May 3, 1932. A. W. MORRIS ET AL 1,856,352

AUTOMATIC CASTING MACHINE

Filed Dec. 31, 1929 2 Sheets-Sheet 1

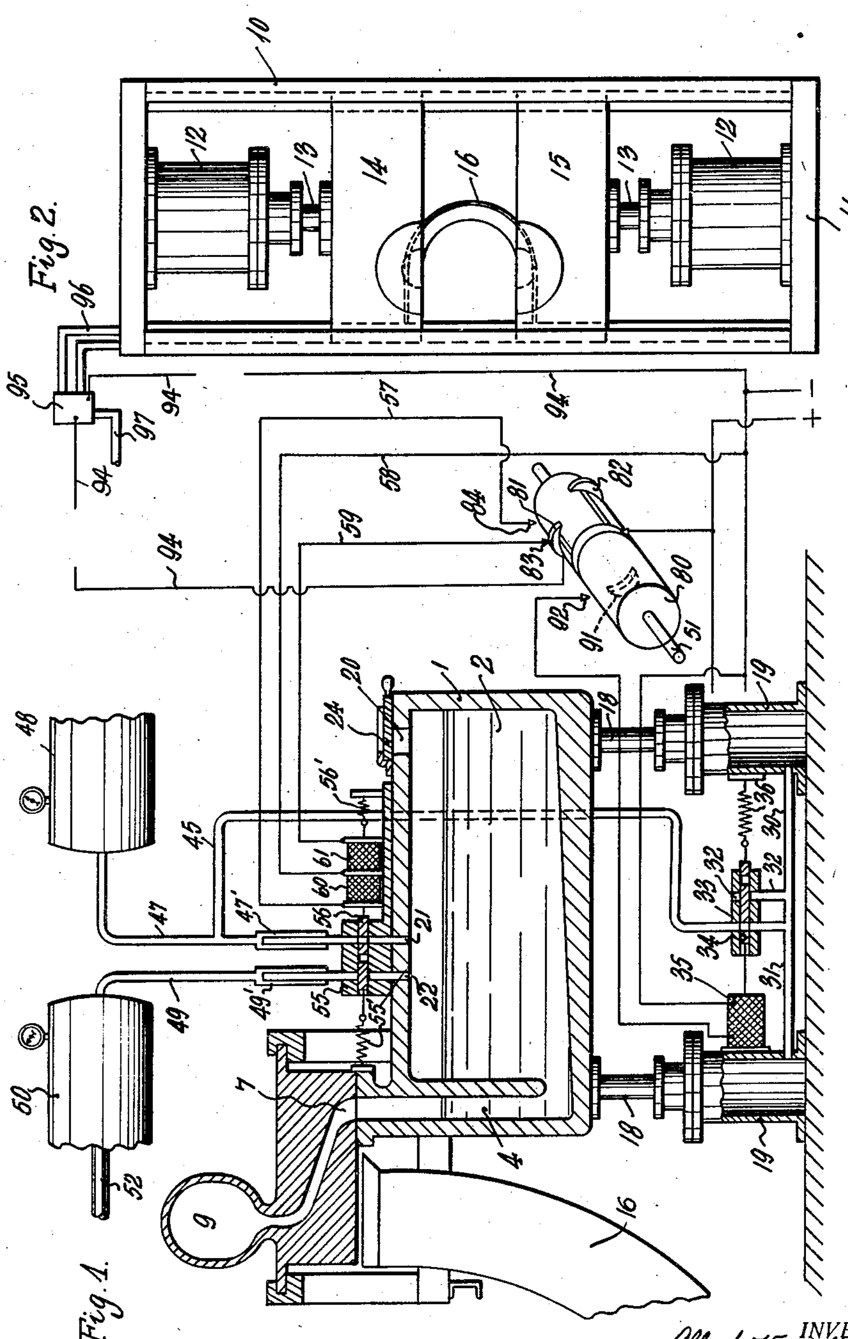

Fig. 2.

Fig. 1.

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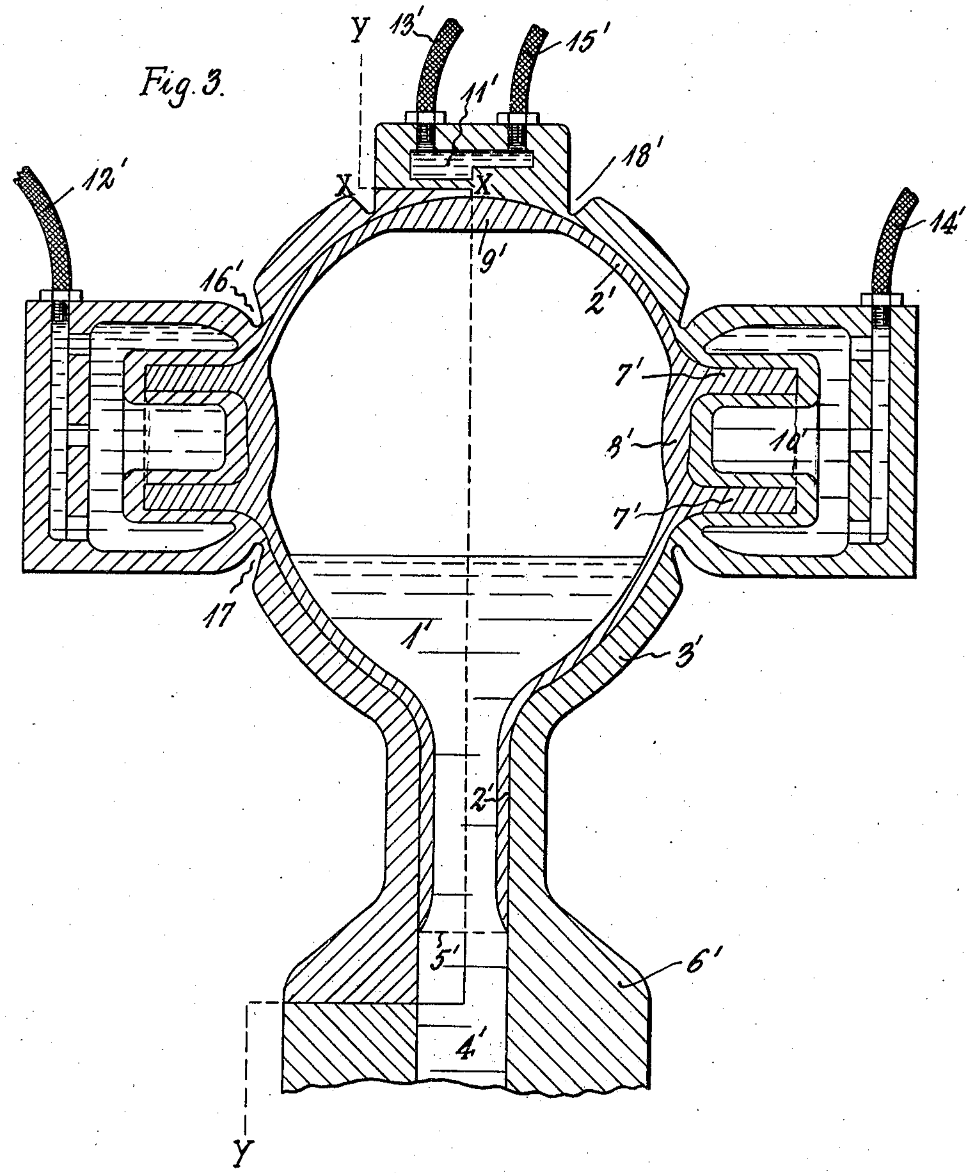
Fig. 3.



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Patented May 3, 1932 **1,856,352**

UNITED STATES PATENT OFFICE

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AUTOMATIC CASTING MACHINE

Application filed December 31, 1929. Serial No. 417,658.

This invention relates to an automatic casting machine for the special purpose of making cored castings without the use of cores. To accomplish our purpose we preferably adapt the machine disclosed in our copending application Serial No. 341,142, filed Feb. 19, 1929, by slight changes, to the particular mode of operation now desired. With a few changes in its construction or arrangement we are able to operate that machine with its many advantages and to also eliminate the need of cores in making hollow castings of various shapes.

The new automatic cycle of operation is to close the mold, to fill the mold through its bottom opening, to hold the mold closed until a hollow casting shell has set while maintaining the molten metal feed column under pressure against the molten metal (acting as a pressure core) in the mold, to then relieve said pressure and drain the molten metal from the interior of the shell through the bottom of the mold back to the charging ladle, to open the mold, and to remove the hollow casting, and to do all these things in exact timed relation. All these operations are not only automatic in a single cycle but the machine is also arranged in its preferred form to automatically repeat the cycle indefinitely.

The automatic feature of the operation is of prime importance. It results not merely in steady and speedy production. The larger importance in our case is found in the contribution such operation makes to the particular metallurgical process. By refining that process the automatic operation results in giving a superior product far beyond the range of hand operated tools and devices. The latter have had a limited and crude use for many years in making hollow castings (mostly in the soft metals) by draining the mold after a shell has set.

But in the development of the casting art, when hollow coreless-made castings of high grade are desired comparable in quality and cross sectional shape to core-made castings, the centrifugal casting method has heretofore been about the only one made available; and the latter has been highly developed. There are many natural limitations in the centrifugal casting operation. Shapes that can be made satisfactorily on our machine are naturally impossible to make by the centrifugal method. But shapes heretofore made by centrifugal casting may also be made on our machine and with distinct advantages, as will be pointed out.

With regard to the changes in the machine of our copending application: They are minor in character and need only the conception of the aims and objects herein fully disclosed for any one to make them. Substantially the same machine can be used. To arrange it for the present purpose we may advisedly time it according to the new character of work to be done. The machines will then differ in their timing elements. The mold is usually, but not necessarily, of a somewhat different design. To show the similarity of the two cases we can take the mold of the copending case and make a hollow casting from it by merely changing the timing elements. These elements control the dwell of the mold in closed position, the dwell of the charging ladle in mold feeding position, the time to relieve the metal feeding pressure, and the time for opening the mold. These time elements determine the operation. It can be readily appreciated now that they can be constructed and arranged to make a hollow casting instead of the solid casting referred to in that application. In the rearrangement it is desirable to design the mold for the shape desired and with a gate so designed that it will not be plugged by frozen metal. But even if only a small opening for molten metal is left, the draining of the metal from the mold will quickly clear that opening.

The present invention has been described with reference to our copending case to show the close relation between the two. It will not be necessary to repeat in this application much that is disclosed in the other with relation to the capacity of the machine for handling the more refractory metals like iron and steel and the high temperature melting alloys. The present machine is planned to make hollow castings with all the many advantages that the prior machine has from a metallurgical standpoint, and without the use of cores.

The object of this invention is to rapidly produce hollow castings of any shape in continuous mass production without the use of cores, particularly castings of refractory metals such as iron or steel, to produce such castings with the high degree of uniformity characteristic of continuous mass production products, to make such castings with wall thicknesses determined by the required mechanical strength and not by the peculiarities of the casting process, and to produce castings of superior all-round qualities at a much lower cost of production. Still other objects will appear from the following description in connection with the drawings, in which—

Fig. 1 is a vertical cross-section of an arrangement of apparatus according to this invention with some of the timing devices schematically indicated;

Fig. 2 is a top plan view of the power-operated mold; and

Fig. 3 is a cross-section of a differentially thermo-conditioned mold as it may be used in the machine for making more complicated shapes of hollow castings.

Referring to Fig. 1 and Fig. 2, we shall now give a general description of the arrangement of apparatus as used for our purposes.

1 is the charging ladle, the greater volume 2 of which is filled with molten metal while the upper volume is filled with some gas, usually air. The ladle can be raised and lowered by means of hydraulic cylinders 19 with piston stems 18. In the extreme raised position shown, conduit 4 of the ladle will register with spout 7 of the mold and allow the charging, setting, and draining step to be performed. These steps are timed by a revolving drum 80 with a number of cams such as 81, 82 which are peripherally and axially suitably spaced on the drum. While the contact brush 83 is riding on its cam 81 the solenoid 61 is energized and pulls the movable plate 56 of the slide valve 55 towards the right as shown in the figure, so that pressure above atmospheric will be transmitted from container 48 through pipe line 47 and port 21 to the charging ladle, with the effect of pressing a charge of molten metal into the interior 9 of the mold. This condition is represented in Fig. 1. When the brush 84 is in contact with its cam 82, the solenoid 60 will pull the slide plate of the valve towards the left and thereby establish a communication between container 50 and the interior of the charging ladle by way of pipe line 49 and port 22. The pipe lines 47 and 49 are shown to be fitted out with telescopic joints 47′ and 49′ to permit vertical movements of the ladle with respect to the pipe extensions fastened to the pressure tanks. Container 50 is supposed to be kept at a pressure below atmospheric so that a powerful draining action will be produced as long as its communication with the charging ladle is maintained. In cases where a less powerful draining action is sufficient, the pipe line 49 will open into atmosphere. The duration of the process of solidification or setting of the shell in the mold is given by the interval between the charging and draining operation. During this interval both brushes 83 and 84 are out of contact with the cams and the plate 56 of slide valve 55 will be in an intermediary position (to which it may be urged as a normal position by the springs 55′ and 56′, thus holding both ports 21 and 22 closed and sustaining the pressure from the charging action. Electric conductors 57, 58, 59 connect the timing gear with the solenoids 60 and 61.

A similar timing device connected to the same drum 80 and comprising a cam 91 and brush 92, is provided for periodically energizing solenoid 35. The function of valve 33 is to periodically admit pressure from tank 48 by way of pipe lines 47, 45, 31, 30 to the two cylinders 19, and to release this pressure to atmosphere through pipe connection 32. The slide plate 34 of the valve 33 is for this purpose normally held to the right by a spring 36, but when the brush 92 strikes its cam 91 the solenoid 35 will pull the plate to the left and thereby open the cylinders to atmosphere so that the ladle will descend. Still another timing device of the same kind, with circuit 94 (shown in part by Fig. 1 and in part by Fig. 2) and also mounted for cam control on the same drum 80 as those shown, controls the movements of the piston stems 13 in the cylinders 12 by pressure charging and discharging those cylinders (see Fig. 2) for opening and closing the two sections 14 and 15 of the mold. This is shown sufficiently by the electrically controlled valve outline 95 and the pipe connections 96 and 97 which connect the source of fluid pressure with the cylinders 12 and operate their pistons 13 in an obvious way. These two sections 14 and 15 are slidingly supported on a frame 10, the cross bars 11 of which take up the thrust of the cylinders. These three timing elements described, by a proper setting of their cams, govern in proper time relation the charging, setting, and draining steps of the mold cavity, the raising and lowering of the charging ladle, and the opening and closing of the mold sections.

The ladle is refilled in certain intervals through gate 20. A plain hand-operable valve 24 is shown for this purpose. In most cases special pouring devices for the periodic operation of this valve will be preferable. Such a timing device would require a more slowly revolving timing disk which might be coupled to the common shaft of the three before-mentioned timers by means of a reduction gear. The timing for the replenishing operation has, of course, to be selected in such a manner that this operation does not interfere with the operation of the ladle for charging, setting, and draining. This may be obtained by mechanical or electrical interlocking means between the two different-speed timing arrangements. Such and similar expediences are well known to those skilled in the mechanical or electrical art, and it is not desired to expand this description to show such details, so the mere hand valve 24 is indicated. The charging ladle can, of course, be replenished through gate 20 from a crane ladle and valve 24 sealed after each filling operation.

When the mold sections 14 and 15 are drawn apart the formed casting will, under the influence of its weight, easily separate from the mold walls and drop into a slanting chute 16 which gradually guides the casting onto a horizontal plane such as a conveyer belt or the like. Instead of receiving and conveying the casting from the mold in this manner it will in other cases be preferable to employ some kind of casting remover, for instance, like the one described in our Patent No. 1,756,602, granted April 29, 1930.

It will have been noted already that there is a difference of importance in the operation of the system in the two cases of core provided—our application Ser. No. 341,142—and coreless castings. In the former case, according to application Ser. No. 341,142, disregarding the comparatively small amount of metal required to fill the connecting conduit between the source and the mold, the metal charge is entirely used up for the formation of the casting, while in the present case of the coreless production most of the charge undergoes a complete reciprocation since the skin or shell that solidifies in the mold constitutes a relatively small amount of the mold-filling quantity of casting material. Most of the charge is drained and returned to the supply tank.

This difference in the behavior of the metal flow or current has a bearing on the arrangement and the operation as well. In the core-provided operation there is ample time for withdrawing the material from the mold. In regard to the proper formation of the casting in the mold it is not essential when the return of the conduit-charge takes place. This is, however, by no means immaterial in the coreless operation, as will become evident from the following considerations. The formation or solidification of the shell in the various sections of the mold cavities is not a simultaneous nor a perfectly uniform process. The greatest dissimilarities may obtain between the upper and lower mold portions or, more generally, between the ones that lie nearest and the ones that lie farthest in the way of the propagating surge or column of casting material. This unavoidable disparity is robbed of its undesirable effects—unevenness of wall thickness and of grain structure—if the steps of charging and draining the mold are carried out with great rapidity. As a consequence, the coreless operation of the system necessitates an accurate time control of both the charging and the draining step in the process. In other words, the character of the draining step in this method becomes of equal importance to that of the charging step. The average charging speed will be determined by the pressure applied to the metal surface in the supply tank, and so will be the average draining speed or, if no artificial pressure means are employed for draining, by the level difference between said surface and the tail end of the receding flow. Each of these two speeds should be predetermined and be sustained during operation within permissible variations. What it is desired to emphasize here is that, quite irrespective of the means employed, there should be an exact control of both the charging and draining operation as to individual duration and mutual time relation.

Another distinguishing feature of the coreless process is to be found in the different thermal behavior of the mold. In the core-provided process, the cooling-off of the liquid mass takes place bilaterally, from inside and from outside; in the coreless process only an outside or skin-effect is present. For this reason and in order to obtain castings or shells with well-defined thicknesses, it is desirable to employ molds of very highly heat-dissipative properties. The effect of such molds on the enclosed liquid mass is a sort of or may actually be a chilling effect. Such a chilling effect has the advantage of creating in the superficial layers of the material a very pronounced temperature gradient which causes the outflowing core material to part from the remaining shell in a well-defined inner surface.

From this, it follows that in the present method the steps for the formation of the casting tend towards shorter duration than in the core-provided process.

Besides the additional exact control of the outflow of the material a very exact thermal conditioning of the mold for rapid heat dissipation is, therefore, desirable.

The exactness with which the timing of the system and thermal conditioning of the mold have to be prepared makes the operation of our machine one of scientific character as compared to former simpler methods of making hollow castings without the use of cores. As a result, a machine arrangement according to this invention is able to produce coreless castings much more rapidly and with much greater uniformity of the product, and the latter is of the greatest importance for successful work.

As to the shapes of castings that can be made in our machine it would, theoretically speaking, be possible to make almost any shape of casting in it; practically there will exist, of course, limitations, particularly in competition with the automatic core-provided method of our copending application Ser. No. 341,142. Where thick walls or massy solid portions are required, the core-provided process offers, naturally, greater advantages since the penetration of the solidification process into the charge is bilateral, and because a considerable amount of heat is preserved between the inner and outer solidified surfaces, which heat can frequently be utilized for annealing purposes, as explained in the before mentioned copending application. The present coreless method is, therefore, particularly adapted for castings of thinner wall or shell thicknesses and of solid portions that do not have dimensions beyond those pertaining to ribs, flanges, bosses, etc.

In all cases where the shape of the casting is more or less deversified as to shell thickness and to solid portions extending therefrom, a very careful differential thermal conditioning of the mold is frequently desirable. The molds employed for such castings may be carefully predetermined in their thermal behavior. The laws governing the conduction, convection, and radiation of heat from a body to a given environment are well established as, like the corresponding laws of electricity, they enable one experienced in the art to predetermine the thermal properties of the mold with great accuracy. As far as we know, molds designed on these principles and for this purpose have never been used before in foundry practice. Heat dissipating plates have been inserted in molds for chilling and superficially hardening portions of the casting. The thermal conditioning of a cyclically power-operated, sectional mold, however, as this method renders desirable, in order to determine thereby to a certain extent the very shape of the casting, is something which, to our knowledge, has never been proposed before.

As an example of a sectional, differentially thermo-conditioned mold, we have shown in Fig. 3 a mold for an arbitrary form of casting for explanatory purposes only.

This mold is mechanically subdivided into two sections which may be supposed to open and close on a plane indicated by the dashed line X—Y.

1′ indicates the liquid core metal which is just being drained through conduit 4′. 2′ is the solidified shell and 3′ a portion of the mold walls. The solidified shell extends only part way until 5′ into the conduit, due to the higher thermal heat resistance of the stronger lower wall portions 6′ of the conduit. The bulb-shaped hollow casting is formed with annular ribs 7′, 7′, and with reinforced wall portions 8′ and 9′. These solid ribs and reinforcements are obtained by an intensive cooling of the adjacent mold portions, which cooling is effected by the circulation of water, oil, or some other suitable fluid in the jacket spaces 10′ and 11′ respectively. The cooling fluid may be introduced by one or several flexible pipe lines like 12′, 13′, and 14′, and be returned by means of similar pipe lines such as indicated at 15′ for the top jacket. This top jacket space 11′ on its left side extends nearer to the mold cavity to compensate for the higher thermal resistance in the horizontal division plane X—X of the mold. It will be noted, furthermore, that the mold walls where they circumlie the artificially cooled mold portions are provided with indentations. These indentations serve the purpose of preventing the cooling effect from the fluid circulation to proceed to those mold portions for which a lower temperature gradient is desired. Through such indentations the mold may be thermally conditioned not only in radial or central direction, but also in lateral direction, whereby special cooling effects are accurately localized. This example will be illustrative of the possibilities as to the shaping of a hollow casting in a thermally differentially pre-conditioned mold.

In connection with the foregoing description it will be apparent now that our machine will permit us to make all kinds of castings, also shapes which heretofore could not be made in any of the coreless methods. We have been able, for instance, to make in our machine, sections for steam or hot water radiators with walls hardly thicker than the shell of an egg. Such radiators are superior to the ones now in use, in as far as they are lighter, cheaper, of better heat-conductivity and yet of perfectly sufficient mechanical strength. This shows how with this machine new and better castings can be made.

For those skilled in the art, the foregoing description of means and mode of operation will be sufficient to employ our invention in many specifically different kinds of apparatus and using differently shaped molds. We have felt that our disclosure of the invention would be clearer from drawings more in the nature of diagrammatic layouts than it would be with all the elaboration of perfectly well known devices such as air valves, electric controls, etc.

There are several important specific features of our invention that might be overlooked without further elaboration in the practical modes of operating a casting machine of our type, as we have conceived them. For example, assume it is desired to make a hollow casting like a cast-iron pipe section with the walls of gradually increasing thickness from one end to the other. We would set the machine so as to fill the mold; when the top of the cooling piece had its minimum wall thickness set, the machine would then start to drain the mold. The pressure on the metal supply controls the rate of draining. Instead of merely releasing this pressure to drain, as previously described, the release of pressure can be controlled so as to make the draining take place about as we wish it in progressive time relation. By releasing the pressure slowly we can have the casting walls taper from top to bottom or we can taper them part way and have them straight part way. All of which is simply accomplished by the control of pressure on the charging ladle. That pressure may be controlled by the nature of the port in slide plate 56, or by the control of the back pressure in tank 50. For illustration, the control of the latter pressure is readily understood. By relieving the pressure on the molten metal into tank 50 and by causing the pressure in the latter to vary by the timed movement of a piston connected to a reciprocating piston rod 52, the rate of pressure release for the draining operation can be made what we wish it. The driving means for piston rod 52 may be a slot cam (not shown operating from timing shaft 51).

By the control we have just referred to it is possible to accomplish an entirely new result that we have not mentioned up to this point. It is to make a hollow "blind" casting of a new kind. This will be understood as a hollow casting wherein there is no trace left in the metal walls of the use of a core in the production of the piece. Ordinarily there is an opening in the piece from which the core material has left it. This opening is frequently plugged up and polished over, but the evidence is always there.

In our apparatus we can make, for example, a hollow cylinder with both ends closed and integral with the side walls and without a joint or break in the walls of any description whatever to indicate its hollow character. To do it, we fill a suitable mold to set the top wall before we start to drain. We start draining the liquid core metal after the top wall and side walls have set. We drain from the mold until the level is where we want the bottom wall. Then we maintain the pressure on the liquid column in the mold until it freezes solid with the top level as the inside level of the bottom wall. Then we drain the column of the unset metal far enough below this (which can be kept liquid by the relatively slower cooling of the mold walls below) to secure a desired thickness of wall. Then when the piece is trimmed from its excess (gate) metal we have our hollow blind casting whose walls have not lost their integrity in even the minutest particular in the draining of the core. Hollow castings of this kind are in many instances desirable. In fact castings are frequently made solid (with a pure waste of metal) simply because it is not desired to have their walls anywhere show signs of having been breached for handling the core. Frequently cores are left in the piece for the same reason. Our article can be produced without either making the casting solid or leaving the core inside. This we consider an especially important feature of the invention along with the others previously mentioned.

From the description and drawings given, those skilled in the art will readily recognize the utility of the means disclosed for many other uses than we have mentioned. It is desired to claim such means without limitation except as may be necessarily imposed by such prior art as is known.

What we claim is:

1. In an automatic casting machine, a sectional mold having a gate on its bottom side, a ladle having a spout for pressure registration with such gate, means to cause said registration and break off the same in predetermined timed relation to the opening and closing of the mold, means to open and close the mold, and pressure means during said registration to feed molten metal to fill the mold, to withdraw molten metal from the mold when the latter has set a hollow casting whereby the withdrawn metal has served in place of a core in exactly predetermined time relation to the setting of said hollow casting.

2. In an automatic casting machine, a sectional mold having a gate on its bottom side, a ladle having a spout for pressure registration with such gate, means to cause said registration and break off the same in predetermined timed relation to the opening and closing of the mold, means to open and close the mold, and pressure means during said registration to automatically feed molten metal to fill the mold, to withdraw molten metal from the mold when the latter has set a hollow casting whereby the withdrawn metal has served in place of a core in exactly predetermined timed relation to the setting of said hollow casting, said opening means including automatic power operated mechanism timed for opening the mold immediately after such registration with the charging ladle is broken.

3. An automatic casting machine comprising a sectional mold, power means to open and close the mold in predetermined timed relation, a mold charging ladle, power means operable in predetermined timed relation to place the ladle and mold in feeding communication, pressure means to feed molten metal from ladle to mold, and timing mechanism to apply and release the pressure means, all constructed and arranged for the mold when closed to be filled with molten metal under pressure until a shell has set and then to empty the interior of the shell of its molten metal.

4. A casting machine comprising a sectional mold, power means to open and close the mold in predetermined timed relation, a

mold charging ladle, power means operable in predetermined timed relation to place the ladle and mold in feeding communication, pressure means to feed molten metal from ladle to mold and timing mechanism to apply and release the pressure means, said timing mechanism having associated means to control the pressure means to hold the mold full until a cast shell is formed, to empty the shell into the ladle and to stop the flow back to the ladle so as to close the exit opening through the shell by chilling the tail end of the molten metal and thereby form a hollow casting with unbreached walls.

In testimony whereof we have affixed our signatures.

ALBERT WOOD MORRIS.
SAMUEL PRICE WETHERILL, JR.