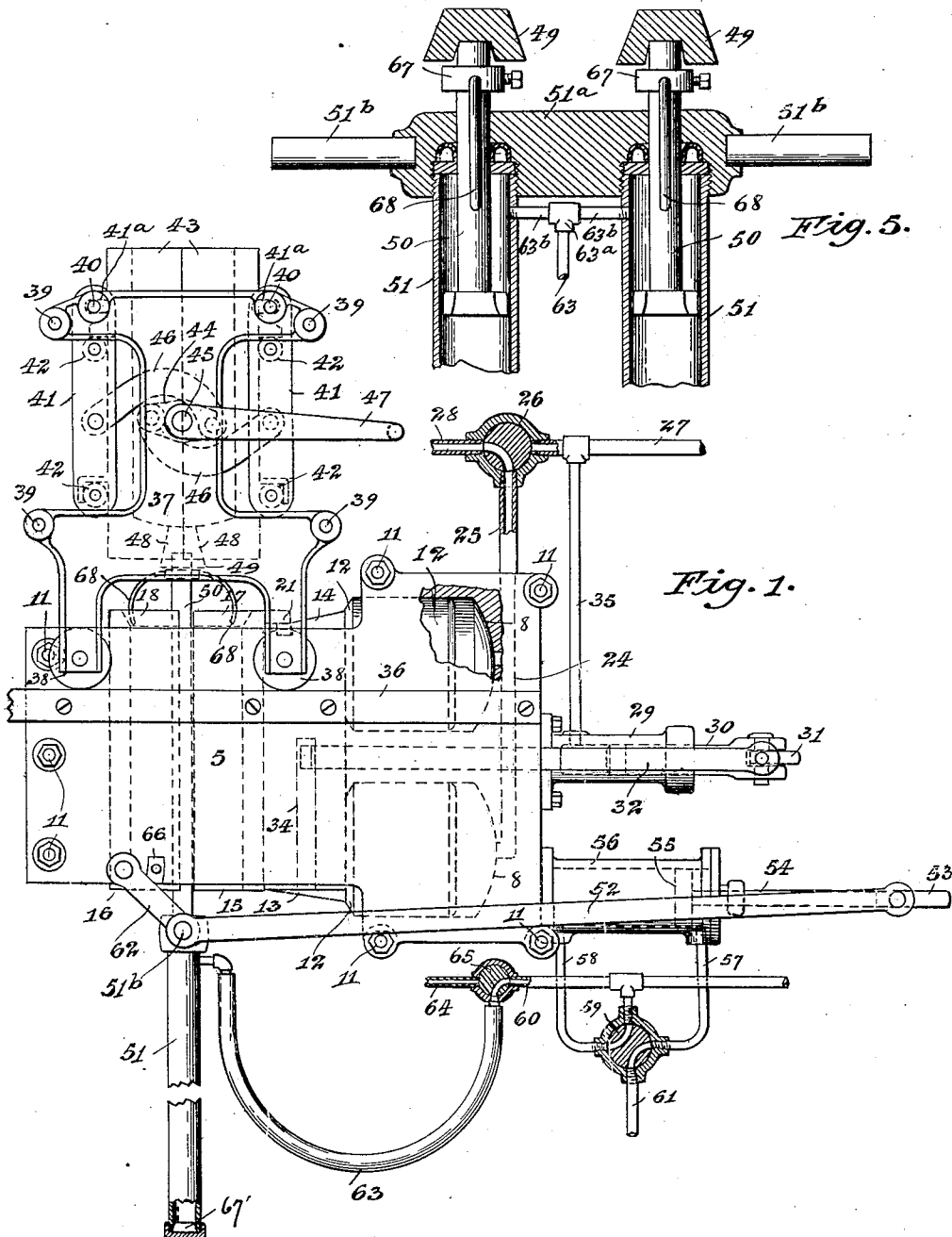


L. E. HOWARD.  
INGOT CASTING AND COMPRESSION MACHINE.  
APPLICATION FILED MAY 24, 1912.

1,056,101.

Patented Mar. 18, 1913.

3 SHEETS—SHEET 1.



WITNESSES:  
S. E. Mann  
S. N. Ford

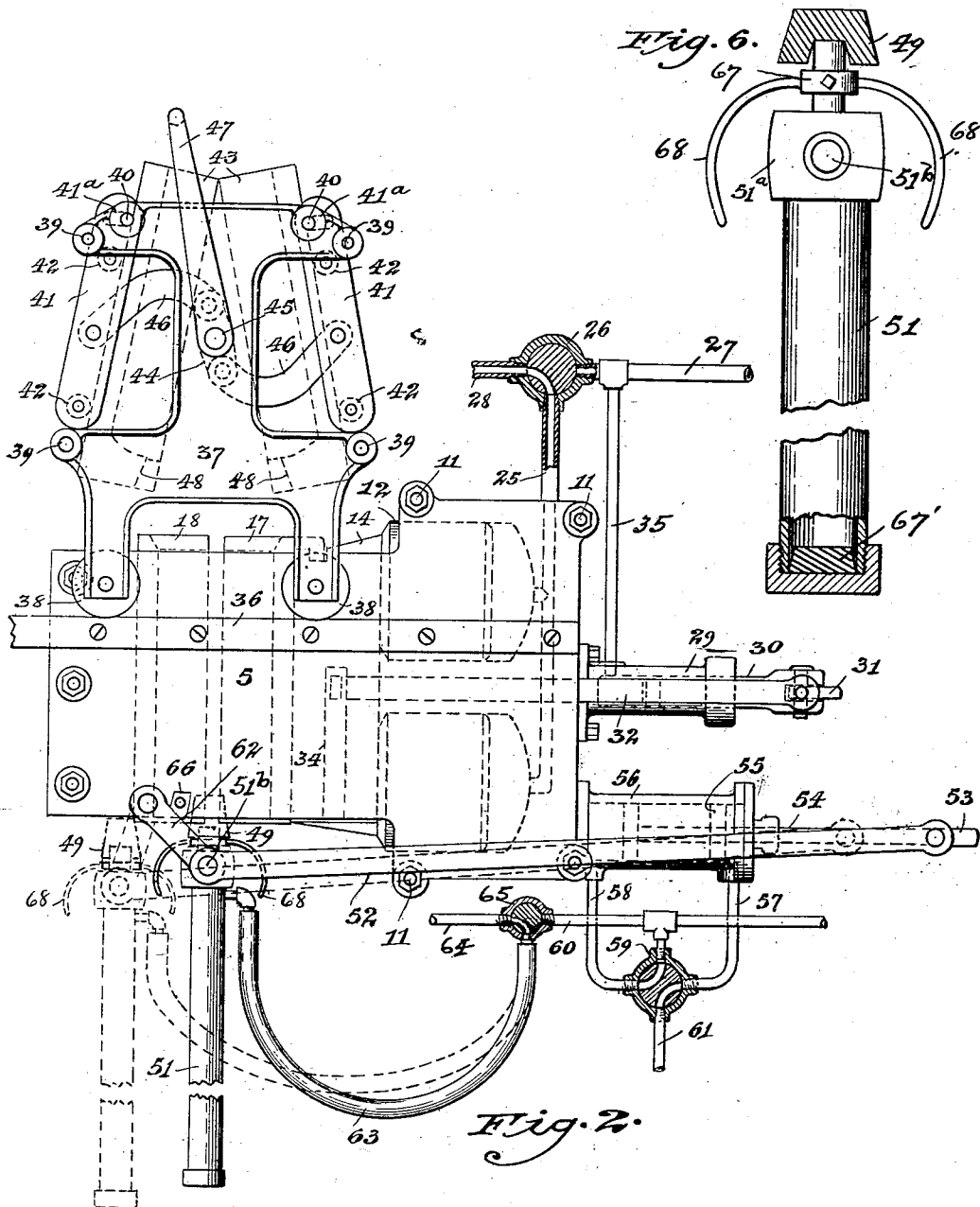
INVENTOR  
Leslie E. Howard,  
BY Offield, Tooles,  
Garro & Offield  
ATTORNEYS.

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3 SHEETS-SHEET 2.



WITNESSES:  
*J. Mamm*  
*S. N. Tornd*

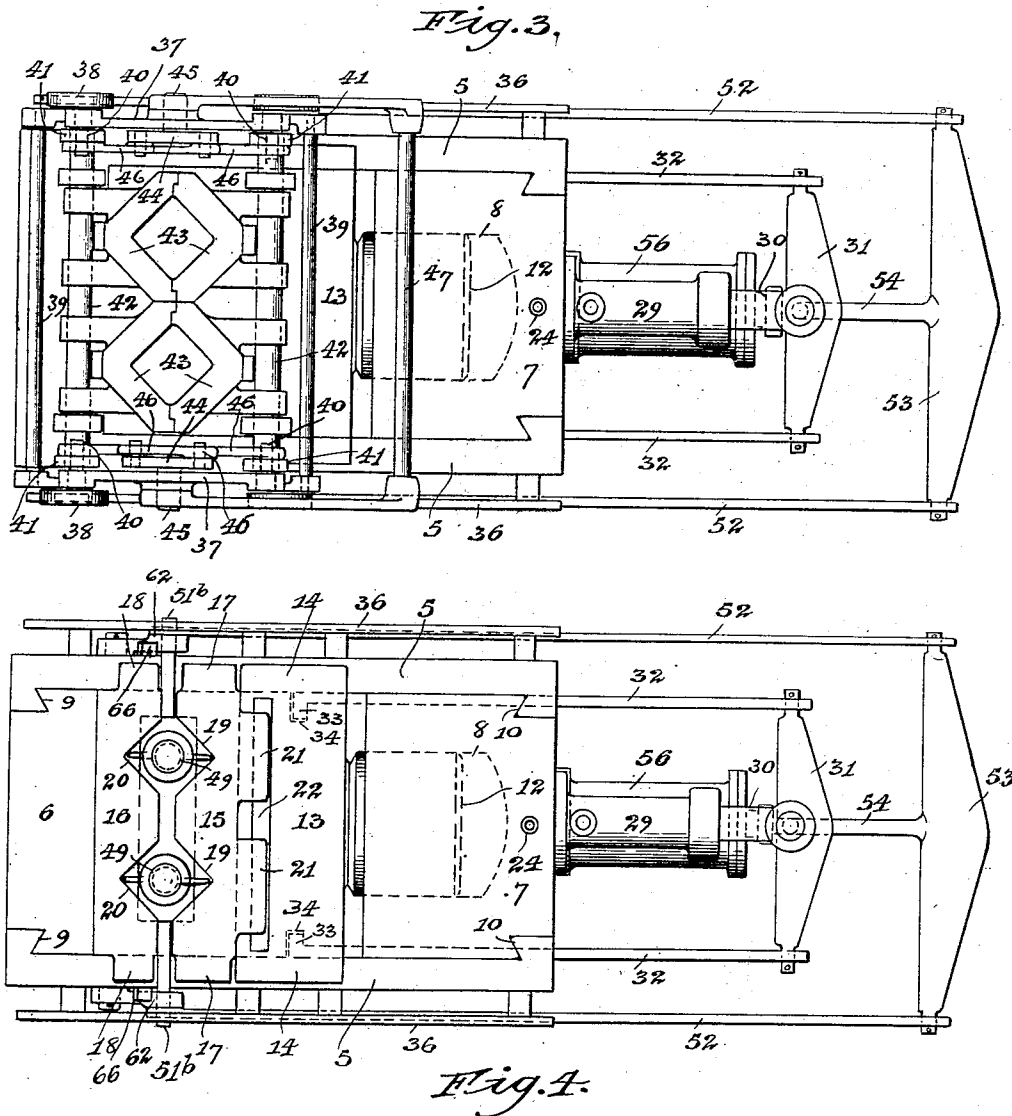
INVENTOR  
*Leslie E. Howard*  
 BY *Offield, Towle,*  
*Transor Offield,*  
 ATTORNEYS.

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3 SHEETS—SHEET 3.



WITNESSES:

*S. J. Mann*  
*E. H. Ford*

*Leslie E. Howard* INVENTOR  
BY *Offield, Towle,*  
*Barrow & Offield*  
ATTORNEYS.

# UNITED STATES PATENT OFFICE.

LESLIE E. HOWARD, OF LOCKPORT, NEW YORK, ASSIGNOR TO SIMONDS MANUFACTURING COMPANY, OF FITCHBURG, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

INGOT CASTING AND COMPRESSION MACHINE.

1,056,101.

Specification of Letters Patent.

Patented Mar. 18, 1913.

Application filed May 24, 1912. Serial No. 699,410.

*To all whom it may concern:*

Be it known that I, LESLIE E. HOWARD, a citizen of the United States, and a resident of Lockport, county of Niagara, State of New York, have invented certain new and useful Improvements in Ingot Casting and Compression Machines, of which the following is a specification.

This invention relates particularly to that class of ingot compression machine wherein lateral pressure is applied to the ingot during the cooling of the latter, for the purpose of preventing the formation of blow-holes and cavities in the ingot due to the separating out of gases from the steel comprising the ingot during the cooling of the same, and the formation of the defect known as "piping," resulting from the shrinkage of the material after the sides and bottom of the ingot have set and hardened and while the center is still molten, which condition allows the molten material from the upper portion of the ingot to feed down and partially replace that drawn toward the sides and bottom of the lower portion of the ingot, due to shrinkage in cooling.

In my Patents No. 922587 granted May 25, 1909, and No. 926489 granted June 29, 1909, I have described two forms of apparatus each consisting briefly of a hydraulic press of special design and; combined therewith, ingot molds so placed that lateral pressure is applied from the hydraulic rams of the press to one or more movable sides of the molds; and in each such apparatus the steel is poured from a suitable container, such as a ladle, directly into the molds contained within the press frame-work, and compressed in these same molds without removing them from the press. In my patents above mentioned I have drawn attention to the desirability of continuing the pressing operation for some time after the ingots have become solid, so as to obtain a certain forging or kneading effect similar to that obtained in hammering and forging with heavy hydraulic forging presses, both of which operations are well known in the art. I have found in the practical operation of my ingot compressing machines, as covered by my former patents above identified, that it is desirable in certain classes of steel to divide the operations of casting and compressing. It is found that for certain

classes of steel the material from which the mold is made is not a suitable material for compressing dies, and, vice-versa, it is also found that a material which will stand up and be commercially practicable for the work of compression dies does not work out well when made into molds into which the molten steel is poured.

I am aware that attempts have been made in the past to take ingots from the molds in which they were poured before they were entirely solidified and give them subsequent operations, such as passing them, through a pair of live rolls, squeezing them in a so-called bulldozer, and other forms of apparatus of like nature; and in all of these forms of apparatus two defects fatal to the method were found. One is that the time elapsing from the stripping of the mold from the ingot to the commencing of the compressing operation or rolling operation is so great that, to use an expression common in the art, the ingot becomes "air struck," resulting in a large number of air-bells or minute blowholes some little distance under the surface or skin of the ingot, and these are not removed or cured by the subsequent operations on the ingot. The second defect in these various forms of apparatus is that the compressing action, whether it be in compressing molds, bulldozers, or squeezers of various sorts, occupies so short a space of time that, on the one hand, the ingot either shrinks considerably after the operation is finished or, on the other hand, is allowed to cool to a point previous to this compression action where the pipes and other defects of like nature are very well defined and never can be wholly cured after once formed and metallic oxids allowed to cool on the surface of such cavities. I have further observed, with respect to the cross-sectional forms of the compressing dies heretofore used and the direction of the application of pressure thereto, that when the pressure is applied in a direction normal to a flat side or wall of the die there is a marked tendency to spread or bulge the ingot laterally in a direction at right-angles to the direction of the pressure, sometimes resulting in cracking the ingot; and this is especially liable to happen where the joints of the die are located in the walls which oppose such spreading or bulging tendency or such walls

are not strongly supported against yielding. In my present invention I have aimed to overcome all these inherent defects and, in addition, to produce an apparatus that will be durable, easily operated, and will place every operation under the absolute control and subject to the judgment of the operator; and especially one in which the forging operation, after the ingot has become solid, may be carried to any extent desired and be limited only by the power delivered to the press.

In carrying out my invention, I provide a hydraulic or other mechanically operated press equipped with one or more compressing dies, and immediately above each such compressing die is arranged a casting mold of a cross-sectional form corresponding substantially with that of the underlying die, but preferably made in two or more separable longitudinal sections, the vertical axis of each mold being in substantial alignment with the vertical axis of the underlying compressing die; and in coöperation with said mold and die I provide means for lowering a freshly cast ingot, without shock or jar, directly from the mold into the die for subsequent compression or squeezing in the latter. The preferred form of mold and die which I employ is rectangular in cross-section, but so disposed that the joints are in a plane that bisects the cross-section diagonally, while the line or direction of pressure is normal to such diagonal plane, for reasons that will hereinafter more fully appear.

In the accompanying drawings I have illustrated one practical embodiment of my invention, in which—

Figure 1 is a view in side elevation of the apparatus, showing the casting mold on one side closed and in readiness to receive the pour. Fig. 2 is a view similar to Fig. 1, but showing the casting mold in open or discharging position and the ingot lowering device in its lowermost position. Fig. 3 is a top plan view of the apparatus. Fig. 4 is also a top plan view, but with the casting molds and their actuating mechanism omitted to more clearly show the structure of the compressing dies. Fig. 5 is an enlarged detail elevation, partly in vertical section, of a portion of the mechanism for lowering the ingots from the molds into the compressing dies. Fig. 6 is a similar view of the parts shown in Fig. 5 in a plane at right-angles to the plane of the latter figure.

Referring to the drawings, 5 designates each of a pair of parallel side-frame members of the press, 6 an interlocking end-frame member, and 7 a cylinder casting constituting the other end-frame member and formed with a pair of cylinder chambers 8 therein. The frame sections are strongly and rigidly united by interlocking joints 9

and 10 (Fig. 4) between the side and end members and by tie-rods 11.

Slidably fitted within the cylinder chambers 8 are rams or plungers 12, the outer faces of which abut against a cross-head 13 that is supported on and between the side-members 5 of the press-frame by means of flanges 14 on the cross-head resting on the upper edges of the side-frame members 5. The other face of the cross-head 13 in turn abuts against the back of a movable die-block 15 that coöperates with a stationary die-block 16; both of said die-blocks being supported on and between the side-members 5 of the press-frame by lateral flanges 17 and 18, respectively. The die-blocks 15 and 16 have formed in their opposite faces V-shaped recesses 19 and 20, respectively, that unitedly form the substantially rectangular cavities of the dies.

It will be observed by reference to Fig. 4 that the formation of each die is such that the joints between the mating sections are in a plane that bisects the cross-section diagonally, and that the line or direction of pressure is normal to such diagonal plane and oblique to the two side walls of the die-cavity on either side of said diagonal plane. I have found by repeated test that such a formation and arrangement of compressing die entirely eliminates the described tendency of the ingot to spread or bulge laterally in the direction of the joints between the two die sections; measurements having shown that there is, rather, an opposite tendency, viz., to slightly contract or condense the ingot in a direction transverse to the line or direction of pressure. This not only insures a more uniform and superior product, but eliminates the danger of cracking the ingot in any direction under the powerful condensing pressure to which it is subjected.

The die-member 15 is loosely connected to the cross-head so as to be retracted by the latter by means of hooks 21 on its upper end engaging a groove-like socket 22 in the top of the cross-head. It is, of course, understood that the back of the die-member 16 abuts squarely against the inner face of the end wall 6 of the frame.

Fluid pressure is supplied to and exhausted from the cylinder chambers 8 through a cored duct 24 in the casting 7 and a pipe 25 leading from a valve 26 through which latter the pipe 25 is alternately connected with a high-pressure supply pipe 27 and an exhaust pipe 28. The cross-head 13 is retracted, in the embodiment of the invention herein illustrated, by power mechanism comprising a cylinder 29 secured to the outer face of the end wall casting 7, a plunger 30 in said cylinder, a cross-head 31 on the outer end of said plunger, and pull-bars 32 connected at their outer ends to the ends of said cross-head 13.

and at their inner ends formed with hooks 33 engaging grooves 34 formed in the opposite sides of the cross-head 13. A branch pressure-fluid supply pipe 35 leads from the supply-pipe 27 to the inner end of cylinder 29, whereby the cross-head 13 is normally maintained fully retracted and the compressing dies open; the cross-section of the plunger 30 being so small relatively to the cross-sections of the rams 15 as to make it unnecessary and practically inexpedient to equip the cylinder 29 with fluid-pressure controlling valves.

Secured to the outer sides of frame members 5 and extending beyond the latter are a pair of horizontal bars 36 that form a track to locate, guide and support a superimposed mold-carrying and operating frame. This frame comprises two parallel side members 37, each having a pair of wheels 38 at its lower end engaging the track-rails 36, said side-frame members being tied together and held suitably spaced by tie-rods 39. Located near the upper ends of these side frames are four pins or studs 40 (Fig. 3) that engage transverse slots 41<sup>a</sup> in the upper ends of two pairs of suspended swing-bars 41, opposing swing-bars of each pair being tied together by heavy cross-rods 42 which, in turn, support the two V-shaped halves 43 of a pair of molds. These swing-bars form the immediate mold-supporting and opening and closing agents, and they are connected for simultaneous actuation by a mechanism comprising, as herein shown, a pair of rocking levers 44 fast on stub-shafts 45 journaled in the side-frames 37, curved links 46 connecting the ends of said rocking levers to the swing-bars, and a bail-shaped operating handle 47 the arms of which straddle the side-frames 37 and at their inner ends are fast on the shafts 45. The molds, of which there may be one, two (as shown), or more, are of the solid bottom type, except that the bottom of each mold is provided with a round tapered opening, one-half of which, indicated at 48 in Fig. 2, is, of course, formed in the bottom of each of the mating half-sections of each mold. During the operation of pouring the molten steel into the molds, these holes are closed by tapered plugs 49 loosely mounted on the upper ends of the plunger rods 50 of a pair of fluid-pressure cylinders 51. As will be seen by reference to the detail views, Figs. 5 and 6, the cylinders 51 are rigidly connected at their upper ends to a combined cylinder-head 51<sup>a</sup>, the ends of which latter carry horizontal trunnions 51<sup>b</sup>, that are mounted in one end of a pair of approximately horizontal bars 52, the other end of said bars being connected to a cross-head 53 fast on the outer end of the rod 54 of a piston 55 that operates in a cylinder 56 secured to the

outer face of the end frame 7 below the cylinder 29. Fluid pressure is alternately admitted to and exhausted from opposite sides of the piston 55 through pipes 57 and 58 and a two-way cock 59 controlling the communication of said pipes 57 and 58 with a low-pressure supply pipe 60 and exhaust pipe 61. The trunnions 51<sup>b</sup> are also journaled in the lower ends of a pair of swinging links 62 that are suspended from the side-frame members 5; and fluid pressure is admitted to and exhausted from the cylinders 51 through a flexible pipe or hose 63, a coupling 63<sup>a</sup>, and branch pipes 63<sup>b</sup> leading into the cylinders 51; the other end of hose 63 communicating alternately with supply and exhaust pipes 60 and 64, respectively, through a controlling cock 65. Stops 66 on the side-frames 5 limit the inward swing of the links 62 to a point at which the plugs 49 are substantially in axial alignment with the holes in the bottoms of the superposed molds. For guiding the plunger-stems 50 and plugs 49 during their upward movement into registration with the holes in the bottoms of the molds, I employ on each plunger-stem a collar 67, from opposite sides of which extend a pair of outwardly and downwardly curved spring-arms 68, as best shown in Fig. 6, said arms slidably engaging the walls of the separated die-sections as the plungers rise, and both supporting the upper ends of said plungers and guiding the plugs into registration with the holes in the bottoms of the molds.

In the operation of the apparatus, the high-pressure is, as stated, at all times on the cylinder 29 which holds the cross-head 13 and the rams 12 (upon which at the commencement of the operation there is no pressure) to their extreme retracted position, leaving the compressing dies open. The superimposed molds are closed by depressing the handle 47, which operates the toggle opening and closing gear, carrying the same slightly past the center into a locked position, as shown in Fig. 1. Low pressure is then admitted to the inner end of cylinder 56, which causes the cylinders 51 to take the position shown in Fig. 1 wherein their vertical axes are in axial alignment with the vertical axes of the molds, and pressure is then admitted to these cylinders 51 thus causing the tapered plugs on the upper ends of the rams of said cylinders to rise, enter, and tightly close the bottoms of the molds, as shown in Fig. 1. The molten steel is then poured into the molds and, after a brief interval in which the sides and bottom of each ingot solidify, leaving the interiors of the ingots in a fluid state, the molds are opened by raising the operating handle 47, as shown in Fig. 2, which leaves the ingots supported only by the bottom closure plugs 49. After the molds are fully opened, the valve 65 is

shifted so as to allow the fluid pressure in cylinders 51 to exhaust, which, in turn, allows the plungers of these cylinders and the ingots resting on the upper ends (plugs 49) of the plungers to gently but positively descend into the compressing dies. It should here be noted that the bottom closure plugs 49 not only act as supports for the ingot after the molds are opened to allow the descent of the ingots into the compressing dies, but they also act as locating points to keep the ingots in position vertically over the dies while the molds are being opened, and prevent in a large measure the ingots sticking or clinging to either half of the molds. As soon as the ingots are lowered into position in the compressing dies, fluid pressure is applied to the large high-pressure cylinder chambers 8, compressing the ingots; there being such a preponderance of cross-sectional area, and consequently of pressure, in the cylinder chambers, as to overcome the resistance offered by the pull-back cylinder 29 which serves to retract the cross-head and dies. Shortly after the pressure has been applied to the compressing dies (so that the ingots are held from dropping through the latter), the action of cylinder 56 is reversed, whereby the cylinders 51 are swung to one side of the bottoms of the compressing dies, as shown by the dotted line position of cylinder 51 and its actuating mechanism in Fig. 2. The compressing operation is continued until the ingot is quite cold, obtaining in a marked degree the forging action described in my earlier Patent No. 926,489, above referred to. After the compressing action is completed, the valve 26 is shifted to exhaust the fluid pressure from the cylinder chambers 8; whereupon the constant pressure in the cylinder 29 causes the cross-head 13, the high-pressure rams 12, and the movable members of the compressing dies to be retracted, opening the dies and allowing the ingots to fall through into an underlying pit or other receptacle.

By locating the molds directly above the compressing dies, it is possible to transfer the ingot from the former into the latter with such expedition as to entirely obviate the disadvantages hereinabove referred to as accompanying previous efforts along the line of the separate molding and compressing process. It should be noted, however, that the lowering of the molded ingot into the compressing mold requires a gentle yet positive action, free from any jarring, since otherwise the action of lowering of the ingot would result in bursting the latter. For this purpose, the cylinder 51 carrying the mold bottom closure plug is preferably provided at its bottom with a soft rubber cushion, indicated at 67, which arrests the downward motion of the ram without any shock, although this rubber cushion could,

of course, be replaced with some form of pneumatic cushion,—the essential thing being that the downward motion shall be arrested positively yet gently, to avoid danger of bursting the ingot through jar or shock on account of the very thin shell of solid steel and the relatively large volume of molten interior.

The object in mounting the superposed frame structure carrying the mold or molds upon a track is to enable it to be run to one side of the press-frame to enable the die or dies to be readily removed and replaced, when required, as well as to enable the operator to more readily observe the behavior of the molten core or cores during the forging action, since the proper extent and duration of the pressure can be readily determined by a trained operator by observation of the metal in the upper end of the ingot or ingots during such forging action. This manner of mounting, however, is not essential.

It will be evident, of course, that the apparatus shown and described might be considerably modified in details, as by the substitution of other mechanical parts, either power-operated or manually-operated, for effecting the operation of the apparatus and movable parts, without involving any departure from the principle of the invention or sacrificing any of the advantages thereof. Hence, I do not limit the invention to the specific details of the apparatus shown and described except to the extent clearly indicated in specific claims.

I claim—

1. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, of a mold positioned above and in substantial axial alinement with said die, and means for lowering a partially cooled ingot from said mold into said die.

2. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, of a mold made in separable parts positioned above and in substantial axial alinement with said die, means for opening and closing said mold, and means for lowering a partially cooled ingot from said mold into said die.

3. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, of a mold comprising a pair of mating longitudinal sections mounted above said die, means for separating and bringing together said mold sections, and means for lowering a partially cooled ingot from said mold into said die.

4. In an ingot casting and compressing machine, the combination with a compressible die and means for applying lateral pres-

sure thereto, of a mold comprising a pair of mating longitudinal sections, pivotally supported near their upper ends above said die, means for swinging said sections toward and from each other, and means for lowering a partially cooled ingot from said mold into said die.

5. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, of a track, a mold-carrying frame mounted on said track, a mold carried by said frame and movable toward and from a position above and in substantial axial alinement with said die, and means for lowering a partially cooled ingot from said mold into said die.

6. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, a mold made in laterally separable mating sections mounted above said die, means for moving said mold sections together and apart, and an ingot supporting and lowering mechanism comprising a member extending through said die and into the bottom of said mold and engaging the bottom of the ingot, and means for effecting the ascending and controlling the descending movement of said member.

7. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, of a longitudinally divided mold formed with a hole in its bottom wall and positioned above and in substantial axial alinement with said die, means for opening and closing said mold, a rod disposed in axial alinement with and movable through said die and carrying at its upper end a plug adapted to fill the hole in the bottom of said mold during pouring and support the ingot when the mold is opened,

and means for effecting the ascending and controlling the descending movement of said rod.

8. In an ingot casting and compressing machine, the combination with a compressible die, and means for applying lateral pressure thereto, of a longitudinally divided mold formed with a hole in its bottom wall and positioned above and in substantial axial alinement with said die, means for opening and closing said mold, a rod disposed in axial alinement with and movable through said die and carrying at its upper end a plug adapted to fill the hole in the bottom of said mold during pouring and support the ingot when the mold is opened, means for effecting the ascending and controlling the descending movement of said rod, and means on said rod adapted to engage the interior surface of said die to guide said plug into engagement with said hole.

9. In an ingot casting and compressing machine, the combination with a compressible die and means for applying lateral pressure thereto, of a longitudinally divided mold formed with a hole in its bottom wall and positioned above and in axial alinement with said die, means for opening and closing said mold, a fluid-pressure cylinder and plunger-rod beneath said die, a plug on the upper end of said plunger-rod adapted to fill the hole in the bottom of said mold during pouring and support the ingot when the mold is opened, and means for supporting and shifting said cylinder, between an operating position below and in axial alinement with said die and an idle position below and to one side of said die.

LESLIE E. HOWARD.

Witnesses:

SAMUEL N. POND,  
E. G. INGERSOLL.