No. 698,596. Patented Anr. 29, 1902.

C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.)

8 Sheets—Sheet 1.

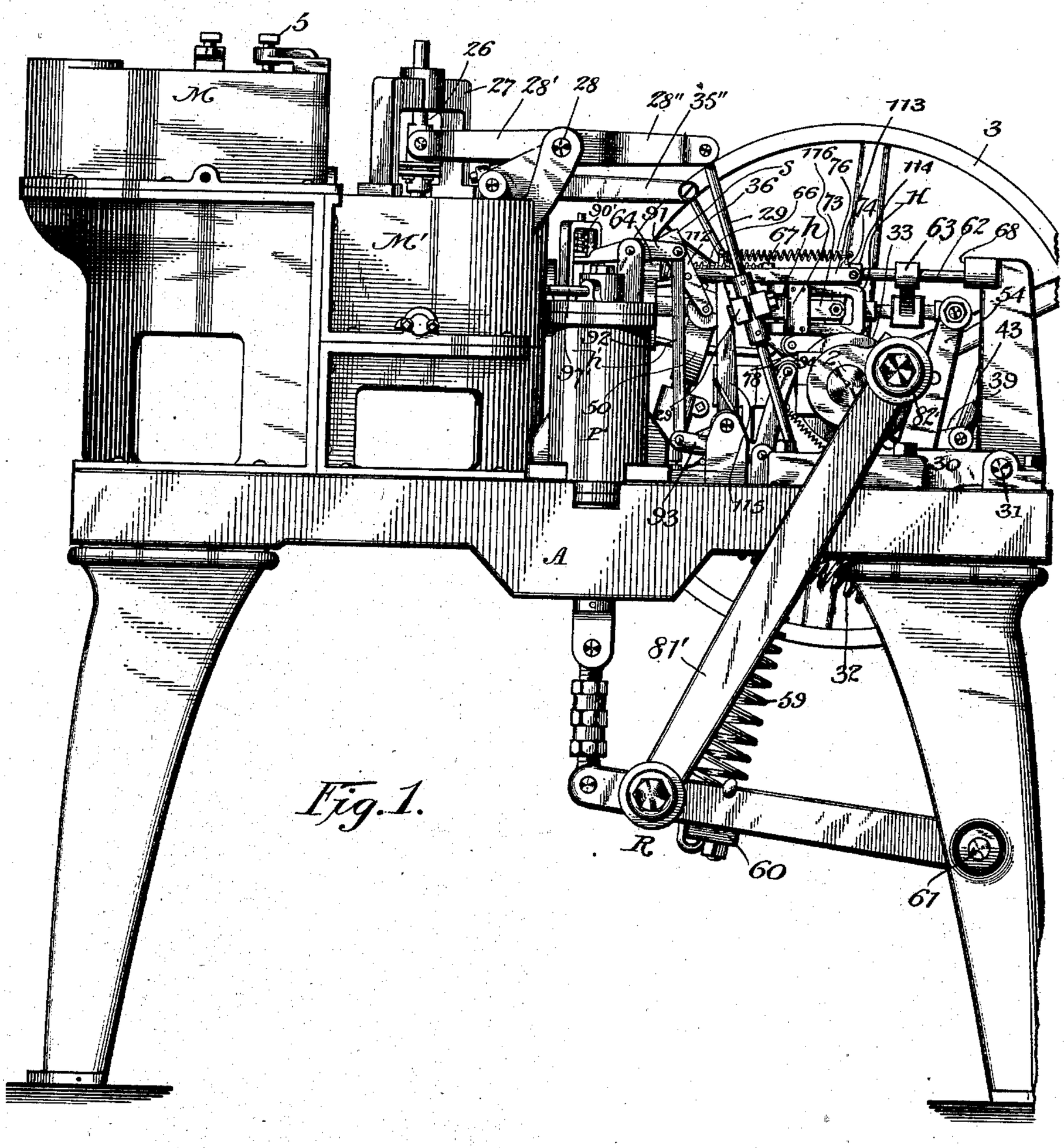

Fig. 1.

Witnesses:
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E. C. Lawrence

Inventor,
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By his Attorney
F. W. Richards.

No. 698,596. Patented Apr. 29, 1902.

C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.) 8 Sheets—Sheet 2.

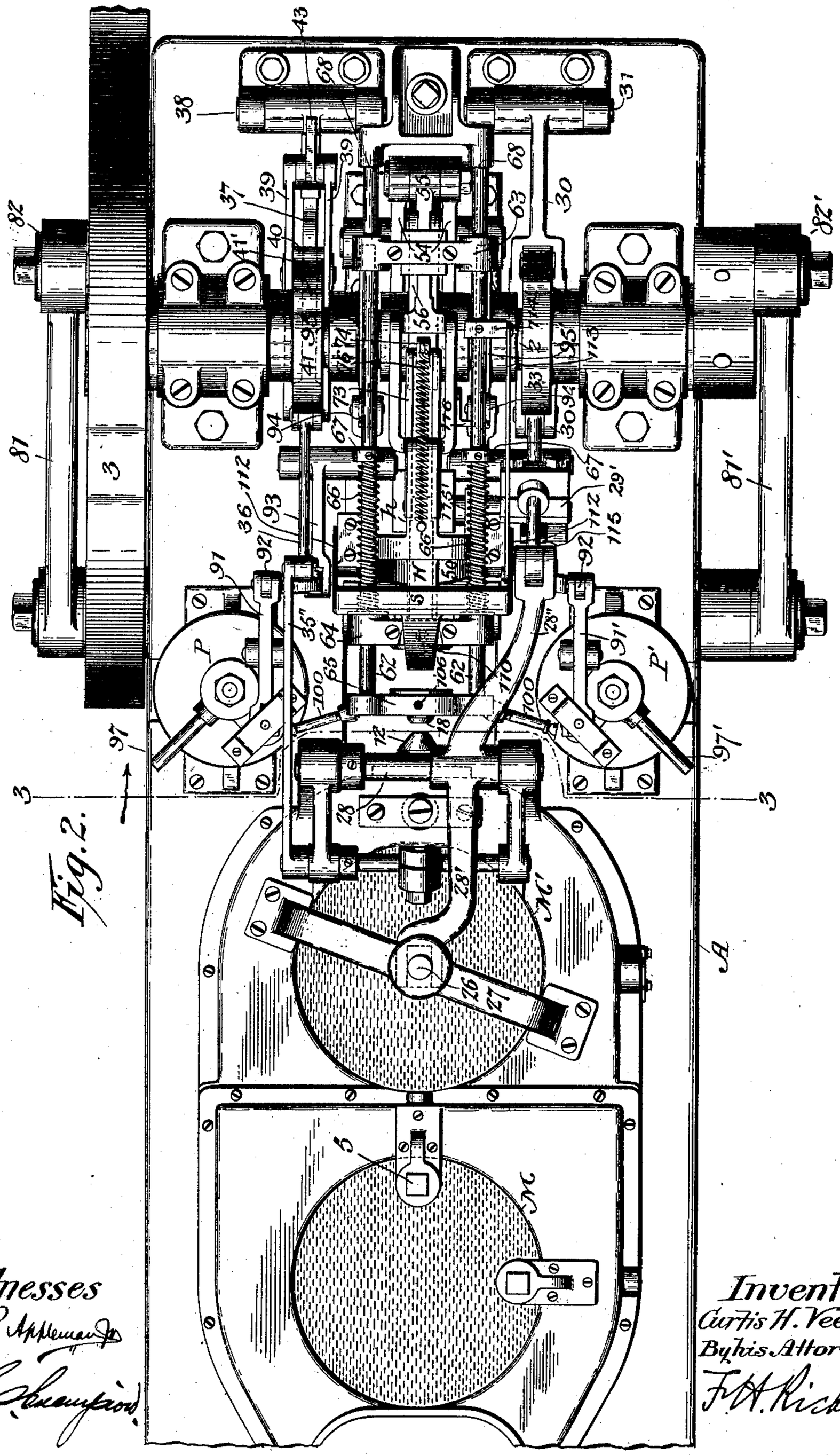

Fig. 2.

Witnesses
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No. 698,596. Patented Apr. 29, 1902.

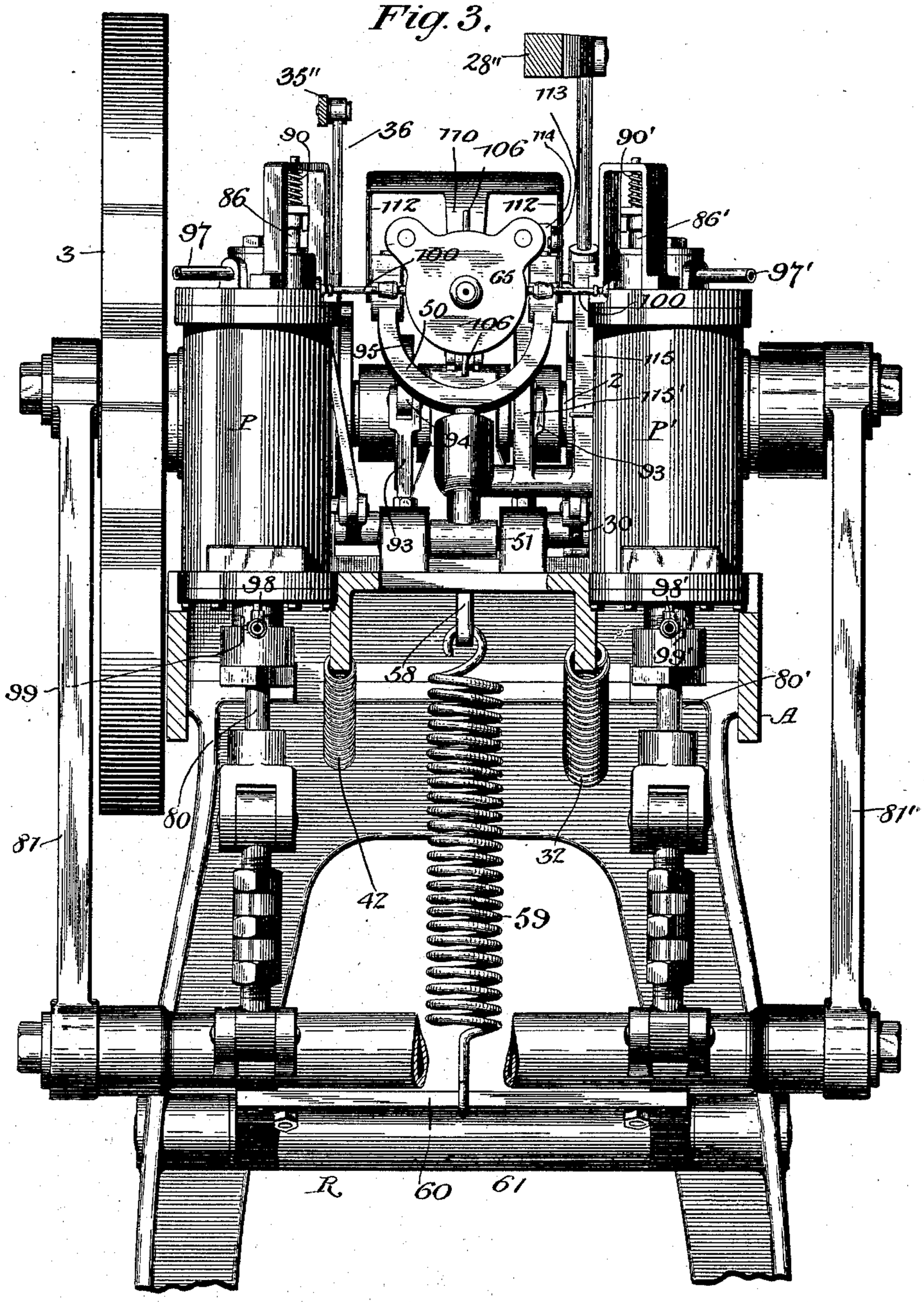
C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.) 8 Sheets—Sheet 3.

Fig. 3.



Witnesses:-
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Patented Apr. 29, 1902.

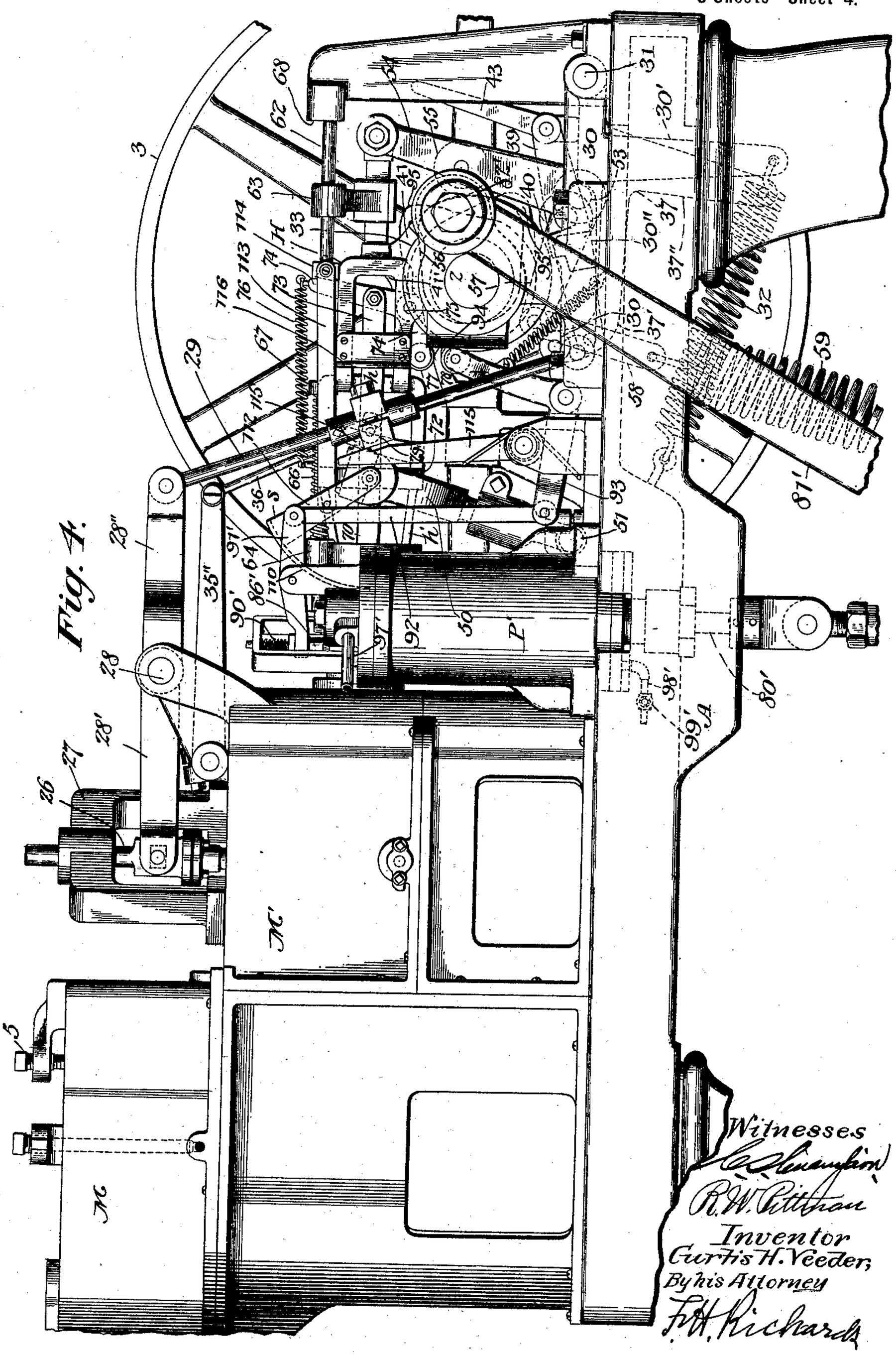
C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.)

8 Sheets—Sheet 4.



No. 698,596. Patented Apr. 29, 1902.

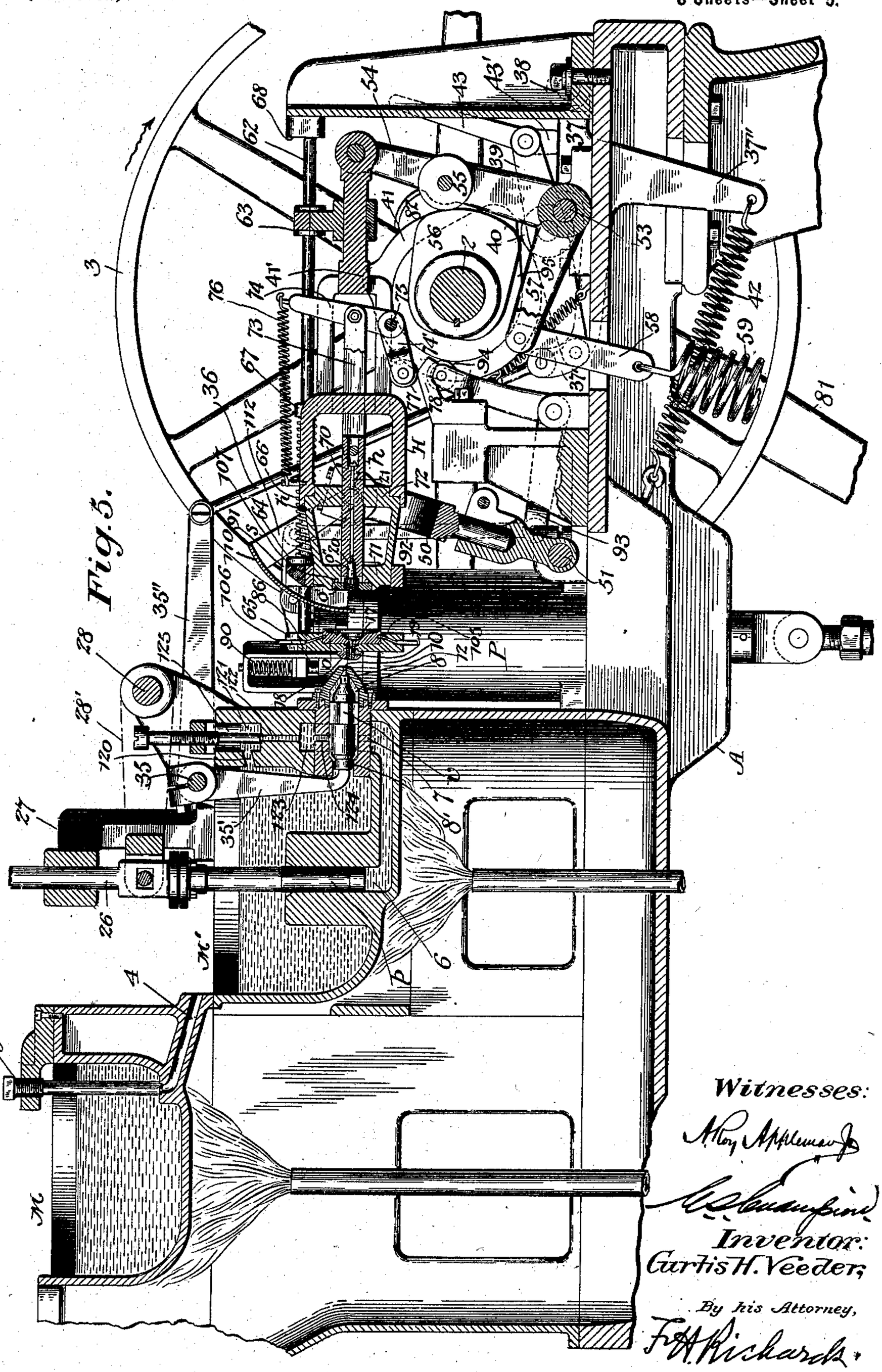
C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.) 8 Sheets—Sheet 5.

Fig. 5.



Witnesses:
M. Roy Applemann Jr.
W. Cunningham

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No. 698,596. Patented Apr. 29, 1902.

C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.) 8 Sheets—Sheet 6.

Fig. 6.

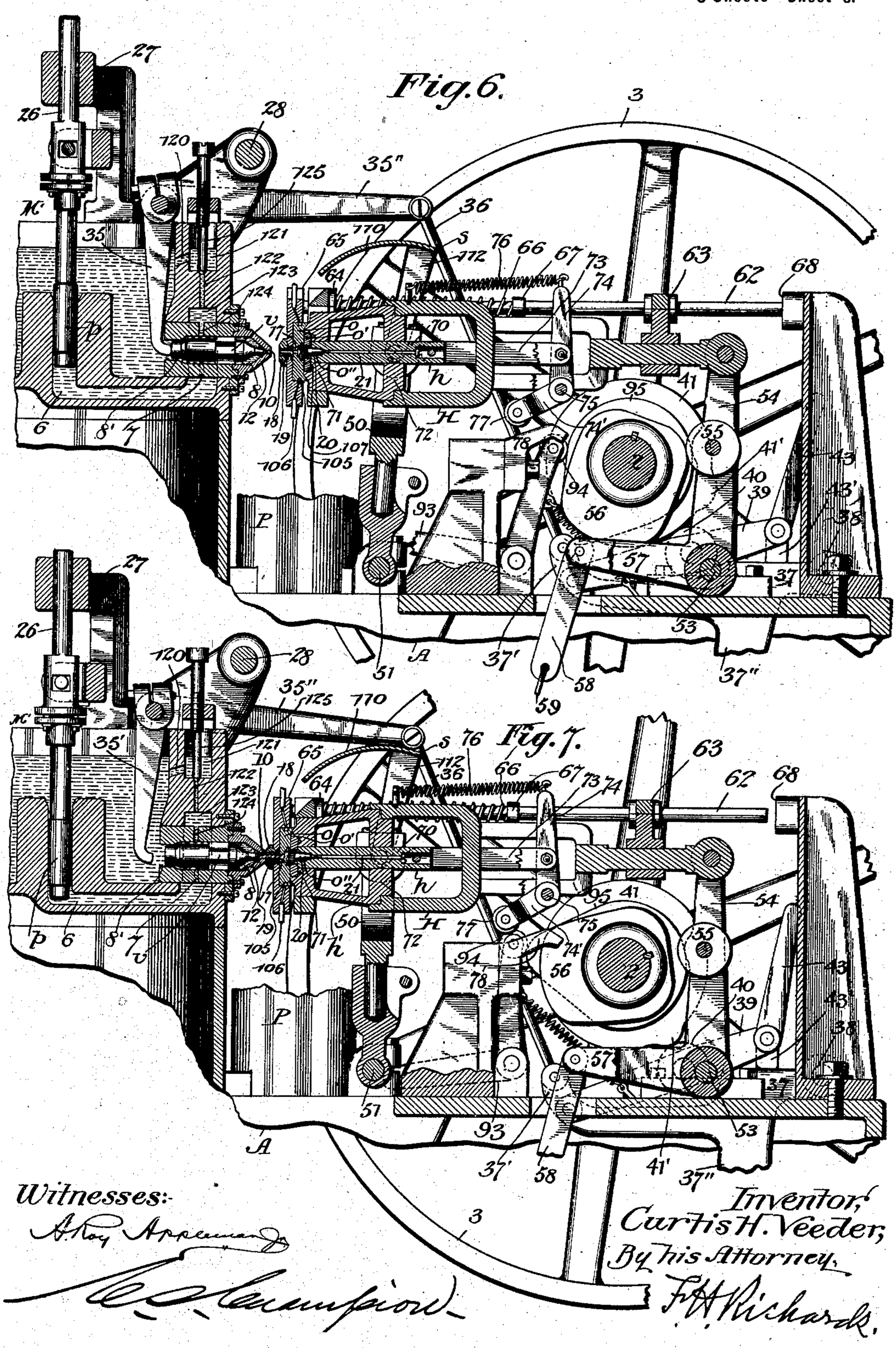

Fig. 7.

Witnesses:

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C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.)

8 Sheets—Sheet 7.

Fig. 11.

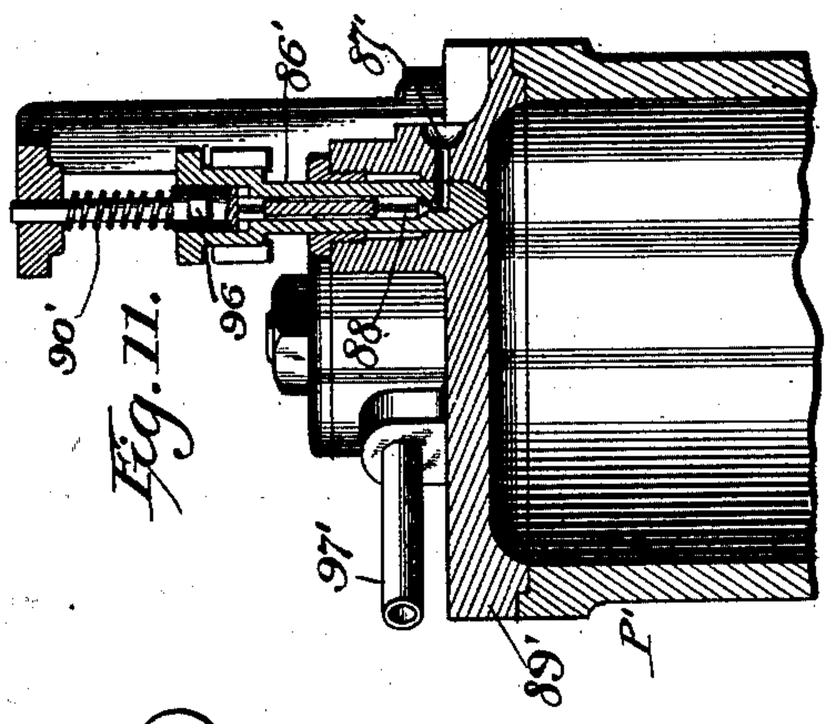


Fig. 9.

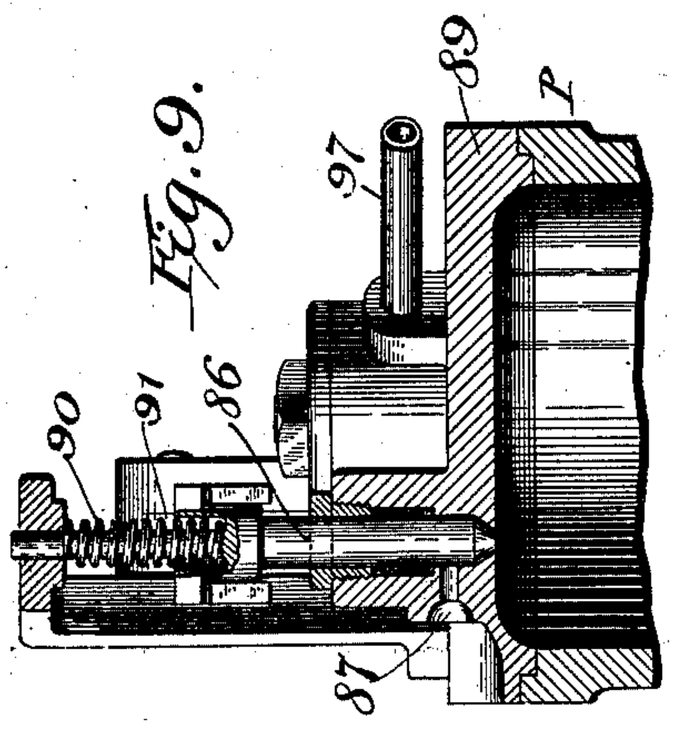


Fig. 10.

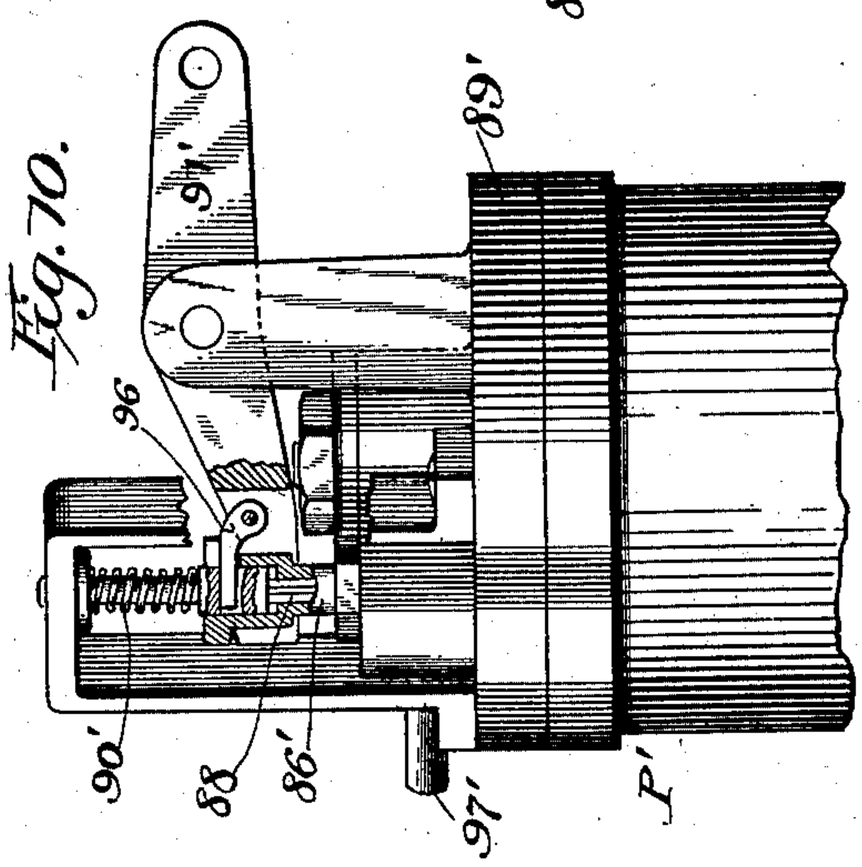
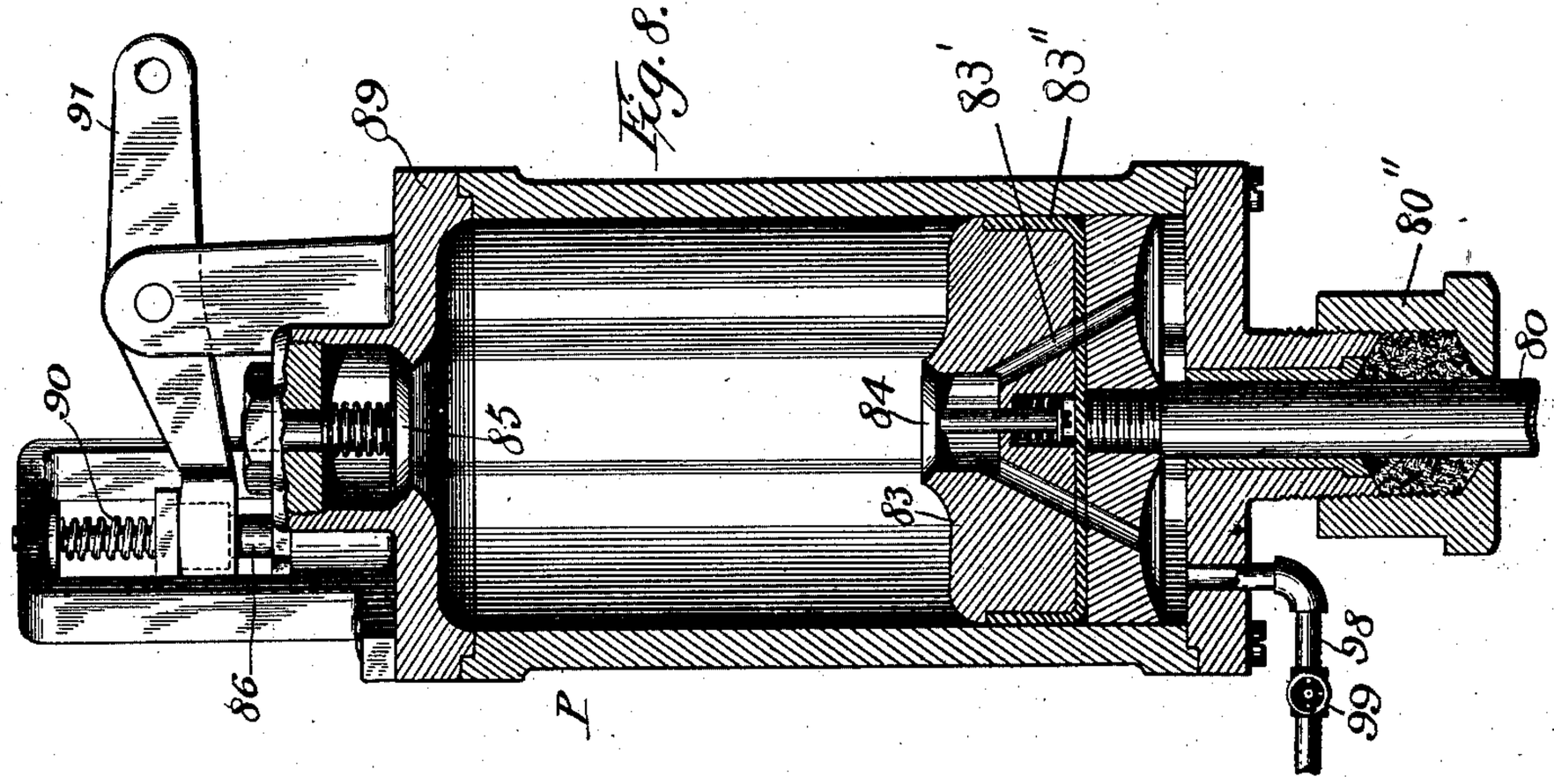


Fig. 8.



Witnesses:
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No. 698,596. Patented Apr. 29, 1902.

C. H. VEEDER.

CASTING MACHINE.

(Application filed Jan. 23, 1900.)

(No Model.) 8 Sheets—Sheet 8.

Fig. 19.

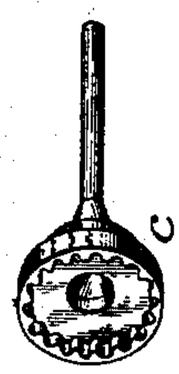


Fig. 18.

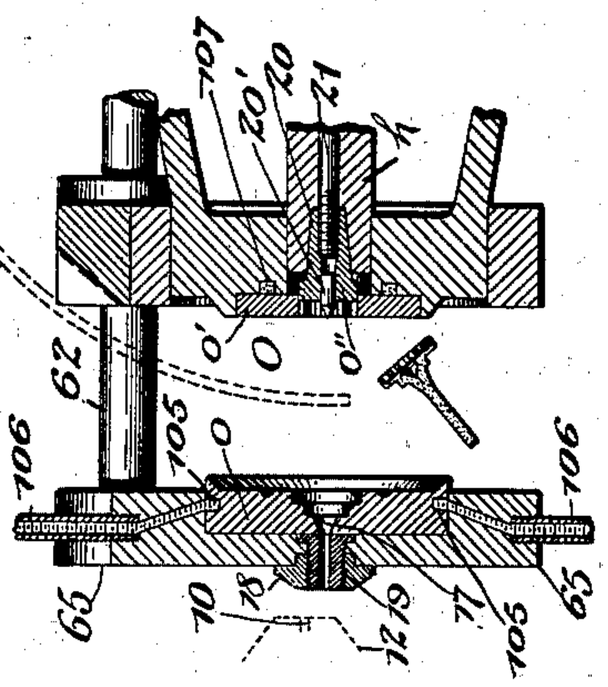


Fig. 17.

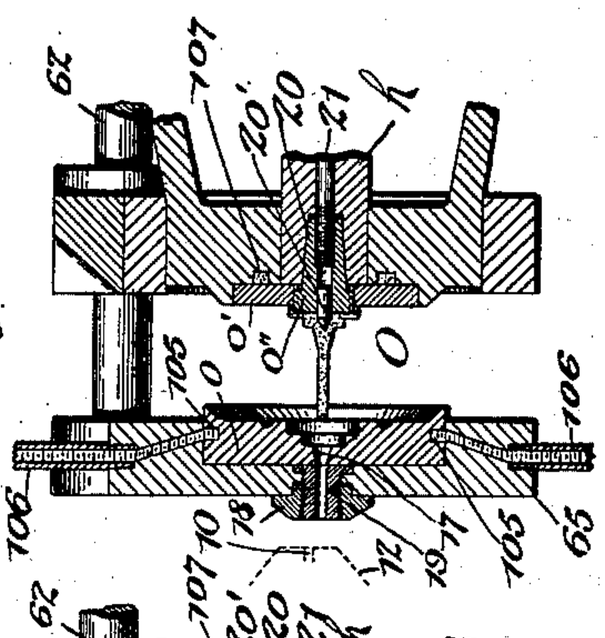


Fig. 13.

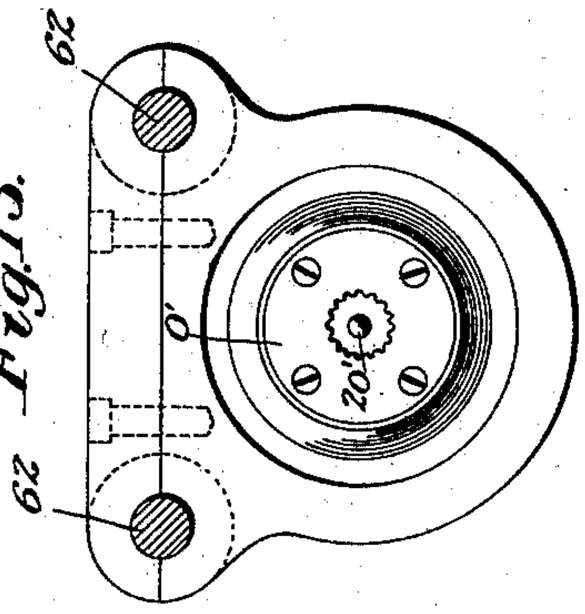


Fig. 16.

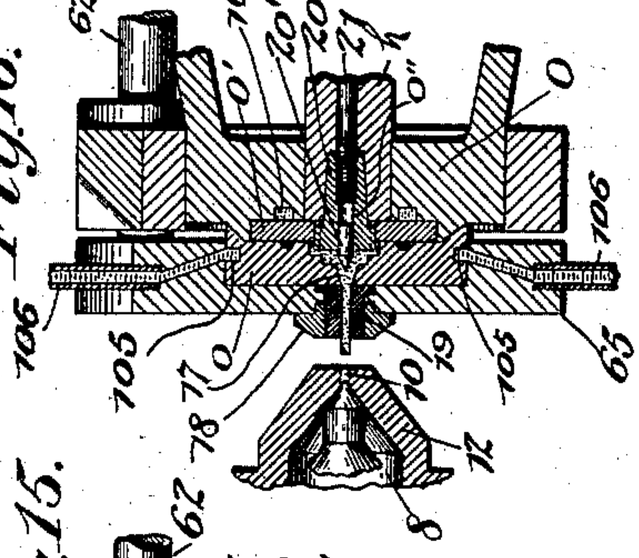


Fig. 12.

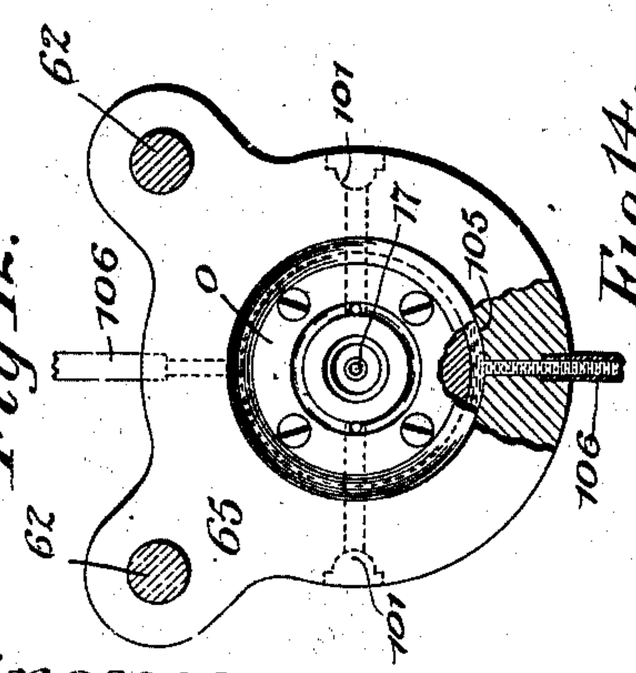


Fig. 14.

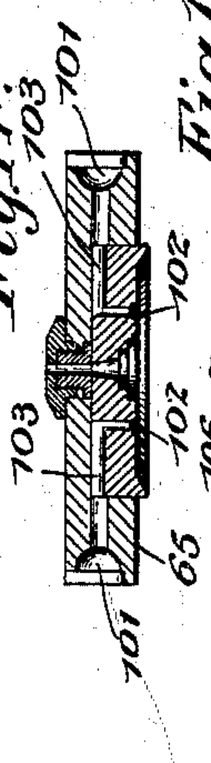
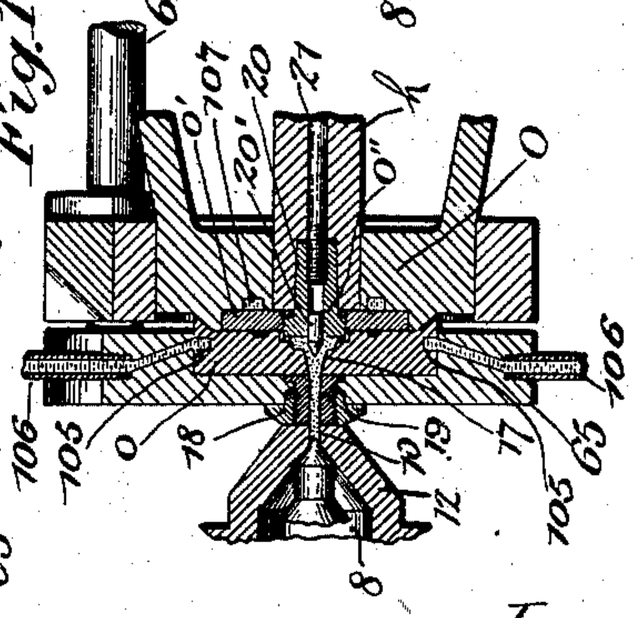


Fig. 15.



Witnesses:

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C. E. Crawford

Inventor,
Curtis H. Veeder,
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F. A. Richards.

UNITED STATES PATENT OFFICE.

CURTIS H. VEEDER, OF HARTFORD, CONNECTICUT.

CASTING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 698,596, dated April 29, 1902.

Application filed January 23, 1900. Serial No. 2,435. (No model.)

To all whom it may concern:

Be it known that I, CURTIS H. VEEDER, a citizen of the United States, residing in Hartford, in the county of Hartford and State of Connecticut, have invented certain new and useful Improvements in Casting-Machines, of which the following is a specification.

This invention relates to casting-machines, and has for its main object the provision of a machine for forming dense castings having faces of such smoothness that the castings will not need to be subjected to the usual operations of planing, turning, &c., but can be used and assembled with other parts with the bearing-surfaces in the condition in which they come from the molds and under conditions where exceptionally well-finished bearing-surfaces are required in order to permit the proper movement of parts upon one another. This result I attain by employing a casting-machine so constructed and capable of operating in such a manner as to condense the molten metal most perfectly during the making of the casting and before the completion thereof. I have found that the best results can be secured by producing a vacuum in the mold into which the metal is to be poured and then forcing molten metal under pressure into the exhausted mold until the mold is completely filled. When castings are formed in this way, all of the spaces and corners of the mold, no matter how small they may be, are completely filled by the molten metal forced thereinto and the casting corresponds exactly in contour to the mold, every minute projection or indentation in which is reproduced perfectly as an indentation or projection in the finished casting, no matter how complex the pattern to be reproduced may be. Moreover, in every case castings formed in this manner are of a dense, homogeneous, and exceedingly fine crystalline structure throughout.

The present invention is in the nature of an improvement upon that shown, described, and claimed in my application, Serial No. 738,269, filed November 27, 1899, to which reference may be made. The present invention embodies many important features of novelty not shown in said application, and the machine in which these features are embodied will preferably operate entirely automatically in order that it may make castings at a high rate of speed without requiring any special care from an attendant.

The molten metal may be delivered to the mold in many ways; but I prefer to inject it into the same under high pressure, so that the stream will be forced violently into every portion of the mold. In the present case I have employed for this purpose mold-filling means operating as a hydraulic ram in which a plunger of relatively large diameter exerts at the proper time a violent pressure upon a column of molten metal and sets the same in motion before it is injected into the mold. Thus the movement of the plunger is converted into kinetic energy or *vis viva* of the molten metal before the latter is permitted to enter the mold, and hence when this molten metal is injected into the mold at the proper time it will be moving under the influence not only of the pressure applied by the plunger, but also of its own kinetic energy, and the stream of metal forced into the mold will therefore be injected into the mold while traveling at a higher rate of speed than it would have if it were forced out by a plunger when not under the influence of its own kinetic energy, as is the case in the operation described in my application hereinbefore mentioned. An additional advantage resulting from the use of a hydraulic ram for injecting the molten stream is that as the metal is in constant motion just before the casting operation it will have no opportunity to cool in the vicinity of the outlet-opening leading to the mold, and the molten bath at that point will at such time be in a condition of most perfect fluidity, owing to the constant circulation of the fluid and the consequent commingling of the hottest portions of the bath with the molten metal adjacent to the walls of the containing vessel and other points where it is most likely to become cool, and therefore less fluid.

One of the most important features of the present invention as distinguished from that described in my aforesaid application is the provision of means for checking crystallization of the casting and chilling the same before it has cooled off and has been removed from the mold. The object of this is to produce a casting in which the metal will be of

a more dense and homogeneous structure and will exhibit when broken a finer fracture than castings made in substantially the same way, but not chilled. As is well known, many metals crystallize most perfectly—that is, they tend to form crystals of maximum size—when permitted to cool slowly, the tendency to crystallize in this manner being more marked with some metals, of course, than with others, antimony being one which tends to form relatively large crystals unless the process of crystallization is checked and the tendency of the metal in cooling to form large crystals is overcome. It has been found in practice that while castings formed *in vacuo* and under pressure are close-grained and finely crystalline, yet when the casting so made is rapidly cooled and chilled before solidification the resultant product has a very much finer grain, the crystals are much more finely divided, and hence the casting is much more perfect in every way and will produce better results. The improvement in the product resulting from this sudden cooling or chilling of the molten metal is not confined to any particular metal, although it is of course much more marked with some metals or alloys than with others, and the action of the metal antimony or of an alloy containing it is only referred to for the sake of illustration, such an alloy being one that will be used frequently in forming castings in a machine of this type.

In the drawings accompanying and forming part of this application, Figure 1 is a side elevation of an automatic casting-machine embodying my present invention. Fig. 2 is an enlarged plan of the same with portions of the framework and other parts broken away. Fig. 3 is a sectional elevation of the same, the section being taken in line 3 3, Fig. 2, looking in the direction of the arrow. Fig. 4 is a side elevation of the same and shows the parts in the same positions as in Fig. 1. Fig. 5 is a substantially central longitudinal section of the same with the parts in the positions shown in Fig. 4—that is, the positions which they assume at the end of the casting operation. Figs. 6 and 7 are views similar to Fig. 5 of a portion of the mechanism and illustrate the parts in successive positions at other stages of the operation. Fig. 8 is an enlarged vertical section of one of the air-pumps. Fig. 9 is a sectional detail of the upper portion of the same, the section being taken in a different plane. Fig. 10 is a sectional elevation of the upper portion of the other air-pump. Fig. 11 is a vertical section of the same, the section being taken in a different plane. Figs. 12 and 13 are enlarged sectional elevations, viewed in the same direction, of the two main portions of the mold. Fig. 14 is a transverse section of that portion of the mold shown in Fig. 12. Figs. 15 to 18, inclusive, are transverse sections illustrating the successive steps in the operation of stripping the casting from the separable mold; and Fig. 19 is an enlarged perspective view of a casting which may be made by my improved machine.

Similar characters designate like parts in all the figures of the drawings.

In my application hereinbefore referred to I illustrated a simple type of mechanism for forming castings; but in the present case I have shown a complete automatic machine, by means of which castings may be formed and ejected from the machine regularly and at a high rate of speed without requiring any considerable amount of attention from an operator.

The several operative parts of my improved machine may be mounted on a suitable framework or bed, such as A, supported on legs in the usual manner and having a main shaft 2, which may be driven by a band-wheel 3 from any suitable source of power, and from this shaft the movements of all of the automatically-operating parts of the machine may be derived.

Any suitable means may be employed for melting and holding the metal from which castings are to be formed; but in the present case I have shown at one end of the framework A two melting-pots, one of which is designated in a general way by M and may be employed to melt the stock and may also form a reservoir, from which the metal may be drawn off from time to time into another or main vessel, such as the melting-pot M′, for use. The contents of these two pots may be kept hot in any suitable manner, ordinarily by gas-jets. From time to time the melting-pot M′ may be replenished from the melting-tank M, as through a channel 4, controlled by a valve 5.

In the construction shown herein the melting-pot M′ has a well 6, from which a passage 7 leads to a chamber 8, having two or more openings leading therefrom. One of these openings is indicated herein by 8′ and is intended to receive molten metal from the tank M′ at a point considerably below the surface of the metal and keep the chamber 8, the passage 7, and the well 6 filled with the molten metal. The other opening, which is designated by 10, serves as an outlet, through which the metal may be delivered to the mold at each operation. The chamber 8 in the present case is formed partly within and partly without the melting-pot M′, a nozzle, such as 12, being secured to said melting-pot in the construction shown and being so shaped internally as to contain a portion of the valve-chamber 8 and also the discharge-opening 10.

For the purpose of controlling the flow of molten metal into the mold I prefer to mount within the valve-chamber 8 and the openings 8′ and 10 a valve so constructed as to close the opening 10 when a casting is not being made. This valve may also serve to open communication through the passage 8′ with the main body of metal in the melting-tank and when so constructed as to accomplish

both of these results constitutes a double-action valve.

For the purpose of supplying a charge of metal to the mold I prefer to make use of mold-filling means embodying a member which will act upon the metal in such a manner as to force the molten charge under high pressure into the mold, and thus assure the filling of all corners thereof. Ordinarily a plunger, such as *p*, will work in the well 6 and when depressed will cause the metal to be injected in a small column or stream into the mold.

The plunger *p* may be carried at the lower end of a plunger-rod 26, which may be supported for vertical reciprocation in a support or cross-piece 27, bolted in this case to the upper side of the melting-pot M′, said plunger-rod being operated in this case by one end 28′ of a lever mounted on a rock-shaft 28, which may be journaled in suitable bearings on said melting-pot, the other end 28″ of said lever being secured to a connecting-rod 29, the operation of which is controlled by the main shaft 2. In the construction shown the lower end of the connecting-rod 29 is pivoted to the forked end of one arm of an angle-lever 30, pivoted on a short pin or shaft 31 at one end of the framework, the other arm 30′ of the angle-lever having secured thereto a coiled spring 32, connected at its other end to a fixed point. In this case a rectangular block 30″ is supported in the bifurcated arm of the angle-lever 30, and it may have a quick-let-off face, as shown in Fig. 4, to coact with a corresponding quick-let-off face of a cam 33 on the shaft 2 in order to permit the plunger *p* to be forced down rapidly by the action of the spring 32 when the block 30″ drops off from the face of the cam 33.

The valve *v* is intended to reciprocate in the chamber 8 and in the openings 8′ and 10 and during a portion of a complete cycle of operations will be controlled in its movements by the molten metal in the various passages and in the main portion of the melting-pot M′ and will move back and forth freely in accordance with the flow of the metal in the one direction or the other; but during another portion of the cycle of operations it is intended in this case that the valve shall be controlled positively to close the passage 10, open the passage 8′, and maintain the passage 8′ open during the early stages of the next descent of the plunger *p*. The valve is practically unbalanced, the area of the passage 8′ being greater than that of the passage 10 and the inertia of the valve, the hydrostatic pressure of the molten metal, and the suction at the opposite side of the mold-space being sufficient to hold the valve closed until the pressure in the valve-chamber is sufficient to overcome these forces, at or after which time the valve will shift very quickly to close the passage 8′, and consequently open the passage 10, so that the molten metal while moving at a high rate of speed will be diverted from one passage into the other. The construction and operation of these parts just described for controlling the delivery of molten metal to the mold would be substantially identical with the construction and operation of the same parts described in my prior application hereinbefore mentioned were it not for the fact that in this case the passage 8′ will be open long enough to get the metal in the passage 7 and in the chamber 8 in motion and keep it in motion until a charge has been injected into the mold, when the kinetic energy or *vis viva* of the molten fluid will be added to the force exerted by the mere thrust of the plunger *p* and will therefore increase the velocity with which the molten metal will be forced through the outlet 10 in the nozzle 12 and thence into the mold. The action just described does not take place in operating the mechanism shown in my application hereinbefore referred to, for the reason that in that case the parts are so organized as to cause the closure of the passage 8′ before the molten metal in the well 6, the passage 7, and the chamber 8 is set in motion. Hence in the present case the stream of molten metal is not only injected forcibly into the mold, but is forced out through the opening 10 while under the influence of its own kinetic energy or *vis viva*, and therefore the mold-filling means herein shown constitutes and operates as a hydraulic ram.

For the purpose of holding the valve *v* during the early stages of the descent of the piston *p* in the position shown, for example, in Fig. 5, with the passage 8′ open, I may make use of any suitable valve-controlling or valve-operating mechanism; but here I have illustrated at 35′ a rock-arm carried by a rock-shaft 35, mounted in suitable bearings and also controlled in its movements by the main shaft 2. The connections to this shaft may be any suitable for the purpose, but in this case are substantially similar to those previously described for operating the plunger. A rock-arm 35″, secured to the rock-shaft, is pivoted in this instance at its free end to the upper end of a connecting-rod 36, the lower end of which is pivoted in turn to a rock-frame 37, pivoted on a short shaft 38, carried in suitable bearings on the framework and somewhat similar to the angle-lever 30. This rock-frame may be constructed in any proper manner, but in this case embodies a pair of angle-arms 37′ and 37″, the former of which has secured thereto a lever formed from a pair of strips 39, properly spaced, and between which an antifriction-roll 40 is supported to coöperate with a cam 41 on the shaft 2, said cam having a small wiper 41′ projecting therefrom for shifting the rock-arm 35′ away from the valve *v* momentarily when a casting is to be made. A spring 42, connected to the arm 37″ and to a fixed point, serves to hold the antifriction-roll 40 in the path of the wiper 41′ on the cam 41 and to operate the rock-arm 35′ quickly to close the valve *v* and cut off

the supply of the metal to the mold. In order to enable the operator to withdraw the roll 40 from the path of the wiper 41′, I have shown at 43 a lever or arm to which the strips 39 are pivoted, said lever having a long heel 43′, the short end of which will rest on the rock-frame 37 when the roll 40 is in its operative position, and the long side of which will rest on said rock-frame when the lever 43 is turned to shift the roll 40 out of action.

An important feature of my present invention is the employment, in connection with mold-filling means and with a mold of suitable construction, of mechanism which will operate to advance one of these toward and retract it from the other alternately, usually at regular intervals, and in the construction shown I employ a separable mold having a plurality of mold-sections, one or more of which may be shifted relatively to another or others and also relatively to the discharge-nozzle of the mold-filling means. When such a separable mold is employed, it may have not only a movement toward and from the mold-filling means to withdraw the sprue of the casting from the latter, but the mold-sections may be also shifted relatively to each other or to one another in such a manner as to strip the casting from the mold, it being understood that no matter how many mold-sections there may be the movements thereof should be controlled by the mechanism automatically and that the mold-sections should have such relative movements as to separate properly without impairing the casting while it is being stripped therefrom.

Many different styles of molds may be employed in connection with my improved machine for forming castings of various shapes so long as the molds differ only in the shapes of the mold-spaces; but in the present case I have illustrated a mold embodying three mold-sections capable of movement relative to one another to permit the stripping of the completed casting therefrom. The mold shown is designated in a general way by O and has three mold-sections, which are indicated, respectively, by *o*, *o′*, and *o″*. (See Figs. 12 to 18, inclusive.) Here the mold-section *o* has the usual ingate or sprue-hole 17, adapted to communicate with the opening 10 in the nozzle 12. Said mold-sections may also coöperate with a pair of nipples, such as 18 and 19, the latter of which in this case practically forms part of the mold and coacts with the mold-section *o* and with the opening 10 in the nozzle 12 to form the sprue-hole. The parts 18 and 19 may be readily replaced at any time, as will be evident, and are so connected as to permit the section *o* to be moved without being shifted themselves.

All of the sections of the mold may be supported by mold-carriers, each mold-section in this case having a separate carrier on which it is supported and by means of which its movements are controlled. Preferably each mold-carrier will be supported by another and in such a manner that each carrier and its mold-section may be positively located and guided during the movements thereof, one mold-section being supported in this case on a main mold-carrier, while the other two mold-sections are carried, respectively, by auxiliary mold-carriers both supported on the main mold-carrier and movable relatively thereto and to each other. Here the mold-section *o′* is fastened directly to the main mold carrier or carriage, which may be substantially a skeleton frame, such as that designated herein by H, this skeleton frame being supported in this instance for movement toward and from the discharge-opening 10 and also having a slight vertical movement, owing to the fact that in the construction illustrated it is actuated by means of and forms one element of a parallel movement. At the end thereof adjacent to the mold this frame H is supported by a two-part swiveled yoke pivoted on the framework at 51, said yoke being designated by 50. At the end thereof remote from the mold the skeleton frame may be supported by a rock-frame also pivoted on the framework, as at 53, the upright portion of the rock-frame being preferably parallel with the yoke 50. Here this rock-frame consists of a pair of rock-arms 54, parallel with each other and pivoted at their upper ends to the rear end of the skeleton frame H. An anti-friction-roll 55 is mounted between these arms 54 and coöperates with a cam 56 on the shaft 2, which cam controls the movements of said frame and of the mold. In the present construction I have also shown an angle-arm 57 in fixed relation with the parallel frame-supporting arms 54, and from this angle-arm 57 a link 58 leads to a strong helical spring 59, the lower end of which is connected to a cross-bar 60 of a rock-frame, (designated in a general way by R,) which serves to operate the mold-exhausting means, (hereinafter to be described,) the rock-shaft of this rock-frame being designated by 61 and being supported between two of the legs of the machine. This spring of course tends to force the skeleton frame and the mold-section carried by it toward the discharge-opening 10, and if the other mold-sections are also supported on the skeleton frame they may also be controlled to a considerable extent by said spring.

In the present construction the mold-section *o* is supported on a mold-carrier positively guided by guide members or openings on or in the skeleton frame. This auxiliary mold-carrier is in this instance a sliding frame having a pair of parallel slide-rods 62, sliding in parallel guideways in cross-pieces, such as 63 and 64, secured to and forming part of the skeleton frame H. This sliding frame is designated in a general way by *h*, and the slide-rods 62 thereof are connected at their forward ends to a cross-head 65, in which the mold-section *o* is mounted. The auxiliary carrier *h* may derive its movements partly from the main carrier H and partly

from a pair of springs 66, coiled around the slide-rods 62 and working between a pair of stops 67, fixed to said slide-rods, and the cross-piece 64 of the frame H. These springs will normally tend to separate the nipple 18 and the nozzle 12 and will normally hold the rear ends of the slide-rods 62 in contact with a stop-face or stop-faces, such as 68, on the frame-work, these stop-faces being of such height as to provide for the slight vertical movement of the slide-rods. The third mold-section *o''* is also preferably mounted on an auxiliary mold-carrier carried on and guided by the main frame H. In the construction shown this second auxiliary mold-carrier, which is designated by *h'*, consists, essentially, of a cylindrical bar 70, supported for reciprocation in corresponding rounded openings in the members 71 and 72 of the skeleton frame, a link-frame, such as 73, being pivoted to the rear end of the bar *h'* and also pivoted to one arm 74 of an angle-lever pivoted on the frame H at 75 and also connected by means of a spring 76 with a fixed point on said frame. The other arm 74' of said angle-lever carries in this case an antifriction-roll 77, adapted to coöperate with a fixed actuator or cam 78 on the main frame of the machine. It will be evident now that the bar *h'*, carrying the mold-section *o''*, will be advanced by the spring 76 to its closed position and will be retracted by the angle-lever when the latter is operated by the cam 78 on the withdrawal of the main frame H from the mold-filling means.

Of course the mold-section *o''* may be formed in many different ways; but here I have illustrated a mold-section having a longitudinally-bored hub 20, with a pin 20' driven therein at one end, while the other end of the bore is threaded to receive the end of a long screw-bolt 21, by means of which the member 20 may be firmly wedged in place in the bore *h*.

It will be noticed that all of the several mold-carriers are actuated toward and from the mold-filling means (in this case in a single path) and that their movements are only varied as to the extent of their travel in such path and as to the time during which such movements take place.

One of the most important features shown and described in my aforesaid application is the employment of means for exhausting air from the mold prior to the casting operation, and this feature is retained in the present mechanism, but in a very much improved form. I have found that the best results cannot be obtained by exhausting the mold at a single operation, as the resultant vacuum is not high enough, and the quantity of air left in the mold while not great is still sufficient to interfere with the casting operation and prevent the obtainment of the finest product. In the present case I have shown in connection with the mold mechanism a plurality of separately-effective mold-exhausting means, and in the preferred construction a pair of successively-effective mold-exhausting devices or air-pumps will be employed to exhaust the air from a single mold, as I have found in practice that after one pump has operated and has almost completely exhausted the mold if another is brought into action and its piston is moved a considerable distance before communication is made with the mold substantially all of the air remaining in the latter will be suddenly drawn out by the high vacuum in the second air-pump, and thus a very high degree of vacuum in the mold will result. Of course the mold-filling means should coöperate with the successively-effective mold-exhausting means in such a manner as to inject the molten metal into the exhausted mold immediately after said mold has been subjected to exhaustion by the second air-pump, and hence the proper timing of these operations is a matter of considerable importance, as the metal should not be injected into the mold until the latter has been completely exhausted, and it should be injected before the vacuum so produced can be impaired.

The differentially-operative mold-exhausting means which I will ordinarily make use of will be a pair of pumps, such as P and P', the former of which is the partial-exhaustion pump and the latter the complete-exhaustion pump. In most respects they may be of any well-known construction, but will be effective at different times, and one of them—in this case the pump P'—may serve as a means for supplying air to the interior of the mold after a casting has been made, in order that the outside atmospheric pressure on the mold-sections may be relieved and the latter separated readily. Of course the air should be admitted to the mold only after the complete formation of the casting, and hence the mold will be alternately exhausted and supplied with air. For the purpose of supplying air to the mold after the casting has been completed one of the air-pumps may not only have a valve for opening communication between the pump-cylinder and the mold, but also an additional or auxiliary valve in the nature of a relief-valve for establishing communication between the outer air and the mold at the propor time. Here the piston-rods 80 and 80' of the two pumps, each passing through an appropriate stuffing-box 80'', are adjustably connected with the rock-frame R and are operated by crank-arms 81 and 81', connected to a pair of cranks 82 and 82' on the main shaft 2, and hence the pistons of the air-pumps are operated directly from such shaft, the spring 59 assisting during the ascent of the pistons. Each pump will have a piston, as 83, with a valve, as 84, therein and an exhaust-valve, as 85, in the cylinder, and each of the two pumps in this case will also have a cover, such as 89 or 89', supporting a valve controlling communication between the pump-cylinder and the mold, but these valves should not operate in unison, but instead the valve 86 of the pump P is intended

to open communication between its pump-cylinder and the mold before communication between the mold and the cylinder is established by the corresponding valve, such as 86′, of the pump P′. The valves 86 and 86′ are preferably puppet-valves, as shown herein, and control ports, such as 87 and 87′, leading to the mold, and the pump P′ may also have an additional valve or admission-valve, which will control communication between the outer air and the pump-cylinder. This auxiliary valve or admission-valve may be a puppet-valve, such as 88, seated in a bore in the main puppet-valve 86′ and controlling communication between the port 87′ and the outer air, all of these valves 86, 86′, and 88 being operated in proper timing, preferably from the main shaft 2, through suitable connections, such as those shown herein. The valve 86 is held to its seat by a spring 90 and is raised therefrom by one end of a lever 91, the other end of which is pivoted to a connecting rod or link 92, the lower end of which in turn is connected to one arm of an angle-lever 93, pivoted on the framework of the machine, the other arm of the angle-lever carrying an antifriction-roll 94, coacting with a cam 95 on the main shaft 2. The connections from the valve-operating lever for the valve 86′ to the shaft 2 being substantially the same as those just described need not be particularly described, but are indicated herein by corresponding figures and prime-marks. It should be noted, however, that the cam 95′ for operating the valve 86′ is not located in the same position on the shaft 2 as the cam 95, but instead is so placed as to raise the valve 86′ after the valve 86 has been lifted and closed again, in order that the mold may be first partially and then completely exhausted.

Referring now particularly to Figs. 10 and 11, I have illustrated the means which I prefer to employ for operating the auxiliary puppet-valve 88 for establishing communication between the outer air and the mold. Here the bifurcated end of the valve-operating lever 91′ carries a pivoted lifting-pawl 96, the working face of which is adapted to engage a coacting face on the valve 88, the pawl in this case working in registering openings in the heads of the stems of the valves 86′ and 88. Hence the pawl 96 not only turns about its own pivot on the lever 91′, but also turns about the point about which it passes through the head of the valve 86′, the result being that when the valve 86′ is lifted the spring will serve to force the valve 88 firmly to its seat, while when the valve 86′ descends to its seat the pawl 96 will lift the relief-valve 88 from its seat and open communication between the outer air and the port 87′. This action of course should not take place until after the casting operation. Proper outlets are provided, as at 97 and 97′, for the escape of the air from the pump-cylinder.

For the purpose of assuring the obtainment of a very high vacuum in each of the cylinders I have illustrated at 98 and 98′ a pair of pipes which will lead to an oil-reservoir, (not shown,) from which reservoir oil will be drawn by the pistons, and this oil will serve not only to lubricate said pistons, but also to form air-seals between the pistons and the walls of the cylinders and between the outlet-valves (one of which is shown at 85) and their seats. Of course this supply of oil should be regulated, as by means of valves 99 and 99′, so that only a fine stream will be drawn through the pipes 98 and 98′, and hence only a small quantity will enter the cylinders at each operation, the oil so drawn in being raised by the piston and forced with the exhausted air through the exhaust-valves of the air-pumps, from which it may pass by way of pipes 97 and 97′ back to the reservoir to be used again. Each piston 83 is shown provided with suitable channels 83′ for the passage of the oil and of course may be appropriately packed, as shown at 83″.

The pumps shown herein are stationary on the bed or framework of the machine, and the mold is movable by means of the mold-shifting mechanism hereinbefore described, and hence it will be evident that a suitable movable or flexible connection from the mold-exhausting means to the mold must be provided in the present case. As the connection from the pump P to the mold is the same as from the pump P′, a description of the connections from the former will be sufficient for both. Here I prefer to make use of a pipe for establishing this connection, such pipe being indicated herein by 100 and being connected with the pump and with the mold by ball-and-socket joints, as clearly illustrated in Figs. 2, 3, 9, 11, 12, and 14, the ports in the pump-cylinders which lead to the mold having ball-sockets, as clearly shown, while the mold-section *o* has corresponding sockets, (indicated herein by 101.) Each pipe is preferably adjustable in length and forms a toggle member, which is straightened out when the mold is closed, and thus tightens the joints and prevents leakage of the air during the exhaustion of the mold.

Figs. 8, 9, and 11, it will be understood, represent the cylinders as detached from their positions on the machine and the connecting-pipes 100 100 removed, showing only the cup-shaped bearings at the outer extremities of the ports 87 and 87′, in which the mentioned ball-and-socket connections of the connecting-pipes fit.

For the purpose of exhausting the air from the mold I deem it desirable to provide an opening which will intersect the meeting face of one of two slightly-separated mold-sections, and in this case such an opening is shown in the mold-section *o*. Here there is preferably a channel 102 in the meeting face the mold and substantially concentric with the mold-space, and from this channel passages, such as 103, may lead to the sockets 101. As before stated, the molds which I employ will

preferably be separable, and I have found that the air can be exhausted most perfectly when it is drawn directly from the meeting-line of juxtaposed sections. Moreover, with such a construction only one mold-section need have outlet-passages for the air and the conical faces at the edges of the mold-section may form the air-tight joint.

I have now described, among other things, the various mechanisms and devices by means of which the mold may be properly exhausted and molten metal injected into the exhausted mold; but I have not described any means for cooling and chilling the casting suddenly before it has hardened and is in condition to be stripped from the mold. Any means suitable for the purpose may be used to cool the contents of the mold suddenly and check the crystallization thereof; but I prefer to circulate around the casting a cooling medium, such as a stream of cold water, while the casting is in the mold. Usually this cooling medium will be circulated directly through the mold, preferably through one or more of the mold-sections, and in this case the sections *o* and *o'* are subjected to the action of different circulating streams of water. The mold-section *o* is cooled and chilled in the present construction by circulating water through a peripheral groove or channel 105, communicating through pipes, such as 106, with a suitable source of supply, (not shown,) while the section *o'* may be correspondingly chilled by circulating the stream through an annular channel 107 in the forward face of the member 71 of the skeleton frame H, (see Fig. 15,) the water being supplied to this channel in substantially the same manner as to the mold-section *o*. The circulation of these streams of water around the casting during the whole of the time that the latter is forming results in a very rapid cooling and hardening of the same before the metal has had time to form large and well-defined crystals. Hence the the result is, as before stated, a casting of much finer grain and more perfectly chilled than when the casting is not subjected to the action of a cooling medium, and, moreover, the formation of the castings is more rapid and a larger product can be turned out in a given time than when the castings are not so chilled.

In connection with the mechanism for separating the several sections of the mold to strip the casting therefrom after the latter has been completed I prefer to employ a mechanically-operative casting-stripper—such, for example, as that shown herein at *s*—said stripper in this case working between the two main mold-sections to strike the sprue of the casting and positively strip and eject the latter from the mold and comprising, preferably, an oscillatory plate, such as 110, secured to a pair of rock-arms, such as 112, pivoted on the frame H, preferably at the point where the yoke 50 is connected to said frame. By referring to Fig. 4 it will be seen that one of these arms 112 has pivoted thereto a link 113, connected at its rear end to a fixed stop 114 on one of the slide-rods 62, and hence said stripper is supported on one of the mold-carriers and is operatively connected with the other, the movements of the parts being such that the stripper will be effective to strike the sprue of the casting after the mold-carrier *h* has been retracted to the position shown in Figs. 5 and 18.

It may happen occasionally that for some reason—as, for instance, if the parts are not adjusted properly—the main frame H may not move forward far enough to close the mold-sections properly, which, it will be noted by referring to Fig. 7, are positively held together by spring-pressure when the antifriction-roll 55 withdraws slightly from the cam 56 and it is desirable to provide means for preventing the injection of molten metal into the mold at such a time and the consequent waste of metal. For this reason I deem it desirable to make use of a safety device—such, for example, as the spring-pressed locking-pawl 115—which will engage a portion of the plunger-operating mechanism of the mold-filling means—as, for example, the stop 29' on the connecting-rod 29—and will not be released from such stop unless the mold-sections come together properly. To assure this, I may make use of a pawl-releasing device, such as a plate 116, on one of the mold-carriers—in this case on the main mold-carrier—which releasing device will coöperate with a face or arm, such as 115', in fixed relation with the pawl 115, but will not strike such arm, and hence will not release the pawl from the stop 29', unless the main mold-carrier has moved to its proper position and the mold-sections have been brought together properly. The pawl will engage the stop at each operation of the machine to form a casting; but it will not be released at any operation unless the mold-sections are in position to form a perfect casting.

For the purpose of getting the molten metal in the tank M' in circulation, thus assuring the presence of an extremely hot and most perfectly fluid metal around the valve *v* and in the chamber 8 and the adjacent passages, I deem it desirable to provide an additional supply-passage leading into the chamber 8, preferably from a different portion of the melting-tank than the passage 7. In this case I have shown a series of communicating passages and chambers leading from the upper portion of the tank, so as to take their supply from a point somewhat near the top of the molten bath. Here a passage 120 leads into a chamber 121, which is connected with another chamber 123 by a passage 122, and from the chamber 123 another passage 124 establishes communication with the valve-chamber 8. The flow of molten metal through these passages and chambers may be prevented except during the period when the machine is being started, and for the purpose of cutting off the supply and yet permitting accu-

mulated air and gas to escape I may make use of a valve, such as 125, substantially similar to that shown at 5. Before the casting operation begins, however, this valve may be opened, while the lever 43 is up and the valve *v* remains closed, and the machine may be started, which of course will result in circulating the metal not only through the passages 7 and 8′ into the chamber 8 from the bottom of the bath, but also through the passages just described from a point near the top of the bath, thus assuring a very perfect circulation of the metal in the tank and in the chamber 8 before the actual casting operation begins. The principal functions of this valve 125, however, are to prevent the lowering of the pressure of the jet of molten metal, the cushioning of its blow, and the formation of blow-holes in the casting, all of which would result from the accumulation of air and gas in the chamber 8.

The operation of a casting-machine constructed in accordance with my present invention as hereinbefore set forth is as follows: The valve 125 will be opened while the lever 43 remains up, whereupon the machine will be started and the driving-wheel permitted to make a few rotations in order to get the molten metal in circulation, and thus assure the filling of the chamber 8 with hot and perfectly fluid metal. Thereupon the valve 125 may be closed again and the lever 43 pushed down to permit the valve *v* to be operated by wiper 40′, all this being merely preliminary to the operation of the machine for forming a casting. Assuming that all of the parts are are in their normal positions—that is, with the valve *v* closed and the sections of the mold in their open positions relative to one another, as shown in Fig. 5—the driving-wheel 3 and the shaft 2 will be rotated in the direction of the arrow, and as the antifriction-roll 55 rides down the face of the cam 56 the spring 59 will shift the frame H toward the opening 10 and at the same time slightly elevate said frame to bring the sprue-hole into position to register with such opening, although the frame *h* will not at first move toward the opening 10, but will merely rise, owing to the fact that the springs 66 will be effective to keep the slide-rods 62 in contact with the stop-faces 68 until the main frame H reaches the position shown in Fig. 6 and becomes effective to actuate said frame *h* and its mold-section positively, the shifting of the frame H in this direction being effected by a spring 59 and said frame being firmly pressed forward as the antifriction-roll 55 leaves the face of the cam 56. Hence said spring 59 exerts at such time a constant pressure upon these frames and tends to press the mold-sections *o* and *o′* firmly together and also to hold the nipple 18 tightly against the nozzle 12. Before the mold-sections *o* and *o′* close, however, the antifriction-roll 77, rising from the cam 78, permits the spring 76 to become effective to shift the bar *h′* toward the opening 10 to force the mold-section *o″* to its closed position, and this spring 76 will tend to keep such mold-section in its closed position so long as said antifriction-roll 77 is clear of the cam 78. While the sections of the mold are closing the cranks on the shaft 2 are rotating and the crank-arms 81 and 81′ are operating to draw down the pistons of the two air-pumps, and thus produce vacua in the two pump-cylinders and admit a small amount of oil thereinto through the valves in the pistons. Thereafter and while the mold-sections are closed the cams 95 and 95′ on the shaft 2 will operate successively to raise the puppet-valves 86 and 86′, and thus first partially and afterward completely exhaust the mold, the valves 86 and 86′ opening and closing successively and the pistons then rising in the pump-cylinders to force out through the pipes 97 and 97′ the air exhausted from the mold and also the oil in said cylinders. By this time the block 30″ will have slipped off the face of the cam 33, and the spring 32 will be effective to force down the plunger *p* and set in motion the metal in the passage 7 and the chamber 8, and the kinetic energy of the moving metal will when the valve *v* is opened serve as an additional means for forcing the jet of molten metal into the exhausted mold. The cam 41 is so located as to open this valve *v* (see Fig. 7) before the plunger reaches the limit of its downward movement, and hence as the valve *v* opens the passage 10 and closes the passage 8′ the whole force of the plunger will be added to the *vis viva* of the moving body of metal to force a stream of molten metal under very high pressure into the closed and exhausted mold. This molten metal will be cooled and chilled almost instantaneously as it enters the mold, owing to the circulation of the streams of water around the mold-sections, and the tendency of the cooling body to crystallize will be checked and a very high grade casting with an extremely fine crystalline structure will result. As soon as the proper amount of metal has been supplied to the mold the valve *v* will close again and the plunger *p* will rise, and thereupon the mold may be opened; but before the mold-sections separate the auxiliary or admission valve 88, carried by the puppet-valve 86′, will open communication between the outer air and the mold in order to facilitate the separation of the mold-sections. Thereupon the antifriction-roll 55 will ride up the face of the cam 56 and retract and lower the main frame H, the first movement being to the position shown in Fig. 16 to withdraw a portion of the sprue of the casting *c* from the opening 10, whereupon the ends of the slide-rods 62 will again strike the stop-faces 68, and the frame *h* will be at the rearward limit of its slight reciprocatory movement. The main frame H, however, will continue to move to the rear, as seen in Figs. 5 and 17, and the major portion of the casting will be stripped from the mold—that is to say, it will be

stripped from the mold-section *o*. When the antifriction-roll 77 comes into contact with the cam 78, the frame *h'* will be shifted to the rear to strip the mold-section *o''* from the casting, as shown in Figs. 5 and 18. If the casting still adheres to the mold-section *o'*, as will frequently be the case, the stripper *s* will then strike the sprue of the casting *c* and strip the last portion of the engaged surface away from the mold, whereupon the casting will drop and may be received in a suitable receptacle, (not shown,) the stripper being afterward retracted from its position between the mold-sections by an upward movement. It should be understood, of course, that the valve 88 will have closed before the pumps become effective to exhaust the mold again during the next cycle of operations of the machine. Each time that the plunger reaches the limit of its upward movement the stop 29' will be engaged by the pawl 115, and if the mold-sections come together properly the pawl-releasing plate 116 will strike the arm 115' and release said pawl to permit the plunger to descend again; but if the mold-sections do not come together properly the pawl will not be released, the plunger will not descend, and there will be no waste of the molten metal.

Having described my invention, I claim—

1. In a casting-machine, the combination with means for subjecting a mass of molten metal to a pressure greater than atmospheric, and a mold, of a plurality of air-pumps for producing a vacuum in the mold; a valve for controlling the entrance to the exhausted mold of molten metal; a power-driven device in the machine; and mechanism operatively connected with such device which first renders one of the air-pumps effective to exhaust the mold, then renders such pump ineffective and a second pump effective to further exhaust the partially-exhausted mold, and finally during the second exhaustion actuates the said valve and thereby admits molten metal under pressure to the mold.

2. In a casting-machine, the combination with means for subjecting a mass of molten metal to a pressure greater than atmospheric, and a mold, of a plurality of air-pumps communicating with the mold for producing a vacuum therein; valves controlling the passage-ways leading from the air-pump cylinders to the mold; a valve for controlling the entrance to the exhausted mold of molten metal; a power-driven device in the machine, and mechanism operatively connected with such device, which first actuates the pistons of the air-pumps, and opens the valve in the passage-way leading from one of the air-pump cylinders to the mold, then closes this latter valve and opens the valve in the passage-way leading from the second air-pump cylinder to the mold, and finally, before the piston of the last-mentioned cylinder has reached the end of its stroke, opens said valve controlling the flow of molten metal to the mold.

3. In a casting-machine, the combination with a plunger for subjecting molten metal to pressure, and a mold, of a plurality of air-pumps communicating with the mold for producing a vacuum therein; valves controlling the passage-ways leading from the air-pump cylinders to the mold; a valve for controlling the entrance to the exhausted mold of molten metal; a power-driven device in the machine; and mechanism operatively connected with such device, which first actuates the pistons of the air-pumps and opens the valve in the passage-way leading from one of the air-pump cylinders to the mold, then closes this latter valve and opens the valve in the passage-way leading from a second air-pump cylinder, and finally, before the piston of the last-mentioned cylinder has reached the end of its stroke, actuates the plunger and opens said valve controlling the flow of molten metal to the mold.

4. In a casting-machine, the combination with means for subjecting a mass of molten metal to a pressure greater than atmospheric, a mold, and an air-valve for admitting air to the mold at a predetermined time, of a plurality of air-pumps for producing a vacuum in the mold; a valve for controlling the entrance to the exhausted mold of molten metal; a power-driven device in the machine; and mechanism operatively connected with such device which first renders one of the air-pumps effective to exhaust the mold, then renders such pump ineffective and a second pump effective to further exhaust the partially-exhausted mold, then during the second exhaustion actuates the said metal-controlling device and admits molten metal to the mold, and finally opens said air-valve and admits air to the mold.

5. In a casting-machine, the combination with means for subjecting a mass of molten metal to a pressure greater than atmospheric, a mold, and an air-valve for admitting air to the mold at a predetermined time, of a plurality of air-pumps communicating with the mold for producing a vacuum therein; valves controlling the passage-ways leading from the air-pump cylinders to the mold; a valve for controlling the entrance to the exhausted mold of molten metal; a power-driven device in the machine; and mechanism operatively connected with such device which first actuates the pistons in the air-pumps and opens the valve in the passage-way leading from one of the air-pump cylinders to the mold, then closes this latter valve and opens the valve in the passage-way leading from a second cylinder to the mold, then, before the piston of the last-mentioned cylinder has reached the end of its stroke, opens the said metal-controlling valve, and finally opens said air-valve and admits air to the mold.

6. In a casting-machine, the combination with a plunger for subjecting molten metal to pressure, a mold, and an air-valve for admitting air to the mold at a predetermined time,

of a plurality of air-pumps communicating with the mold for producing a vacuum therein; valves controlling the passage-ways leading from the air-pump cylinders to the mold; a valve for controlling the entrance to the exhausted mold of molten metal; a power-driven device in the machine; and mechanism operatively connected with such device which first actuates the pistons of the air-pumps and opens the valve in the passage-way leading from one of the cylinders to the pump, then closes this latter valve and opens the valve in the passage-way leading from a second air-pump cylinder to the mold, then, before the piston of the last-mentioned cylinder has reached the end of its stroke, actuates the plunger and opens the said metal-controlling valve, and finally opens said air-valve and admits air to the valve.

7. In a casting-machine, the combination with a plunger for subjecting molten metal to pressure, and a mold, of a plurality of air-pumps communicating with the mold for producing a vacuum therein; valves controlling the passage-ways leading from the air-pump cylinders to the mold; a valve for controlling the entrance into the exhausted mold of molten metal; a main shaft from which the pistons of said air-pump cylinders are actuated; and a series of cams operatively connected to the shaft, and with said plunger and the valves in the passage-ways leading from the air-pump cylinders, and with said metal-controlling valve, and which actuate the same in the following order during the exhausting movement of the pistons, namely: first the valve in one of said passage-ways to open the same, then this valve and the valve in another of the passage-ways to close the first valve before opening the second, and finally the plunger and the metal-controlling valve to admit molten metal under pressure into the mold.

8. In a casting-machine, the combination with a plunger for subjecting molten metal to pressure, a mold, and an air-valve for admitting air at a predetermined time to the mold, of a plurality of air-pumps communicating with the mold for producing a vacuum therein; valves controlling the passage-ways leading from the air-pump cylinders to the mold; a valve for controlling the entrance into the exhausted mold of molten metal; a main shaft from which the pistons of said air-pump cylinders are actuated; and a series of cams operatively connected to the shaft, and with said plunger and the valves in the passage-ways leading from the air-pump cylinders, and with said metal-controlling valve, and which actuate the same in the following order during the exhausting movement of the pistons, namely: first the valve in one of said passage-ways to open the same, then this valve and a valve in another of the passage-ways to close the first valve before opening the second, then the plunger and the metal-controlling valve to admit molten metal under pressure into the mold, and finally the air-valve to admit air into the mold.

9. In a casting-machine, the combination with a separable mold, of means for first producing a vacuum in the mold; means for next causing the filling of the mold with molten metal; means for afterward admitting air to the mold; means for finally separating the mold; and mechanism for causing the operation of the several means in the order specified.

10. In a casting-machine, the combination with a separable mold, of a plurality of separate means for producing a vacuum; means for causing the filling of the mold with molten metal; means for admitting air to the mold; means for separating the mold; and mechanism operatively connected to the machine for actuating the aforesaid means in the following order, to wit: to first render one of said vacuum-producing means effective to exhaust air from the mold, then to connect the partially-exhausted mold with a second vacuum-producing means, then to cause the injection into the mold of molten metal, then to admit air to the mold, and finally to separate the mold.

11. In a casting-machine, the combination with a separable mold, of a plurality of separate means embodying a pair of air-pumps for producing a vacuum; means for causing the filling of the mold with the molten metal; means for admitting air to the mold; means for separating the mold; and mechanism operatively connected to the machine for actuating the aforesaid means in the following order, to wit: to first render one of said air-pumps effective to exhaust air from the mold, then to connect the partially-exhausted mold with the other air-pump, then to cause the injection into the mold of molten metal, then to admit air to the mold, and finally to separate the mold.

12. In a casting-machine, the combination with a mold and with mold-filling means, of an air-pump embodying a main puppet-valve controlling communication between the pump-cylinder and the mold, and an auxiliary valve carried by the main valve and controlling communication between the mold and the outer air.

13. In a casting-machine, the combination with a mold and with mold-filling means, of an air-pump; a main valve controlling communication between the pump-cylinder and the mold; an auxiliary valve carried by the main valve and controlling communication between the mold and the outer air; and a valve-actuating mechanism for operating the main and auxiliary valves with relation to each other.

14. In a casting-machine, the combination with a shiftable mold having mold-sections adapted to move toward and away from each other transversely to the plane of their surface of contact and provided with a groove intersecting said surface, of a nozzle through

which molten metal is injected into the mold; means for moving the mold into a casting position in contact with said nozzle and for withdrawing it therefrom; mechanism for separating the mold-sections upon the filling of the mold and after its withdrawal from its casting position; an air-pump cylinder and a flexible connection extending between the mold and the air-pump cylinder and communicating with said groove.

15. In a casting-machine, the combination with a mold having mold-sections adapted to move toward and away from each other transversely to their surface of contact and provided with a groove intersecting said surface, of mechanism for separating the mold-sections upon the filling of the mold, a conduit communicating with the groove through which air is exhausted from the mold; a valve for controlling the admission of air to the groove; means for applying a pressure to molten metal in the machine to effect its forcible injection into the exhausted mold; and mechanism for operating said valve to admit air into the mold after the injection of the metal thereinto.

16. In a casting-machine, the combination with a discharge-nozzle, and an air-pump cylinder, of a mold shiftable relatively to the cylinder and to the discharge-nozzle; means for guiding the mold, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; a flexible connection extending between the mold and the air-pump cylinder; and mechanism operatively connected to the machine which first causes the advance of the mold toward the nozzle, then the exhaustion of the mold, and finally the injection of molten metal into the exhausted mold.

17. In a casting-machine, the combination with a discharge-nozzle, and an air-pump cylinder, of a mold shiftable relatively to the cylinder and to the discharge-nozzle; means for guiding the mold in its movements, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; an air-admission valve; a flexible connection extending between the mold and the air-pump cylinder; and mechanism operatively connected to the machine which first causes the advance of the mold toward the nozzle, then the exhaustion of the mold, then the injection of molten metal into the exhausted mold, and finally the admission of air to the mold subsequent to the injection of metal thereinto.

18. In a casting-machine, the combination with a discharge-nozzle, and an air-pump cylinder, of a sectional mold shiftable relatively to the cylinder and to the discharge-nozzle; means for guiding the mold, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; a flexible connection extending between the mold and the air-pump cylinder; and mechanism operatively connected to the machine which first causes the advance of the mold toward the nozzle, then the exhaustion of the mold, and finally the withdrawal of the mold from the nozzle, and its separation.

19. In a casting-machine, the combination with a discharge-nozzle, and an air-pump cylinder, of a sectional mold shiftable relatively to the cylinder and to the discharge-nozzle; means for guiding the mold in its movements, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; an air-admission valve; a flexible connection extending between the mold and the air-pump cylinder; and mechanism operatively connected to the machine which first causes the advance of the mold toward the nozzle, then the exhaustion of the mold, then the injection of molten metal into the exhausted mold, then the admission of air to the mold subsequent to the injection of metal thereinto, and finally the withdrawal of the mold from the nozzle, and its separation.

20. In a casting-machine, the combination with a discharge-nozzle, and a pair of air-pump cylinders, of a sectional mold shiftable relatively to the cylinders and the discharge-nozzle; means for guiding the mold in its movements, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; an air-admission valve; flexible connections extending between the mold and the air-pump cylinders; and mechanism operatively connected to the machine which first causes the advance of the mold toward the nozzle, then the exhaustion of the mold, then the admission of air into the mold subsequent to the injection of metal thereinto, and finally the withdrawal of the mold from the nozzle, and its separation.

21. In a casting-machine, the combination with a discharge-nozzle and an air-pump cylinder, of a sectional mold shiftable relatively to said cylinder; means for guiding the mold in its movements and for advancing the same to a casting position in which it contacts with said nozzle and for withdrawing it from such position; an air-admission valve for said cylinder; means for positively operating such valve; means for separating the sections of the mold from each other; and a flexible connection extending between and connecting the air-pump cylinder with the mold.

22. In a casting-machine, the combination with a discharge-nozzle, and an air-pump cylinder, of a sectional mold shiftable relatively to said cylinder; means for guiding the mold in its movements, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; a main valve for admitting air from the mold to the air-pump cylinder; an air-admission valve carried by the main valve for admitting air to the mold before its with-

drawal and separation; and a flexible connection extending between and connecting the air-pump cylinder with the mold.

23. In a casting-machine, the combination with a discharge-nozzle, and two air-pump cylinders, of a sectional mold shiftable relatively to said cylinders; means for guiding the mold in its movements, and for advancing the same into a casting position in which it contacts with said nozzle, and for withdrawing it from such position; an air-admission valve; flexible connections extending between and connecting the air-pump cylinders with the mold; and mechanism operatively connected to the machine which first causes the advance of the mold toward the nozzle, then the exhaustion of the mold, then the admission of air to the mold subsequent to the injection of metal thereinto, and finally the withdrawal of the mold from the nozzle, and the separation of its sections one from the other.

24. In a casting-machine, the combination with a mold; means for subjecting molten metal to a pressure greater than atmospheric; means for holding the metal and permitting it to flow, in consequence of such pressure, in a direction other than into the mold; and a plurality of air-pumps for producing a vacuum in the mold, of means for shifting the direction of flow of the molten metal; a power-driven device in the machine; and mechanism operatively connected with such device which renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow in the metal and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of the flow, actuates the means for shifting the direction of such movement, thereby effecting the diversion of the flow toward and into the mold.

25. In a casting-machine, the combination with a melting-tank and a chamber connected to the tank and normally shut off from communication with the mold, of means for subjecting a mass of molten metal communicating with that in the chamber to a pressure greater than atmospheric and thereby set up a movement in the body of metal in the chamber outward into the tank; means for suddenly opening communication between the chamber and the mold and for simultaneously arresting the flow of metal from the chamber into the tank; a plurality of air-pumps for producing a vacuum in the mold; a power-driven device in the machine; and mechanism operatively connected with such device which renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow in the metal and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of such flow, actuates the means for opening communication between the chamber and the mold and simultaneously arresting the flow of metal in other directions, thereby diverting the direction of flow toward and into the mold.

26. In a casting-machine, the combination with a melting-tank, a mold and a chamber in normal communication with the tank, of means for subjecting a mass of molten metal communicating with that in the chamber to a pressure greater than atmospheric and thereby set up a movement in the body of metal in the chamber outward into the tank; a valve for closing communication between the chamber and the tank; a valve for controlling the inlet of molten metal to the mold from the chamber; a plurality of air-pumps for producing a vacuum in the mold; a power-driven device in the machine; and mechanism operatively connected with such device which renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow of the metal in the chamber, and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of such flow, actuates said valves to thereby close communication between the chamber and the tank and simultaneously open communication between the chamber and the mold.

27. In a casting-machine, the combination with a melting-tank; a mold and a chamber in normal communication with the tank, of means for subjecting a mass of molten metal communicating with that in the chamber to a pressure greater than atmospheric and thereby set up a movement in the body of metal in the chamber outward into the tank; a double-action valve for controlling communication between the chamber and the mold and the chamber and the tank; a plurality of air-pumps for producing a vacuum in the mold; a power-driven device in the machine; and mechanism operatively connected with such device which renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow of the metal in the chamber, and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of such flow, actuates said valve to thereby simultaneously close communication between the chamber and the tank and open communication between the chamber and the mold.

28. In a casting-machine, the combination with means for subjecting a mass of molten metal to a greater pressure than atmospheric; means for holding the metal and permitting it to flow in consequence of such pressure in a direction other than into the mold; a nozzle; a shiftable mold; means for shifting the mold toward and away from the nozzle; and a plurality of air-pumps for producing a vacu-

um in the mold, of means for shifting the direction of flow of the molten metal and diverting the same toward and into the mold; a power-driven device in the machine; and mechanism operatively connected with such device which first actuates the means for shifting the mold toward the nozzle; then renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow of the metal and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of the flow, actuates the means for shifting the direction thereof, thereby diverting the flow toward and into the mold.

29. In a casting-machine, the combination with a melting-tank; a nozzle; a shiftable mold; a chamber connected to the tank and normally cut off from communication with the mold; means for shifting the mold toward and away from the nozzle; and a plurality of air-pumps, of means for subjecting a mass of molten metal communicating with that in the chamber to a pressure greater than atmospheric and thereby set up a movement of the body of metal in the chamber outward into the tank; means for suddenly opening communication between the chamber and the mold and for simultaneously arresting the flow of metal into the tank; a power-driven device in the machine; and mechanism operatively connected with such device which first actuates the means for shifting the mold toward the nozzle; then renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow of the metal in the chamber and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of the flow, actuates the means for opening communication between the chamber and the mold and simultaneously arresting the flow of metal into the tank, thereby diverting the flow toward and into the mold.

30. In a casting-machine, the combination with a mold having a passage-way in its body for a chilling liquid; means for subjecting molten metal to a pressure greater than atmospheric; means for holding the metal and permitting it to flow in consequence of such pressure in a direction other than into the mold; and a plurality of air-pumps for producing a vacuum in the mold, of means for shifting the direction of flow of the molten metal; a power-driven device in the machine; and mechanism operatively connected with such device which renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow in the metal and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of the flow, actuates the means for shifting the direction of such movement, thereby effecting the diversion of the flow toward and into the mold.

31. In a casting-machine, the combination with means for subjecting a mass of molten metal to a pressure greater than atmospheric; means for holding the metal and permitting it to flow, in consequence of such pressure, in a direction other than into the mold; a nozzle; a shiftable mold having a passage-way in its body for a chilling liquid; means for shifting the mold toward and away from the nozzle; and a plurality of air-pumps for producing a vacuum in the mold, of means for shifting the direction of flow of the molten metal and diverting the same toward and into the mold; a power-driven device in the machine; and mechanism operatively connected with such device which first actuates the means for shifting the mold toward the nozzle; then renders one of the air-pumps effective to partially exhaust the mold, said pressure means effective to establish the flow of the metal and the operating-pump subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold; and then, subsequent to the establishment of the flow, actuates the means for shifting the direction thereof, thereby diverting the flow toward and into the mold.

32. In a casting-machine, the combination with a separable mold embodying a part of mold-sections of mold-filling means having a discharge-nozzle operatively connected with the machine for supplying molten metal to the mold; and mechanism operatively connected to the machine for shifting said mold-sections different distances in a common path relatively to each other toward and from said opening and into and out of operative relation with the mold-filling means.

33. In a casting-machine, the combination with a discharge-nozzle; a reciprocatory mold embodying mold-sections separable from one another and movable different distances relatively to the discharge-nozzle, of a plurality of air-pumps for producing a vacuum in the mold; means for forcibly injecting molten metal thereinto; a power-driven device in the machine; and mechanism operatively connected with such device which first shifts the mold into contact with said discharge-nozzle and closes the mold-sections, then renders one of the air-pumps effective to partially exhaust the mold and subsequently ineffective and a second pump effective to further exhaust the partially-exhausted mold, then renders the means effective for forcibly injecting molten metal into the mold, and finally shifts the mold out of contact with the discharge-nozzle and separates the mold-sections.

34. In a casting-machine, the combination with a separable mold embodying a pair of mold-sections coöperative for forming a cast-

ing, of mold-filling means having a discharge-opening for supplying molten metal to the mold, and power mechanism for shifting said mold-sections different distances in the same direction relatively to each other to effect the opening and closing of the mold.

35. In a casting-machine, the combination with a sectional mold, of a carrier for each mold-section; carrier-actuating mechanism for shifting the carriers and separating the mold-sections from each other; a casting-stripper pivotally connected at different points of its length to one of said sections and to a member relatively to which said section moves when actuated, said stripper being disposed in the plane of movement of the section in which it is pivotally connected and having its pivotal axis extending transversely to the plane of movement of such section, whereby the stripper is caused to swing transversely to the sprue of the casting.

36. In a casting-machine, the combination with a nozzle through which molten metal is injected into the mold, of a sectional mold, and mechanism for shifting the mold-sections as a unit away from the nozzle, and then stopping the movement of one mold-section and continuing the movement of another section in the line of retracting movement of the mold.

37. A sectional mold embodying a plurality of mold-sections, in combination with a main carrier upon which the mold is mounted, one of the mold-sections being mounted upon said main carrier and being adapted to move relatively thereto; a spring for urging the said relatively movable section into contact with its coöperative section; and a stop for limiting the motion of said relatively movable section at some time before the mold reaches the limit of its retracting movement.

38. A sectional mold in combination with a spring for urging the mold into its casting position; means for retracting it therefrom; a carrier upon which the mold is mounted, springs for urging the various mold-sections into a position in which they contact with each other; a stop for limiting the retracting movement of one of the sections; and means for separating the remaining mold-sections during the further retracting movement of the mold.

39. In a casting-machine, the combination with a separable mold and with mold-section carriers adapted to be moved different distances in the same direction to close the mold, of a plurality of pressure-exerting means adapted to exert upon the mold-sections different pressures toward the mold-filling means to press the mold firmly in contact with the latter and to press the mold-sections together during the filling of the mold.

40. In a casting-machine, the combination with a separable mold, of mold-filling means comprising a plunger; a mold-carrier for each section; mold-carrier-operating means for closing said mold-sections; a spring-actuated locking-pawl operative for preventing the operation of the plunger until all of said mold-sections are in proper position; and a pawl-releasing device carried by the mold and effective to release the locking-pawl when the mold is in its proper position.

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