may be obtained by comparing the output of blast furnaces in 1869 with those of 1909. The average output per man per year in 1869 was 66.5 tons. In 1909 it was 569.4 tons, an increase of nine times as great within 40 years. During the same time the number of employees less than doubled, increasing from 27,000 to 43,000.[1]

Third. Greater safety has come with machinery. Contrary possibly to popular expectation, machinery introduced into the blast furnaces has made the work much safer. According to Mr. Frank Stewart "about 60% of the fatal accidents of a furnace occur to top-fillers, and the removal of the top-filler's position by the skip-hoist dismisses this kind of accident in the future." Again, according to Mr. Dutton, the skimmer and shot-gun have made the helpers' work immeasurably safer. Mr. Dutton has no figures to support his statements, but he surmised that the accidents to the helpers had been reduced to half their number, due to the coming in of these machine methods. The very fact that positions known as "the dangerous occupations" no longer exist shows definitely that machines have lessened accidents.

Fourth. A higher type of worker is demanded, due to the coming in of mechanical methods. More of intellectual skill and less of physical power is desired. Top-fillers, bottom-fillers, barrowmen, and pig-bed men are the men whose occupations call for nothing more than brute force and physical energy. Yet these are the very positions that have been displaced by machines. In lieu of them we find larrymen, stock foremen, and piggery employees—workers who do not need the physical prowess but of whom is demanded greater intellectual control.

As regards income, the bottom-fillers, barrowmen, top-fillers and pig-bed-men are kept within the range of 18 cents to 23 cents per hour

[1] Report on Iron and Steel for 1909, p. 208, Census Bureau, August, 25, 1911.

in all of the furnaces studied. The larrymen, larry-helpers, and piggery men range in rates from 21 cents to 30 cents per hour. The rates paid the former group average about 21½ cents per hour, while those of the latter average 25 cents per hour.

Convincingly and definitely, four changes are found in the furnaces investigated: First, mechanical inventions are being introduced; second, they call for fewer workers; third, the work is safer; and fourth, they demand higher types of workers, as shown by skill and mentality.

We now turn to the industry so closely related to the blast furnace, namely, the open hearth, and record further the changes that have taken place in the production of crude iron and steel on account of machinery and invention.

## THE OPEN HEARTH

The open hearth produces steel. Steel is carbonized iron. That is, if we take pure iron and add to it a small percentage of carbon (say one-fourth of 1%) the result obtained is that hard, tenacious, pliable, durable metal which we call steel. Pure iron, however, is seldom used in making open hearth steel. Pig iron, scrap iron, and scrap steel are used instead. This stock has far more than the needed amount of carbon. Therefore the purpose of the open hearth becomes mainly one of reducing the high percentage of carbon. One writer has described the purpose of the open hearth briefly as follows: "The carbon in the iron must be reduced from about 5% to 6% to less than one-half of 1%. Sulphur, silica, and phosphorus must be taken out while other ingredients, such as manganese, chromium, nickel, and tungsten, are to be added." In general the purpose of the open hearth process is to take impurities from pig iron and add certain ingredients which give the beneficial properties characteristic of steel.

The open hearth building is a large, immense structure two or three hundred feet wide, and sometimes as much as an eighth of a mile in length. The roof is made very high, approximately sixty feet, and is so arranged as to carry off the heat and fumes that come from the furnaces. The open hearth building can readily be distinguished by the large number of stacks, which are evenly spaced and form a regular row along the one side of the plant. These stacks carry away smoke from the gas producers, which, as we shall learn later, play an important part in open hearth equipment. Running lengthwise through the center of the building is a single row of furnaces, usually 4 to 20, or more, in number.

Each of these furnaces is a complete unit in itself. Many are placed under the same roof so as to obtain the efficiencies that come with large-scale production. (See row of furnaces in Photo III.) Each furnace is rectangular in shape, constructed of fire-brick, and averages about 30 feet in length, 22 to 25 feet in width, and from 12 to 15 feet in height, not considering the deep and necessary foundations. At one end of the furnace through a brick extension the gas is introduced into the furnace. Where coal dust is used for heating purposes in lieu of gas there is a large blow pipe through which the ignited coal is blown into the furnace. Where electric furnaces are used large induction bars rest in the center of the furnace from which combustion heat is thrown off.

At the front of the furnace are two or three openings through which the charge is introduced. Large doors are lowered and raised by hydraulic or electric power The inside of the furnace is called the hearth. Here is where the iron is placed so as to be heated and cooked until it has changed sufficiently in chemical composition so as to become steel. The molten metal resting in the hearth is called the bath. It runs about 2½ feet deep, with an area of 15 feet by 20 feet. At the back of the furnace is the tap, or "runner," through which the molten steel is poured from the furnace. The steel is first poured into large kettle arrangements, called ladles, in shape similar to a deep type of soup bowl. They are from 7 to 10 feet deep, and range in width from 6 to 12 feet in diameter. They carry as high as 35 tons of molten metal. Electric cranes carry these ladles, or "hot-pots," as they are termed, over the tops of vertical molds. The hot-pot is tapped through a small hole in its bottom, and the molds are soon filled with the molten steel. (See Photo IV.)

When the steel has hardened these molds are stripped off and we have remaining a piece of steel about 12 inches square and from 5 to 8 feet in length. This is called an ingot.

Along the outside of the open hearth building one sees many cylindrical ovens 20 to 25 feet in height and about 15 feet in diameter. These are gas producers. In them we have soft bituminous coal introduced from which gas is extracted. This gas is then channeled into the furnaces in order to heat the bath to those temperatures whereby desired chemical reactions take place.

### The Open Hearth Occupations.

In the actual operation of the open hearth there are four distinct

Photo III

Charging machine—showing bins or "buggies" filled with scrap. This gives an excellent view of the charging floor, and the long row of furnaces.

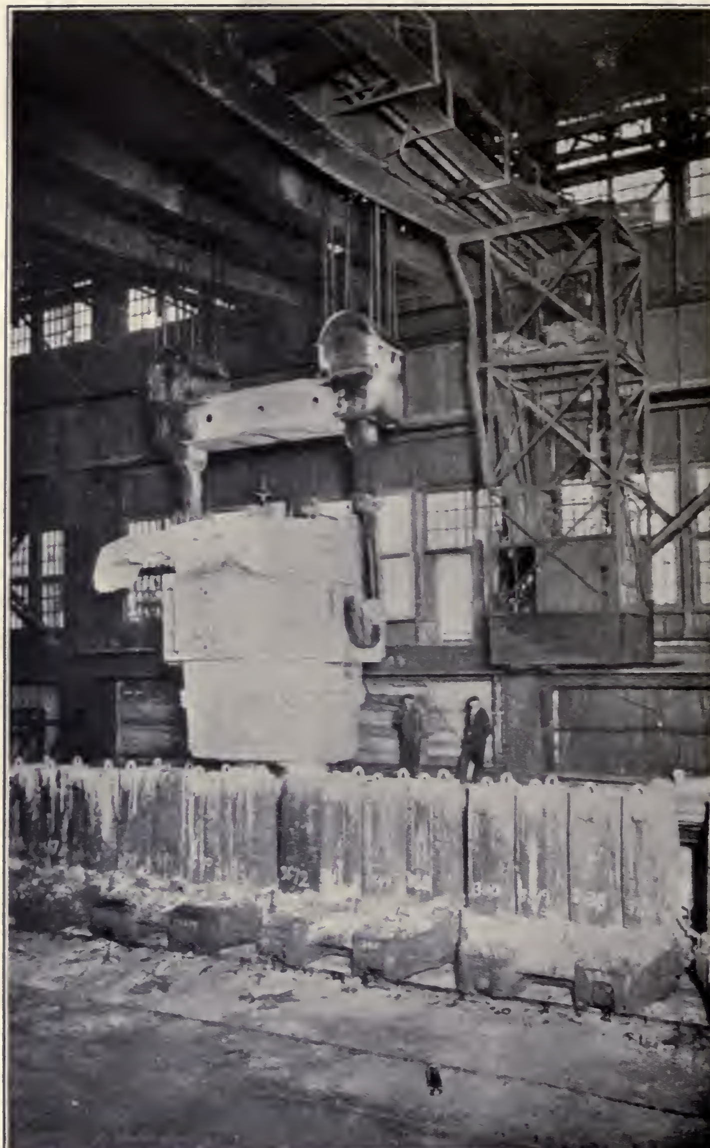


PHOTO IV

Filling molds from ladle. Loops on top of molds used for "stripper" to get a firm grip.

working levels of labor operations.

First. *The Charging Floor.* This is the level from which the materials are put into the furnace, and is about 30 feet from the ground.

Second. *The Ladleman's Platform.* This is the pourer's level, and is about 12 feet from the ground.

Third. *The Ground or Pit Level.* Here are placed the molds in order to be filled.

Fourth. *The Electric Cranes*—which operate overhead.

In addition to these four levels we find much miscellaneous work, as, for instance, skull-cracking, relining ladles, cleaning brick, etc. Let us now consider the labor operations performed in each of these groupings, following closely those jobs where marked changes have been made due to the coming in of machinery.

THE CHARGING LEVEL

The labor positions on the charging level are the melter, first and second helper, charger, pull-way boys, and gas-men, all of whom in turn are interested in getting stock and fuel into the hearth and in the actual operation of the furnace. Machinery has done little to change the fundamental demands made of the melter or his helpers, either as to numbers or qualifications; also as regards pull-up boys, although their work has been made somewhat easier due to improved power machinery.

The great labor changes are in the new conditions brought about by the charging machine and the mechanical methods of operating gas producers.

The charging of the furnace has had such a marked influence on output and on labor conditions that it will in no way be amiss to trace in some detail the different methods used. Possibly this machine has worked the greatest labor change of all mechanical appliance put into open hearth operation. The early method of stocking the furnace was by hand. This method consisted in taking a 15 foot bar of iron flattened at one end like a pancake turner. Upon the flat end of this bar the workers placed the iron, and then shoved it into the furnace. The bar, or "peel," as it was termed, would then be withdrawn for another filling.

According to Mr. Scott Greenwalt, former Superintendent of Open Hearths at Midland Steel Company, now with the Bethlehem Steel Company, "this work was the hardest and most strenuous of the whole steel industry. The heavy lifting of iron, the heat, glare and fumes from the open furnace, combined to make the work most exhausing. Negroes and Irish were employed almost entirely. All wore heavy red flannel shirts to protect themselves from the excessive heat, and if it were not for the rest periods that occurred between the charging times, no human being could have endured the work for a continuous day." One worker put in in these no uncertain terms: "It was working aside of hell ahead of time."

Six to eight men were required to fill a small 25-ton furnace by the peel method. To operate six 25-ton furnaces about 40 unskilled workers were needed.

The peel method, though still found in Europe, has almost entirely gone out of use in America. In 1895 it began to be replaced by the "dumper-method." This method consists of having the iron hauled to the front of the furnace in iron bins. A crane picks up the bins one at a time and dumps them into the furnace. Usually in this process of filling the furnace is tilted, thus making for easy access of material. This dumper method was short-lived, for soon after its invention the charging machine came into operation.

This charging machine revolutionized the industry. One skilled employee operating the modern charging machine can stock six to eight furnaces which under the peel method would have required 40 peel handlers. Besides, the furnaces are now so large that it is doubtful if peel men should distribute the iron sufficiently well to do good heating.

Greater output was also made possible. Mr. James Gledhill, Assistant Superintendent of the American Iron and Steel Manufacturing Company, stated, "The sole factor accounting for the increased output was the charging machine."

The charging machine consists of a broad electrically propelled platform upon which sits the operator. This platform has projecting in front of it a long steel arm like a battering ram. (See Photo VI and III.) The end of this ram is made to fit into steel boxes holding several tons of iron. The ram picks up the steel box of stock, shoves it into the hearth, dumps it, and then withdraws from the furnace for a second box. The filled boxes are brought in on narrow gage cars which run on tracks parallel to the furnaces. (See Photo VI and III.) The charging machine is also on wheels and is capable of operation at all the furnaces.

Peel chargers at Steelton received 13 cents an hour; at Harrisburg they received 15 cents an hour. Everywhere the common labor wage

Photo VI

Charging machine and operator filling the furnace. Mental, not physical power is the leading demand of this labor.

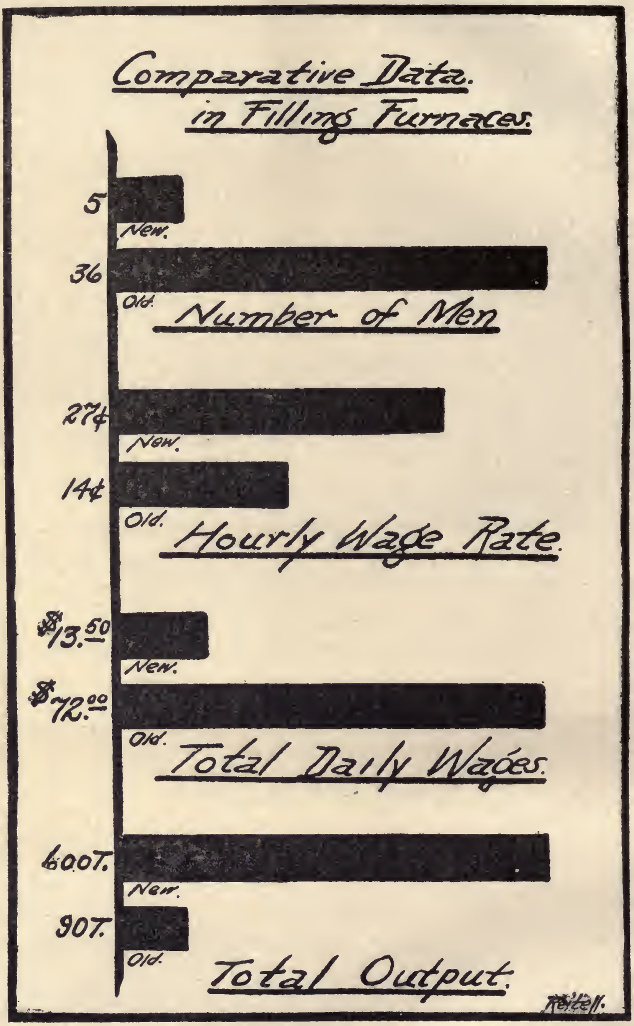
was usually paid. At one plant today 27½ cents per hour is paid for the charger; at another 28½ cents is paid. At two other plants 30 cents per hour was received.

The statement of an official at Lebanon tells of the changing type. We were standing before the charging machine watching it filling the furnace with iron, and when his attention was brought to the matter of labor types he pointed to the small stature and light weight of the operator. "There is your answer," he stated, "no muscle, no physical resistance; just sufficient skill and cleverness to operate six levers. Imagine such a little shrimp trying to handle a peel."

One superintendent has worked out a comparison of labor costs, also the approximate output under the peel and under the charging machine methods. He has included the necessary locomotive shifting crew with the charging costs under modern conditions. It should be mentioned that these figures regarding the peel are given only as an approximation, but as far as it can be discerned they are a fair portrayal of the conditions as they existed.

| Method | No. of Men | Rate of Wages | Total Wages | Output |
|---|---|---|---|---|
| Peel | 36 | Common labor Then 14c, now 20c | $72.00 | 90 Tons |
| Charging machine and tracks | 5 | 27c | 13.50 | 600 Tons |

Charting these figures we have:




Where pig iron is brought direct from the blast furnace to the open hearth in a molton state, the small ladles dump the iron into a huge 50-ton ladle called a "mixer." This huge ladle, handled by an electric crane, then pours the iron into the furnace. Photo VII shows this method at work. Note the absence of workingmen on the charging floor. Only one skilled man operating the crane is necessary.

Photo VII
Charging floor where the hot metal from the "mixer" is being charged into the furnace. Note absence of workers.

Photo V

The pit side of open hearth. Steps lead up to pourer's or ladleman's level. Row of molds being filled from ladle. The row of furnaces is to the right.

### Gas Producer Operation

Gas production plays an important place in the operation of the open hearth. The combustion of gas in the hearth gives the required heat for certain necessary chemical reactions in the bath.

To produce gas, soft coal is burned in a thick, heavy fire, and the gases given off are collected. This gas is purified and channeled to the furnaces, where it becomes ignited. The soft coal clinkers, and therefore demands constant poking with long bars to keep a fire going. If 8 or 10 gas producers were used at a plant, 18 to 20 laborers were necessary to carry on this work. In addition they attended to the filling of the producers.

A mechanical change which replaced this poking method was the Frazer Talbot and other forms of mechanical producers. Steel arms inside the producer were made to move up and down, thus preventing clinkers. This has cut the needed labor in operating gas producers considerably. The Assistant Superintendent at Steelton claims that only about a third the number of men are needed. Mr. Greenwalt, at Lebanon, claimed that "a great reduction had taken place—possibly 75% less than what was formerly needed."

Gas men receive 18 cents to 22 cents per hour. This mechanical change means a reduction of the amount of unskilled labor with no change in skill required.

As regards the charging level, we see the great changes brought in were by the charging machine, the mechanical appliances in gas producing, and the "mixer." Unskilled labor has been displaced by machinery; skilled labor has been taken on.

### The Second Level—The Pouring Level

The charging and gas producing take place on one side of the long row of furnaces. The pouring, casting, pit work and handling of molds and slag occur on the opposite side. On a platform about ten feet from the ground several operations are found which are connected with getting the metal from the hearth into the molds. (See Photo V (x).) These operations are pourer or ladleman, nozzle-setter, and nozzle-setter helpers. The pourer has charge of the flow from the hearth into the ladles. He regulates the flow and takes care of the hot slag. The nozzle-setter has control of the tapping from the ladles into the molds. To aid him he has from four to as high as eighteen or twenty men. The platform upon which these men work is on a level with the tops of the molds. At pouring time the men on the ladleman's platform must work with speed, also with great care. Handling metal at liquid heat is dangerous under any circumstances.

The shift from the stationary ram cranes, which were situated at every furnace to the overhead traveling cranes, has reduced the number of helpers.

Opportunity was given to see the pouring under both the stationary-crane method and under the traveling cranes. At Pencoyd each furnace has its stationary crane. This crane has attached at the end of a long extending arm a ladle. The ladle is filled at the furnace, and then the long arm carries it out over the tops of the molds. If many furnaces are ripe for the tapping a large labor force is required. While two furnaces were being tapped at Pencoyd, 37 men were counted at work in the pouring process. At Steelton, where the most recent types of open hearths are being operated, the large ladle goes to the "ripe" furnace, receives the hot steel, and then travels to the molds where the ingots are made.

Only 12 men were engaged in the pouring work at Steelton. This change of crane operation was the only mechanical or labor change on the pouring level.

### The Ground Level

Possibly the greatest change in the open hearth as regards the welfare and safety of the laborers has occurred in connection with the surroundings of the pit men. Pit men are those who tend to an endless amount of work in the way of preparing the molds for casting and in cleaning up after the casting, or pouring, has taken place. Several mechanical factors have come in which have had a decided effect in changing the labor conditions for pit men. They are:—

First. The coming in of traveling cranes. These cranes are used in cleaning-up work. They have reduced the necessary labor force of pit-men almost one-half. No barrowmen are needed as the crane carries the dirt and scrap to the cars in steel boxes.

Second. The coming in of the thimble eliminated a great deal of the slag work. The thimble is a hot-pot, or ladle, shaped like a cone standing on its apex. It is very broad at the top (12 feet), and is kept near the "runner" of the hearth so as to catch the overflow of steel and slag. (See Photo VIII) The cranes also drain the dregs of the hot-pots into the thimble. When full, the thimble is carried out by

Photo VIII

Pit side of furnace. Steel being tapped from hearth. Note "the thimble"—to catch the slag which will soon run from top of huge ladle.

crane and then by locomotive. Formerly the overflow was allowed to run on the ground, and then after cooling was broken up by laborers and treated as scrap.

Third. The coming in of molds placed upon cars. It is necessary to describe in detail the difference in handling the molds so as we may see clearly the benefits.

Under the old method the steel was poured from the stationary crane into molds arranged in two or three semi-circular rows in a pit near the ladle crane. Around the base of these molds worked the pit men. When the steel had hardened sufficiently the overhead crane, with its chains fastened to the lugs of the mold, stripped the mold from the ingot. If the mold stuck the pitman took heavy sledges and loosened them. Work among these hot molds was extremely dangerous. One superintendent claimed that more open hearth accidents had occurred to pitmen than to all other employees. All of us remember the horrible accident at one steel plant where a dropping of a ladle buried three pitmen in molten metal.

At Harrisburg, at Steelton, at Lebanon, in fact in most plants, the molds are now placed on cars and as filled are drawn away by locomotives. (See Photo IV and V.)

Fourth. The mechanical stripper. This machine has removed both men and danger from the pit. In lieu of having pitmen fasten the crane chains to the molds, so as to strip ingots, this gigantic machine 35 feet in height drops its huge hand over the mold and tightly grasps it. As the mold is being lifted by this electric power machine a plunger forces the ingot from the mold. Where 8 or 10 pitmen were constantly at work helping a crane to do stripping the mechanical stripper operates with only one employee. The operator of the stripper is treated on the same basis as a craneman, receives the same wages, and has the same ranking. Here is another instance where physical power has been replaced by mental power. Skill to operate levers, not muscles to swing sledges.

On the ground level the great change observed is the removal of the need of much "common labor;" also a decided betterment as regards safety.

## Cranemen's Level

Cranes have been marked influence in removing common, unskilled labor from the steel mills. In the handling of brick, slag, stock, etc., the crane has replaced barrow and barrowmen. "What fifteen or twenty men could haul away in a day by means of barrows is carried in two or three trips with the crane." The important thing to note in the coming in of cranes, especially the electric cranes, is the shift in type of labor needed. In every mill investigated the craneman, save for exceptional instances, were native whites receiving 8 cents to 10 cents per hour more than common labor. The great demands made upon cranemen in open hearth work is not physical power, but skill and vigilance. The mismovement of a lever might easily upset tons of metal, topple ingots, or crush furnaces. Cranemen therefore must use mental control constantly or must witness costly mistakes. Error by a craneman is always costly. Dump a wheelbarrow, and who cares? Have a crane make a false move and no end of trouble is likely to ensue.

## Outside Labor

When the ladles are emptied some of the steel is certain to remain and harden. This is dumped from the ladle, and, due to its round shape, takes the name of a skull. Generally this is pure steel, and therefore is valuable for remelting. An important operation found at all open hearths is the breaking of skulls so as to render them small enough to enter the furnace doors.

When two open-hearth operators went to Midland Steel Company as superintendents of the rolling mills and open hearths, the first demand they made in the way of machinery was for a magnetic-drop-ball apparatus, and for a Hayward bucket, both to be used entirely for cracking skulls and loading them on cars to be taken to the charging floor. One of these men stated that "twenty to twenty-five 'Hunkies' were used to break up these skulls, costing $30 to $35 a day in wages. With the magnet and ball all the steel skulls were broken and collected with but four workers, two skilled men to operate the machinery, and two laborers for helping."

Figures approximating this change were given as follows:

| | Number of Men | Total Daily Wages | Hourly Rate |
|---|---|---|---|
| Hand or sledge breaking | 20 | $36.00 | .18 |
| Drop ball and bucket | 4 | 9.10 | .22¾ |

The drop-ball is operated by having a metal plate attached to an overhead crane, the plate being so arranged that it can be powerfully magnetized. This plate then picks up a heavy iron ball 30 inches or so in diameter, and weighing over a ton. This ball is lifted to a height of 25 feet directly over a skull. Then the magnet is broken. With a thud the skull is broken into six or eight pieces sufficiently small to enter the furnace door. The Hayward buckets are a mechanical shovel with large protruding teeth. This operates on a revolving electric crane, and scoops up the steel pieces and places them on cars.

Around every open hearth repairs to furnaces are in progress. Many workers such as bricklayers, bricklayers' helpers, and common labor are constantly at work. The laborers clean out furnaces, clean brick, etc., while the bricklayers, with their helpers, construct new furnaces. It was impossible to get labor data on these employees, first, because of the great variety and type of work which they were doing. Second their employment is usually not under the open hearth control, but the workers come from the bricklaying and other departments.

In summarizing the labor changes characteristic of the open hearth in general, one finds a large falling off in the number of unskilled labor required, and an increased demand for skilled or semi-skilled workers. Mental control is demanded in lieu of physical power.

Unfortunately, comparative total income it is impossible to obtain in open-hearth operation. Men in many occupations are paid on a tonnage basis, others, part tonnage and part time, while still other groups work entirely on a time schedule.

A comparison is possible as regards the total amount of labor required to operate an old and a modern furnace. One employer gave the following estimate from his experience:

LABOR FORCE IN MODERN AND OLDER TYPES OF OPEN HEARTHS

(Necessary Labor Supply to Operate Four 50-Ton Furnaces 24 Hours; Two 12-Hour Shifts)

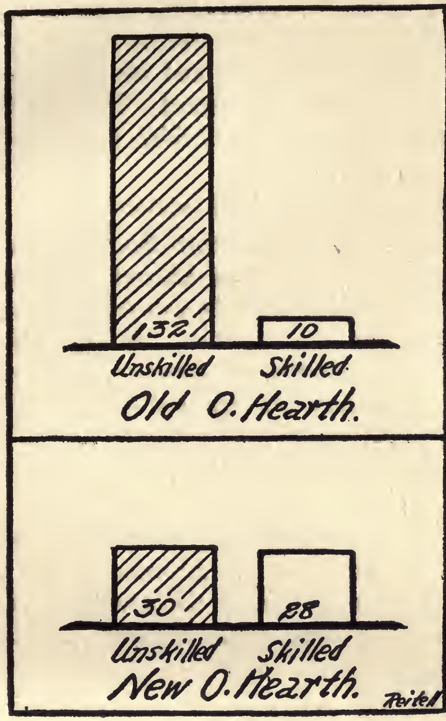
| Occupation | Older Open Hearth | Modern Open Hearth |
|---|---|---|
| Melters | 2 | 2 |
| Helpers (First) | 4 | 4 |
| Helpers (Second) | 8 | 8 |
| Ladlemen | 2 | 2 |
| Nozzle-setter | 2 | 2 |
| Nozzle-setter helpers | 6 | 2 |
| Door boys | 8 | 6 |
| Stockers, gasmen and chargers | 38 | 10 |
| Pitmen | 32 | 14 |
| Stripping ingots | 14 | 4 |
| Skull cracking | 26 | 4 |
| TOTAL | 142 | 58 |

If we analyze the table carefully with a view to dividing the labor into skilled and unskilled, or, better than that, work which predominantly is physical and that which in the main is mental, the above figures would give:

LABOR EFFORT ONE DAY'S OPERATION

| Type of Work | Old | New |
|---|---|---|
| Mental control, (Skilled labor) | 10 | 28 |
| Physical power, (Unskilled labor) | 132 | 30 |
| TOTAL | 142 | 58 |

The following chart will perhaps illustrate this important change in a more impressive way:



## MACHINERY AND MAN

Having passed through these detailed operations covering the blast furnace and open hearth, let us turn to the larger aspect of these changing men and machines. There were seen new methods, new machinery, and new types of labor coming in, and old methods, old machinery, and old types thrown into the discard. The two industries are in constant flux, and everywhere, on all sides, this replacing process continues.

Observations and data collected warrant,—

First. The blast furnace and open hearth during the last forty years have introduced an increasing amount of mechanical processes. Within this time have developed the skip-hoist, larry-car, pig-casting machine, charging machine, stripper, and skull-cracker—machinery of tremendous size, complexity, and capacity, machinery whose operation in every single instance has displaced operations that were carried on by hand. Colossal machines operated by skilled minds have displaced the unskilled hands who wheeled the barrow, slung the sledge, or heaved the heavy peel.

Second. Fewer workers are required. One visiting a modern open-hearth or blast furnace is not surprised by the great number of workers, but rather on account of the scarceness of them. As one visitor to a full-running open hearth expressed it, "Don't any people work in this factory?"

In other words, the mechanical inventions introduced required a far less amount of labor for carrying on operations. The larryman removes the need of twenty barrowmen; the charger has displaced the thirty or thirty-five peel handlers, and so on. This does not mean that fewer men are working in open hearths and blast furnaces, taking the nation as a whole. These industries have grown, and are continuing to grow, to such extent that an increasing number of men is being needed.[1] It indicates rather a fewer number of men necessary to carry on specific operations.

Third. The work is safer. The popular notion that greater machinery means greater danger to workers finds no approval in fact when the blast-furnace and open-hearth industries are considered. As was

[1] In blast furnaces in 1869, 27,500 workers were employed, while in 1909 43,000 were working. Tonnage during this same period increased from 1,800,000 tons to 25,600,000 tons. This same trend is found in open hearths. Thirteenth Census of U. S., Vol. X, page 208.

seen in the blast furnaces, so also in open hearths, not more, but fewer accidents occur with the coming in of mechanical appliances. Influences have been at work bringing in this beneficial result. The machines have displaced dangerous occupations, as, for instance, the skip-hoist removing the top-fillers, and the stripper doing away with the need of pitmen.

One superintendent of open hearths claimed that the coming in of mechanical methods has reduced accidents to pitmen at least 75%. In this employer's plant during one year when the old pit methods were in vogue, 68 men were injured, of which 14 proved fatal. In 1915 in the modern plant, 22 injuries were recorded, and only one fatal.

In the crude iron and steel industries much of the dangerous work has been done away with simply because the workers in the dangerous occupations are no more needed. Machinery now does their work.

The fourth conclusion, and one of no small importance, is the higher type of man that comes hand in hand with machinery. The results in both industries, and especially in the open hearth, show without question that a greater mentality and a more skilled worker is needed.

The change observed is mental control removing physical effort, a general shift from muscular power to intellectual skill. The strong-of-body is no more needed. A keen, watchful, and alert mental supremacy is being demanded. Seeing this change from physcial to mental effort, does it justify the conclusion that the mental type is the higher? Judging by wages received the answer is in the affirmative! Larrymen, pig-machine men, chargers, and cranemen all receive a larger income than unskilled labor. However, an income test at best is objectionable. It may mean simply that the market conditions are such that one obtains a higher wage on account of difference in supply.

A better proof than this is possible. Go back a few centuries. Compare the physical stature of the earlier with the modern man, and if anything, the 1917 fellow comparatively has lost in weight. Wherein has been progress and growth? Answer,—Control over surroundings through inventive genius and intellectual skill. If the growth of civilization connotes anything, it connotes a growth in mental prowess. And this being true, the trend observed in blast furnace and open hearth is in keeping with this general progress. A step from heavy, cumbersome, physical labor to alert, keen, and ever-awake mental activity represents a change from a lower to a higher man, just as our civilization with its intellectual growth has advanced above the Fiji Islander, who still depends on physical strength.

But observe the "higher type" from a far more practical point of view, namely, the increased cost of errors that comes with greater machines. In the industries studied the costliness of mistakes made by workers varies in direct ratio to the increase in mechanical methods.

As an assistant superintendent claimed: "An error in judgment on the part of the operator of a charging machine may so injure either the machine or furnace that as much as a week may be required to make repairs." He was more emphatic regarding craneman. "They must be exceedingly careful, working as they do with molten metal over the heads of workers and near molds that topple with a slight jar." As was stated before, "Upset a wheelbarrow, and who cares?" Topple a ladle into the pit-floor, and no end of cost and trouble results.

If no other proof were found than this growing costliness of error which comes with machinery, it would be sufficient to show the need of a more careful intellectual worker.

Facts bear out Dr. Carrol D. Wright when he claims that muddled brains are in danger when working near complex machines. Observe also that complex machines are in danger when muddled brains operate them. A more complex machine, and a higher type of labor becomes the natural adjustment.

Machinery is becoming more complex and more gigantic in influence; therefore the more responsible the labor effort required in its operation. And for labor to meet the needs of new machinery the call is for stronger minds, not stronger muscles—for mental superiority, not for physical prowess.