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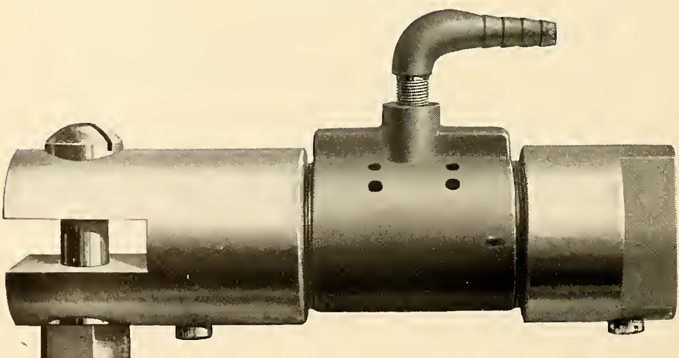

Tabor Vibrator.

MACHINE MOLDING

BY

WILFRED LEWIS, M.E.

From a Lecture delivered at

THE FRANKLIN INSTITUTE

PHILADELPHIA

May 18th, 1911

Repeated by request at Columbia University, U. S. Naval Academy and read before the New England Foundrymen's Association and the Worcester Polytechnic Alumni Association

COMPLIMENTS OF

THE TABOR MANUFACTURING COMPANY

18TH AND HAMILTON STREETS

PHILADELPHIA, PA.

MACHINE MOLDING

BY

WILFRED LEWIS, M.E.

President The Tabor Manufacturing Company

The art of molding is probably as old as civilization, and it may have reached a high state of development before any of the events which make up ancient history took place. In fact the molders' skill, as exemplified in many antique works of art, has been one of the great civilizing forces of the world, and it may be questioned whether we can produce to-day any finer examples of this art than are to be found among the relics of antiquity. But as civilization has progressed the demand for the products of the foundry has increased to such an extent as to call for new processes, better methods and greater efficiency. The printing press, the steam engine, the loom, and, more recently, the internal combustion engine, have stimulated the activities of men, augmented their productive capacities and so enlarged the possibilities for commercial intercourse that it is difficult to realize how few of the comforts of life now enjoyed by the masses were within reach of the well-to-do or even the wealthy members of society as it was constituted two hundred or even one hundred years ago. George Washington, for example, began his career as a surveyor; carried with him the bare necessities of life, often slept out of doors on a bed of hay or straw, swam the streams that were too deep to ford, and later on, after enduring innumerable privations and hardships in many hard-fought campaigns, laid the foundation for the government which stands as a monument to his sagacity, courage and determination. There were no Pullman cars for him and no potentate, however great or wealthy, could have traveled a hundred years ago with the luxurious ease now within the reach of very moderate means.

Going back a little further to Columbus, in the height of his glory as the first admiral of what was then the greatest power in the world, we can imagine his quarters on a flagship which was but little if any better in size and comfort than the lifeboat of a modern steamer. In short, since man first began to utilize the forces of nature, so abundantly provided for his material comfort and enjoyment, the productive capacity of the world has increased at a rate which staggers the mind to follow and reduces to nothingness the spells wrought by Aladdin and his wonderful lamp.

To compare the industrial progress made since the discovery of America with all that went before would be a hopeless task, but it is not hard to believe that the nineteenth century alone surpassed in the development of the arts and sciences all that was inherited from the past and that in all probability the twentieth century will do the same. The present rate of industrial progress is indeed so rapid as to almost defy pursuit, and it is only possible to keep in touch with it in spots where our own special interests are involved.

No man nor set of men can grasp the enormous accumulation of knowledge bound up with advancing civilization, and as fast as the work of yesterday can be recorded the achievements of today are almost out of sight. This cannot go on forever at undiminished speed, and it is clearly due to the awakening of man to a knowledge of the natural forces within his grasp. It is accompanied at the same time by the destruction of the resources upon which it feeds and grows, and it will sooner or later be followed by a reaction when posterity begins to descend the slope leading back to the ashes from which so much greatness and power has been derived. A great deal of permanent value will no doubt remain, but with the prospect of exhausted resources before us, however distant that time may be, we may well pause for a moment to consider not only the conservation of natural resources, but also the efficiency of human labor upon which the conversion of our resources into wealth depends. We cannot eat our cake and have it, but we can make it last a long time and enjoy it with more satisfaction if we do not bolt it all at once.

But the conquest of nature is not to be halted by sentimental considerations and the consumption of our resources will no doubt go on unabated until their conservation becomes a crying need. Its consideration now as a matter of national importance is one of the most hopeful signs of the times, and, fortunately for all of us, efficiency as well as economy in all the affairs of life is coming into the foreground and receiving more attention than it ever has before.

People are beginning to realize that the high cost of living is due chiefly to extravagance and waste, and that there is such a thing as Scientific Management[1] by which human labor may be conserved and its products enormously increased. When rightly understood and applied this benefits the wage-earner, the employer and the public as well, and goes a long way toward the solution of the labor problem which is inseparable from the cost of living.

Improvements in machinery, combined with power for its operation, have worked wonders in the output of labor, but only a fraction of what can be realized from the same amount of human effort when more intelligently directed and controlled. The all-round mechanics of former years have well-nigh disappeared and good workmen, if obtained at all, must be recruited from such raw material as can be found unemployed. There is always an abundance of the inefficient kind, and the problem now confronting the manufacturer is how to make it efficient and valuable. The answer to this is to be found in the introduction of an educational system of management not unlike the laboratory system adopted in some of our schools and colleges. Men must not be left to their own devices to pick up such knowledge as may make them inferior or merely good enough workmen. They must be systematically taught to perform the work assigned to them by shop bosses or foremen who are interested in the result, and whose chief function it is to teach. In this way every shop in the country may become in effect a trade school of the most valuable kind, in which the pupils are not only taught how to do certain things but how to do them quickly and well and earn a substantial reward commensurate with the skill attained. No labor-saving machine can produce results without human aid in one way or another, and many a machine, good for its purpose, has been abandoned to the scrap heap, not from any inherent defect or inability to effect a saving, but simply as the result of awkward or inefficient handling. We must have efficient workmen as well as efficient machines to obtain the best results, and foundries need both as much as, or possibly more than any other kind of operating plant to-day.

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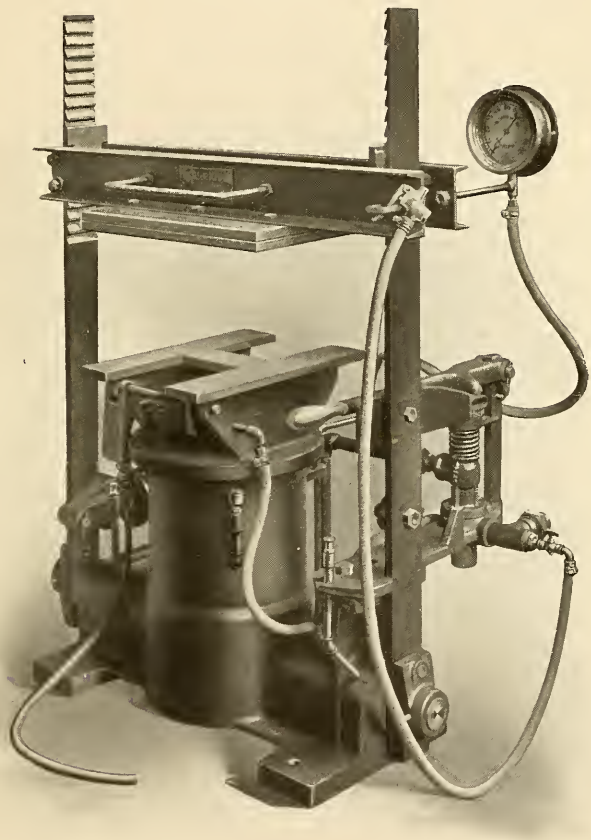
[1] Formerly known as "The Taylor System." See "Shop Management," Transactions of A. S. M. E., 1903, and "The Principles of Sceintific Management," Harper & Brothers, 1910, by Frederick W. Taylor, M. E. Sc. D.

Although modern industry depends upon the foundry for a large part of its products and the ingenuity of inventors has been busily engaged for generations in the evolution of labor-saving machinery, very little of this effort has been devoted to the improvement of the foundry itself, and it is only within comparatively recent years that machine molding has developed much importance as an art. In the year 1800 an English patent was granted for molding screws, the patterns for which were backed out of the sand by lead screws of the same pitch. This was simply a pattern drawing machine of rather ingenious construction, but the English records do not touch again upon machine molding until 1839, when a very similar patent appears. From this time forward more interest seems to have been aroused and these patents were soon followed by others for packing sand by mechanical means, including hydraulic cylinders, stampers and rollers of the road-roller type. Machines for molding gears and pipes also appear in the first half of the nineteenth century, and in 1843 we find an American patent on the molding of cannon balls. Later, in 1869, the first jarring machine patent was taken out, but it is not proposed to give a history of the art of machine molding from patent office records, and it may simply be noted that the art began in a small way on bench work and continued chiefly in its application to small molds that one or two men could handle until the end of the last century. Larger work was not generally regarded as applicable to machine molding until the jarring machine began to emerge from a long period of obscurity and demonstrate its peculiar fitness for ramming large bodies of sand. Its development for large work belongs mainly to the present century and through its means the art of machine molding has been extended to embrace nearly everything molded in sand. But there are, of course, exceptions and peculiar difficulties which will always depend upon the molder's skill for their proper execution, with or without the aid of machine, and like any other equipment the installation of molding machines must depend upon the saving to be effected by their use and the outlay needed to effect that saving. This leads at once to the consideration of foundry costs, the analysis of which should point the way to their reduction. These costs are made up of many important elements beyond the scope of the subject, and the effect of one item only need be considered, that of machine molding, leaving all other items to be treated in the same way by those who are interested in attaining the highest efficiency in every detail of operation.

Machine molding began, as has been said, on small work and probably one of the best known appliances is the little hand squeezer. This is a very simple and effective machine de-

Small Power Squeezer.

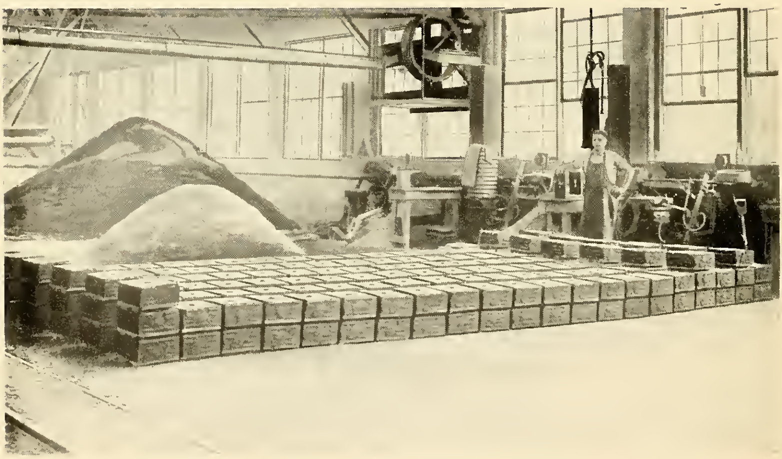
Fig. 1.



signed to save part of the time consumed in ramming. Figure 1 is a little power squeezer adapted to the same class of work as the hand squeezer which saved the work of ramming but put upon the operator the work of squeezing. There the man still did the work but with greater despatch, and therefore more efficiently. Here the machine does the squeezing and the operator is less fatigued and can work faster. In support of this statement the floor shown in Fig. 2 may be offered as evidence.

Here 270 molds, 12″ x 16″ x 7″ deep, have been put down by one man in six hours, and it is stated that this daily performance has recently been increased to 315 in the foundry of the American Hardware Corporation, where nearly 100 machines of the same type can be seen at work. Of course these performances by expert operators are not to be expected along the whole line, where the average may be in the neighborhood of 200 molds a day, but they

Fig. 2.



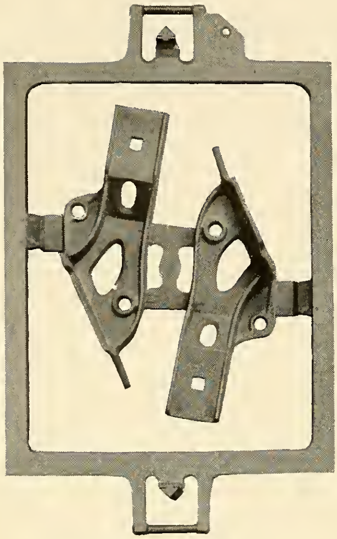
270 Molds Made By One Man in 6 Hours on Power Squeezer.

show what is possible, if not always probable, and it remains to be seen how a proper day's work on any given pattern can be fairly estimated. We are frequently asked to say what our machines will do and what production we will guarantee, regardless of the fact that we never know anything about the man operating the machine and seldom very much about the patterns to be used, the cores to be set or the precautions found necessary to insure success in molding the same patterns by hand. We know in a general way the type of machine required, but until we have actually made molds and poured castings, we are at a disadvantage and cannot safely guess at results which should be determined from a careful analysis of the experience gained in molding by hand. The foundryman contemplating the introduction of machines has had the necessary experience, but he seldom, if ever, has it in a shape available for analysis, and the importance of making observations in detail and recording the time required for each and every step taken in the production of a mold will be shown. This has been brought out very forcibly by Mr. Knoepple in the April number of the *Engineering Magazine*. The suggestions there made are in line with the practice of the Tabor Manufacturing Company for the last five or six years, but the matter is one that has only begun to receive the attention it deserves as an important feature of Scientific Management. Consider, for example, a set of patterns mounted in a vibrator frame 13 inches by 17 inches for use on a squeezer. See Fig. 3. They can be molded either by hand or by power, but if we mold them by hand and note down the time taken by every step in the process we shall see where to look for a saving and what to expect when molded by power.

Table I shows the result of observations taken by an experienced man with a stop watch on molding by hand, and also the same observations on the same mold made by machine. The time is taken in minutes and hundredths for convenience in summing up. Certain operations must be performed whether the mold is made by hand or machine, and the table shows the difference in time of the two methods. In machine work certain operations are unnecessary, as also shown by the table. For instance, item 9 must be done more thoroughly and takes more time when the mold is completed by hand. Item 11, butt ramming, 0.30 min. is equivalent to squeezing by power, but it takes five times as long. Item 22 is now done by power as a separate operation. Item 26 to rap pattern takes 0.48 min. against 0.12 to start vibrator and lift cope at one operation on machine. Item 32 patching up, 0.30 min. is not called for on machine. Items 33, 34 and 36 are the same in both cases, and in molding by power an additional operation (stopping off carriers, 0.06 min.) is required. In making this mold there are 30 operations by hand, footing up 4.20 min., and 27 operations on the machine, footing up 2.10 min., which makes the machine time just one-half of the time required when molding by hand without the use of compressed air.

Patterns Mounted in Vibrator Frame.

Fig. 3.



PATTERNS IN FRAME.

DRAG HALF OF MOLD.

HARD SAND MATCH.

COPE HALF OF MOLD.

Table I.

		Element time per piece hand molding	Element time per piece machine molding
1	Pick up hard sand match and put on table	0.04	0.04
2	Pick up pattern and put on hard sand match	0.04	0.04
3	Pick up drag and put in place	0.07	0.07
4	Shake parting on pattern	0.08	0.08
5	Pick up riddle and put on flask	0.02	0.02
6	Fill riddle with sand	0.04	0.04
7	Riddle sand on pattern	0.08	0.08
8	Fill drag with sand (3 shovels full)	0.08	0.08
9	Peen around edge of drag with shovel (butt ram hand mold)	0.10	0.05
10	Put two more shovels full in drag	0.06	...
11	Butt ram	0.30	...
12	Strike off mold (and put bottom-board in place)	0.10	0.07
13	Pick up bottom-board and place on mold (hand-rammed mold)	0.08	...
14	Bring yoke over and squeeze 60 lbs. pressure	...	0.06
15	Roll mold over	0.08	0.08
16	Remove hard sand match (start vibrator on machine)	0.07	0.03
17	Blow sand off mold with bellows (with compressed air on machine)	0.07	0.05
18	Repeat operations 6 to 10, inclusive, for cope	0.29	0.29
19	Fill cope with sand (4 shovels full)	0.10	0.10
20	Repeat operations 12 to 15, inclusive, for cope	0.56	...
21	Repeat operations 12, 15 and 17 for cope	...	0.18
22	Mark sprue hole (with cope board)	0.05	...
23	Remove cope board	...	0.03
24	Blow mold off with compressed air	...	0.05
25	Cut sprue hole	0.12	0.08
26	Rap pattern, spike going through sprue hole into pattern	0.48	...
27	Round sprue	0.10	...
28	Remove cope mold (start vibrator on machine)	0.09	0.12
29	Blow pattern off with bellows	0.09	...
30	Blow mold off with compressed air	...	0.05
31	Draw pattern from mold (start vibrator on machine)	0.45	0.10
32	Patch up mold (with slick)	0.30	...
33	Close mold	0.12	0.12
34	Remove flask	0.07	0.07
35	Stop off carrier	...	0.06
36	Place mold on floor	0.07	0.06
	Total	4.20	2.10

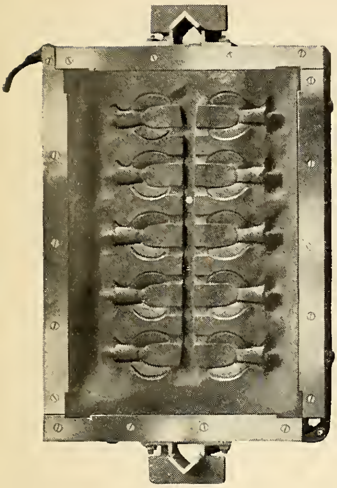
It is also apparent from a study of this time-table that the use of compressed air alone instead of bellows will effect a saving, and that the vibrator in connection with hand molding will also effect a greater saving. Making the necessary substitution in the column for hand molding in the table for the use of blower and vibrator, it will be found that this additional equipment alone would reduce the molding time from 4.20 min. to 3.06 min. It therefore appears that the blower and vibrator can be used to save 1.14 min. per mold and the squeezer 0.96 min. more. This looks as though the blower and vibrator alone saved so much that it might not be worth while to put in the machine, but if we look again at the increased production, taking hand work as the basis for comparison, we see that the output from the use of the former is $4.20 \div 3.06$ or 1.38, while from the use of the latter it is $4.20 \div 2.10 = 2$, that is, an increase of only 38 per cent. on hand work against 100 per cent. on machine work.

But it may be argued that another element of time remains to be considered, and it must be admitted that no account has yet been taken of the time required to distribute a large number of molds on the floor. It remains to be shown how far a mold can be carried and placed on the floor in .06 min., the time noted, but this time should be taken to about the middle of the space to be covered, and perhaps some additional time should be allowed for this item, but on the other hand it may be said that no allowance has been made for the inexperience of the operator, who was in this case a pattern-fitter and not a molder or demonstrator. The time given will vary with different men, and it was taken in these cases simply for the purpose of illustrating the method by which important conclusions can be reached. No better data can be obtained for fixing prices, and when time is taken by an observer of experience who understands his business the stop watch never runs unless useful work is being done in the right way. A reasonable allowance should always be made for contingencies, and a bonus put upon the performance of the work specified in the alloted time.

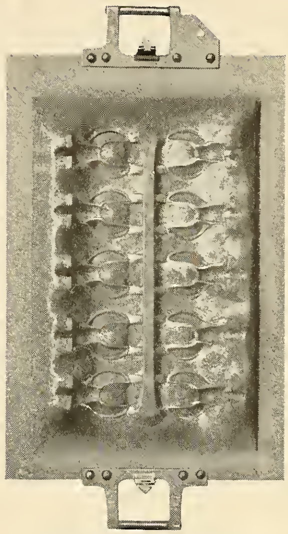
When patterns are cast in an aluminum match plate, as shown in Fig. 4, both cope and drag can be squeezed at the same time, the number of operations on the machine is reduced from 27 to 25 and the total time from 2.10 to 1.76 min.

Patterns Cast in Aluminum Match Plate.

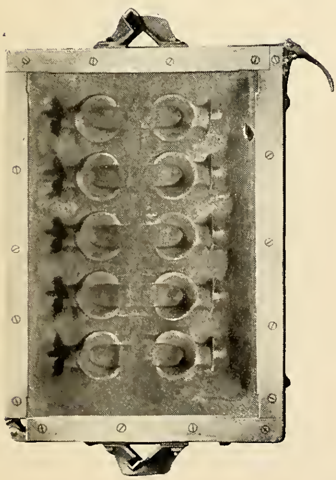
Fig. 4.



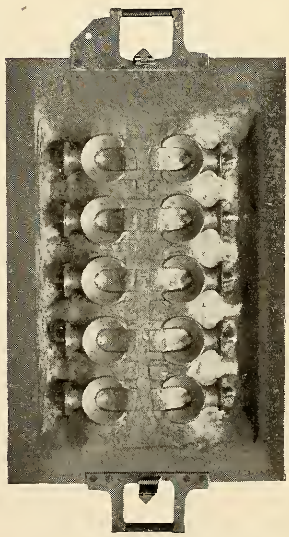
COPE HALF OF MOLD.



COPE SIDE OF PLATE.



DRAG HALF OF MOLD.



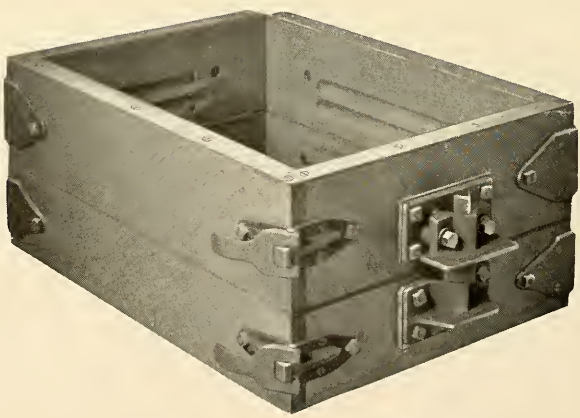
DRAG SIDE OF PLATE.

The snap flasks used are of the usual type, as shown in Fig. 5, and in these experiments about 12 inches by 17 inches, 4-inch cope, 4½-inch drag. The machine will squeeze molds as large as 14 inches by 20 inches, but the best production can generally be realized on smaller sizes.

Instead of the aluminum match plate, patterns may be mounted on a steel plate, as shown in Fig. 6, and when split or flat back this is a very convenient method.

They may also be mounted on a paraffined board held in a vibrator frame, as shown in Fig. 7, and when so arranged the molding time is substantially the same as for the aluminum match plate mounting.

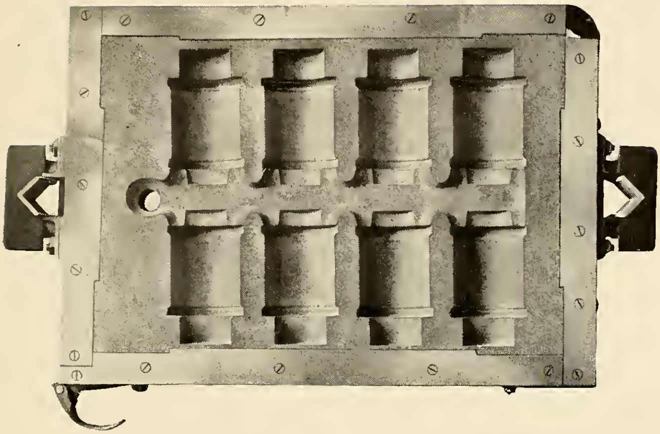
Fig. 5.



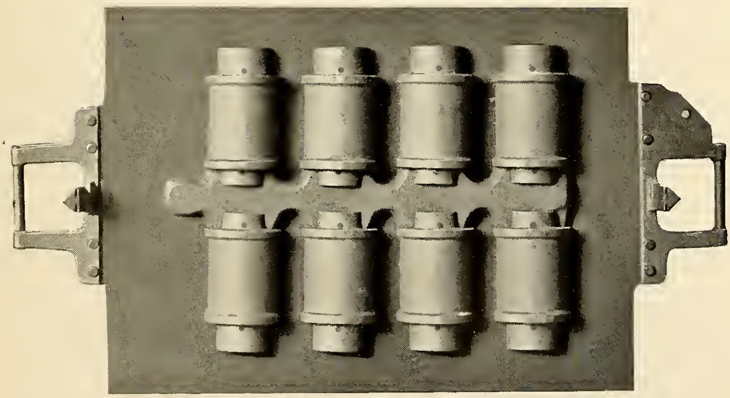
Snap Flask.

PATTERNS MOUNTED ON STEEL PLATE.

FIG. 6.



COPE HALF OF MOLD.



COPE SIDE OF PLATE.

SIDE VIEW OF PLATE.

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Fig. 7.

Paraffined Board.

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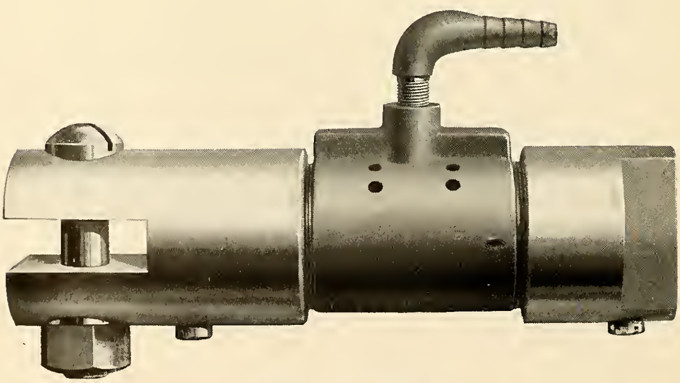
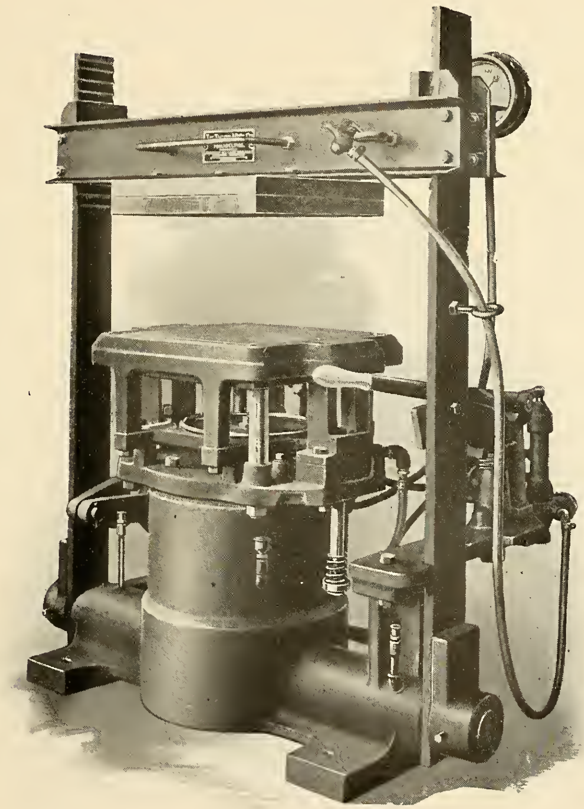


Tabor Vibrator.

without stripping plates and are applicable to a great variety of work made in solid or snap flasks. There is less handling time on this machine than on the power squeezer, and since each half of the mold is made separately the strain on the operator is not so great.

It is also possible to cope off, by means of supporting stools,

Fig. 9.



Small Power Squeezing Split-Pattern Machine.

pockets of hanging sand that would be impracticable on a squeezer. It is a very fast machine, but no time study has yet been made to show where it gains on the squeezer by reducing the number of operations required and the total molding time. There are some jobs, however, which can be made as quickly on one machine as on the other, and although this is a much higher class of machine than the squeezer it does not follow that it is better for every purpose.

On such machines the cope and drag are frequently made from the same set of patterns, and it is therefore a matter of first importance to have them so located on the pattern plate as to match perfectly when the mold is closed.

Fig. 10.

Fig. 10 shows a set of patterns mounted for a split pattern moulding machine, the cope and drag being moulded from a double set of half patterns, the impression of the right-hand set in the drag matching those of the left-hand set in the cope and similarly, the left-hand set in the drag matching the right-hand set in the cope.

The securing of these two sets of half patterns to the plate in a manner to insure accurate matching of cope and drag can be best accomplished by the transfer-plate method.

The first operation in preparing such a set of patterns is to make the pattern plate, drilling in it two dowel holes, one of which is shown in Fig. 10 at the end of the gate. These holes are drilled from a jig supplied with the machine, and their location defines the center line of the plate. For the case shown four complete patterns are first made, the two halves being doweled together as usual before turning.

They are then numbered and separated, and the halves without dowel pins are located on one side of the pattern plate and used as jigs to drill that side of the plate as shown in Fig. 11. It is necessary to repeat the holes thus made on the opposite side of the plate and these must bear the same relation to the center line of the pattern plate.

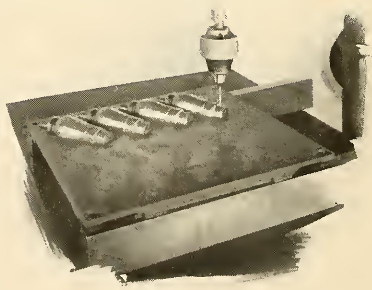


Fig. 11.

To insure this a transfer plate of rather more than half the size of the pattern plate is made. Holes to match the center-line holes of the pattern plate are drilled in the transfer plate, and the transfer and pattern plates are placed together; dowel pins are inserted in the center-line holes, and the two plates are placed under the drill press with the pattern plate on top, as shown in Fig. 12. In this position the pattern plate is used as a jig to repeat its pattern pin holes in the transfer plate. The transfer plate is then turned over, not around on the pattern plate, as shown in Fig. 13, the center dowel pins are re-inserted, and the transfer plate is used as a jig to drill the holes in the second side of the pattern plate, all as shown in Fig. 14. When the transfer plate is removed, the pattern plate appears as shown in Fig. 15, and obviously the second set of holes must be truly symmetrical with the first set and the half patterns when doweled to these two sets of holes, due regard being paid to their numbering, must also be truly symmetrical and produce perfect joints when moulded.

Fig. 12.

In the operation of this machine the valve lever on the right, shown in Fig. 9, is pressed down to squeeze the mold when the head is up, and the same lever is raised to start the vibrator and draw the pattern when the head is thrown back after squeezing. This lever is also so interlocked with the swinging head as to prevent movement in the wrong direction at any time. Small split-pattern machines are also made with hand draft, and by some operators hand draft is preferred to power, but it is applicable only to small machines and mechanically the construction of the power draft is superior.

Fig. 13.

Split-pattern machines have been on the market for many years and their value is recognized and appreciated, but unfortunately they have to be built for a flask of fixed dimensions or at least fixed in length or width to fit the flask pins on the machine. They are expensive to build, rather inflexible in their application, and within the last few years they have been superseded very largely by roll-over machines with straight pattern draft to ram by hand or by power. An ingenious hand-ramming roll-over machine, with mechanism for rapping the pattern carrier and dropping the flask from the pattern, was brought out by Teetor in 1889, in which plated patterns are

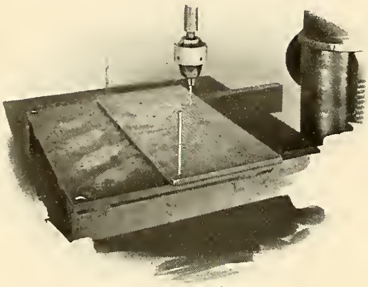
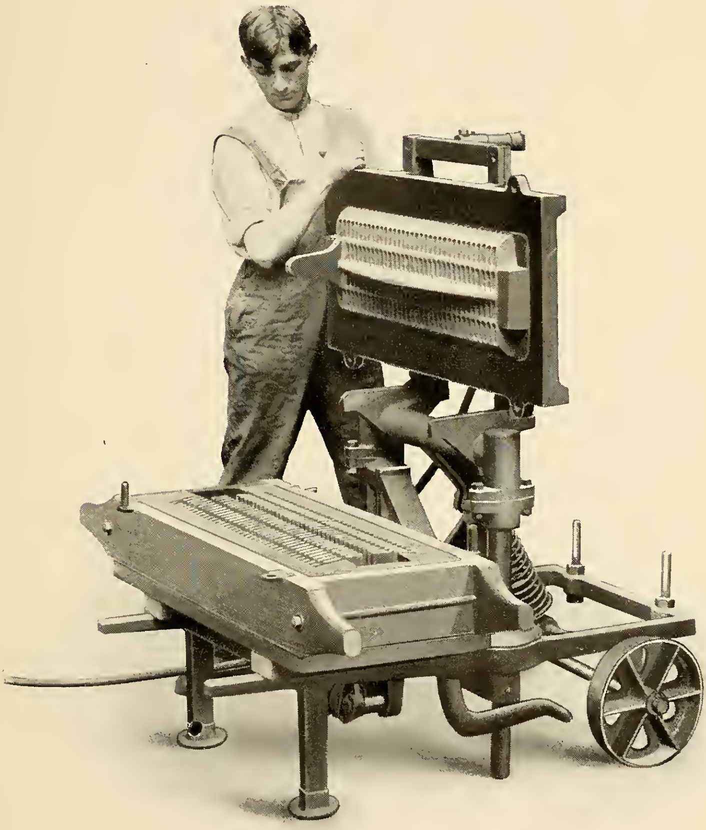


Fig. 14.

Fig. 15.

carried in a roll-over frame to which the flask is clamped and rammed in the usual way by hand. When rolled over, a support beneath is brought up by a hand lever, the flask is unclamped and the pattern rapped by turning a hand wheel on the trunnion shaft. At the same time the pattern is drawn by lowering the flask. A few of these machines can still be found in use, but

FIG. 16.

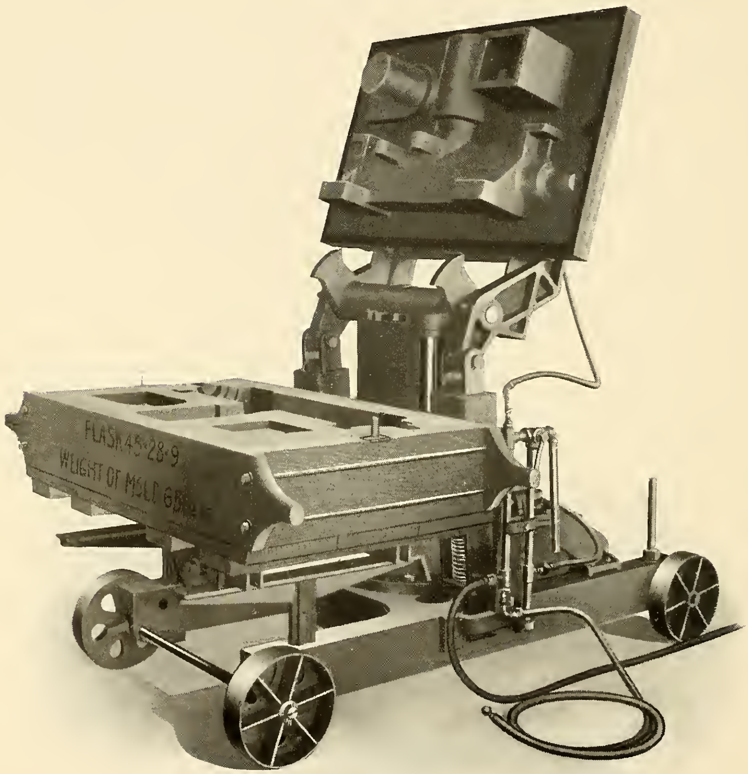


TABOR ROLL-OVER MACHINE WITH HAND DRAFT.

the rapping mechanism is not durable, the machine is rather limited in its scope and other types have displaced it for some time.

The French machine of Bonvillan & Ronceray is a modification of this type, in which the outer trunnion is omitted and power is added for squeezing the mold and drawing the pattern. This will be remembered as having been exhibited at the Foundry Convention held in Philadelphia in 1907. It has a number of attractive

Fig. 17.



Power Roll-Over Machine With Power Draft.

features and is said to be very successful in France, where hydraulic power is more popular than it is here, but the machine has not been so successful on this side of the Atlantic, for the simple reason, no doubt, that water cannot compete with air as a working fluid for foundry use.

The advantage of rolling over to draw a pattern is well known and in some cases it is an absolute necessity. This has led to the development of a large number of roll-over machines, nearly all of which drop the mold away from the pattern after the manner of Teetor, but there is one exception, as shown in Fig. 16, and this lifts the pattern from the mold in what is generally admitted to be the logical way. Logical because the pattern is generally lighter than the mold and preferably the part to be manipulated. The machine illustrated is shown as fitted with a grate-bar pattern having 140 deep pockets, into which the sand is thrown by hand or settled by jarring the swing frame against its stops before ramming in the usual way by hand. Throwing the sand by hand is preferred, because the jarring process is not uniform and naturally varies with the distance of different parts of the pattern from the turning center.

The flask used in this case is 14 inches by 37 inches by 5 inches deep, and the time required for a complete cycle of operations was 5.81 min. The cope for this grate bar is almost flat and requires no machine. It could be made by a helper who would have enough spare time to assist in rolling over, and probably eight to ten molds an hour could be made by experienced men.

In this machine, which takes a flask 24 inches wide and has 7-inch pattern draft, the swing frame and sliding head are counterbalanced by helical springs. These can be adjusted to the weights to be carried and the pattern is drawn by a hand lever at one side.

Since the weight that can be conveniently rolled over by hand is limited to three or four hundred pounds, heavier molds naturally require power, and in Fig. 17 we have a machine which rolls over and draws the pattern by means of a cylinder and plunger, using compressed air on hydraulic oil or water to effect the movements.

The illustraton shows the pattern drawn and rolling back into position for another flask. In these machines a vibrator is attached to the swing frame and this materially assists in making a perfect draw, the main object of these roll-over machines. They are designed to save pattern drawing and finishing time, and where patterns are of such a character that the margin for this saving is small the time study will show it and possibly suggest a jarring machine instead. But molding machines do much more than save time in molding and are often worth all they cost in the saving of patterns, the saving in metal and the saving in machine work by reason of the greater uniformity and closer finish of the castings produced.

An important feature of these machines is the levelling cradle, of which a number of types have been developed to set the flask with reference to the pattern board regardless of irregularities in the bottom board upon which it rests.

Such machines may be fitted with long patterns overhanging the swing frame for a considerable distance at each end. This possibility indicates the scope of the machine and the advantage of rolling over about an axis parallel to the length of the flask instead of about a normal axis as is done on machines of the French type.

Time study on large work may show that a material saving is effected in finishing, in ramming or in both, and where ramming time is the principal item a jarring machine is the equipment most needed to reduce costs. There are quite a number of jarring machines on the market, all of them covered by the original claim of Hainsworth in his patent of 1869, which is so refreshing for its simplicity and breadth that it is worth quoting:

"The packing of sand, for a mold, in a flask, by raising the same, together with the pattern, and letting them all drop upon a hard bed, substantially as shown and described."

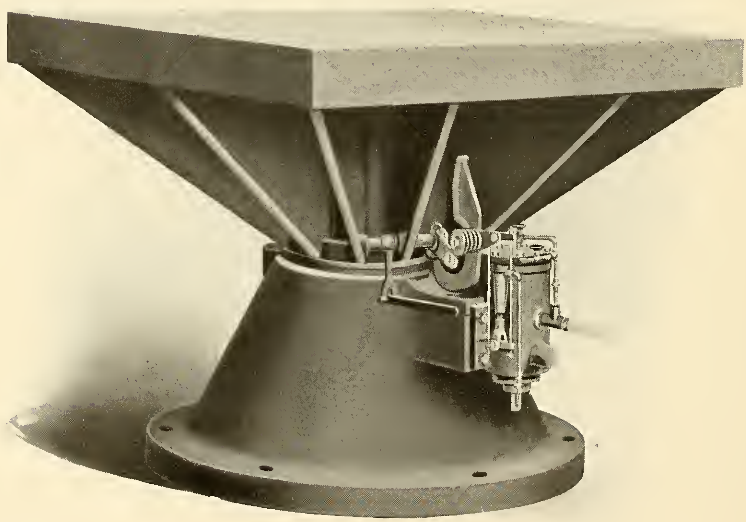
There were no permutations and combinations of elements making an extended series of claims calculated to exhaust the patience of the reader. All he wanted was the whole field, and he secured it in a single claim, but it is not certain that the packing of sand in this way was altogether original with Hainsworth, and there is ample ground to suspect that groceries of all kinds have been packed in paper bags by the same jolting process before the memory of man runs otherwise, and some of these (dried currants, for instance) there is reason to believe have always contained a liberal admixture of sand. The packing of sand by jarring is therefore in all probability as old as the hills, but since the broad claim of Hainsworth no longer troubles us we must look among later improvements within the field that he covered for the development of the art. This patent seems to have attracted very little attention when it appeared and no further inventions along this line are on record until 1878, when Jarvis Adams gave some impetus to the art and later followed it by a number of patents. The Adams machines were, however, rather crude and very little progress in the art was really made until compressed air came into general use as a medium for the transmission of power.

At the present time nearly all jarring machine builders contemplate the use of compressed air, whereas originally, and until about the beginning of the present century, they were operated mainly by hand or by cams on a power shaft. The development of the jarring machine is an interesting study, but no attempt will be made to follow it through all its ramifications; a few examples only representing the last ten years will be considered. In the Tabor machine first built the jarring table was struck underneath by a heavy plunger actuated by compressed air. The blow raised the table a short distance from its support, upon which it fell back, striking a second blow. Some of these machines are stilll in use, but it cannot be said that they are very efficient or successful, and they were superseded five or six years ago by the Tabor jarring machine now in common use, as shown in Fig. 18.

This is a plain machine with the jarring cylinder formed in the table mounted upon an upstanding plunger. *By this construction the table is given enormous strength and stiffness and the central blow of impact is distributed equally in all directions.* The plunger is part of a heavy piece of cast iron forming the anvil, which in turn rests upon a large mass of concrete. Originally the main valve was operated directly by tappets attached to the table adjustable for any desired length of stroke, and later it was modified to operate through the medium of a pilot valve. To avoid unnecessary intensity in the blow struck by the table upon its anvil a few layers of leather or other non-resilient material are introduced as a cushion. These reduce the wear and tear and noise, without having any material effect upon the action of the machine on sand.

The plunger base rests upon concrete to form an anvil, and as to the mass of concrete, it may be said from the operating standpoint the more the better, but this must be limited, of course, with regard to the cost and the natural bed beneath. In a general way, about two cubic feet of concrete for every square inch of area in the jarring cylinder is recommended, but if there is a rock bottom beneath, the use of very little concrete is advisable, or just enough to level up under the cast-iron plunger base. Some builders recommend more concrete than this, some less, and in addition to the concrete a heavy wooden cribwork is frequently put in beneath to prevent the transmission of the shock of impact into the ground. This is in accordance with the usual practice

FIG. 18.



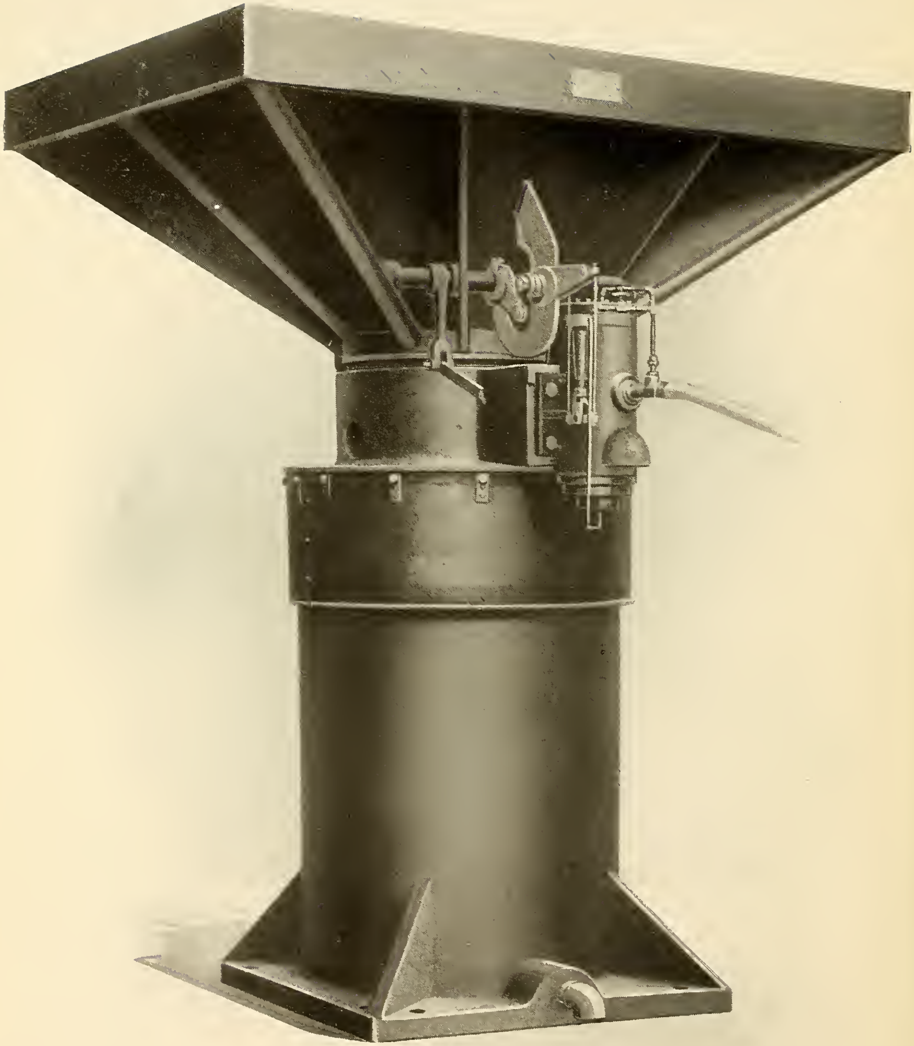
PLAIN JARRING MACHINE.

under steam-hammer anvils, and it may have some beneficial effect but it does not eliminate the whole trouble and the wooden crib is scarcely worth its additional cost. It is not generally safe to set up finished molds with hanging sand in the neighborhood of a jarring machine of this type and in some foundries the jarring machine has been put out of service for days or weeks pending the completion of large floor work. In fact, the damaging effect of large jarring machines is too well known to need confirmation, and to reduce this to a minimum, the drop of the table has been decreased while the foundation has been increased.

But there is a limit to the relief afforded by reducing the drop, because upon this the ramming effect primarily depends. The shorter the stroke the less the ultimate density attained and the less the efficiency of the machine. This can be demonstrated in a practical way by ramming up a deep mold on short strokes until the sand ceases to pack any further. Increasing the length of stroke very considerably alters the effect of the next blow. The sand will pack further immediately and the conclusion in favor of the long stroke as more efficient in packing sand is inevitable.

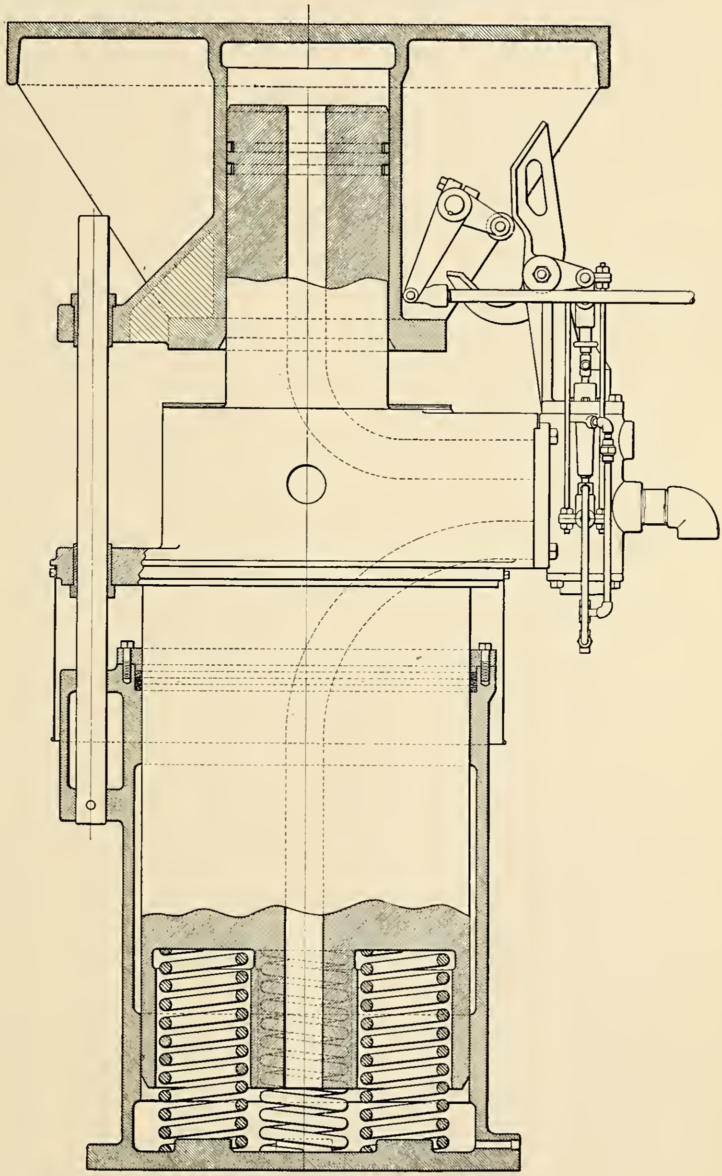
With the object of eliminating ground shock and yet retaining the use of any stroke desired the Shockless Jarring Machine, Fig. 19, has been desinged. *It requires no foundation other than a base to sustain the static load upon it, and it is more efficient in operation than a plain machine mounted on a wooden crib whose anvil weighs twice as much.* The principle upon which it operates will be understood from the sectional elevation shown in Fig. 20. The plunger base forming the anvil is mounted for convenience in an anvil cylinder and rests upon a number of long compression springs. When air is admitted to the jarring cylinder the entire weight of the anvil, table, and load is carried upon these springs and they are therefore compressed and in readiness to expand when the air is exhausted and the table falls. At the beginning of this movement the loaded table is impelled downward by the same force that moves the anvil upward, and although some of the force of the springs is exhausted as the anvil rises, the loaded table and the anvil acquire substantially equal momenta which neutralize each other when impact takes place. To compensate in a measure for the loss of spring pressure as the anvil rises, the exhaust from the jarring cylinder may be carried into the anvil chamber before being discharged. This is accomplished by a combination valve, consisting of a large main valve of the steam-hammer type in connection with a small pop valve such as is used on small power squeezers and split-pattern machines. These valves are attached to the anvil or plunger base and the pop valve is opened and closed by tappets on the jarring table. When the table drops the pop valve opens, admitting pressure beneath the main valve, which rises and puts the jarring cylinder in communication with the air supply, at the same time

Fig. 19.



Tabor Shockless Jarring Machine.

Fig. 20.



Section of Shockless Jarring Machine.

opening the anvil cylinder to exhaust. When the limit of stroke is reached the pilot valve opens to exhaust and the main valve opens to drop the table. The air from the jarring cylinder rushes into the anvil cylinder, expanding to much lower pressure, which is nevertheless very effective in the large anvil cylinder and causes the loaded table and anvil to collide with greater force and effect upon the sand. The supply of air to these valves is controlled by an air cock at the operating stand and the table runs automatically as long as the air is turned on. At the same time the stroke of the table is controlled by another lever, adjustable, if desired, while the machine is running. The purpose of the pilot valve is to provide a controlling means, easily manipulated, that will give the delayed action required by the main valve. This always presents full openings during the table movement up or down, and *the ample lap on the ports gives time for expansion in the jarring cylinder under light or medium loads after the air supply has been cut off.* Of course, under full load, or thereabout, there can be no appreciable expansion in the jarring cylinder.

Fig. 19 is taken from a photograph of a 13-inch shockless machine with 4-foot by 6-foot table. A machine of this type will ram any mold, large or small, in a minute or less time, and the saving to be effected by its use on large work is practically the whole of the ramming time by hand. It will not ram small work, such as that on which time study was first given, as quickly as a squeezer or split-pattern machine, and such a jarring machine for half molds weighing less than 1000 pounds is not often recommended, but for large deep work particularly it is by far the best machine for packing sand. It is not, however, every pattern that can be rammed in this way, and care must always be taken to avoid projections on the pattern which interfere with the proper flow of sand. This sometimes necessitates the use of a core not required for hand ramming, but the patterns when mounted for jarring require fewer repairs and the cost of adaptation to the jarring process is soon recovered. Although the jarring machine is not universal in its application, it covers a very broad field of work, and by this method of ramming the sand is packed as it should be, densest at the surface of the pattern and of decreasing density above, thus favoring the escape of gases when the mold is poured.

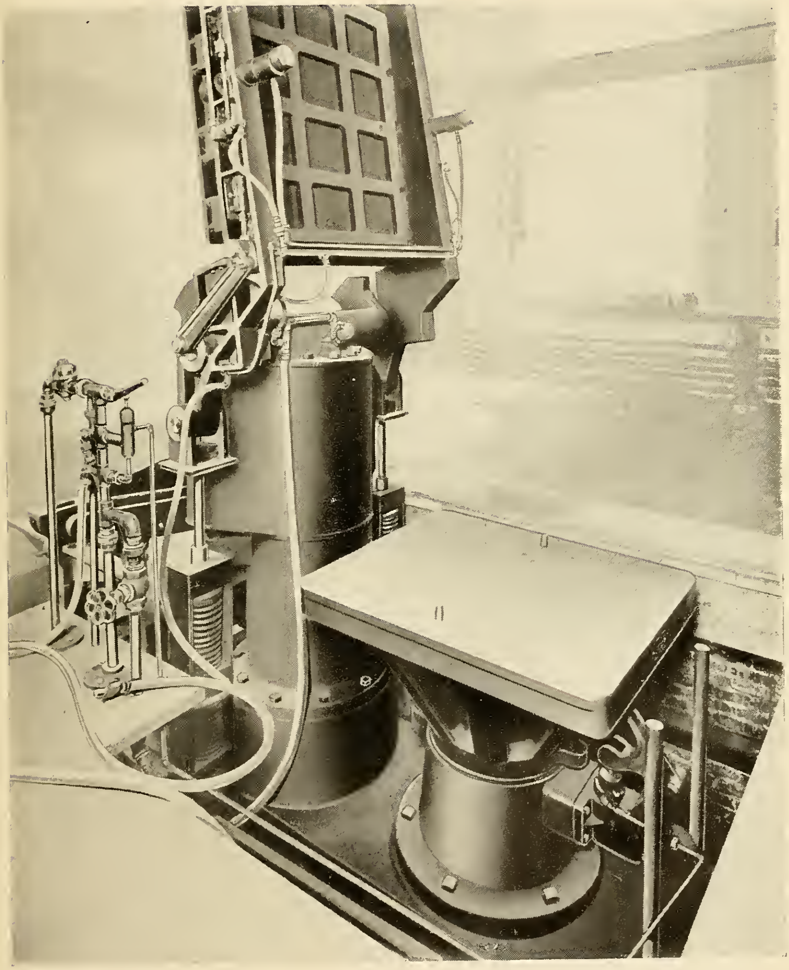
The packing of sand by jarring is naturally greater in a vertical direction than horizontally, but this difference varies with different sands, some of which are much more plastic than others. Sand for steel castings is especially so, and this will pack around patterns that could not be used for cast-iron. Other sands have so little bond in their composition as to pack only under very hard ramming with a large excess of sand or a heavy weight on top, and to obtain the best results a good deal of judgment and patience is frequently required. This has led to the provision for a variable drop under easy control, as shown in Figs. 18, 19 and 20. Here an adjustable stop on a bell crank lever or rock shaft, carried by the jarring table, is made to engage the pilot valve lever, and the position of this stop is controlled by a latched lever on the operating stand. By this means the stroke can be varied while the machine is running, and good practice sometimes requires a short stroke followed by longer ones as the sand settles into the flask. A long stroke at first when the mold is deep sometimes causes the entrained air to force a passage to the surface and cut a channel in the sand, and this can be avoided by a few short strokes to settle the sand in the deep pockets before ramming as hard as desired to compact the mold. The back and sides of a mold are not, of course, rammed as hard as the bottom, and to increase the density in these parts the sand may be heaped up on the back of the mold, or a sand frame can be used in which a definite depth of excess sand is carried. It frequently happens, however, that the labor of handling a large amount of excess sand is greater than that of butt ramming the back of a mold by hand after the jarring has been completed. It is also practicable to follow the jarring by squeezing, and for this purpose the little squeezer shown in Fig. 1 is arranged to jar as well as to squeeze. When so arranged, however, the base is made much heavier to act as an anvil, and means may be provided to jar automatically. Machines of this type are applicable especially to deep work, and care must be taken not to squeeze too hard. This pressure is measured by a gauge attached to the squeezing cylinder, and the proper combination of blows and pressure can be determined by experiment in any given case.

When deep molds are packed by squeezing only they are much harder on the back next to the squeezing head than they are at the pattern surface. This is due to friction between the sand, flask and pattern, which resists the flow and produces just the opposite effect from jarring. In fact, the difference in density is so great as to suggest the advantage of packing the sand from the bottom up instead of from the top down, and before jarring machines came into general use, bottom ramming machines, in which the patterns were pushed up into the sand, were recognized as ideal in principle, and they were used with more or less success. But the method is open to the objection that it necessitates a predetermined quantity of sand reduced in bulk by a definite amount of compression, and these conditions upon which success depends are not always realized in practice. The amount of sand contained in a given space will vary with its temper and the manner in which it is handled, and unless these conditions are invariable the sand will not be uniformly packed by bottom ramming, and jar ramming is seen to have advantages not possessed by any other method

In jar ramming nothing, of course, can be more efficient than an anvil bedded on rock and therefore of practically infinite weight, but even a rock bottom does not prevent the transmission of ground waves, and when a wooden crib is used to cushion the blow the anvil yields to the impact and softens the effect. The advantage of the uprising anvil will therefore be demonstrated and its action illustrated by reference to two cars on a horizontal track. Let these cars be of equal mass or weight and let them be separated a given distance. Now block the wheels of one car and draw the other to it by a uniform force. Assuming the impact to be inelastic the two cars will move on together at half the velocity acquired by the moving car at the time of impact. The shock of collision is the same on both cars; one gains what the other loses, one-half of the velocity of impact, and the square of that change in velocity represents the ramming effect. If the stationary car had been of infinite mass the moving car would have lost all of its velocity and suffered four times the ramming effect.

Or, we may say, to invert the comparison, when one car strikes another of the same weight the ramming effect is one-quarter of what it would be if the car ran into a stone wall, or encountered a mass so much superior as to have substantially the effect of infinite mass in checking its velocity. Now, if both cars are free to move and are drawn together by the same force as in the first instance, the same amount of kinetic energy will be developed, but it will be divided between the two cars and totally absorbed by inelastic impact, each car sustaining one-half the shock instead of one-quarter. Therefore, when both cars move together the shock of impact is twice as great as when one car waits to receive a blow from the other one. Furthermore, the highest efficiency, or the greatest shock, is realized between any

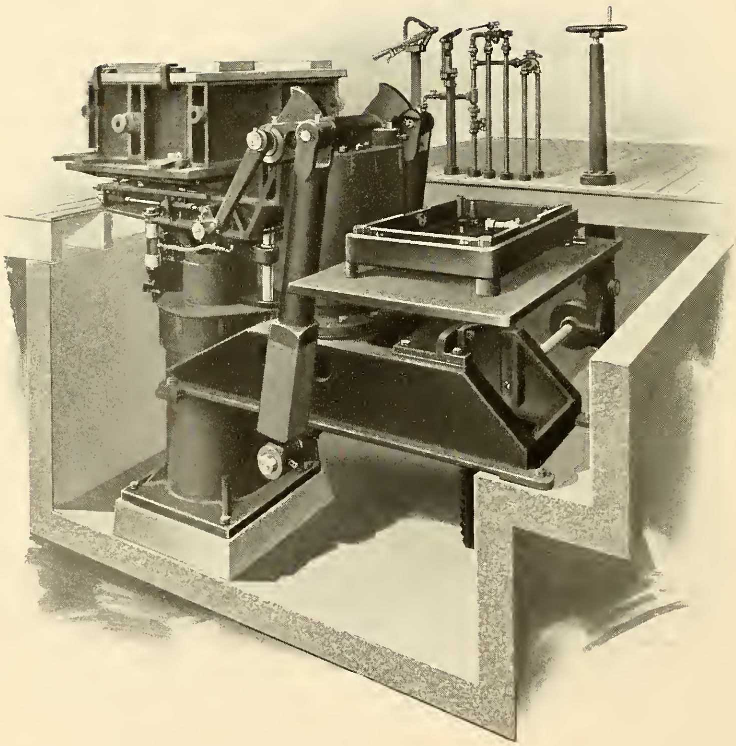
Fig. 21.



Combined Power Roll-Over and Plain Jarring Machine.

given pair of cars for any given amount of work done when both cars are actuated by the same force and acquire equal momenta in equal times. This is true for cars of unequal weight as well

Fig. 22.



Combined Power Roll-Over and Shockless Jarring Machine.

as for the cars of equal weight just considered, and it can be shown when one car is made heavier than the other to act as an anvil that when both cars are free to move the shock on the lighter car is greater than it would be against a car of double the weight standing to receive the blow. It is not claimed that the shockless jarring machine is always twice as efficient as a plain machine having the same weight of anvil mounted on a wooden crib, although it is sometimes more than twice as efficient. It is simply maintained that *the shockless jarring machine is more efficient than a plain machine having an anvil twice as heavy mounted on a wooden crib.* But the efficiency of a jarring machine does not depend altogether upon the weight of its anvil; *solidity of construction* contributes something and the *length of stroke* still more.

Instances could be cited where production has been increased five times by the installation of a jarring machine and still greater gains have been made from machines which combine the jarring and pattern drawing features just described.

Fig. 21 shows such a power roll-over machine in combination with a plain jarring machine, and Fig. 22 shows a power roll-over machine in combination with a shockless jarring machine.

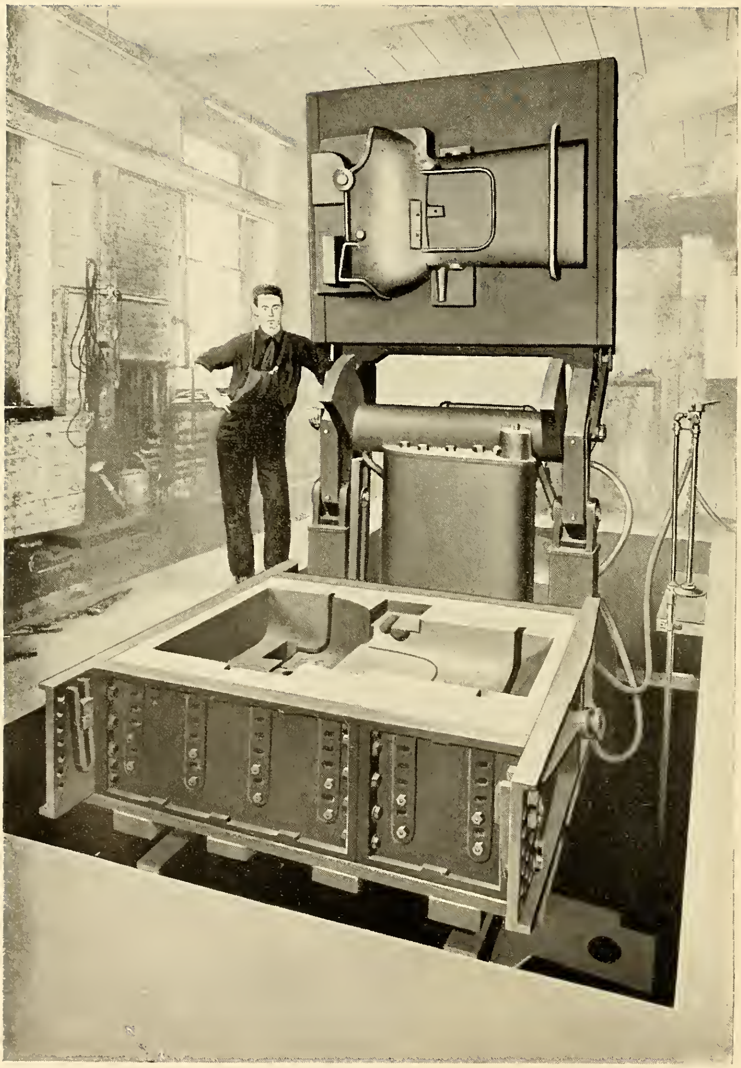
Fig. 23 shows a grinder frame mold made on the plain combination machine. This half mold was made by two men in ten minutes and a complete mold, including core setting, could be made in half an hour.

Originally two men made two molds a day by hand. With the aid of a jarring machine they made five a day, and it appears from the time taken for a half mold on a combination machine that twenty a day might be expected. This machine was built however for another purpose and the grinder frame pattern was simply used to demonstrate the capacity of the machine.

Fig. 24 illustrates another combination of pattern drawing and jarring machine in which the pattern drawing cylinders are mounted on the anvil base and coupled by a squaring shaft to work in unison. The power used is compressed air and this acts upon liquid within the pattern drawing plungers to lift a flask from its pattern through a stripping plate or to lift out a pattern after the flask has been rolled over.

This is a convenient machine for miscellaneous work, but where a large number of molds are required from the same pattern the machines shown in Figs. 21 and 22 are more efficient.

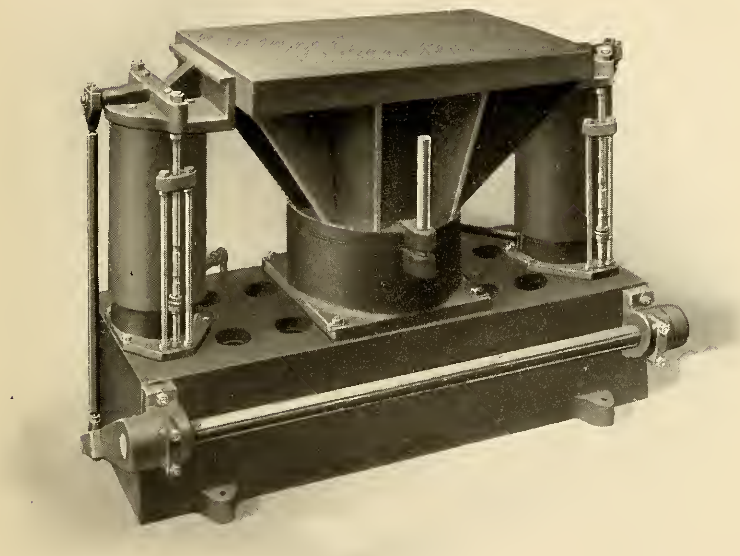
Fig. 23



Half Mold 45" x 60" x 18" Weighing 4,000 Lbs. Made on Combined Machine.

Fig. 25 illustrates a Portable Shockless Jarring Machine to ram half molds weighing about 1,000 lbs. and weighing itself about 2,000 lbs. It is mounted on broad-faced wheels to run on planks laid in the foundry floor and the anvil is carried on spring

FIG. 24.

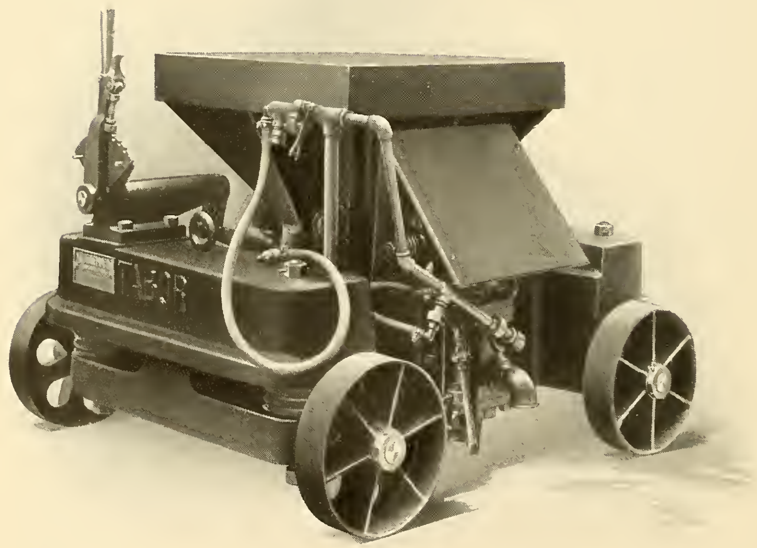


COMBINED JARRING AND STRIPPING MACHINE.

trucks arranged to absorb shocks and vibrations. It will be seen that similar trucks extended to displace the wheels and take a permanent bearing on foundations may be used under the machine shown in Fig. 24 to convert it into a shockless combination machine. In shockless machines of this type, however, no advantage can be taken of the energy remaining in the compressed air when exhausted from the jarring cylinder, and the anvil is boosted to meet the falling table by the action of its supporting springs only.

The machines shown in Figs. 21 and 22 which jar ram roll-over and draw the pattern by power may be combined with a squeezer as

Fig. 25.



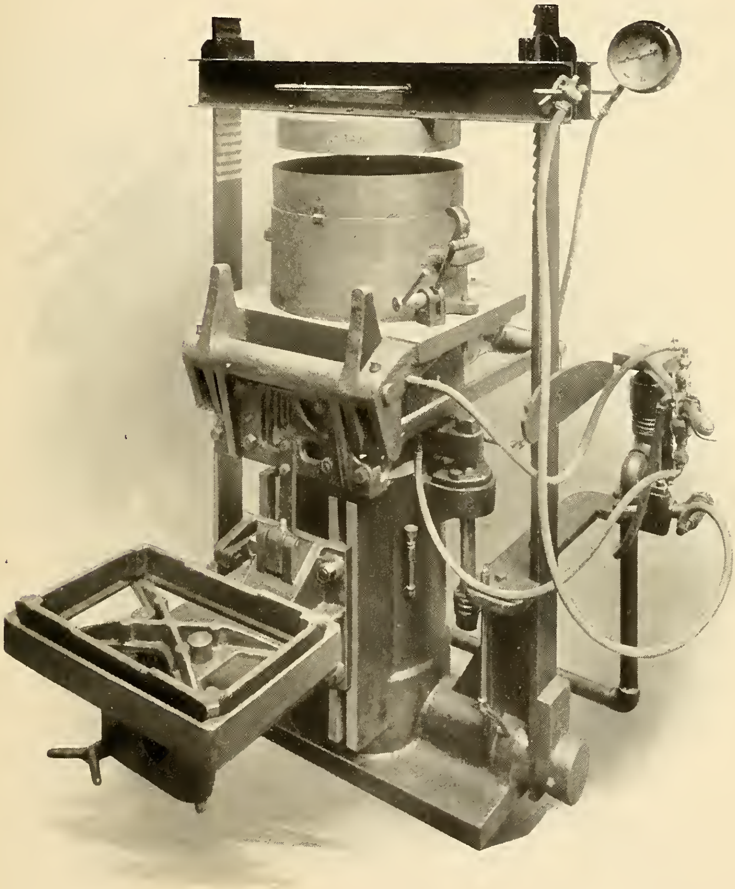
Portable Shockless Jarring Machine.

shown in Fig. 26 to jar ram squeeze roll over and draw the pattern by power, and the same machine on shallow work may simply be used to squeeze roll over and draw the pattern by power.

Jar ramming in combination with other methods of molding therefore opens up a broad field which promises to bring the art of molding more completely under the domination of machines.

Fig. 27 represents a mammoth jarring machine of the shockless type recently completed for ramming half-molds up to 25 tons in

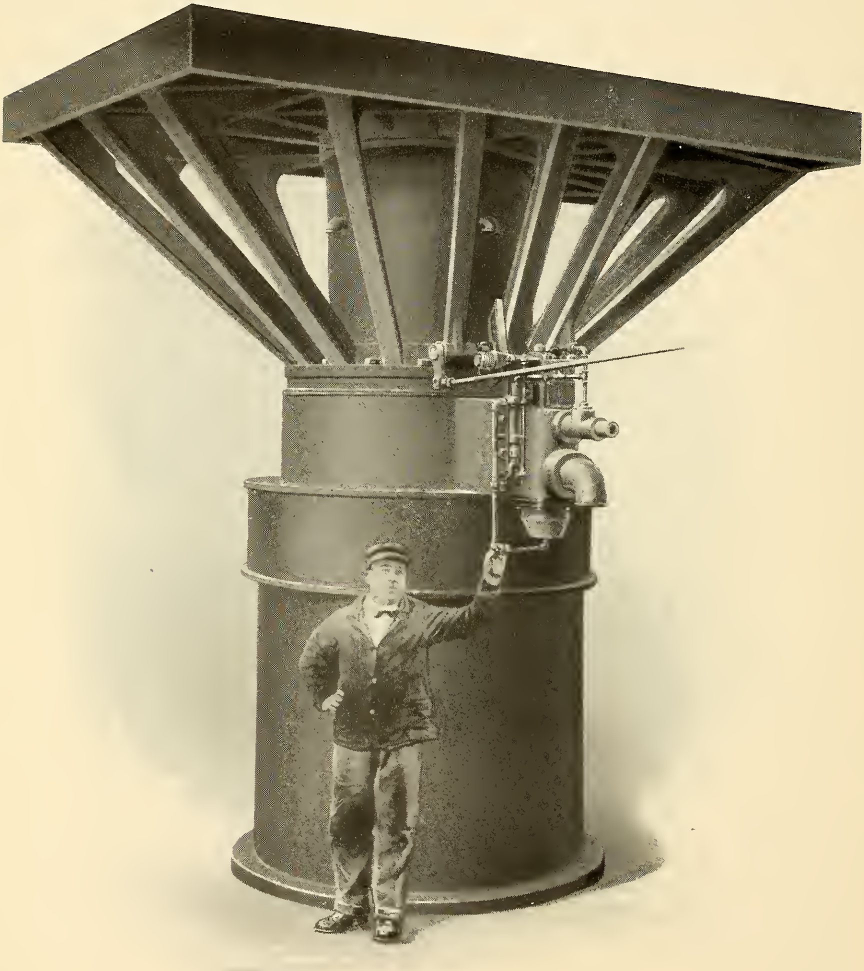
Fig. 26.



Jarring Squeezing Roll-Over Machine.

weight. The table is of cast steel, 8′ x 12′ on top and this is mounted on a plunger 3′ in diameter with an enlarged base 5′ in diameter weighing about 65,000 lbs. The whole machine weighs between 90,000 and 100,000 lbs., including about 3,000 lbs. of steel springs which support the plunger. It is believed to be the largest

Fig. 27.



36″ Tabor Shockless Jarring Machine with Table 8′ x 12′.

jarring machine of any type yet built and while running no shock whatever can be felt in the floor on which it stands. Another advantage to be considered from the use of shockless machines is their permanence of position when once leveled up and set with concrete. A common complaint from the use of plain jarring machines is made on account of change of alignment from constant hammering on a settling foundation and the heavier the weight to be handled the greater the advantage of the shockless machine.

Although the foregoing is not a complete summary of the art of machine molding and many types of machines have necessarily been omitted, the point to which particular attention is invited is the harvest awaiting the introduction of Scientific Management in the foundry and its bearing upon the proper selection and use of molding machines.

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