GRIMES

Molding Machines

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MOLDING MACHINES

...BY...

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

GEORGE LYMAN GRIMES

ENTITLED M O L D I N G M A C H I N E S

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OF Mechanical Engineer

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

TABLE OF CONTENTS

MOLDING MACHINES

Introduction

In a great many lines of work the foundry is called on to make duplicate castings in large quantities. This has centered the thought and attention of foundrymen on the question of maximum output or tonnage for minimum cost. Some have tried to make a mold that is nearly indestructable, while others have turned their attention to molding machines with sand handling machinery, table conveyors to carry the molds past the cupolas where the iron is melted continuously, the flasks shaken out, sand screened, tempered and returned to begin the cycle of operations over again.

One of the best known systems of this kind is that at the Westinghouse Airbrake Company foundry. There one machine makes the drag which is placed on a table conveyor. The necessary cores are set while the conveyor is moving toward another machine which makes the cope, and the mold is closed. Farther down the foundry clamps are put on and then the molds are poured. At the end of the foundry the molds are taken off the conveyor, dumped on a screen, and the sand and the castings are separated. The sand is then tempered, riddled and carried back to the molding machines and the castings are sent to the cleaning room. The flasks are returned to the machines by the table conveyor.

The introduction of molding and other labor saving machinery in the foundry has been slow, on account of the opposition of the molders and the mistakes of the pioneers. This is true to such an extent that a writer in a recent number of a paper devoted to the

foundry interests states: "That in proportion to the extent to which time and money have been spent in studying the details of proposed improvements generally, and the changes that could be profitably made, the foundry continues to be neglected to a greater extent than any other department of iron and steel manufacture." And a great many men will agree with him.

The objects in view in introducing molding machines are to save labor, to increase the output of the foundry, and to decrease the amount of skill required of the operators, thus reducing the cost of production; at the same time producing more uniform and, if possible, better castings than can be made by what is ordinarily called hand or floor molding.

The process of making a mold consists of the following sequence of operations: placing the flask over the pattern, filling the flask with sand, ramming the sand, drawing the pattern from the sand, closing and clamping the mold ready for the metal.

Machines have been built to perform one or more of these operations. The greater the number of operations performed by the machine, the more complicated the machine necessarily becomes, both in regard to first cost and also for maintenance. The conditions under which the machines operate govern the type to be used. Each machine will save money if used on the class of work for which it is adapted, but will be a disappointment if used under other conditions.

In a foundry where the product is the same year after year and many thousands of each piece made, machines which will perform the greatest number of operations and reduce the skill and number of the men required to the minimum can be installed to advantage.

On the other hand, in jobbing foundries the machine which will produce the greatest variety of output for the smallest cost for patterns and special equipment for each job would be the one selected. Many foundrymen are of the opinion that the simpler machines which perform but few operations, provided they do them well, are better than the more complicated machines. They also think that if the thought and energy expended to make the designs universal had been directed toward making them more simple, especially as the machines must be used in the dust and sand of the foundry, much better machines would have been built.

A recent writer states that originally an ingenious founder built a machine that would draw the pattern from the sand; then some one devised the stripping plate. He states that records show the first scheme to have been used in the first half of the last century. The ramming of the molds by power came later.

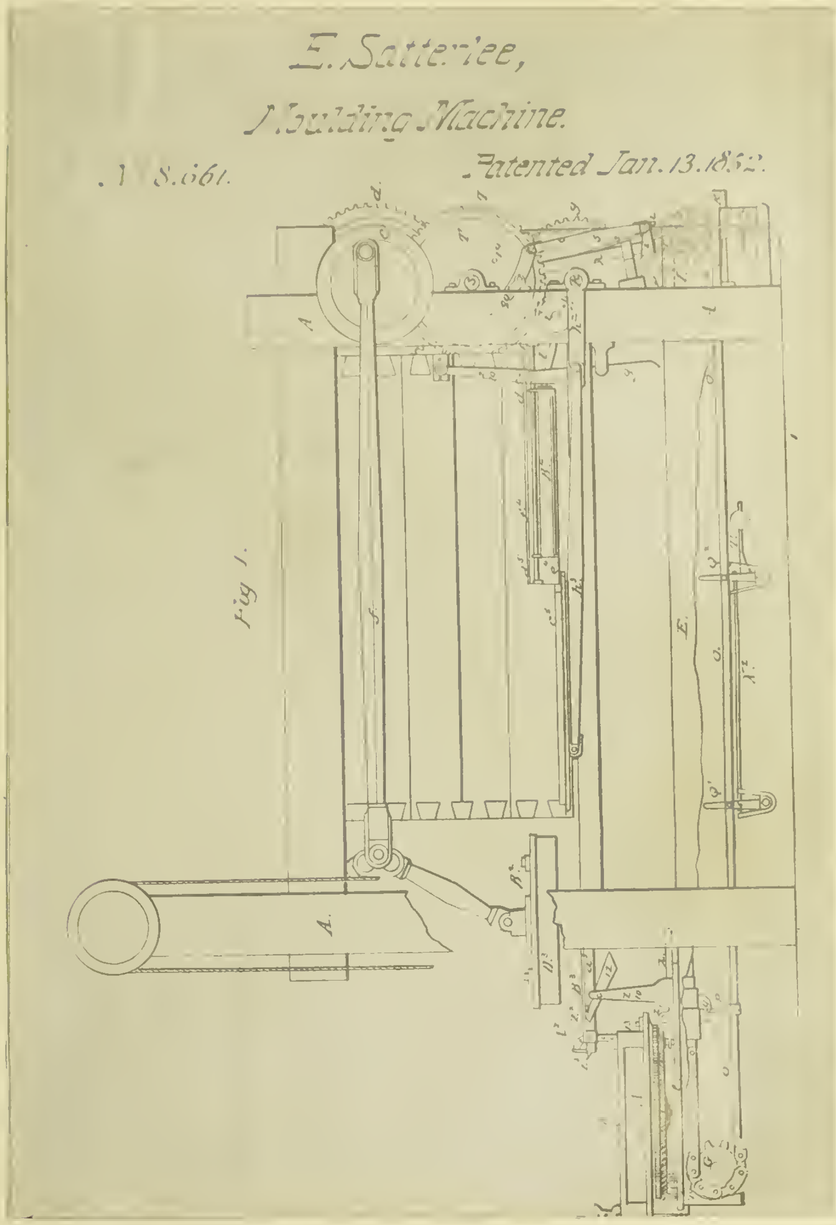
EARLY MOLDING MACHINES

In my research, the earliest record I have been able to find of a molding machine was a patent granted in 1852 to E. Satterlee for a complicated machine, for which he claims the following:-

"First. The making of molds by the alternate motions of a sifter, sliding knife to cut off the sand when the flask is filled, a press, and movable bed connected with and worked by the continuous motion of a single shaft substantially as described in this specification. I do not claim the press as my invention.

Second. The moving, stopping, and starting of the bed to and from the points where the operations of sifting, filling and pressing the sand are done by the continuous rotary motion of a single shaft, substantially as described in this specification.

Plate No. 1



Machine to sift the sand, fill the flask, and ram the mold.

Third. The method of striking the surplus sand from the top of the flask after the curb is removed by means of a self-adjusting bar or knife, substantially as described in this specification."

In other words, his machine sifts the sand, fills the flask and does the ramming, leaving the drawing of the pattern, which requires some little skill of the operator, to be done by hand. Plate No. 1 gives some idea of the complicated nature of the machine and shows how unsuitable it would be for a foundry.

The next man to receive a patent for a molding machine was granted one in 1856; he had the stripping plate idea, but he did not claim it. He simply claimed an arrangement for one pattern to serve for a number of different heights of castings simply by the length of the pattern exposed above the stripping plate. See Plate No. 2.

In 1859 an Englishman thought that, if the molder did not have to turn the flask over, more molds could be made in a day; so made application and received a patent for a machine to roll the flasks. See Plate No. 3.

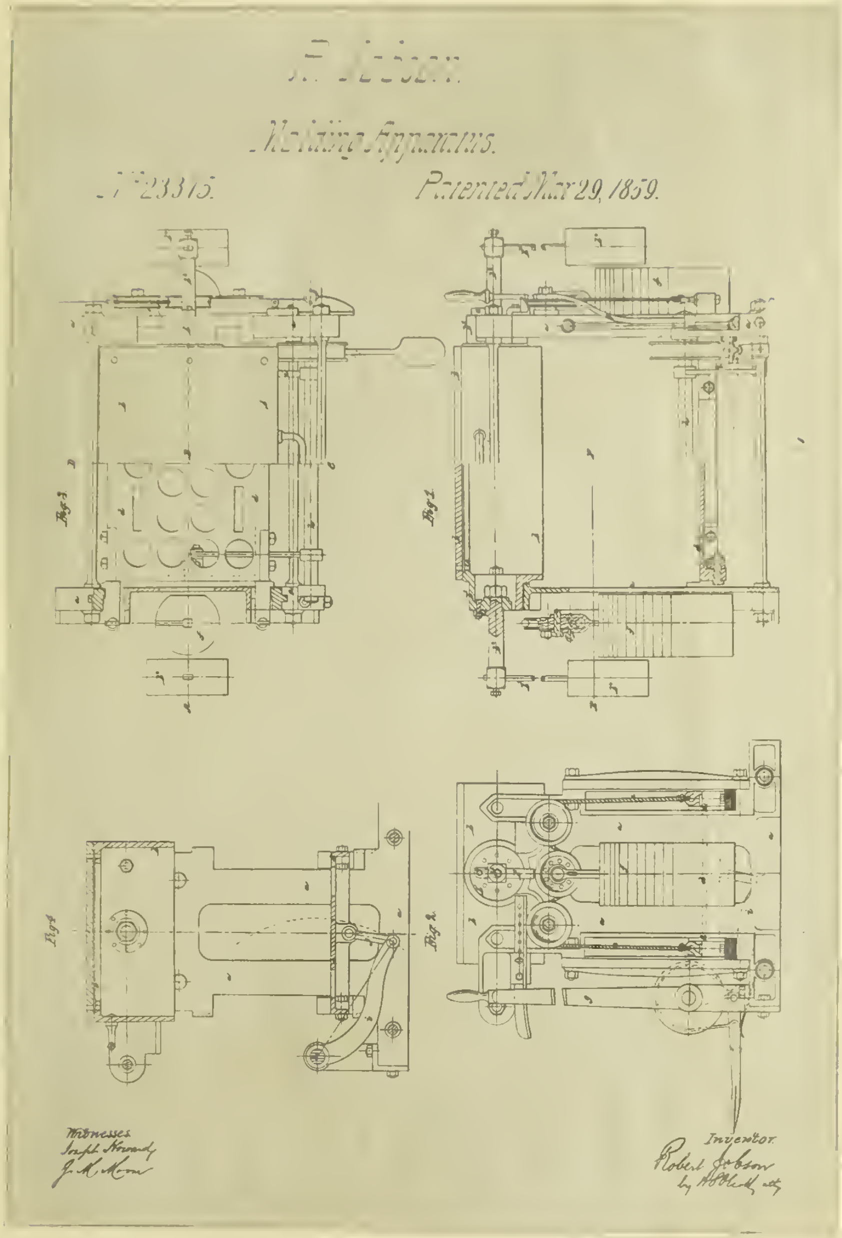
The first two men who believed that the drawing of the pattern from the sand was the most important operation in the making of a mold received patents in 1865 and 1866. The first man designed a machine that would draw the pattern down away from the sand, as can be seen in the first cut in Plate No. 4. The second drew the patterns through a stripping plate, as shown by the second cut.

The examples cited show that the opinions of the pioneers differed; and, as the number of men thinking along the line of reduction of foundry costs by the introduction of molding machinery has increased, so have the different ideas.

Plate No. 2

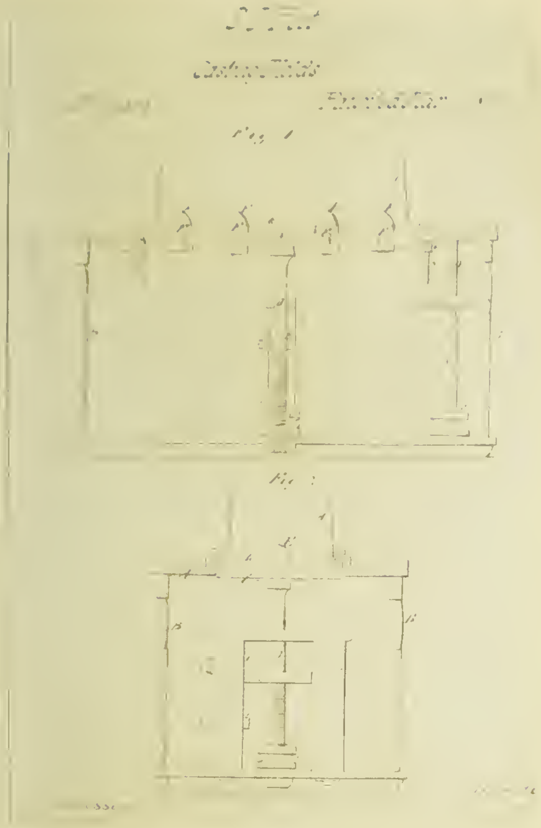
An arrangement for making castings of different heights from the same pattern.

Plate No. 3



Machine to roll the flasks over.

Plate No. 4



Second Cut

First Cut

Looking over the advertisements of the different machines, I find the following statements. One man says: "Remember that most anybody can learn to ram up a mold in a little while; it is the costly and expert molder who is needed to mend things when the pattern is yanked out of a mold after the old fashion." Another says: "We believe easy work should be power rammed." The first has a hand rammed stripping plate machine and the other a power rammed machine.

HAND MOLDING MACHINES

Molding machines as manufactured today may be divided into two general classes, depending upon the method of operation, namely, hand or power rammed machines.

Hand machines may be either portable or stationary. Some men claim that,by moving the machine over the pile of sand and leaving the finished molds behind, time can be saved. In some foundries the molding floors are divided into sections with tracks imbedded in the floor for the molding machines to run on. But the economy to be obtained by portable machines decreases as the size of the flask increases.

Taken in the broadest sense, the term hand machine may be applied to a great many mechanical aids to molding. As an example of what I mean by mechanical aids to molding, I will describe the arrangement for making engine beds at the foundry of one of the large engine building concerns. As the part to be machined is on the top of the bed, in order to get clean castings where the finished surface is required, the top is cast down.

The regular way to mold this piece would be to put the pat-

tern on a follow board, place a flask over the pattern, ram in the sand, roll the flask over and take off the follow board; then smooth off the surface separating the two halves of the flask, put on the part of the flask to make the cope, ram in the sand, lift off the cope, draw the pattern, cut the necessary gates and set the cores to make the bed lighter. Then put the two halves of the flask together and the mold is complete.

At the engine works the part of the flask for the drag or bottom half of the mold is mounted on trunions, reducing the labor of rolling the flask to the minimum. The cope is made on another device, which makes the core for the inside of the bed at the same time. This device is called a hand machine. It is an arrangement in which the sand is rammed into the flask by hand rammers and the high parts of the pattern for the core drawn through a stripping plate. The necessary gates are cut in the drag and the sprues are cut in the cope. Then the cope is lifted off this hand machine and placed on the drag, and the mold is complete. By this method of work only a very small amount of patching is required, as the pattern to be drawn by hand is plain and smooth,and the corners liable to break off of the cope are kept in place by the stripping plate.

Hand machines are made in two types,- hand presses or squeezers and lifts or devices for drawing the patterns from the sand.

The hand press or squeezer is one of the simplest of molding machines and merely squeezes or presses the sand into the flask, leaving the other operations necessary for making a complete mold to the skill of the operator. Ordinarily, the pressure is applied vertically; either the ramming head moves down, or the table on

which the flask rests is raised. In a few special cases the plunger moves horizontally, as seen in Plate No. 5.

In the majority of cases the pressure is applied by compound leverage with pin connections. The pin connections are cheaper to make and replace, and are more durable in the sand of the foundry than sliding movements.

Mr. S. H. Stupakoff, in a paper read at the annual convention of the American Foundrymen's Association at Milwaukee, June, 1903, classes the hand machines or squeezers under the following heads:-

Hand machines with movable table.

Hand presses with overhead mechanism.

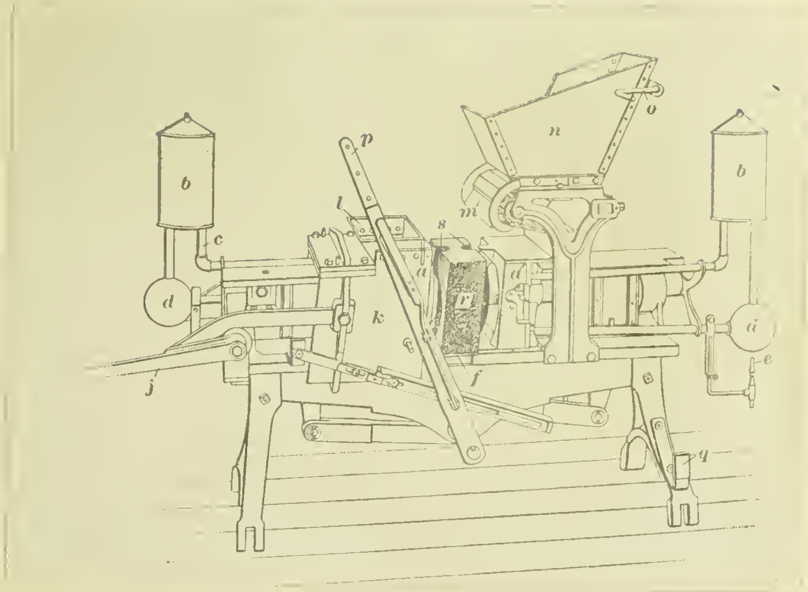
Machines with movable pressure head.

Machines with double function hand levers.

Hand machine with movable table: Plate No. 6 is a good example of a machine with movable table. As will be seen from the cut, the table is supported by four posts marked aa and is raised by the bell crank lever marked bb and the link c. One objection that can be raised to this machine is that the sand can lodge at the points dd and work into the bearings, which guide the table supports, and make them wear very rapidly and the table move unevenly.

Hand press with overhead mechanism: As will be seen from Plate 7, this machine consists of a toggle enclosed in a case which is supposed to be dust proof. The machine may be fastened to a post or mounted on a portable table. In either case the operator must move the flask under the press when he wishes to ram the sand, and pull it out from under the press while making the other operations. This requires two movements that are practical-

Plate No. 5



ly useless and the time required to make them is wasted.

In use a hand lever is attached to the square 16, a movement of the lever will rock the toothed toggle segments 14 and 15 through the link 17 and raise or lower the plunger 12. The length of stroke by this construction is short.

One point in favor of this machine is the fact that all of the mechanism of the machine liable to be damaged by sand is above and out of the way. The only grit that might get in the bearings would come from the dust in the air.

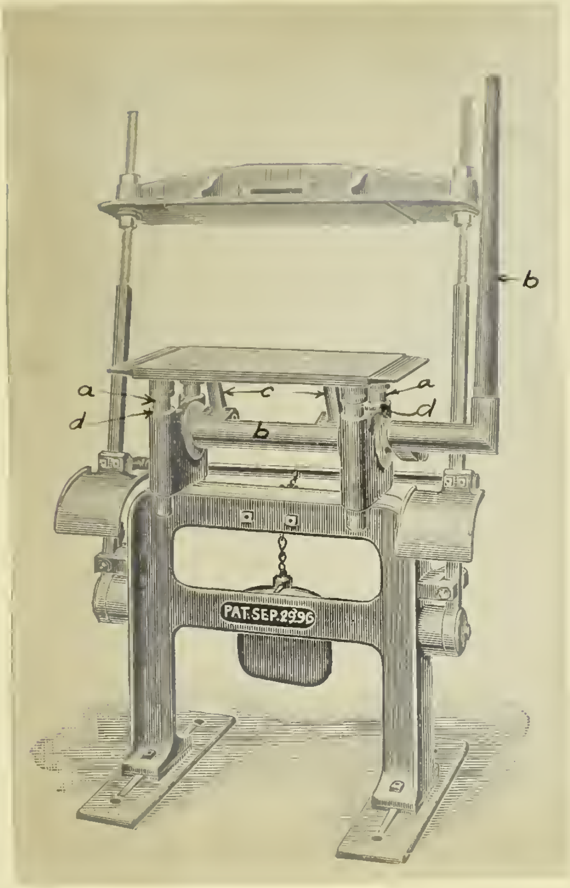
Machines with movable pressure head: Plate No. 8 shows a squeezer or hand press in which the pressure head is lowered to ram the sand. The pressure head a is fastened by pin connections to the cross-head bb sliding in the guides cc. The operator by moving the bell crank lever dd through the link ee raises or lowers the cross-head b and thus raises or lowers the pressure head. In both this machine and the one shown in Plate No. 6, the operator must swing the pressure head over the flask before the pressure is applied.

Machines with double function hand lever: The best known squeezer in this section of the country is the one shown in Plate No. 9. The first part of the movement of the hand lever brings the pressure head over the flask, and the balance of the movement of the hand lever lowers the pressure head and rams the sand.

With this machine, at the moment when the greatest pressure is required to compress the sand, the hand lever is nearly horizontal, and the man can throw his whole weight on the lever.

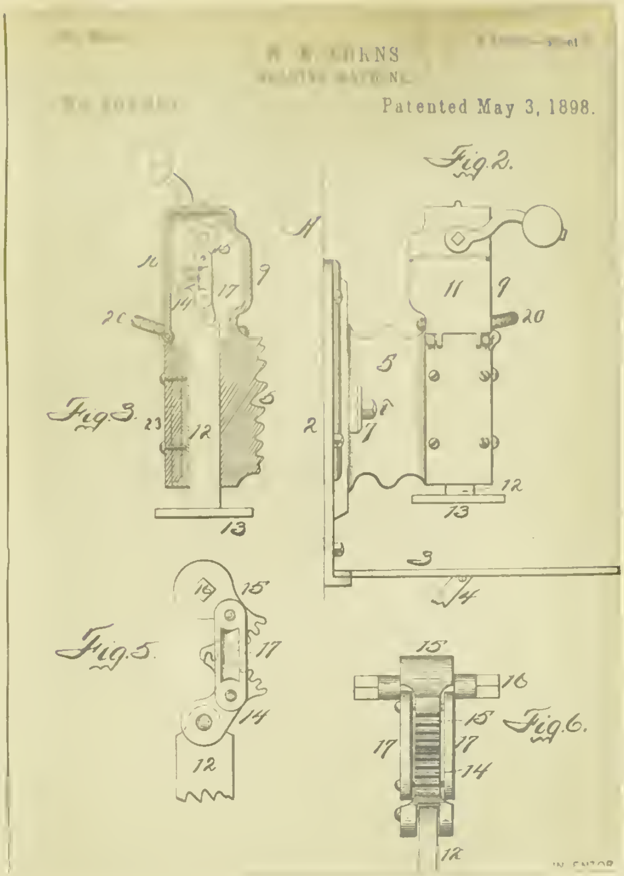
The objections to this machine are the great distance the hand lever must be moved, approximately 120 degrees; also the coun-

Plate No. 6



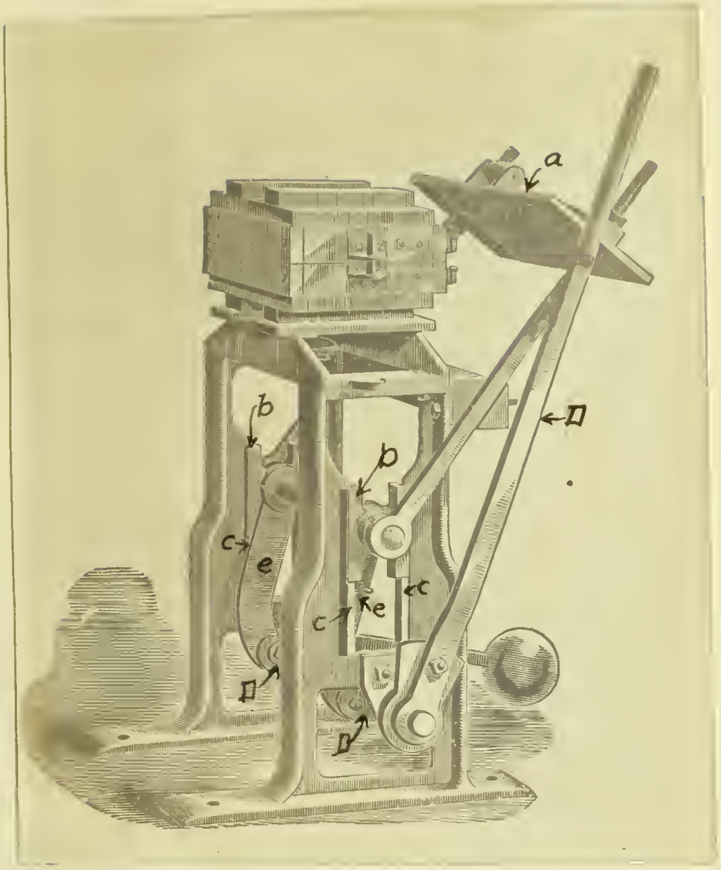
Machine with movable table.

Plate No. 7



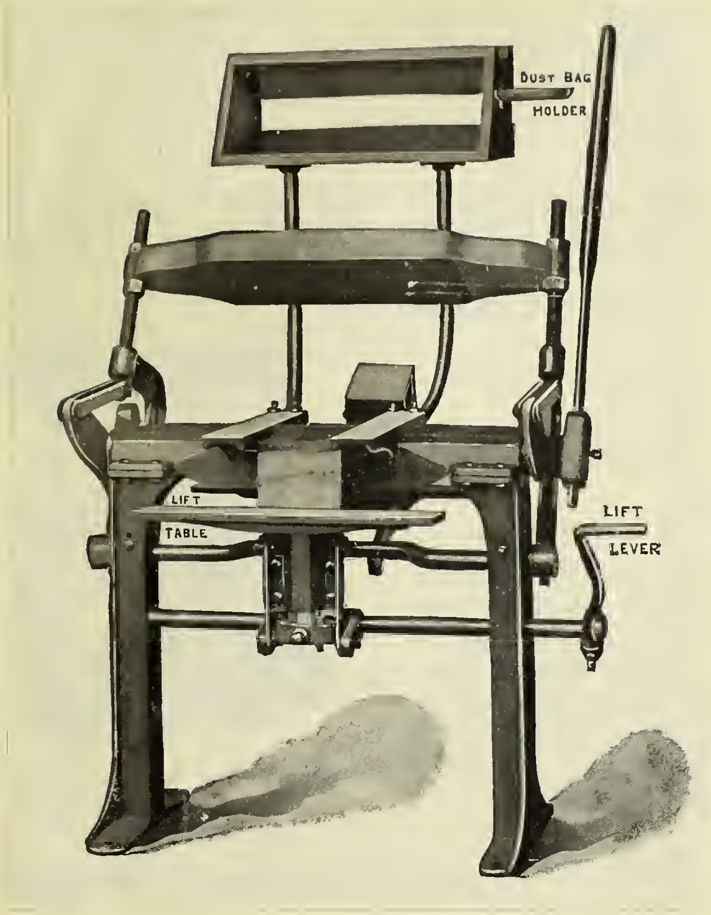
Machine with overhead mechanism.

Plate No. 8



Machine with movable pressure head.

Plate No. 9



Machine with double function hand lever.

terbalance, which assists in raising the pressure head and, swinging it back away from over the flask, is in the position requiring the greatest pressure on the hand lever at the same moment the greatest pressure is required to ram the sand. This reduces the effective pressure on the sand.

The last two machines can be equipped for stripping plate patterns by the makers, thus making machines that will perform two of the operations necessary to complete a mold.

In addition to these machines which are on the market, there has been a large number of special machines built, by various firms throughout the country, for the special kind of work to be accomplished in their own shops. Examples of this kind of machine are pulley molding machines, gear molding machines, and car wheel molding machines.

The majority of the machines using plate patterns are stripping plate machines. The general opinion is that as the flask is above the plate the small corners in the mold will fall of their own weight, in addition to the suction produced between the sand and the pattern plate when the pattern is removed. The stripping plate is made to sustain these corners while the pattern is withdrawn.

The stripping plate,or follower plate as it is sometimes called, has a great many disadvantages. The sand gets between the pattern and the stripping plate and causes a great deal of wear. A stripping plate pattern is very expensive to make, as it consists of two plates. One plate has the patterns fastened to it and the other has holes in it and is the stripping plate proper. The plate with the holes in it must fit the patterns accurately to prevent

as far as possible the sand from getting between the two surfaces. when it becomes necessary to change from one pattern to another, a great deal of time is lost when stripping plate patterns are used. All of these objections tend to keep the machines requiring stripping plate patterns out of the jobbing foundry, as all of the profits on a great many contracts would be expended in making patterns.

A number of schemes have been tried to do away with the stripping plate pattern, and the degree of success has depended upon the class of work. As with everything else in the engineering line, the conditions must be studied carefully before adopting any plan. In one radiator factory which I visited, the men carrying the flasks away from the machine lifted the flask off of the pattern plate. The results were good, but of course the patterns were very shallow, and the guide pins kept the flask in line until the sand was free from the pattern.

Our molding sand has a liberal amount of binding material, which we find is a great advantage, so that the plate can be drawn away from the mold without the corners sticking down, but our patterns are round and relatively shallow, so that the space between the pattern and the sand increases very rapidly. Consequently there is less chance for the formation of a vacuum sufficient to damage the mold than if the pattern were straight.

One inventor thought that if the mold could drop away from the pattern a stripping plate was not necessary, so he designed the machine shown in Plate No. 10. This machine has a revolving pattern plate B, which is fastened to the pressure head. The flask is placed on the upper side of the pattern and filled with

sand. A follow board is then clamped over the flask by the catches marked $\underline{b}^7$, $\underline{b}^8$, $\underline{b}^9$, then the pattern plate is revolved and the table $\underline{D}$ raised, compressing the sand and at the same time releasing the clamps from the follow board. When the table is lowered the mold will drop away from the pattern. Where the two halves of the pattern are not alike, both sides of the pattern plate must be fitted up;otherwise only one side is necessary.

POWER MOLDING MACHINES

Of the machines on the market today the advertisements show only three power rammed machines, and they are all intended for air pressure. But a number of other kinds have been built, using air, steam or water cylinders, or driven by line shafting with cams to compress the sand.

The most novel machine, and the one with which I am least acquainted, is called the pneumatic jarring machine. From the descriptions given, this machine has a cylinder to jar the machine, the theory being that the sand will be packed in a manner similar to the settling of the contents of a barrel by rocking it back and forth on its end. The makers claim that the sand is packed hardest next to the pattern where the iron is to be held, and more loosely farther away from the pattern. This would make a mold that would not strain and yet would be porous enough for the gases to escape quickly, and not cause castings which are called "blowed." This is what all inventors are trying to accomplish.

The most generally advertised machine on the market today is the one shown in Plate 11. This is an illustration of one of the smaller machines made by this firm. The machine consists of a table a fastened to a cylinder b, which slides over a fixed piston

Plate No. 10

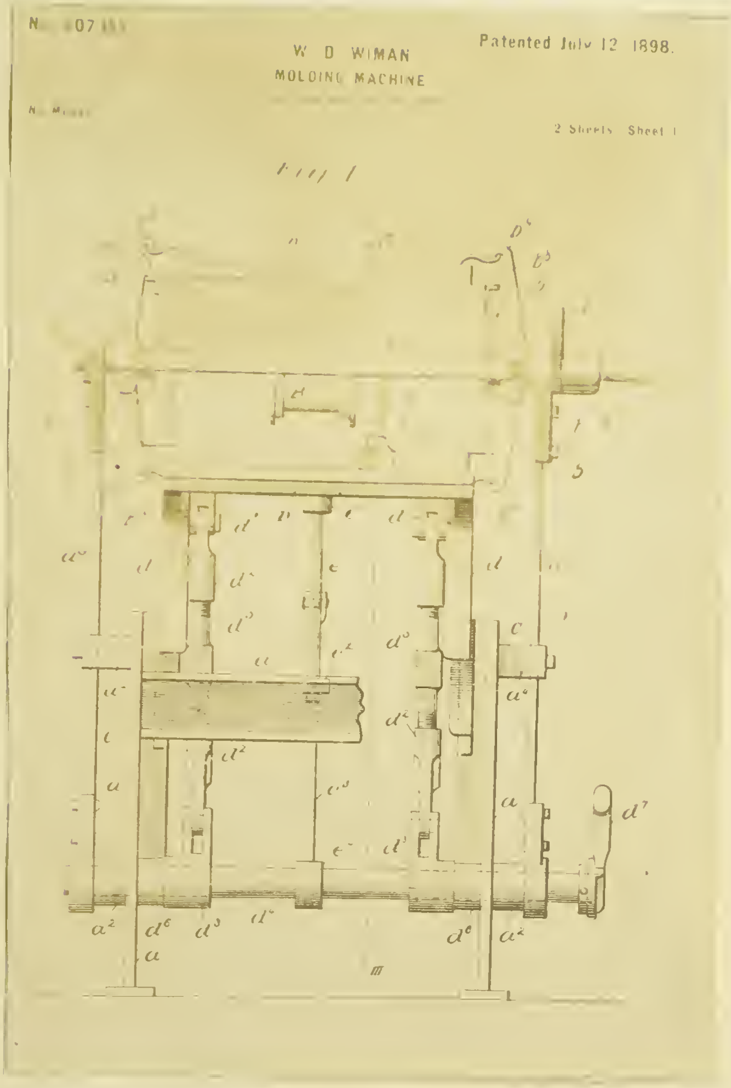

W. D. WIMAN
MOLDING MACHINE
Patented July 12 1898.
2 Sheets—Sheet 1

Plate No. 11

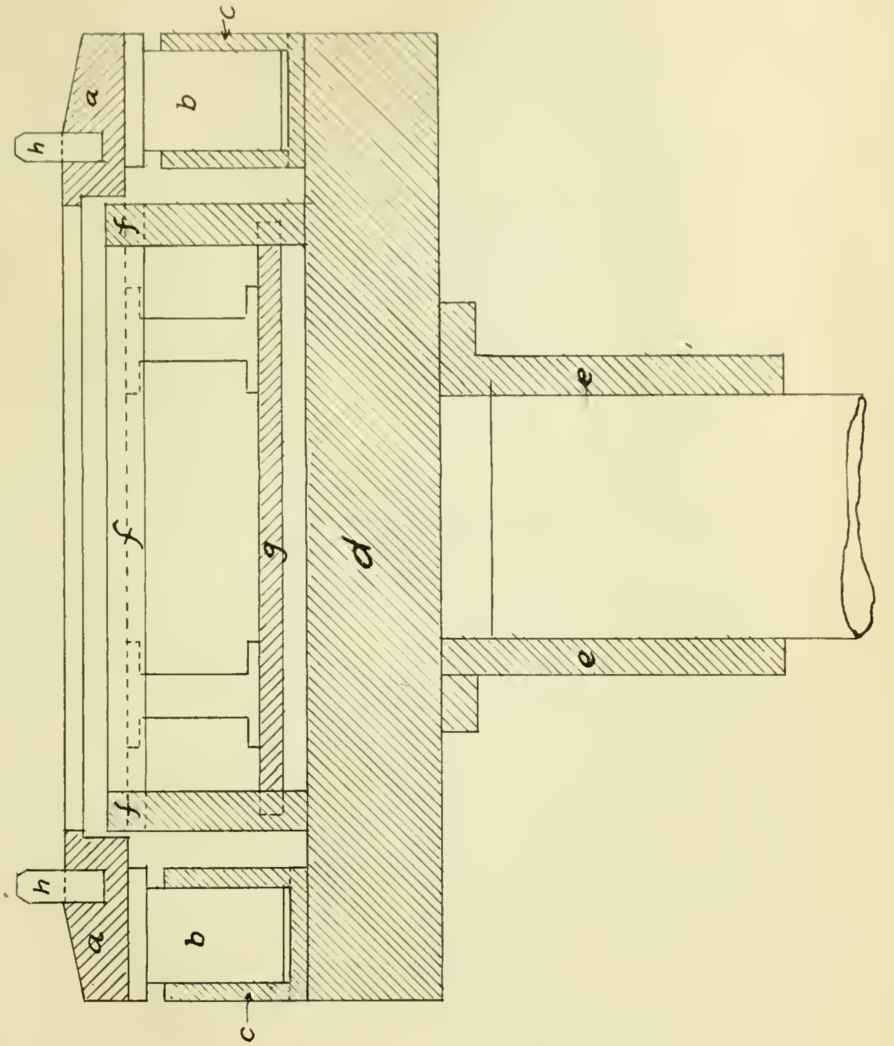
Power rammed machine for snap flask molding.

c when the pressure is applied. The pressure head e is moved into position, over the flask, by hand on the smaller machine, but on the larger machines an auxiliary air cylinder is supplied for that purpose, and so arranged that the first part of the movement of the lever on the controlling valve admits air to the auxiliary cylinder and swings the pressure head into position. When it is in place over the flask, the lever of the valve can be moved to admit air into the main cylinder and ram the mold.

Machines like those in the cut are designed for snap flask work; when used with ordinary patterns, the patterns are fastened on what is called a vibrator frame. This frame is placed between the drag and the match while making the drag, and between the drag and the cope while making the cope. After ramming the mold the operator starts the vibrator shown at j by pressing the lever q with his left knee, and the sand is supposed to be gently disengaged from the pattern so that the two parts of the flask can be separated and the pattern drawn.

This firm makes machines for using pattern plates and iron flasks in which the table a holds the pattern plate. The patterns may be either stripping plate patterns, plain plate patterns, or devices called stools may be used. Plate No. 12 is an outline drawing of the main part of one of the machines arranged for pattern plates. The part marked a is the table which carries the flask guided by the flask pins hh. To this table the plungers for the two auxiliary air cylinders bb are bolted, which when the pressure is turned on slide in the cylinders cc and raise the flask from the pattern. The cylinders cc are fastened to the same casting d that includes the main cylinder e, and the frame is connected to

Plate No. 12



Parts that are fastened together are sectioned lined in the same direction. This is only an outline sketch of the machine and does not show the various supports that are necessary to keep the light frames from breaking when the mold is being rammed.

the same casting by posts. On this machine the vibrator is fastened to the table a, and the valve which admits air into the cylinders cc also controls the admission of air into the vibrator cylinder. The first movement of the valve lever starts the vibrator, and the remainder of the movement stops the vibrator and admits air into the cylinders cc.

Should it be desired to use a plain plate pattern, the plate is fastened to the frame f and after the mold is rammed the vibrator is started; then the pressure is turned into the cylinders bb and the flask is lifted from the pattern ready to be picked up by the crane or the men carrying the flasks away from the machine. If there are any deep corners in the pattern where the sand is liable to stick, stools can be fastened to the plate g, which is part of the table a, and the stools will come through the pattern plate and support the deep pockets of sand until the flask is lifted off from the machine.

When a stripping plate is to be used, the patterns are fastened to the frame f and the stripping plate is fastened to the plate g by posts, or in a recess cut in the table a for the purpose.

The makers build a large number of sizes of the machine. I have seen four different sizes in operation and the smallest one designed for snap flasks is the only one that, in my opinion, has a ramming cylinder of sufficient size. The small machine seems to have a small margin of pressure to spare, that is, the operator can ram a mold too hard by turning the air on very quickly. With the other sizes, in ramming up a mold the air must be turned on very quickly and the sand given a series of blows. As a result the

sand next to the pressure head is packed very hard, while the sand next to the pattern is not rammed sufficiently. This is the reverse of proper ramming.

Most inventors have tried to make a machine which would make the sand in the mold of uniform density all through. If the cylinder on this machine were large enough for the ramming to be done by a gradual squeeze, the pressure would be transmitted through the sand more uniformly, and the proper ramming more nearly attained.

One objection to the larger machines is that the jar,caused when the mold is rammed, is so great that parts of molds on the floor of the foundry near the machines are shaken off and the molds ruined. The machine is complicated and the vibrator shakes the machine to pieces and breaks itself, and must be replaced often. With the care ordinarily given foundry equipment, the machine would be out of service a larger part of the time.

The third kind of power machine advertised is a post machine, so arranged that the ramming cylinder is above the flask and can revolve around the post. This allows the same ramming head to be used for several stands with patterns.

A machine which has proved very satisfactory under some conditions, but which is not now on the market, is the one shown in Plate No. 13 and Plate No. 14. This machine, without any extra attachments, performs more of the operations necessary to make a complete mold than any other machine that I have ever seen.

This machine has been altered and improved to such an extent that the machines in use today are very different from the machine shown in Plates No. 13 and 14, but a good general idea of the machine can be gained from the cuts. As will be seen from the cut

in Plate No. 13, the machine consists of a hopper marked k, into which the helper shovels, or the sand handling machinery delivers, the sand. Directly under this hopper is a sand drawer K^3 which takes a measured amount of sand and delivers it into the flask I, the pressure head B is swung around into place, and the pressure head and the flask are clamped into place by the arm B and the screw B^6. The lever G^7 controls the intermediate friction wheel which starts or stops the large wheel on the cam shaft G'. A complete revolution of the cam shaft G' presses the mold and draws the pattern.

The machine shown in Plates Nos. 13 and 14 is intended for stripping plate patterns. The cams D^7 shown in figure 4, Plate No. 14, are the cams for ramming the sand, and the cams D^9 are the cams that operate the stripping plate. The cams are timed so that both the plate D carrying the stripping plate and the plate D^7 to which the patterns are fastened move up at the same time, but the plate D remains at the top of its stroke until the patterns are entirely free from the sand.

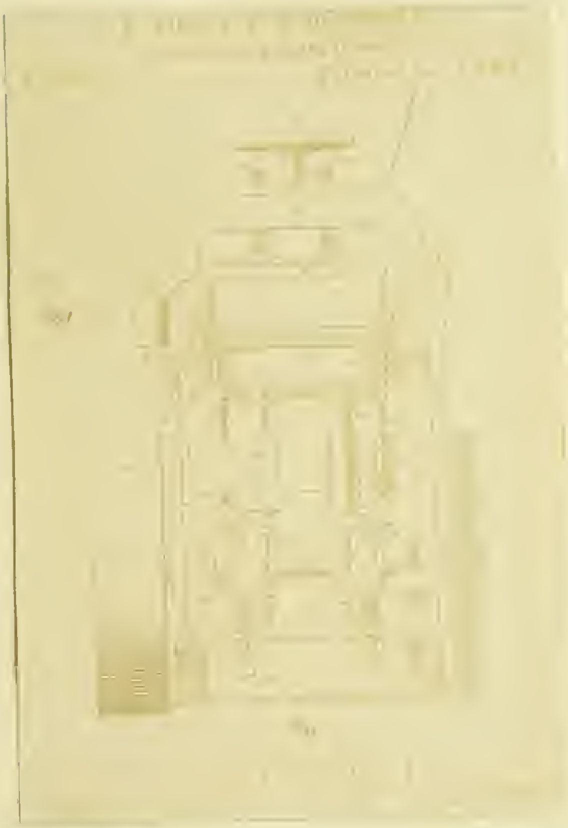
The complicated arrangement shown at G^6 G^7 G^8 G^9 in Plate No. 13 is one of the first arrangements for moving the sand drawer over the flask and returning it to the original position under the hopper.

As will be seen from this description, this machine performs all of the operations necessary to make a complete mold, except the placing of the flask over the pattern and removing the flask from the machine and closing the mold; this reduces the time per mold to a minimum. This machine was very expensive to maintain,

Plate No. 13

Side view of machine.

Plate No. 14



Front view of machine partly in section

due to the complicated mechanism, and was not a commercial success.

One firm that had a large number of these machines realized the weak part of the machine and made a number of changes, such as discarding the stripping plate attachment and the complicated sand drawer mechanism and using plain plate patterns and a steam cylinder instead. This reduces the trouble and expense necessary to maintain the machine.

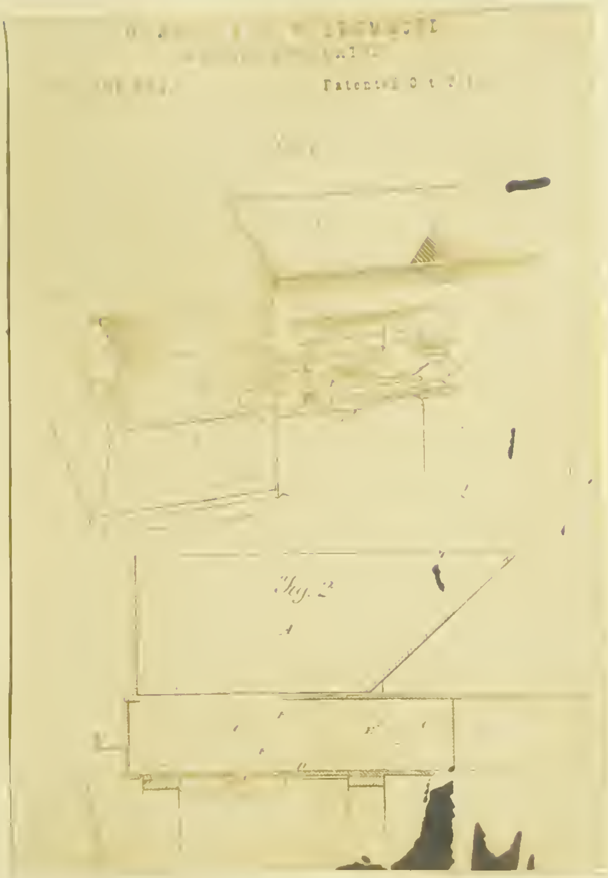
This machine has so many ingenious schemes to accomplish the various movements and shows so much study that it seems quite unfortunate that the men who spent so much thought, time and money could not get the machine introduced.

One of the most interesting details of this machine is the way the inventor keeps the sand from falling out of the sand drawer between the flask and the front of the hopper. Plate No. 13 shows the device. The inventor describes the method of operation quite clearly and briefly, so I will quote the Patent Office descritpion of the device:-

Figure 1 is a perspective view, and figure 2 is a longitudinal vertical section. The same letters indicate the identical parts of each figure.

A is a hopper, supported on the molding machine, and B is the flask to be filled. C is a sliding bottom under, but not fixed to, the drawer. Its movements are controlled by the sliding bars E, which move in the guides E^2 on the supports of the hopper on each side. The bars are connected to the bottom by jaws embracing pins D' projecting from the sides, which cause the bottom to move forward with the bars, while the pins C' on the drawer are engaged by

Plate No. 15



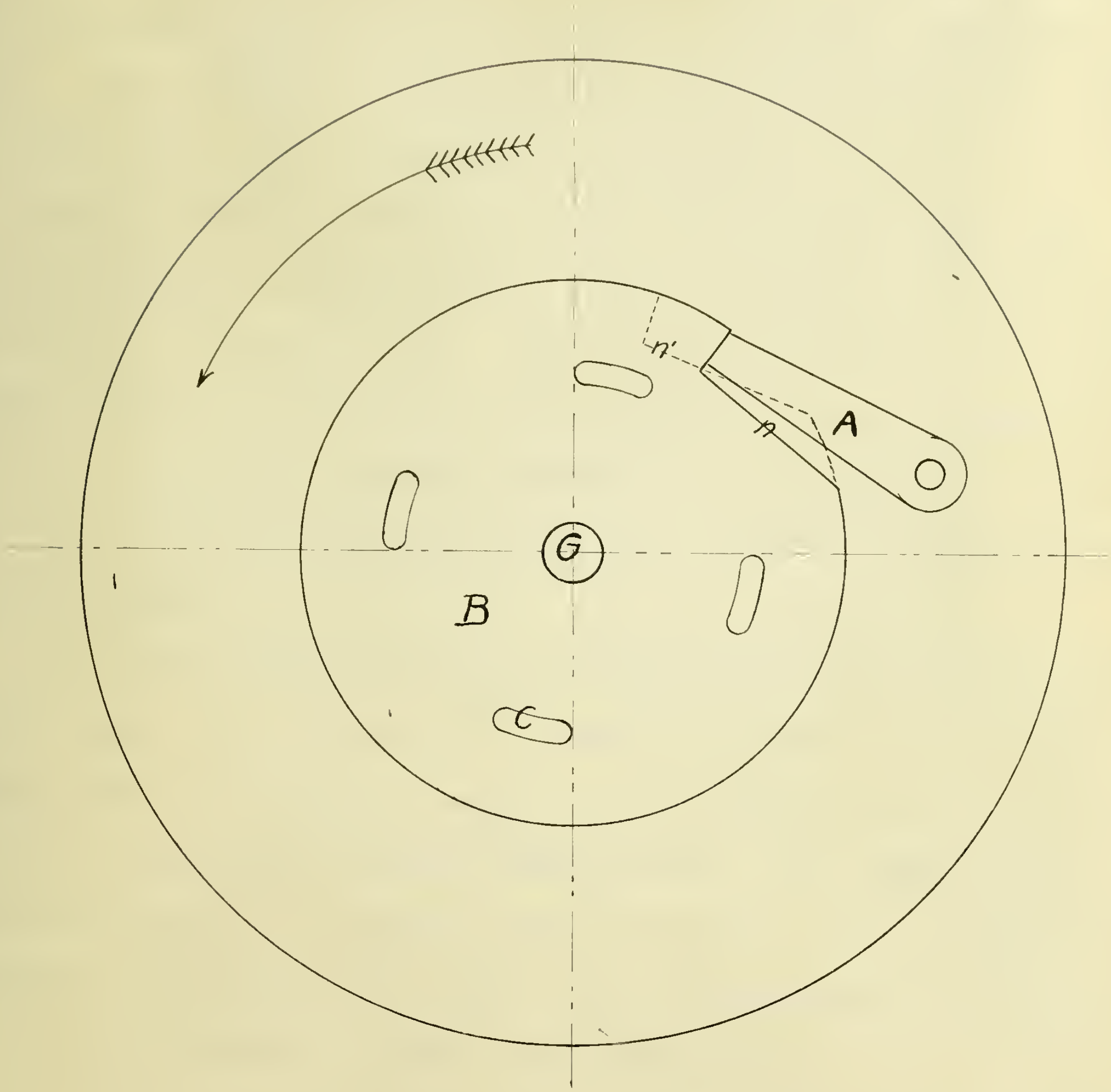
Detail of arrangement for operating the bottom of the sand drawer.

the notches in the top of the bars E. This engagement is made by the bars being raised by the stationary cams E′ in the guides, which raise the bar so as to catch the pin; but when the bottom has been carried far enough to reach the flask B the bent ends of the bars allow them to fall, so as to disengage the pins C′, and at the same time the latches F fall on the points projecting above the bars and lock them, as shown in Fig. 1. The drawer, filled with sand, then is drawn forward with the bottom until it reaches the flask, then leaving the bottom and allowing the sand to fall into the flask. When it is filled the drawer is retracted. The edge of the end piece strikes the flask and carries any surplus sand back onto the bottom D, the pins C′ raise the latches F, and then, striking the points on the bars, draw them back, the bars being raised by the cams E′, so that the pins C′ are engaged in the notches in the top of the bar. As the drawer passes under the hopper it is again filled with sand, and, another flask being substituted, the operation is repeated."

While the sand is falling from the sand drawer into the flask the pattern is a definite distance below the lower edge of the flask. When the pattern is raised it is forced into the sand and the mold is rammed in this manner. In order that the amount of pressure exerted on the sand may be controlled, the device shown in Plate No. 16 is used.

The direction of rotation of the cam shaft G is shown by the arrow. If the force tending to rotate the cam shaft is removed when the notch in the disc B is in the position shown by the dotted lines n, the large friction wheel will drop back until the notch on the disc B is in the position shown at n and in contact

Plate No. 16



with the pawl A. The position of the notch n in the plate B, relative to the time of the cam, determines the distance the pattern is below the lower surface of the flask. As will be seen in disc, B is fastened to the large friction wheel by four bolts, and the holes in the disc are slotted as shown at C; this permits adjustment and gives control over the amount of pressure exerted on the sand. When patterns of approximately the same volume are used, this adjustment does not need to be changed.

Another machine which has proved very satisfactory, under the conditions at the concern where it has been used, is the one shown in Plates No. 17 and No. 18. This machine is called the yielding platen machine, and Plate No. 17 is taken from a photograph, which gives an idea of the general appearance of the machine. Plate No. 18 is the Patent Office drawing of this machine and shows the machine in detail.

The machine consists of two pattern chests L^1 and L^2, as the inventor calls them, mounted on a system of levers, so that they may revolve about the central post A' in the direction of the arrows, and can be alternately raised and lowered. The chests balance each other and retain a horizontal position at all times. Attached to the post A' and arranged so that the pattern chests will swing under it is the pneumatic press to ram the mold.

The method of operation used on this machine is as follows: The helper places the flask on the machine when the pattern chest is in the position shown at L^2 in Fig. 2, Plate No. 18, and cleans off the pattern, then swings this pattern chest around under the sand chute Q where the machine man stands. He puts in the gaggers and soldiers that are necessary and fills the flask with sand; while he

Plate No. 17

Yielding platen molding machine.

Plate No. 18

Yielding platen molding machine.

is doing this the helper is placing another flask on the other pattern chest. When both men are ready the pattern chests are revolved into the position shown by the dotted lines in the cut and the mold is rammed. Then the pattern chests are revolved another quarter of a revolution, the pattern is drawn through the stripping plate, and the helper carries the finished half of the mold away and substitutes another flask, thus beginning the cycle of operations over again. Where the patterns are different in the cope and drag, the pattern for the drag can be placed on one pattern chest and the pattern for the cope on the other.

The most novel feature of this machine is the construction of the pressure head. This is shown in Figs. 2, 3, and 4 in Plate No. 19. I is the flask; H is the sand box which is added to the flask while filling in order that there will be sufficient sand in the mold when packed; C is the pressure head; C' and C^{2} are the sides of a box fastened to the pressure head, five sides of this box being of iron and the sixth side a flexible diaphragm. The space in the box is filled with water or with a non-freezing liquid when the machines are in use in winter.

In ramming a mold it is very desirable that the sand should be packed uniformly throughout the entire mold. With a plain plate on the pressure head when the patterns are very deep, the sand is packed more closely over the high parts of the patterns than it is over the shallow parts. This is wrong, as the high points are the places most liable to blow away, and if the sand is harder at those points than at any other the castings are certain to be lost. Various schemes have been tried to remedy this fault, and this scheme shown in Plate No. 19 is very satisfactory.

Plate No. 19

Yielding platen molding machine.

The flexible diaphragm, subject only to the pressure of the water confined above it, will give an equal pressure per square inch over the whole surface of the flask. Such action will depress some parts of the surface more than others. If the surface of the sand is straight before ramming and after the flask is rammed the surface of the sand reproduces the shape of the pattern, it shows that the sand is rammed uniformly. The flasks rammed with a flexible diaphragm have that appearance.

Some inventors have tried to make a pressure head with a series of plungers with springs behind them to receive the pressure. Another tried pebbles behind the plungers. Another thought that a spiral screw would force the sand into the mold with equal pressure.

The firm that makes the machine shown in Plate No. 11 recommend what they call a peening frame, which consists of a frame of wood fastened to the pressure head and having projections to depress the sand farther at the points where the pattern is shallow. This requires a frame for every pattern and is not very feasible.

With the machine shown in Plate No. 13, the operator takes sand out of the flask over the high points of the patterns.

PRESSURES FOR MOLDING MACHINES

In designing a molding machine the question arises as to how much pressure is required to ram a mold, and whether the pressure should be greater as the flask is made deeper. That is, does the pressure required to ram a mold depend upon the area of the top of the flask or does it depend upon the volume?

From the observations I have made of the operation of various machines, I believe that the force necessary to ram a mold should

vary as the volume of the flask varies, and that there is a constant by which the volume of the flask can be multiplied to get the total force that should be exerted on the flask. Knowing this total force and the pressure per square inch which can be carried, the diameter of the ramming cylinder can be obtained if the ramming is to be done by a cylinder.

An English firm gives the following as the pressures necessary with their machine:

Steam	40 to 50	lbs. per square inch.
Air (pneumatic) . .	40 to 50	" " " "
Water (hydraulic) .	900	" " " "

They also publish a table showing the power necessary to run these machines:-

Size of Flasks		Depth of Flasks		Dia. of Steam or Air Cylinder	Dia. of Water Cylinder	Steam used per Mold	Water used per Mold	Horse Power	
Round	Square	Top	Bott.					No Molds hour	H.P. used
in.	in.	in.	in.	in.	in.	lbs.	gals.÷		
12	13 x 10	4	6 1/2	18	4 1/2	0.462	1 1/4	60	1
15	15 x 15	4	6 1/2	21	43.4	0.630	1 1/2	60	1 1/2
20	26 x 16	4	7 1/2	28	53.4	1.11	2 1/2	40	1 1/2
26	29 x 19	5	7 1/4	31	6 3/8	1.379	3		
32	34 x 24	6	7 1/4	40	8 3/8	2.365	3 1/2		

The makers claim that by means of a small size of this machine, three young persons are capable of producing from 400 to 800 molds per day, depending upon the pattern and the form of the casting required.

Taking the data from the above table, I have figured the pres-

sure per square inch of area of the top of the flask with a pressure of 40 and 50 lbs. per square inch on the air cylinder: and also the pressure per cubic inch of sand in the deepest part of the flask, under the same conditions. The constant which might be called the volume constant is the one I believe should be used in designing a molding machine.

The following is the table:

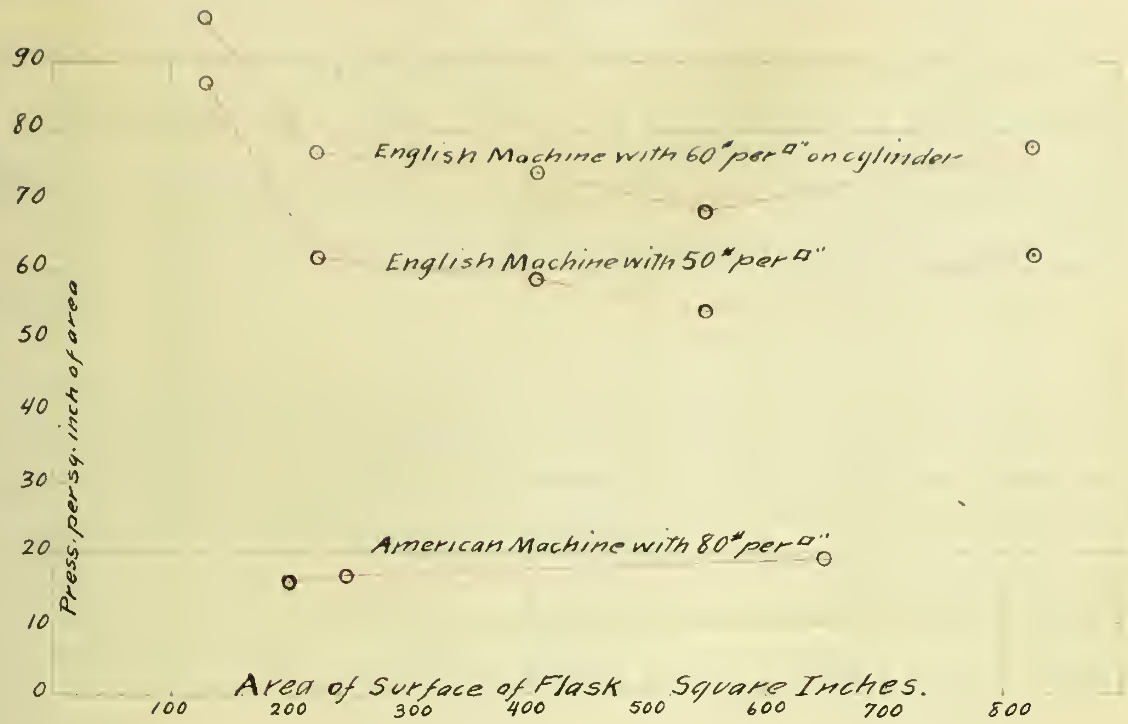
Sizes of Flask	Depth of Flask	Dia. of Steam or Air	Total Press. on Plunger At 40#	Total Press. on Plunger At 50#	Press. per sq. inch Surface of Flask At 40#	Press. per sq. inch Surface of Flask At 50#	Press per cu. inch of Vol. of Flask At 40#	Press per cu. inch of Vol. of Flask At 50#
13 x 10	6 1/2	18	10,179	12,724	85.9	97.8	12.04	15.06
15 x 15	6 1/2	21	13,854	17,318	61.5	76.9	9.48	11.89
26 x 16	7 1/4	28	24,630	30,786	59.2	74.0	8.17	10.04
29 x 19	7 1/4	31	30,191	37,738	54.8	68.4	7.56	9.46
34 x 24	7 1/4	40	50,264	62,830	61.6	77.0	8.49	10.62

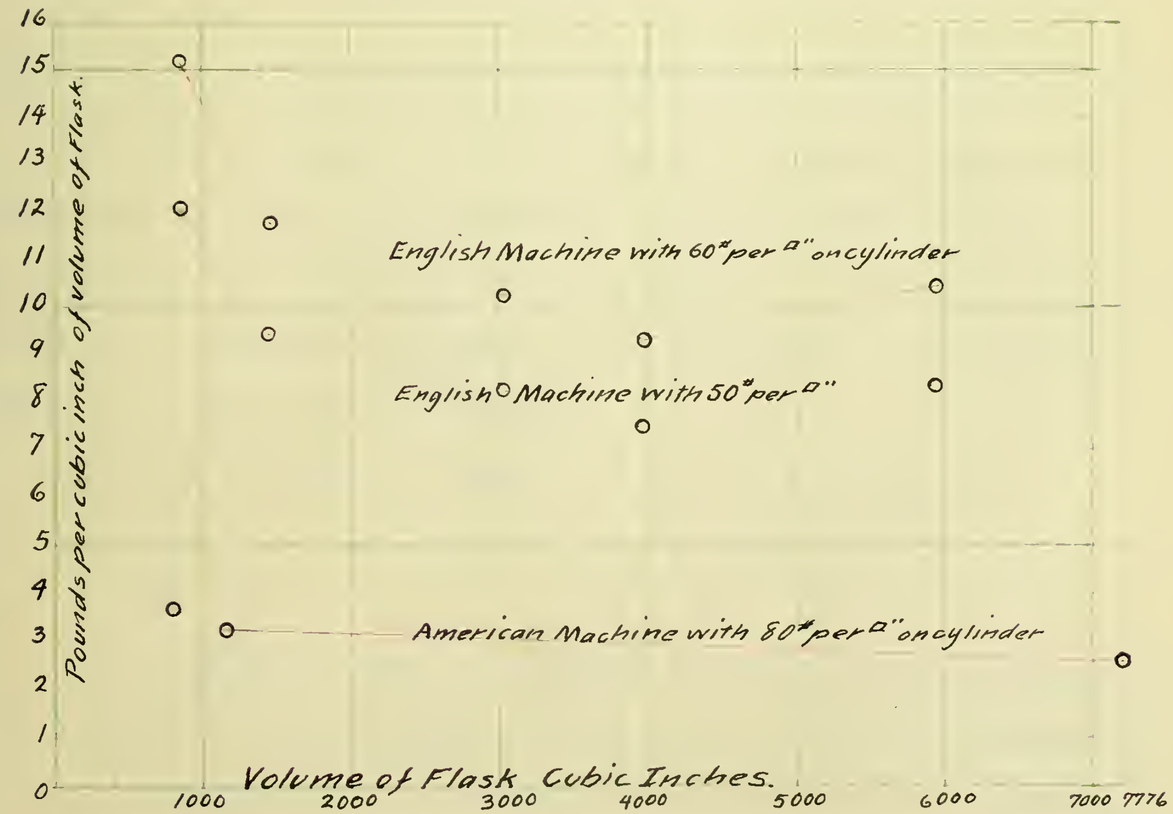
As can be seen from the above table, this firm does not seem to follow any rule, depending upon the size or volume of the flask, for determining the size of the cylinder.

In Plate No. 20 I have plotted the values given in the above table. Using the area of the flask for abscissas,and the pressure per square inch of surface of the flask for ordinates, gives one series of points; and using the volume of the flask for abscissas and the pressure per cubic inch of volume of the flask for ordinates gives the other series of points. The remaining series of points are obtained in the same way for the machine shown in Plate No. 11.

It will be seen that the English firm considers that a much

Plate No. 20


90
80
70
60
50
40
30
20
10
0
Press. per sq. inch of area
English Machine with 60# per □" on cylinder
English Machine with 50# per □"
American Machine with 80# per □"
Area of Surface of Flask Square Inches.
100
200
300
400
500
600
700
800


16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Pounds per cubic inch of volume of Flask.
English Machine with 60# per □" on cylinder
English Machine with 50# per □"
American Machine with 80# per □" on cylinder
Volume of Flask Cubic Inches.
1000
2000
3000
4000
5000
6000
7000
7776

greater pressure is required to ram a mold than the American firm considers necessary. As I have stated before, I believe that the American machine has too small a cylinder.

The following table gives the dimensions of the American machine, corresponding to the ones given for the English machine.

The data in the following table are for the machine shown in Plate No. 11.

Sizes of Flask	Depth of Flask	Air Dia.	Cylinder % of Area of Flask	Total Press. on Plunger at 80# per	Press. per sq. inch Surface of Flask	Press. per cu. inch of Vol. of Flask
10 x 20	4	7	19.24	3078.8	15.39	3.848
$12\frac{1}{2}$ x 20	4 3/4	8	20.00	4021.2	16.04	3.387
15 x 26	8					
24 x 27	12	14	23.75	12315.21	19.00	1.583

With this machine it is necessary to place a frame over the flask which will hold the necessary amount of sand to make up for the reduction in volume due to the ramming, so that the flask will be full when the sand is rammed. The following is the height of frame used on one class of work:-

12 1/2 x 20 flask, frame used is 2 3/4 in. high
15 x 26 " " " " 3 3/4 " "
24 x 27 " " " " 3 " "

On the class of work I saw made on the 24 x 27 machine, the machine man did so much hand ramming that a frame much lower in proportion to the depth of the flask can be used than is necessary with the smaller machines.

It is somewhat difficult to determine the pressure exerted on the sand in a machine of the type shown in Plate 13, because it is belt driven, and without a dynamometer test any figures would be approximate.

We estimate that the machine will receive eight horse-power from the belt for a 12 1/2 x 20 molding machine. With that as a basis the pressure on the sand for this size machine will be 16.8 lbs. per square inch of surface of the flask, or 3.53 lbs. per cubic inch of sand in the flask.

With this machine the pattern plate is below the lower surface of the flask, while the sand drawer is filling the flask with sand, an amount depending upon the depth of the flask. The following table gives the sizes of flasks and the amount the plate is below the lower edge of the flask.

Sizes of Flasks	Depth of Flask	Distance below lower edge of flask	Per cent of Vol. of Flask added
$12\frac{1}{2}$ x 20	3 3/4	1 3/8	36.66%
$12\frac{1}{2}$ x 20	5	1 1/2	30.00%
14 x 22	6	1 3/4	29.19%
15 x 26	8	2 3/8	29.68%
15 x 26	9	2 7/16	27.08%

CAPACITY OF MOLDING MACHINES

The feature in connection with machine molding which appeals to the business manager of a concern is the relative capacity or the quantity of work which the high priced skilled molder without a machine can turn out in a day, and the quantity produced by the

unskilled man with the aid of a molding machine.

Take for example the molding of a large size valve body. A skilled molder can, by having the sand tempered and the molds shaken out for him, make one casting a day by working hard. Two relatively unskilled men with a device for drawing the pattern can make six castings in one day if the molds are shaken out for them.

With a molding machine like the one shown in Plate No. 11, a machine operator, helper, and a gang of three laborers to pour the molds and dump out the finished castings, can make twenty castings of the same piece in one day.

The loss due to bad castings will differ very little with the three methods of work, but will be a little greater in the castings made by the skilled molder. This shows very plainly the saving which can be made by introducing molding machines where a number of castings are required from the same pattern.

The following table gives an approximate idea of the machine capacities. These values are approximate only, because the conditions govern the capacity to a great extent, and unless the specific conditions are given showing the kind of pattern, depth of flask, method of receiving the sand and filling the flask, the means for disposing of the completed molds, kind of sand and whether the men pour their own molds or not are known, no true comparison can be made.

Mach. No.	Size of Flasks	Depth of Flask	No. of Men	Sand received	Flasks Placed on	Work cored or not	Molds poured or not	Aver. No. of Molds
1	10 x 20	4 #	1	Shoveling	Floor	not	not	160
1	10 x 20	4	1	"	"	cored	not	150
1	10 x 20	4	1	"	"	not	poured	126
2	$12\frac{1}{2}$ x 20	3 3/4	3	Conveyor	Conveyor	cored	not	700
3	$12\frac{1}{2}$ x 20	5	3	"	"	"	"	600
4	14 x 22	6	4	"	"	"	"	300
5	16 x 20	6	4	"	"	"	"	540
6	15 x 26	8	4	"	Floor	"	"	140
7	$12\frac{1}{2}$ x 20	4 3/4	1	"	Conveyor	"	"	300
8	10 x 20	4	1	Shoveling	Floor	"	"	170
9	15 x 26	8	4	Conveyor	"	"	"	80
10	24 x 27	12	3	Shoveling	"	"	"	30
11	16 x 16	9	3	Conveyor	"	not	poured	275
12	24 x 24	9	4	"	"	cored	"	
13	42 x 60	9	4	"	"	not	"	20

Machine No. 1 is the machine shown in Plate No. 9, and machines No. 2, 3, 4, 5, and 6 are of the type shown in Plate No. 13.

Machines Nos. 7, 8, 9, and 10 are shown in Plate No. 11.

The remaining machines are like the cut shown in Plate No.17

The figures given in the column entitled "Depth of Flask" are for each half of the mold. The complete mold will be twice the depth given.

One firm advertises that one man with a power rammed snap flask machine made 355 molds in 8 hours, and with their hand rammed stripping plate machine made 320 molds in 8 hours.

The average capacities shown in the table of machine capacities are for a full day's work of ten hours.

With the machine No. 10 the complement of men consists of one machine man, one helper, and one core-setter. The flasks are placed on and taken off from the machine by a pneumatic jib crane, and another gang pours and dumps the molds.

The foundry using machines Nos. 11, 12 and 13 has a system of overhead tracks with portable air cylinders which permits very rapid handling of the flasks.

REFERENCES

In writing this paper I have used the following references:-

Books

Modern Foundry Practice, by John Sharp.

International Library of Technology: International Textbook Company.

Periodicals

The Foundry,- several numbers.

The Engineering News, June 18, 1903.

The Engineering Magazine, March. 1904.

Patent Office Records.

I sent for copies of all of the specifications of molding machines which are in print.

Visits to Foundries.

At various times I have visited the foundries of the follow-

ing concerns: The Westinghouse Airbrake Co.; Niagara Radiator Co.; The Singer Sewing Machine Co.; The Westinghouse Machine Co.; R. D. Wood & Co.; the Allis plant of the Allis-Chalmers Co.; The Atlas Engine Works; Link Belt Machinery Co.; Detroit Stove Works; and other smaller concerns.