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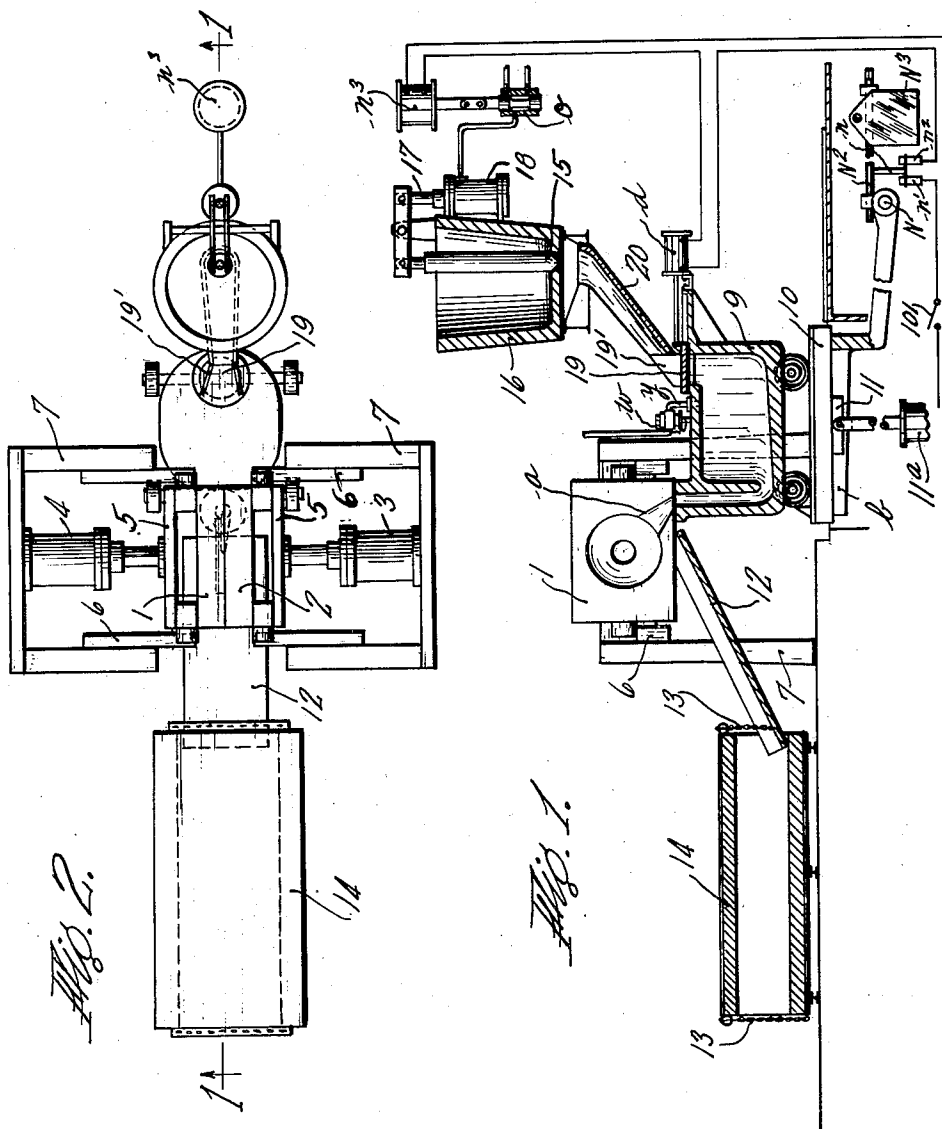
A. W. MORRIS ET AL

1,815,360

METHOD FOR CASTING METALS

Filed Feb. 19, 1929

5 Sheets-Sheet 1



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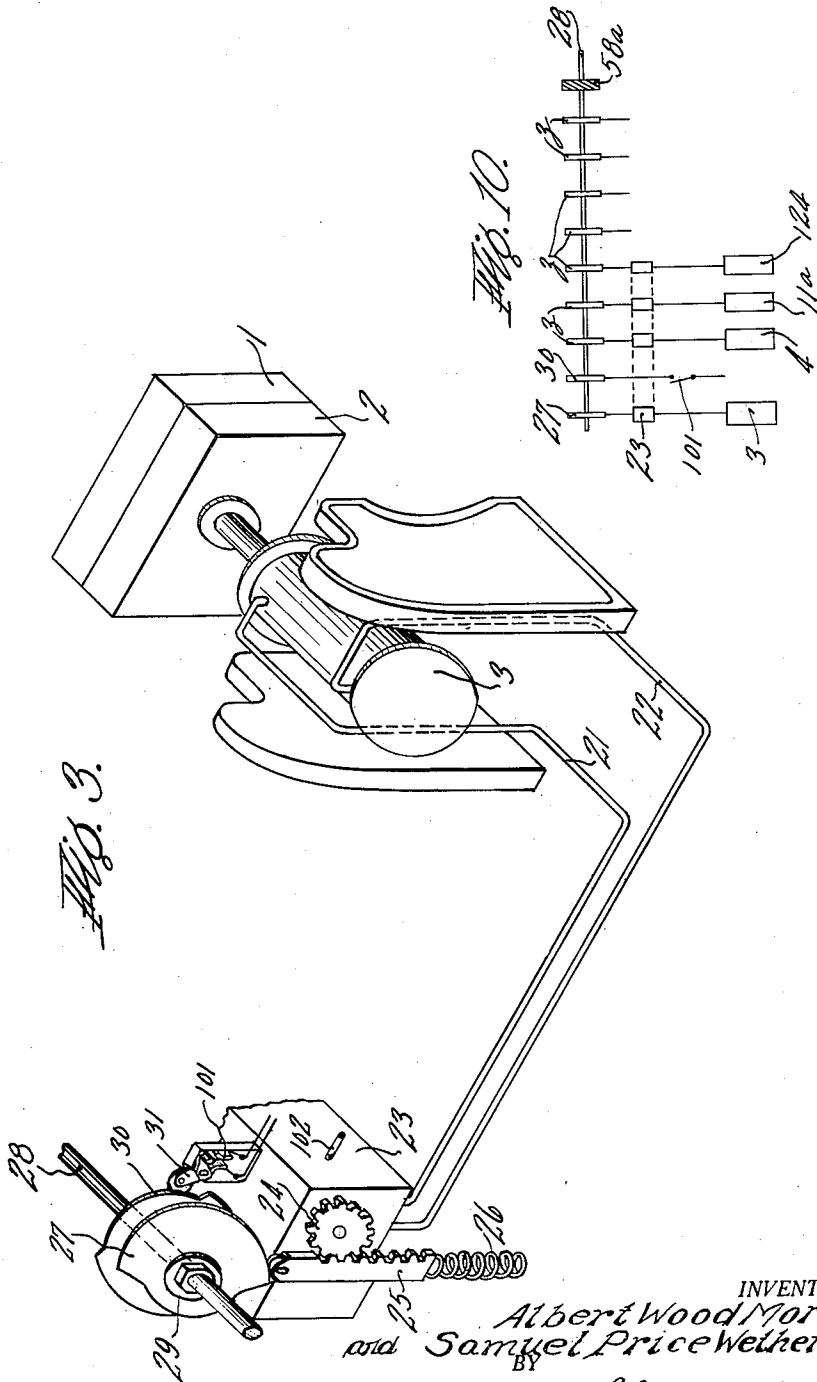
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5 Sheets-Sheet 2



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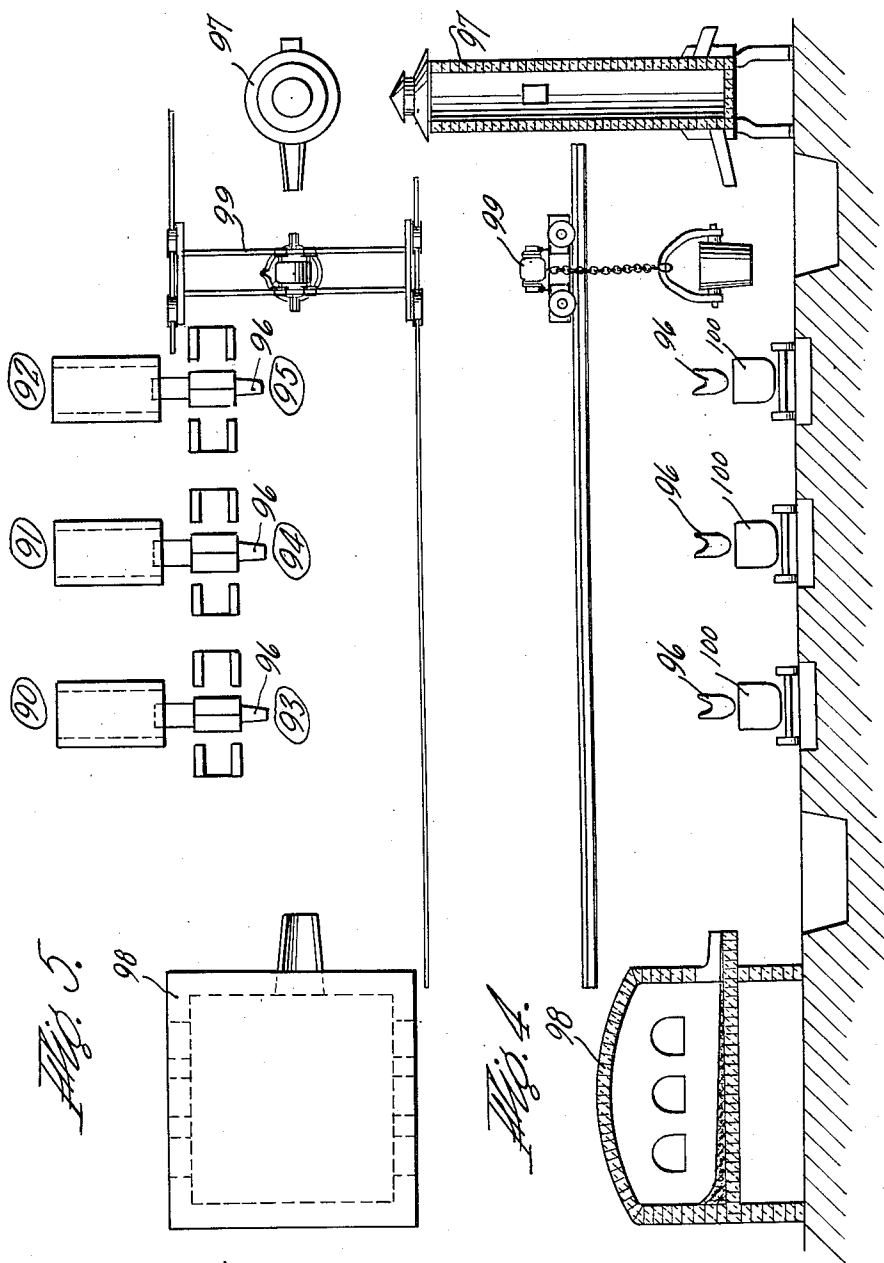
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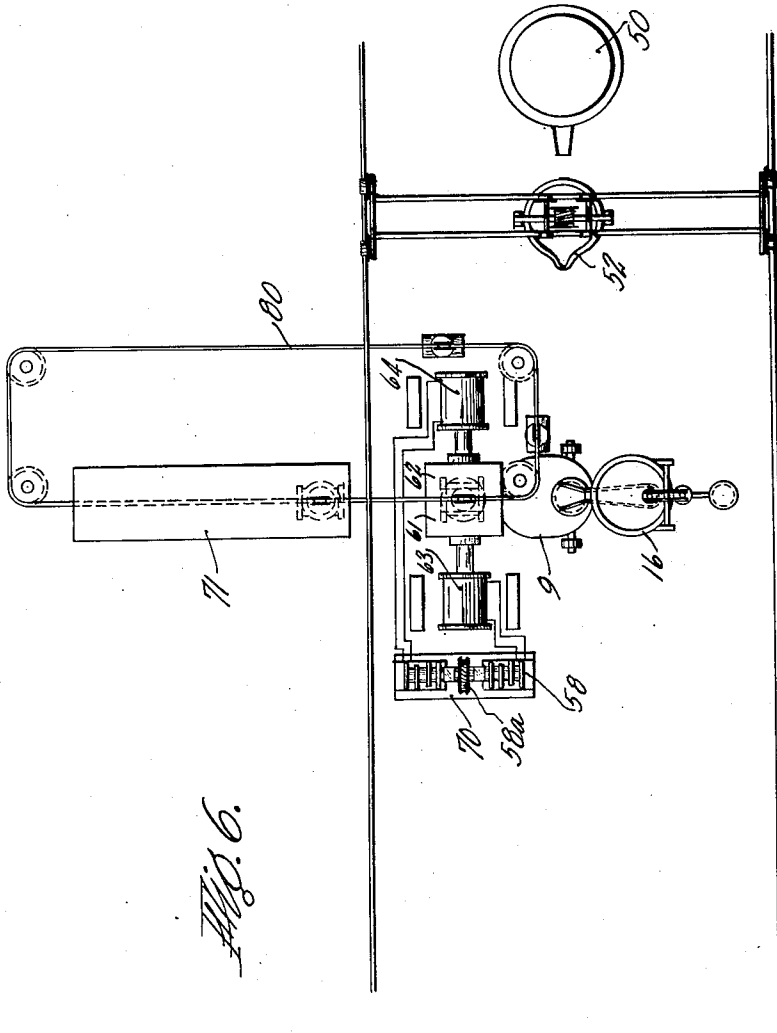
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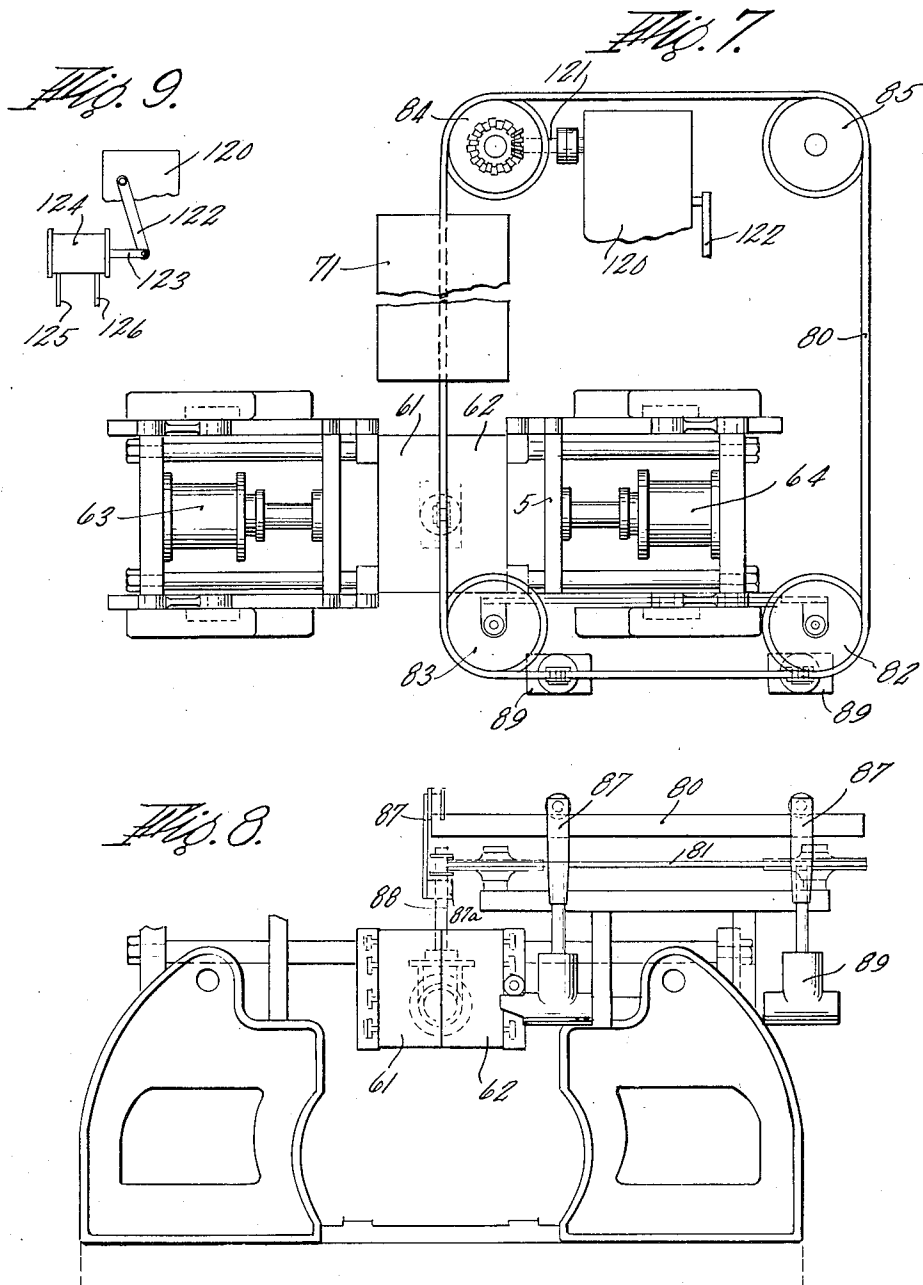
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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

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METHOD FOR CASTING METALS

Application filed February 19, 1929. Serial No. 341,142.

Our invention relates to methods for casting metals in an improved manner.

According to one of the principal features of our invention we have devised a method for casting the high melting temperature metals and particularly iron and steel, in which method the operator is primarily just an ordinary workman who attends the carrying out of the method, and the arrangement of the method gives the desired high quality to the product and the efficiency to the whole operation. To bring this about we have to coordinate a variety of useful apparatus, the details of which may be widely varied without departing from the disclosure of our invention. This fact will be clear as the disclosure proceeds.

Some of the various features of the invention will be obvious from the following detailed description, while some will be particularly emphasized in such description.

Referring to the accompanying drawings:

Fig. 1 shows a section on line 1—1 of Fig. 2; this figure also includes a showing of parts of the control devices and controlling circuits not shown in Fig. 2;

Fig. 2 shows the assembly of a casting machine or device for manipulating the halves of a permanent casting mold, a mold charging ladle for the mold, an automatic metal supply or feeding means or supply ladle for the charging ladle, a device we call a normalizer, and a transfer device to move a finished casting to the normalizer immediately upon the opening of the permanent mold halves;

Fig. 3 is a detail view showing the shaft of a timing mechanism and parts of the control means for manipulating or timing one of the mold halves of Fig. 2 in relation to the other half. The detail for the second mold half is arranged in the same way as that shown, but such additional detail is omitted to avoid confusion and the showing of Fig. 3 is separated from Fig. 2 for the same reason—to avoid confusion in the drawings. On the timing shaft is also a switch controlling cam for additional control of the machine apparatus;

Figs. 4 and 5 show an arrangement in dia-

gram form for illustrative purposes of a group of automatic casting machines and hot metal supply means with relation to the supply ladles. These views are schematic only and will be understood best from the description later to be given;

Fig. 6 is a schematic view of casting machine, timing mechanism, mold charging ladle, charging ladle supply means, and hot metal service means, normalizer, and conveyor mechanism for cores—the latter being operable also to remove the castings from the casting machine to the normalizer;

Figs. 7 and 8 are plan and side views, respectively, of the casting machine, normalizer, and conveyor shown in more detail than in Fig. 6 but with many structural parts (particularly the timing mechanism) removed to avoid confusion;

Fig. 9 is a detail indicating a part of the step-by-step driving mechanism for the conveyor shown in Figs. 6, 7, and 8; and

Fig. 10 is a diagram view showing the arrangement for coordinating the automatic parts of the assembly of apparatus under the control of the timing mechanism, with the exception of the hot metal supply for the mold charging ladle which is under an independent timing control, but one that is rendered inoperative at certain periods by the principal timing mechanism.

In presenting a complete disclosure of the invention many of the machine details are omitted since anyone skilled in the art can readily supply them in a great variety of particular forms. Since the invention herein claimed is to be found in the method of proceeding with the molding operations, the drawings are intended to indicate the useful tools (whether individual machines or static apparatus). The coordinated arrangement of these tools is disclosed in one or two practical illustrations to enable any one to carry out the invention.

Referring to Figs. 1 and 2, we show a simple form of permanent mold (which may be provided with any sort of molding cavity) in two mating parts 1 and 2. These mold parts 1 and 2 are brought together and separated by the timed movements of pistons in opposed

cylinders 3 and 4. The piston rods extending from the cylinders move carriages 5 which have rolls supported on tracks 6 mounted in machine frame 7. This arrangement supports the mold halves so they are entirely surrounded by air except at skeleton supporting points. It is clear that by timing the operation of the cylinder pistons the mold halves can be brought together, stay together a fixed period of time and then separate for a fixed period of time and repeat this cycle indefinitely for rapidly repeated casting operations.

In Fig. 1 the gate *a* for the mold cavity is indicated. A charging ladle 9 (mounted on wheels and on a weighing platform 10 carrying track sections for the wheels) is arranged with its discharge spout in registration line with the mold gate *a*. The mold charging operation is to lift platform 10 by a power operated piston rod 11, operable by piston 11*a*, from its forked scale beam frame *b* until the discharge spout is pressed into registration with the mold gate *a*. This lifting movement of ladle 9 registers an air pressure port in its upper wall with an air pressure inlet pipe *y* and presses upwardly a spring pressed valve stem *w* to open the normally closed air valve in pressure pipe *y*, as shown. The operation described admits air pressure to closed ladle 9 through pipe *y* to force metal by a bottom pressure pouring operation into the cavity of closed mold 1-2. After a suitable time the charging ladle 9 is lowered, the mold halves are separated, and the cast piece drops from the mold to slide 12, whereby it is immediately transferred through the flexible door 13 into the normalizer 14, and door 13 (as a curtain) closes the latter.

The weight of the metal in ladle 9 (together with the weight of such ladle) when placed on the platform 10 above the forked end of scale beam *b*, and the weight of the platform determines when valve 15 of supply ladle 16 is opened by piston rod 17 manipulated by fluid in cylinder 18. The point is that ladle 9 is replenished through door 19 with hot metal (provided hot metal is in turn supplied to ladle 16) when its supply falls below a certain weight. Then the weight of the new supply operates through the scale beam *b* to shut valve 15. The means for this operation, as well as the opening of door 19, will now be described first with reference to Fig. 1.

The necessary movement of charging ladle 9 consists in an upward step to press its discharge nozzle in registration with mold gate *a*, at the same time connecting with the air pressure in pipe *y*, and a downward step away from the mold halves to permit them to open. The air cylinder 11*a* (indicated conventionally) operates piston 11 for this up and down movement. The charging door 19, slidable into open and closed position by

magnet *d* (the operation being indicated by conventional means to avoid confusion in the drawings), is pressed (by the movement which brings registration with mold gate *a*) into tightly closed position against wing stop members 19' extending into position from spout 20. This is desirable since in mold charging position air pressure is admitted to ladle 9 and the door 19 should then be held tightly closed.

When the ladle 9 is lowered it is resting on the scale beam frame *b* (from which its weight was lifted when piston rod 11 was elevated). In this lowered position of ladle 9 resting on the scale beam, frame door 19 is in position to open and all air pressure from pipe *y* is shut off. The scale frame *b* is pivoted at N and provided with an adjustable weight N³ slidable on extension bar N². It is obvious that when the weight of ladle 9 and contents is sufficient, weight N³ will be kept up and its switch bar *n* be removed from contacts *n*¹ and *n*². This is the normal position with ladle 9 down out of mold charging position. As soon as the hot metal needs replenishing in ladle 9 its weight is not sufficient to keep bar N² and its weight N³ in the upper position. So they fall (lifting ladle 9 upwardly a small amount but not enough to require special consideration) and switch contact *n* bridges contacts *n*¹-*n*², closing an energizing circuit for magnet *n*³ (provided switch 101 is closed and such switch is in closed or open position, respectively, according to the position of the master timing mechanism and the open or closed position of the mold halves, as will be explained).

The magnet *n*³ operates a control valve *o* to connect the air cylinder 18 with an air pressure power line to operate or lift valve 15 or, when the magnet is deenergized, to exhaust the cylinder and permit valve 15 to close by gravity. All this will be obvious from the valve and connections shown. As the parts are shown in Fig. 1, cylinder 18 is exhausted to the outlet line, but when valve rod of valve *o* is lifted by magnet *n*³ the operation will connect cylinder 18 to a suitable fluid pressure source whereby its piston is operated to lower piston rod 17 and lift weighted valve 15 through the lever connection shown.

In the same circuit with magnet *n*³, magnet *d* is connected to open door 19 whenever valve 15 is opened. The armature of magnet *d* may be spring pressed to door closing position when the magnet circuit is opened. The simple means shown is illustrative of the operations rather than the more complicated means that may be more elaborate and desirable to use in some embodiments of the invention.

It will now be clear that when the hot metal supply in ladle 9 needs replenishing

its lack of weight results in energizing magnets n^3 and d whereby door 19 is opened and hot metal fed from supply ladle 16 until the added weight in ladle 19 results in breaking the circuit of the magnets, closing door 19 and valve 15. It is also clear that the adjustment of weight N^3 on bar N^2 will determine the full charge of ladle 9. As we will point out later, the hot metal supply for ladle 16 is preferably under the human control of foundry attendants who intermittently feed it from a crane ladle.

From the description previously given, it will be obvious that the mold halves 1 and 2 may be closed and opened periodically (preferably through a timing mechanism to be described) with a dwell in closed position long enough to receive a charge of hot metal from ladle 9 and to cool the same enough for discharging it as a cast piece. And by the arrangement shown in Fig. 1, as soon as the mold is opened the cast piece is immediately transferred to normalizer 14. It is further obvious that these operations are arranged so they can be carried on in a predetermined timed sequence beyond the normal control of the human operator or machine tender for the mold charging operation or the ladle replenishing operation, or both. The showing in Figs. 1 and 2 is made simple and the reasons for this will shortly appear. It might be even simpler if we put on the machine tender the work of opening door 19 and frequently replenishing ladle 9 with hot metal from a major supply as a crane handled ladle operable from a cupola supply. What we want the simple showing of Figs. 1 and 2 for, is to emphasize the mode of operation and apparatus arrangement desirable from a consideration of the following features in the casting of metal such as iron and steel (not intending to omit any other metals like the copper alloys or others that melt at high temperatures and in the handling of which the high temperature creates many difficulties).

We will take iron as an example in the consideration of the features of the invention now to be discussed. In the operation of an automatic casting machine the quantity of metal used up by the rapid operations of the machine over any substantial period of time is large with relation to the metal parts of the machine itself. When the metal handled in the machine is molten iron, and more particularly when each piece cast is large, the quantity of heat that must be dissipated is enormous. These facts underlie one or more definite problems concerning the metal supply, its temperature control, and the heat treatment of the work in considering desirable operations with high temperature melting metals.

Referring to the arrangement in Figs. 1 and 2, it will be seen that we have provided a

charging ladle that has no self-contained heating unit for the metal or any firing operation in the machine assembly. It will be clear that to operate the machine we have arranged a means for intermittently replenishing the metal in the charging pot and in the same replenishing operation we have included the step of supplying all the heat necessary to maintain the molten metal in condition for casting. This heat is carried in solely by the fresh supply of hot metal intermittently given to the charging ladle 9. We have taken advantage of the fact that the art of maintaining a large mass of molten metal at a desired temperature for casting in foundry practice is highly developed. For this reason we preferably omit the whole firing step from any close association with the necessarily rapid steps of the casting operations. We arrange the capacity of the charging ladle with relation to the capacity of the rapid casting operations in such a proportion that when a hot metal supply is given to the charging ladle it will be used up and a fresh supply given rapidly enough to avoid all firing operations at the machine. The heat radiation capacity of charging ladle 9 is readily known, so that to carry out our idea it is only necessary to intermittently replenish ladle 9 with a hot metal charge far enough above the desired casting temperature to compensate for the radiation. Such a charge may be brought from a major supply and put in supply ladle 16 or directly into ladle 9.

A characteristic feature that we wish to emphasize, as employed in our invention, is the rapid "turnover" of the metal in the casting operations and our idea for supplying such metal in small intermittently-fed quantities to avoid any substantial hot metal storage and consequent firing operations at the place where rapidly repeated casting steps are carried out. We preferably accomplish this by having charging ladle 9 small in comparison with the volume of metal that is cast from it in a short period of time. This results in avoiding an expensive equipment for storing and heating metal in an arrangement of apparatus such as shown in Figs. 1 and 2. The charging ladle 9 may be of such inexpensive character that it may be replaced at slight cost whereby the apparatus for carrying out an exceedingly large production in castings is essentially an apparatus freed from the complications of all substantial metal storage and firing equipment and the latter is supplied, under our ideas, at a central station which may serve any desired number of production units, as will be pointed out.

The importance of the normalizer 14 in relation to the casting step will now be described. From Fig. 1 it is clear that immediately upon the the opening of mold halves 1 and 2 the cast iron from the mold falls into the normalizer 14. The preferred operation

is to keep the mold halves together after the mold charging step, just about long enough for the casting to be self-supporting when released, but not long enough to cool beyond a working factor of safety for the self-supporting purpose. When released the interior of the casting may even be in molten condition (in large castings) and only the shell of the casting solidified. It will be noted that the mold halves are mounted in suspended position entirely surrounded by air, so that there may be an exceedingly rapid heat dissipation from the permanent mold halves 1 and 2. Our operation provides for this rapid heat dissipation, but with its effect on the cast metal only for that very short period of time necessary to solidify the metal enough for discharge purposes. It is our idea, particularly with cast iron or steel, to discharge the casting in substantially the hottest condition that will still permit its form to be maintained. In such condition it is received within the normalizer 14. And from such condition it cools off slowly enough within the normalizer to give the metal a heat treatment supplied by the casting heat of the metal.

In one aspect the normalizer may be considered an annealing oven. But the castings made under our method (including the step of instantly transferring the casting from the mold to the normalizer) are superior, we feel, to castings which are annealed in the usual manner. The reason for this is that when the casting is formed in the mold it is not thereafter cooled rapidly enough at any time (when our method is followed) to acquire that condition which requires annealing. That is to say, the metallurgical structure of the metal is not set under strain and then the strain corrected by the ordinary annealing step. Instead, by our method, the metal is uniformly set so as to never pass through the strain stage which is often so damaging to cast iron articles of commerce and which is not at all uniformly corrected in the annealing step of the ordinary manufacture. This statement of the advantage of our method does not need, according to our understanding, any substantial qualifications due to the fact that the cast piece must cool enough in the mold to be ejected in self-supporting form. In cooling cast iron the metal first expands and then contracts. We believe it solidifies (enough to retain its form) before it contracts to the volume from which it started to expand. If, in such a solidified state (whether the interior is liquid or not), it is ejected from the mold and then allowed to cool slowly enough in normalizer 14, it is our opinion that the metal does not pass through that stage which renders annealing necessary. This opinion, however, is not a necessary thing in the advantages derived from our invention.

It will be understood that normalizer 14

is shown simply as a closed container having heat insulated walls and flexible end doors 13, to retain the heat of the castings sufficiently to give the long cooling time desired. The art of cooling in annealing ovens after the annealing heat is applied is so well understood that nothing further need be said except to point out that in our case sufficient heat is with absolute uniformity carried into the oven by the castings coming direct from the mold, rather than obtained from extraneous sources. Otherwise our cooling oven is like an annealing oven but we have called it a normalizer to distinguish our cooling step from the ordinary annealing step. While the saving of heat ordinarily used in the annealing operations is important in our operation, we believe the uniform heat treatment given to the castings is even more important, since it gives better quality to the castings.

We have discussed the normalizer 14 and its effect on cast iron and steel in our method. It has advantages in giving desired heat treatment to castings of other high melting temperature metals where rapid cooling is preferably avoided.

In Fig. 3 we show schematically the means for automatically operating either one of the mold halves 1 or 2. Cylinder 3 has a piston and fluid inlet pipes 21 and 22 connected at opposite ends. These pipes lead to a control valve of any suitable type in valve box 23. The particular control valve (not shown) for cylinder 3 may have its movable part operated by gear 24, which in turn is operable by a rack bar 25 pressed upwardly by spring 26 and moved downwardly by cam 27 keyed on rotatable timing shaft 28. The up and down movement of rack 25 oscillates gear 24. Through suitable ports in the particular control valve related to the ends of pipes 21 and 22, the latter are alternately put in communication with suitable air pressure and exhaust lines not shown. The pipe 102 indicates an air pressure line from any suitable source to all the control valves, to be mentioned and grouped for convenience in valve box 23.

In the position of the parts shown in Fig. 3 the mold halves are closed. If shaft 28 is rotating clockwise the dwell on cam 27 will hold the control in mold closing position for about one-half a revolution, then permit spring 26 to elevate bar 25, move gear 24 so the control will be in open position for something less than half a revolution. As shaft 28 rotates in carefully predetermined timed relation to the work to be done, it is clear that mold half 2 is moved alternately into open and closed position. Mold half 1 is under a similar control not shown, but which can obviously be associated with valve box 23 and timing shaft 28, and timed in corresponding sequence. Cam 30 on shaft 28

opens a rocker arm switch bar 31 which is in circuit with magnets n^3 and d , shown in Fig. 1, and this switch bar controls the switch there shown as 101, in circuit with control magnets n^3 and d . This switch 101 is kept open when the control valves for pistons 3 and 4 are in mold closing position, and is closed when in mold opening position. By this control means it will be impossible to pour metal from ladle 16 when charging ladle 9 needs to be elevated to mold charging position. The timed sequence for the up and down movement of charging ladle 9 through cylinder 11a and piston 11 (Fig. 1) is controlled by a suitable control valve mechanism associated with valve box 23 and operated by a cam on timing shaft 28 in a like manner to the operation of cylinder 3 (Fig. 3). The timing arrangement of the various parts will be clearer from the diagram in Fig. 10.

In Figs. 4 and 5 we have indicated in plan and elevation a mass production layout for practicing our invention. A cupola 97 and open hearth furnace 98 indicate respectively suitable sources or supply points of molten iron and steel respectively. Tracks carrying a crane ladle mechanism 99 run from one supply to the other to take from either one. Between these supplies are a series of production units which may be lined up in opposed rows, one adjacent each track (only one row being indicated). These units are merely indicated by the outlines of casting machines and normalizers 93—90, 94—91, 95—92. A mold charging ladle for each is shown in Fig. 4 at 100. Each charging ladle 100 is shown mounted on wheels to be drawn out on tracks from under the mold halves when desired. The feed spouts to the charging ladles are indicated at 96 and are similar to spout 20, Fig. 1. The normal operation of each unit, as described in connection with Figs. 1 and 2, will use up a single charge of hot metal (within the capacity of the charging pot) very rapidly and such pots may be fed, as shown in Fig. 1, through supply ladles 16 or directly by hand manipulation of the charging ladle door and of the crane ladle, if desired, in order to avoid the complication of the automatic feed from the supply ladle 16, as in Fig. 1. But the automatic feed from ladle 16 is preferable in many aspects of the invention.

It is important to note that even when this hand operation is injected into the scheme the skill of the human operator is practically eliminated in the casting steps. In a mass production arrangement the metal in the crane ladle is continually and normally replenishing its supply from either cupola 97 or furnace 98. So if the operator misses or overlooks the time of feeding one of the charging ladles 100, the metal from the previous charge in the latter is used up in any

event quickly enough to avoid bad castings. The automatic machine overlooked by the crane operator may continue to operate but it makes no castings. If it is supplied with metal from the crane ladle at all, the casting steps result in good castings, assuming only that the major metal supply in cupola, furnace, or crane ladle is maintained within the desired temperature range for casting. The latter is a customary thing, easy to accomplish and dependable, whereas the maintenance of temperature as high as required by molten iron or steel by firing operations, or large storage supply means forming a part of the casting machine or tools and located at each unit, is not only inefficient and expensive but in many lines of work absolutely prohibitive. It is this fact we believe that has much to do with the very slow development of taking the work involved in casting metals like iron and steel out of the hands of the skilled operator and putting it under automatic operations and under the control of mass production methods.

In Figs. 6, 7, and 8 we have somewhat elaborated the showing of our arrangement of casting apparatus or tools as arranged to carry out our method in its preferred form. Some aspects of the invention will be better understood from these figures taken in conjunction with what has been said with reference to Figs. 1 to 3.

In Fig. 6 a cupola supply 50 of hot metal is shown. Tracks for a crane ladle 52 run from the cupola to one unit of the casting apparatus. In this unit of the casting apparatus a supply ladle corresponding to ladle 16 in Fig. 1, and a charging ladle corresponding to ladle 9 and each operable as described, are shown. The crane pot 52 keeps ladle 16 supplied by human attendance. This arrangement permits the firing operation and large storage of hot metal to be kept at cupola 50 or other suitably fired main supply source represented by 50, an intermediate relatively small supply in ladle 16, and the final small charging supply in ladle 9. By operating the casting machine steadily, hot metal is always available, but the work of maintaining it in large enough quantities is placed away from the automatic machine and as shown upon the standard practice of the foundry in heating and having such casting metal available.

We have indicated in Fig. 6 the mold halves 61 and 62 operable by pistons from cylinders 63 and 64 and the air pressure lines from each cylinder (each similar to that shown in Fig. 3) running to the control mechanism 70. The timing shaft in the latter is driven by gear 58a and has cams to operate all the control valves of the several cylinders, as already described.

In the same figure we have indicated an elongated normalizer 71 (long enough to keep the castings within it for their desired

heat treatment) through which a chain conveyor mechanism carries the finished castings. The same mechanism is used to intermittently carry cores between the permanent mold halves so that each casting may be of the cored type when desired. This conveyor mechanism is best shown in Figs. 7 and 8.

In these figures parts of the casting machine, such as the mold carriages, are omitted where desirable and some liberty is taken in the drawings to avoid confusion. A circular track 80 (suitably mounted on a frame not shown) overlies a conveyor chain 81 (Fig. 8), trained around the four sprockets 82, 83, 84, and 85.

The shaft of sprocket 84 is the driven shaft for giving exactly equivalent intermittent motions in the travel of the chain. This may be brought about by operating the shaft of the bevel gear device shown in Fig. 7 through any conventional drive here indicated for illustration by a gear box 120. Within this box is a set of gears connected at the driven end to shaft 121 and at the driving end to rocking lever 122. The latter is periodically rocked by the operation of piston rod 123 reciprocated by a piston in air cylinder 124 (see Fig. 9). The latter has air conduits 125 and 126 and operable under the timed control of a cam which may be considered as added on the timing shaft 28, and a control valve corresponding in character to the operation of the cylinders 3 and 4 of Fig. 1. The rocking of lever 122 is transmitted to a pawl and ratchet mechanism in gear box 120 to drive the gears therein and shaft 121 an exact amount in one direction only, but at desired intermittent intervals. Shaft 121 is turned just enough in each driving operation to move chain 81 to carry a core into registering position between the mold halves when the latter are open and to carry a finished casting from the mold halves as soon as they are opened to a position inside the normalizer, as will appear. There are many other ways in which the desired intermittent drive of conveyor chain 81 might be accomplished in timed relation, as by a magnetically braked motor drive under the control of a timing switch operated either by contacts on or adjacent track 80 as the hangers move step by step or through a cam operated switch connected to the principal timing mechanism of the machine. It is not believed that the showing of this invention will be any clearer by any elaboration of known means for driving a shaft, as 121, in exact measured degree and in intermittent periods of measured time.

A series of spaced hangers 87 roll on track 80 and each one is suitably and removably connected, as by spring fork 87a underlying a flange on rod 88, to support the weight of

the core rod 88 and its burden, which rod is connected to the chain to be moved thereby. Each rod 88 carries a core 89 as the hanger is moved, to a position to overlie mold halves 61 and 62. It should be understood that these rods 88 are equally spaced around the chain a distance equal to a single movement of the chain. Cylinder 124 operates the conveyor in step-by-step movements controlled by the timing mechanism. Thus a core is positioned between the mold halves 61 and 62 when they are opened. In the operation the mold halves close, the charging ladle pours, the mold halves open, the finished cored casting is moved immediately into the normalizer 71 by the intermittent conveyor operation, and the succeeding core 89 is positioned between the mold halves for a like operation. The normalizer needs to have a flexible door (indicated in Fig. 1) or like contrivance at each end to receive and pass the finished castings and the conveyor. The conveyor, as shown in Fig. 9, in a part of its travel is completely enveloped by the normalizer 71. Further, the normalizer should be long enough to finish its heat treatment as the castings leave it in the normal operation of the conveyor.

The conveyor mechanism has large stretches of exposed travel outside of the normalizer 71 and away from the casting machine so the castings can be conveniently removed and new cores placed on the hangers and connected to chain 81 by an attendant or attendants stationed adjacent these exposed stretches.

In Fig. 10 we have shown a diagram indicating the timing shaft 28 with cams 27 and 30 previously mentioned and other cams located thereon to operate the various control valves and devices for the automatic casting machine, as described. Each of the controlled valves and cylinders mentioned is indicated by appropriate reference characters with lines running to the cams at that time them. Any other accessories, such as means to manipulate permanent core parts associated with the permanent mold may be timed in a similar manner to that specifically described, and a few additional cams are indicated on shaft 28 for this purpose. From what has been said in connection with Fig. 3 the combined operation will be understood. It should be kept in mind, however, that the supply of hot metal to the charging ladle 19 of the machine is not under the control of the main timing shaft 28 except in the negative sense that the ladle 16 cannot have its valve open unless the charging pot 9 is in position and in timed relation to receive a charge. The positive control of the hot metal supply-giving operation to the charging ladle is dependent on the weight of metal in ladle 9. This consideration of supplying ladle 9 may be unnecessary when it is con-

sidered that the hot metal should in any event be intermittently supplied in comparatively small quantities to either ladle 16 or ladle 9, and can be done either automatically or by hand, as described. In this sense the supply of the metal and heat to the machine is one and the same operation and said supply operation is, according to one feature of our invention, under the positive and normal human control of the attendants.

From the foregoing description it will now be clear that we have arranged tools and apparatus to carry out our improved casting method. The particulars with respect to the casting machine, its control means, its metal supply means, and the various accessories may be varied by those skilled in the art within the wide range of useful structure assembled to carry out our purpose. The disclosure given is characterized by its main and subsidiary arrangements and purposes, some of which may be used a part only of the time, depending on the character of work to be done.

We fully realize that, instructed by our disclosure, many types of known automatic metal casting machines, particularly those not heretofore used for operating with high melting temperature metals, timing mechanism, metal supply means, can all be assembled and arranged with slight variations obvious after our disclosure is made, to carry out the method or mode of operation herein described. For these reasons we have not emphasized more than the broad arrangement of these things considered as tools to follow our plan of casting which results in doing the work, particularly when difficult metals like iron and steel are concerned, without depending on the skill of the operators with relation to the extremely critical periods and temperatures involved in the casting, as well as the heat treatment of such metal. A preferred apparatus for carrying out our method is claimed separately in a co-pending application.

Having described our invention, we desire to claim it as broadly as the prior art and the consideration of equivalents will permit, according to the annexed claims.

1. The method of enabling metals, having high melting temperatures like iron or steel or copper alloys or others all distinguishable from metals having low melting temperatures like type metal, to be cast in an automatic casting machine of the type employing a permanent mold and operable through rapidly repeated cycles beyond the normal control of the operator, which method consists in controlling the heat conditions of the metal being cast solely by the step of intermittently feeding quantities of the hot metal to the automatic casting machine at a temperature high enough above the desired mold charging temperature to compensate

for heat radiation in the machine before the mold charging operation in the actual casting of such metal and feeding said metal in such small quantities relatively to the output of the machine that the temperature of such metal when fed to the machine need not be excessively above the right temperature for charging the permanent mold in the casting cycle whereby all firing operations and large hot metal storage means may be avoided within an automatic casting machine of the said type.

2. The method of feeding hot metal having a high melting temperature and from an external source to an automatic casting machine of the type employing a permanent mold and operable in rapidly repeated casting cycles beyond the normal control of the operator, which method consists in intermittently feeding the metal to the machine in small quantities relatively to the output of the machine and with each such quantity at a high enough temperature to pass through the casting cycles in the consumption of such metal in the machine, and without the need of other heat supply means within the machine, whereby the automatic features of the machine are divorced from the firing problems consequent upon a large bulk of high melting temperature metal and whereby the major supply of such metal may be located remote from such an automatic machine having an exceedingly large capacity for consuming very hot metal in its rapid casting cycles.

3. The method of feeding the supply of metal for casting to an automatic casting machine of the type employing a permanent mold and operable in rapid automatically repeated casting cycles, which method consists in intermittently supplying to the machine small quantities of the metal hot enough to avoid the necessity of supplying other heat in the machine and often enough to maintain a feed for the automatic operations whereby the casting operations are dependent upon the automatic cycle beyond the normal control of the attendant while the supply feed of hot metal for such operations is dependent upon a storage and heating source remote from the machine and under the control of the attendant.

4. The method of casting metals having high temperature melting points like iron or steel in which an automatic casting machine is used of the type employing a permanent mold and operable in rapidly repeated casting cycles, which method consists in heating such metal for casting at a point remote from the machine as under standard foundry practice and then intermittently feeding small quantities of the heated metal to the machine often enough to keep it constantly supplied with all its necessary heat and metal, each such quantity being sufficient for

only a few automatically repeated casting cycles whereby in the casting operations the time of making the successive castings by repeated operations and releasing them from the mold is uniform and normally beyond the human control of the attendants while the work of supplying metal and heat is normally under the human control of the attendants as by foundry practice divorced from the operations of the automatic machine.

In testimony whereof we have affixed our signatures.

ALBERT WOOD MORRIS.
SAMUEL P. WETHERILL, JR.

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