H. H. DOEHLER.

ART OF AND APPARATUS FOR CASTING FLUID METAL.

APPLICATION FILED JAN. 12, 1909.

973,483.

Patented Oct. 25, 1910.

2 SHEETS—SHEET 1.

Fig. 1.

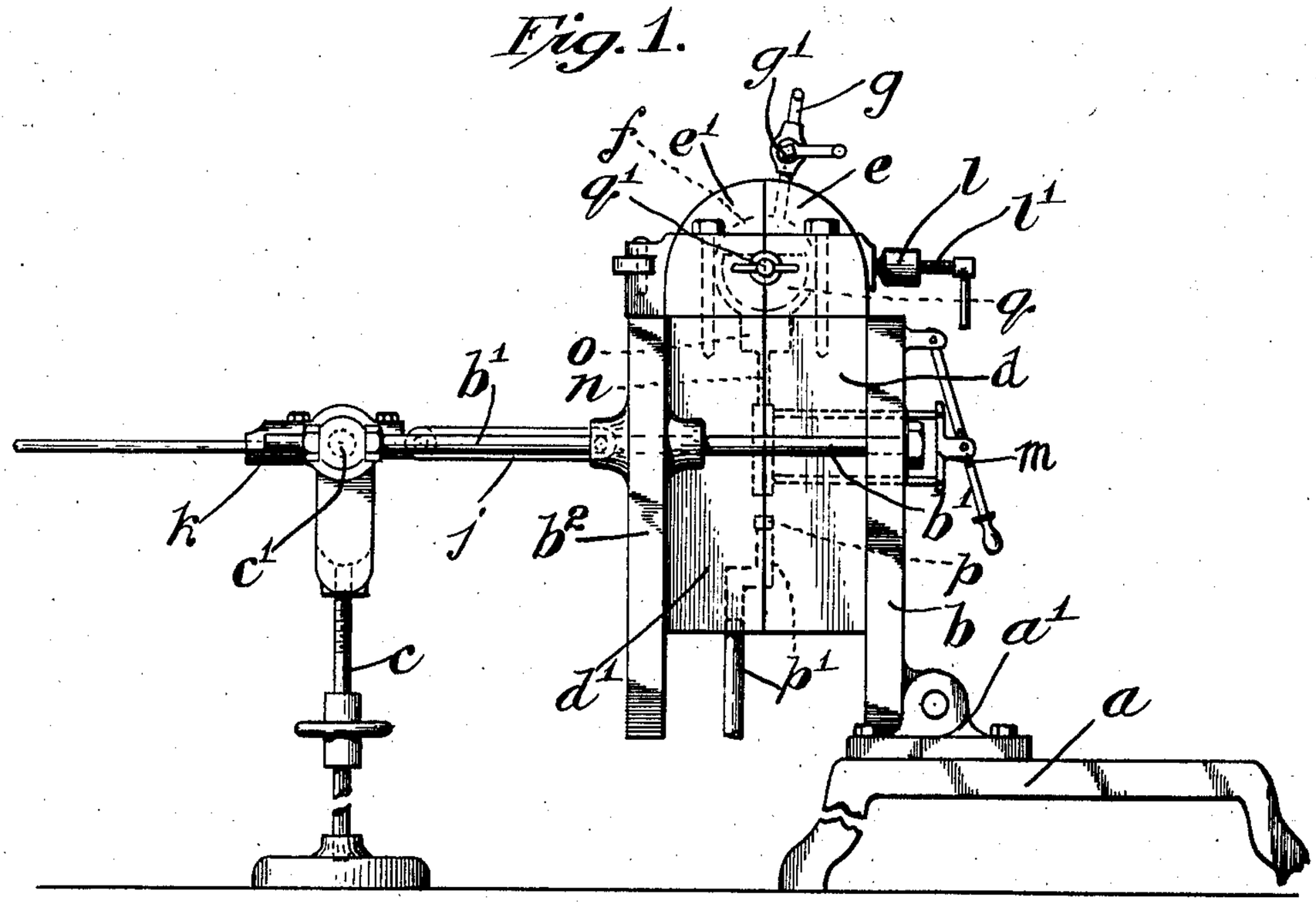
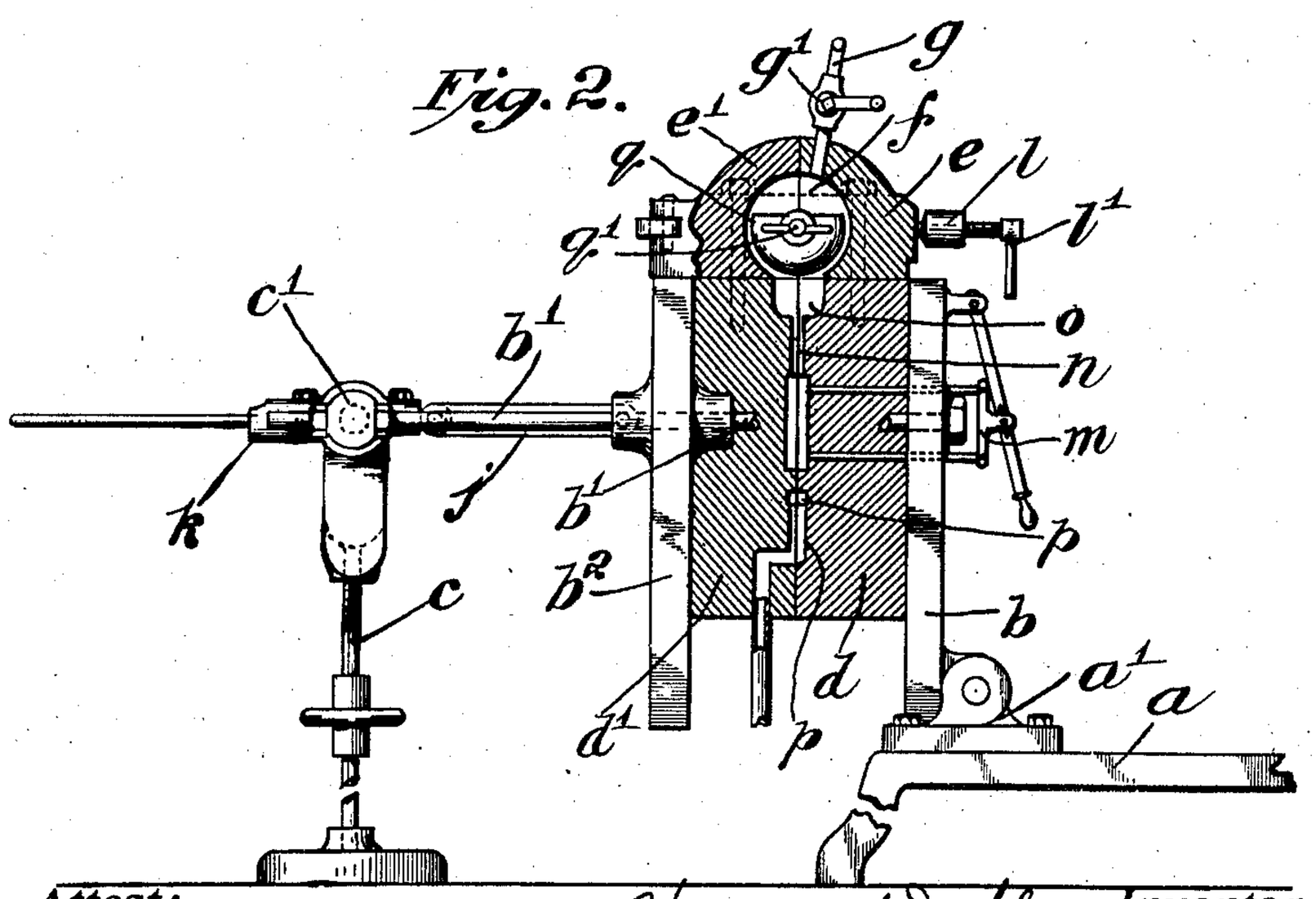


Fig. 2.



Attest:

C. D. Mitchell

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2 SHEETS—SHEET 2.

Fig. 3.

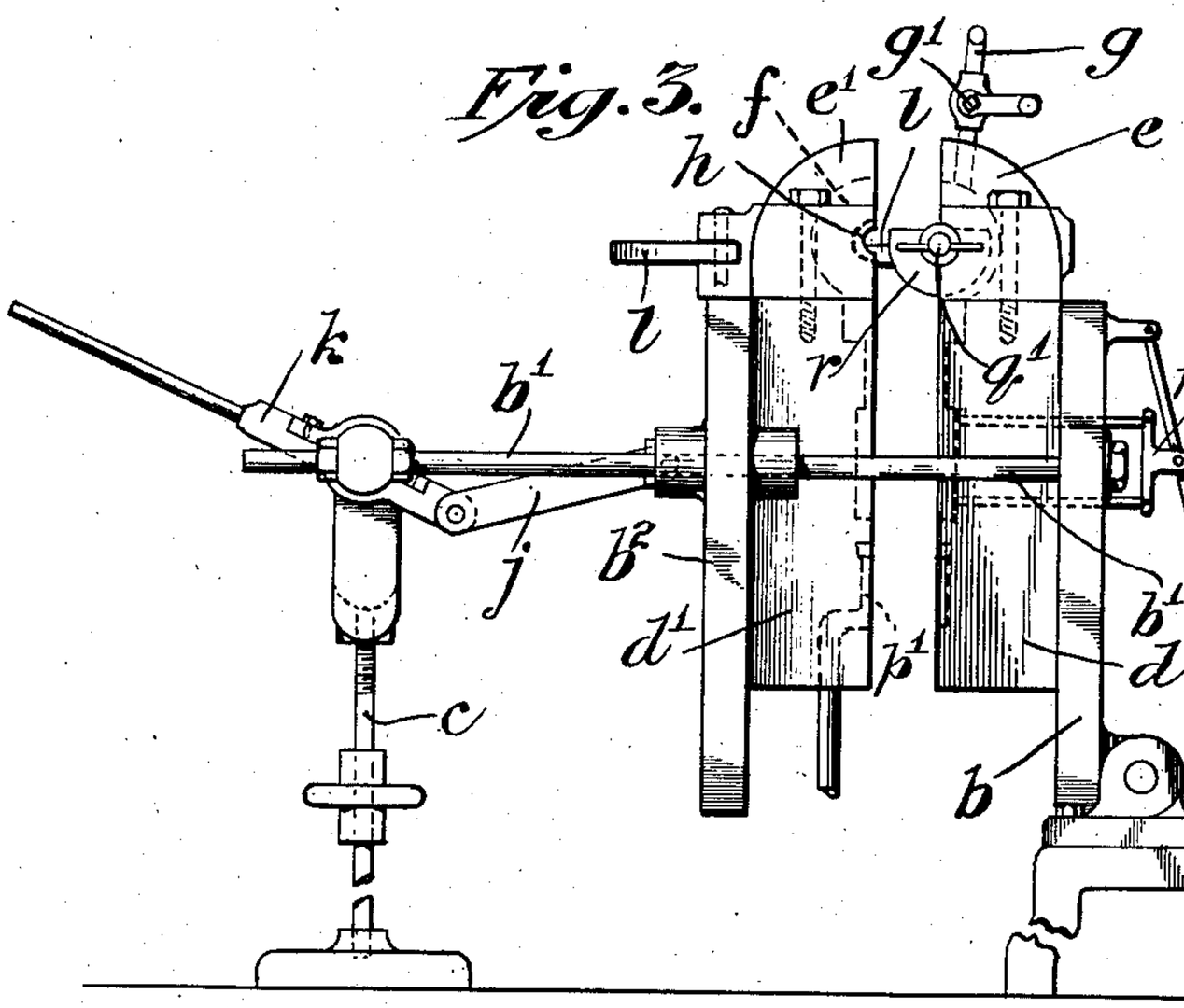


Fig. 5.

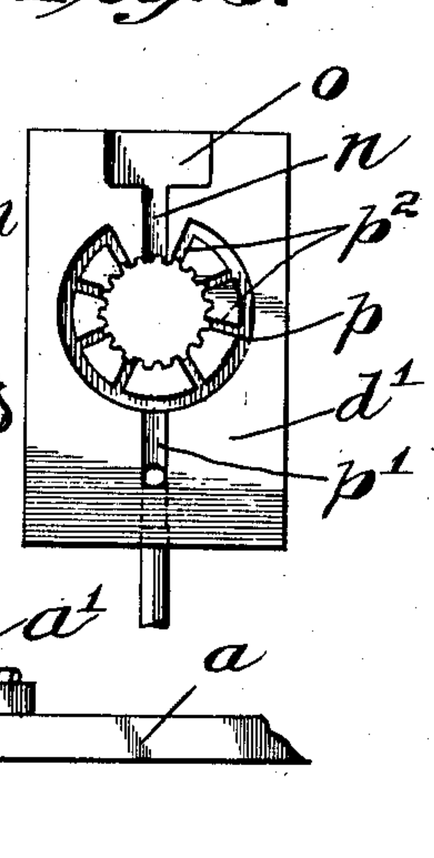


Fig. 4.

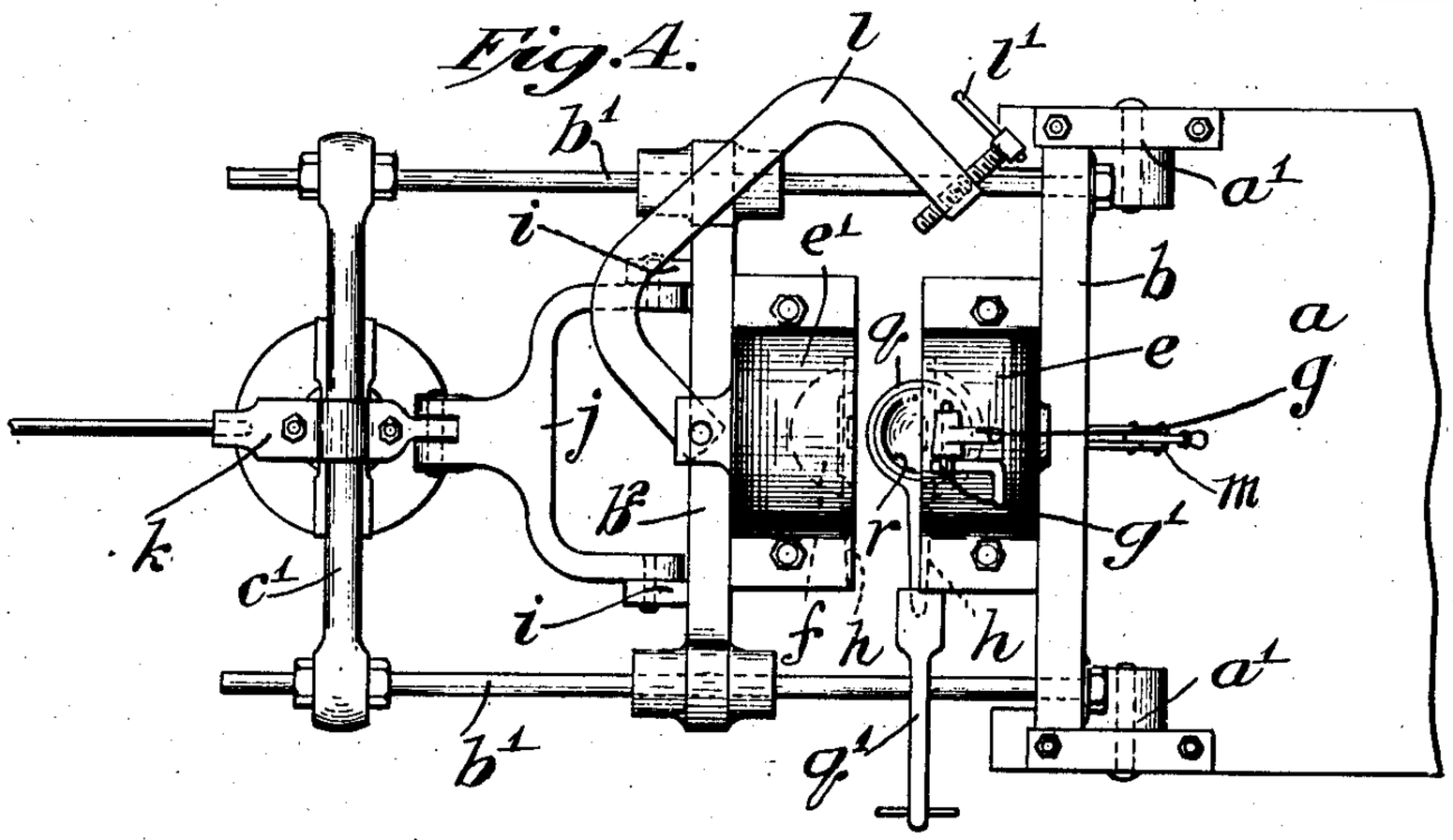


Fig. 6.

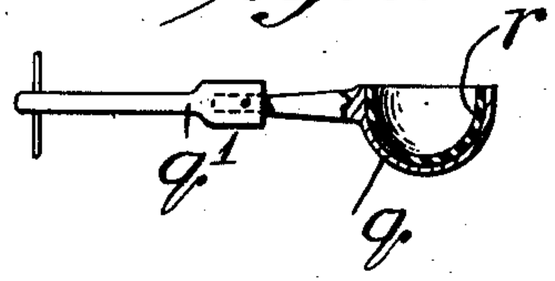
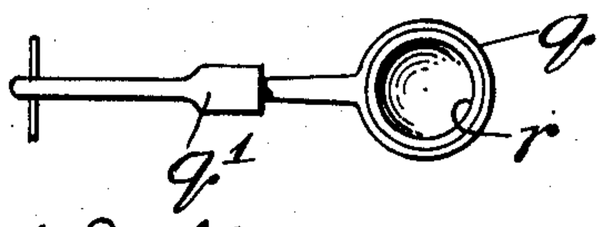


Fig. 7.



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UNITED STATES PATENT OFFICE.

HERMAN H. DOEHLER, OF NEW YORK, N. Y.

ART OF AND APPARATUS FOR CASTING FLUID METAL.

973,483. Specification of Letters Patent. Patented Oct. 25, 1910.

Application filed January 12, 1909. Serial No. 471,886.

To all whom it may concern:

Be it known that I, HERMAN H. DOEHLER, a citizen of the United States, residing in the borough of Brooklyn, city of New York, county of Kings, and State of New York, have invented certain new and useful Improvements in the Art of and Apparatus for Casting Fluid Metal, of which the following is a specification, reference being had therein to the accompanying drawings, which form a part thereof.

My invention relates to the art of and apparatus for casting fluid metal and more particularly for casting such metal under elastic fluid pressure, for compacting and compressing the cast fluid in the mold.

There have, heretofore, been devised various methods and apparatus for casting fluid metal in molds and compressing or compacting the same therein, but the nature thereof has been such as to restrict the character of the metal cast, or the character of the mold used, thus placing limitations upon the art and the apparatus which would make them impracticable for high class work or for commercial use. In most cases, excepting in processes and apparatus in use in making dental plates, or similar articles, wherein but one article is made from a mold, the metal being cast is drawn directly from a melting pot filled with metal kept in a fluid state by a furnace surrounding said pot, a pumping or forcing member being submerged in this metal with the twofold object of a convenient withdrawal of a portion of the metal for use in casting, and the maintenance of high temperatures in the pumping or forcing member to prevent the chilling of the metal and that obstruction of the member resulting therefrom. This type of apparatus is capable of high efficiency with metal having a low fusing point, such as zinc, and tin mixtures, although even with such, in most alloys the metal deteriorates rapidly, becomes rapidly oxidized, and loses its strength and utility for making castings, by reason of the continued heating thereof, the presence of dross and oxids, and that affinity of the alloy for the metal entering into the apparatus. These objections apply to practically all of the white metal alloys having a low fusing point, and in addition to these objections, it is impossible to use an alloy having a high fusing point in this type of apparatus because of the intense heat required to flux same and the increased tendency of the alloy to consume the apparatus when the metal is fluid or to braze the various moving parts thereof together when the metal chills. It has been suggested that the substitution of an elastic fluid such as compressed air for forcing the metal and compressing it in the mold, would obviate these objections, but I have found that to withstand the high temperatures within a melting pot, it would be necessary to use materials in making the melting pot, and the pressure pot, which would withstand the high temperatures, such as lava, or graphite, and that the strength of these materials is not such as to withstand the heavy pressure necessary to effect that high degree of compression of the metal in the mold, necessary to secure perfect castings with good sharp outlines. It has also been suggested in connection with the manufacture of car wheels, pig iron or other similar articles that the fluid metal be first poured into the mold and thereafter subjected to pressure from a moving part of the mold or compressed air, to compact same. This proposed process is impracticable as failing to secure that precision in the casting required in high class work and furthermore as being inoperative with aluminum or brass alloys or even white metal alloys, which when cast set in the mold and chill almost instantaneously.

The main object of my invention is to provide a method of casting fluid metals having a high fusing point, such as brass or aluminum, capable of being conducted under such conditions as will permit the production of commercial castings in large quantities from one and the same mold.

A further object is to provide a method of this character wherein a substantially exact quantity of fluid metal will be rapidly conveyed to the mold and be practically simultaneously subjected to high pressure, so that the pouring and compressing will be substantially simultaneous and thus avoid those imperfections in the castings which would result were the metal permitted to set, even through the chilling of the portion thereof contacting with the mold before subjected to pressure.

A still further object is to provide a method or art of the character described, wherein the elastic fluid pressure relied upon to compress or compact the metal in the mold, will also serve to increase the rapidity of the charging of the mold; and wherein

the fluid metal as it enters the mold will be relieved from any back pressure of air compressed in the mold by the inflowing metal, in a manner to direct or convey the fluid metal into all parts of the mold.

A still further object is to provide a method or art wherein the equilibrium of the pressures on the opposite sides of the metal being cast will be destroyed with the heavier pressure outside the mold to avoid the imprisonment of air in the metal being cast, either by the splashing of the metal prior to its entering the mold, or a rotary movement or swirling of the metal after it enters the mold, or the compression of air between the incoming metal and the walls, abutments or angles of or in the mold.

A still further object is to provide a method or art by which the molten metal will be first poured, and after pouring be followed up by fluid pressure while it is concentrated in and flowing slowly through a constricted channel passing to the mold, whereby the metal will enter the mold and be compacted therein under high pressure with a resultant perfect casting with sharp outlines.

A still further object is to provide an apparatus for carrying out the aforesaid process, art or method which may be used without subjecting same to those high temperatures necessary to reduce the metal to a fluid state and which will withstand the high pressure used in carrying out said process, art or method.

A still further object is to provide an apparatus of this character utilizing compressed air for charging and compressing the fluid metal, which embodies therein a pressure chamber through which the molten metal is introduced to the apparatus, said pressure chamber being so constructed that the flow of the metal will be so directed and controlled as to avoid a jet of air being directed upon the surface of the molten metal, with a resultant splashing of the metal, reduction in the quantity of same passing to the mold, the imprisonment therein of air from said jet, or its entrance to the mold ahead of the fluid metal.

A still further object is to provide in an apparatus of this character a removable ladle which will have the twofold features of non-conductivity to prevent the chilling of the metal prior to its introduction to the apparatus or the mold, and sufficient strength to resist the high pressures prevailing in the pressure chamber during the process of casting.

A still further object is to provide in an apparatus of this character a ladle which may be inverted for the purpose of pouring the metal into the mold and when so inverted will act to receive the air current thereon, deflect it from a straight course and protect the fluid metal therefrom until it has left the pressure chamber and is flowing toward the mold.

A still further object is to provide in an apparatus a removable ladle adapted to be mounted in a closed pressure chamber, the bearing of which will be so constructed as to cause the pressure within the pressure chamber to cause said bearing to automatically pack itself to prevent the escape of the air or other elastic fluid about said bearing.

A still further object is to provide in an apparatus of this character, the pressure chamber of which will have a spherical interior and a depressed portion adjacent to the outlet thereof, whereby the metal poured from the ladle will be collected and positioned below the lines of curvature of the compression chamber and the pressure exerted by the compressed air will be directed upon the top of same so as to avoid the splashing of metal due to the obstruction of the direction of flow of the air as defined by the sides of the pressure chamber.

A still further object is to provide an apparatus wherein a measured quantity of metal substantially equaling the volume of metal necessary to form a given casting, will be introduced to the pressure chamber with each actuation of the apparatus, thus avoiding the clogging or fouling of the apparatus, and causing the entire quantity of metal used with each casting to be removed from the apparatus and the mold, at the end of each casting operation to insure clean metal free of oxid and dross for each casting.

A still further object is to provide an apparatus of this character embodying therein means whereby a suction may be applied so as to relieve the pressures within the mold at those points where the inflowing metal would ordinarily pocket and compress the air, thus directing the flow to these particular localities within the mold and avoiding surface imperfections as well as accomplishing that venting of the mold essential to casting under pressure, which apparatus will also embody means for feeding the metal under pressure.

A still further object is to provide an apparatus of this character wherein all parts thereof are readily accessible after each casting operation in order that the entire measured quantity of metal may be removed from the mold, the pressure chamber, in case of an imperfect casting, and the ingate to the mold.

A still further object is to provide an apparatus of this character having an open ingate and no moving part in or about same thus avoiding all such parts which, when used with higher fusing metals, become inoperative through brazing, wearing, warping or assimilation by the metal being cast.

A still further object is to provide an apparatus which shall consist of a bi-part mold, a bi-part pressure chamber and a bi-part ingate, the parts of which elements respectively may be simultaneously separated; and when united may be made perfectly air tight for insuring a more or less perfect vacuum within the mold, and the maintenance of the pressure within the pressure chamber, and a still further object is to provide an apparatus of this character which will be simple in design and inexpensive to manufacture.

The invention consists in a process, art or method of casting fluid metal which consists broadly in pouring a measured quantity of fluid metal from within an inclosed chamber into a metallic mold and forcing and compressing the metal by following it up with an elastic fluid under high pressure, and in such other novel features of said method or art; and in the novel features of construction and combination of parts of the apparatus for carrying out said process, all as hereinafter set forth and described and more particularly pointed out in the claims hereto appended.

Referring to the drawings:—Figure 1 is a side elevation of an apparatus embodying my invention adapted to carry out or perform my aforesaid method or art; Fig. 2 is a vertical section of the apparatus shown in Fig. 1; Fig. 3 is a view of said apparatus similar to that shown in Fig. 1, excepting that the sectional mold and pressure chamber are shown partly opened; Fig. 4 is a plan view of the apparatus shown in Fig. 3; Fig. 5 is a detailed view of one member of a sectional mold; Fig. 6 is a detailed view of the ladle showing the bowl thereof in section, and Fig. 7 is a plan view of the said ladle.

Like letters refer to like parts throughout the several views.

In the practice of my aforesaid method or art, I aim to secure all of those advantages of pouring molten metal secured by the ordinary foundry practice, with the additional advantages found in the more recently developed practice of casting molten metal under pressure in metallic molds. To secure the desired results, the handling of the molten metal must be such as to avoid the completion of the casting operation by either of these practices, a necessity which in the practice of my method or art presents a clear line of demarcation between the steps, principles or characteristics of these two practices utilized, which in some instances, is however, so narrow as to result, to all intents and purposes, in a substantially continuous or simultaneous application of the two principles.

In carrying out my aforesaid method or art, the first essential is an inclosed pressure chamber from which the metal is poured, and the pressure within which is applied at the proper instant; the second essential is a metallic mold adapted to receive and shape the molten metal; the third essential is a constricted channel connecting the said pressure chamber and the said mold through which the molten metal must pass and in which it will be concentrated during the casting operation so as to form a moving barrier of molten metal between the mold and the pressure chamber, flowing toward the former, the movement of which will be accelerated by the application of elastic fluid pressure within the chamber, and the presence of which in the said constricted channel will exclude the elastic fluid under compression from said mold so that the entire expansive force of said fluid will be utilized in accomplishing the rapid charging of the mold and the compression of the molten metal simultaneously with its entrance to said mold; and the last essential is the use of a measured quantity of molten metal, and by measured quantity I mean a quantity approximating in weight and bulk the volume of the metal in the completed casting. This assumes importance because of the necessity for eliminating the melting pots of the prior art, for preserving the quality of the metal and preventing its deterioration by reason of its impregnation with oxygen or other gases due to the action of the fluid under compression thereon, and for securing the desired degree of compactness of the metal through the said elastic fluid under comprission, while it is within the mold.

With these four essentials in mind, I will now describe in detail, the manner of carrying out my aforesaid method or art, which will be more readily understood by referring to Figs. 2 and 5 of the accompanying drawings.

The metal to be used in casting is melted or reduced to a fluid state in a separate melting pot or crucible, the usual precautions being taken to preserve the purity of the metal and maintaining it at the desired temperature. This molten metal as it is to be used, is removed from this melting pot (not shown in the drawings) by a ladle, which preferably is insulated to prevent heat radiation, and the filled ladle is placed within the pressure chamber. By reference to said Figs. 2 and 5 it will be observed that the pressure chamber is disposed above the mold proper and is in communication therewith through an ingate constricted relative to the said pressure chamber. The mold and the walls of the pressure chamber are closed after the ladle is placed in the latter, the pressures within the mold and the said chamber at this stage being balanced so as to have an equilibrium of pressures on both sides of the said ingate. Under normal

conditions this pressure will be one atmosphere, although if desired, as will more fully appear hereinafter, a more or less perfect vacuum may be formed within the mold and the pressure chamber, in order to facilitate the charging of the mold, or to prevent the imprisonment of air between the inflowing metal and the sides of, or obstructions, or abutments in, the mold, by directing the flow of metal, in intricate castings, as it enters the mold. The same result under most conditions can be secured by freely venting the mold adjacent to said abutments or obstructions; and the use of a vacuum or partial vacuum, while in most cases desirable, is not absolutely necessary in the practice of my said method or art. It will be observed, however, that whether or not a vacuum is used the pressures throughout the apparatus when it is ready for carrying on my method or art is the same. The apparatus being thus prepared, the ladle containing the molten metal is overturned, pouring the contained molten metal directly into an ingate of a mold or in a sub-chamber in the pressure chamber, and thence to the ingate of the mold. When so poured, the molten metal will be concentrated within said ingate or said sub-chamber and said ingate, either of which is constricted relative to the pressure chamber, and will begin to flow by gravity through said ingate into the mold. Immediately after, or practically simultaneously with, the pouring of the molten metal, air or other gas under high pressure, the pressure varying according to the nature of the casting being made, is admitted to the pressure chamber in a manner to prevent an air jet from impinging directly upon the molten metal and to result in the subsequent expansion of this air accomplishing the charging of the metal. Were an air jet to impinge directly upon the surface of the molten metal, it would have a tendency to splash same about the pressure chamber, imprison air in the metal being charged, and possibly pass through the metal in the ingate and enter the mold before the metal itself.

It will be observed that as the metal is poured into the constricted passage forming the ingate to the mold, it is flowing under conditions found common in foundry practice and forms a moving barrier of molten metal between the pressure chamber and the mold, there being an equilibrium of pressures on the opposite sides of said moving barrier. As pressure is applied to the pressure chamber, however, this equilibrium is destroyed with the preponderating pressure on the side toward the pressure chamber. This destruction of the equilibrium of pressures, serves to suddenly accelerate the flow of the metal converting the entire charge into a metallic ram as it enters the mold and forcing it to all parts thereof, filling up all cavities and interstices within the mold practically instantaneously. The said pressure, back of the inflowing metal, by its continued expansion serves to compress the metal substantially simultaneously with its entry into the mold, such compression being by either a direct superficial pressure upon the last of the metal entering the mold, or through the volume of metal flowing thereto.

In carrying out said method or art I have found that irrespective of the fusing point of the metal used, it will set practically simultaneously with its entrance to the mold, so that it is essential to my method or art that the pressure for compacting or compressing the metal in the mold be applied substantially simultaneously with the entrance of the metal to the mold in order to insure perfect castings, the specific gravity of the metal used regulating the instant of application of the pressure. The use of a vacuum in carrying out my process has, as its main advantage, the elimination of air within the mold. This is not for the purpose of reducing the pressure necessary to secure the desired degree of compression of the metal, but it is apparent that air in the mold might be compressed and imprisoned between the metal and a portion of the mold, or in the metal itself in case its entrance to the mold should be by a swirling motion and thus cause an imperfect finish or blow holes in the casting, which condition would be largely obviated by a reduction of the volume of air in the mold prior to the entrance of the metal.

In certain intricate castings, the form of the mold must be such as to present small angles or pockets therein, to retard, or impart a natural tendency to, the flow of the metal which through the rapid setting or chilling of the metal being cast, might have a tendency to either imprison air at this point, or retard the flow of metal in the mold to an extent to permit it to chill or set before the mold is completely filled. To obviate this possibility, I arrange at any such point an additional vent or conduit leading to a vacuum chamber or pump, not shown, so as to not only reduce the resistance at such a point but induce a natural flow of the metal to any point which, under normal conditions, would be less readily filled with the molten metal. This direction or control of the inflowing metal is essential only in certain types of castings and therefore is not absolutely essential to the invention considered broadly. It has, nevertheless, an important bearing upon the continued practice of the invention and as a minor detail is a desirable feature in the successful practice of my method or art.

In the accompanying drawings I have

illustrated an apparatus embodying the essential characteristics necessary in carrying out my heretofore described method or art. This apparatus comprises a base or frame *a* having straps *a'* thereon in which is mounted a mold plate *b*. To adapt this plate to molds into which the metal must flow at different angles, I preferably mount said plate *b* pivotally in said straps. Carried on opposite sides of said plate *b* are a plurality of guide rods *b'*, the outer ends of which are secured to a rod *c'* carried on an adjustable standard *c*. It will be observed that the pitch of the plate *b* may thus be regulated by raising or lowering the rod *c'*.

Slidably mounted on the rods *b'*, by means of elongated bosses thereon, is a second mold plate b^2 parallel with, and oppositely disposed relative to, the plate *b*. The rods *b'* are arranged at a point intermediate the top and bottom of said plates *b* b^2 in order to avoid over-balancing of these plates. The plates *b* b^2 are adapted to have secured thereto, in any desired manner, the parts *d d'* of a sectional metallic mold adapted to shape the fluid metal. The plate b^2, as will more fully appear hereinafter, being movable relative to the plate *b* upon the guides *b'*, it will be understood that the parts of the mold may be readily separated for the purpose of ejecting a finished casting.

Secured to the bi-part mold *d d'* are the parts *e e'* of a sectional head forming the pressure chamber *f*, the parts *e e'* of said head being adapted to be separated, with the parts of the mold, for the purpose of introducing the charge of molten metal thereto. It will be observed that the head containing the pressure chamber surmounts the mold so that the operation of charging may be initiated through gravity. While I have shown a bi-part head, such is merely a matter of convenience, and a head employing any means for permitting access to the pressure chamber will be the full equivalent of the head described. Leading to the pressure chamber *f* is an air line *g* controlled by a valve *g'* which may or may not contain a vent as desired. Opening into the pressure chamber *f* is a bearing *h* in the head, which bearing is adapted to be opened when the head is opened in order to permit the mounting of the pouring ladle therein. This bearing is below the inlet of the air line *g* and at one side thereof, to position the ladle directly below said air inlet. The bearing *h* is tapered with the larger end adjacent to said pressure chamber so that the pressure within said chamber will have a tendency to force the ladle outwardly and thus cause its shank to pack against the sides of said bearing. The binding between said bearing and said shank is immaterial as the same will occur only after the ladle has been turned to pour the metal.

Pivotally connected to lugs *i*, on the mold plate b^2 is a yoke *j* by means of which the said mold plate b^2 is reciprocated on the rods *b'* by a lever *k* pivotally mounted on the rod *c'*, and having its short arm pivotally connected to the said yoke. Suitable reinforcing or locking means for the head *e e'* are provided, such means in the simplest form consisting of a vise *l* pivotally mounted on one of the parts of said head as *e'* and carrying an adjustment screw *l'* adapted to engage the other part of the head *e*, for the purpose of holding the abutting surfaces of said parts *e e'* in engagement with each other, irrespective of the pressures within the pressure chamber *f*. The dimensions and adjustment of the yoke *j* and lever *k* are such that when the mold is closed, these parts will be alined, thus transmitting all strains to the rods *b'* through the said mechanism and the rod *c'*.

Either of the parts *d d'* of the mold may be fitted with a suitable ejector mechanism indicated in the drawings by the letter *m*. A sectional mold adapted to be opened after the completion of a casting and provided with an ejector mechanism for removing the casting, is old and well known in this art and no claim of invention as to this feature *per se* is made, such being merely a necessary incident in any casting apparatus utilizing metallic molds. The details of these features are therefore immaterial to the invention and any desired construction of sectional mold and ejector mechanism may be utilized.

In my improved apparatus it will be observed, the pressure chamber and the mold constitute practically the entire apparatus utilized in effecting the charging of the latter, which construction not only affords compactness and simplicity, but permits the adaptation of the apparatus to each particular casting.

It is to be observed that the air line *g* is connected to the stationary part of the mold head *e* the feed pipe being flexible at some point to permit that slight movement of the head in varying the angle thereof. The manner of sinking the mold or die is the same as in ordinary machine shop practice so far as the configuration of the casting itself is concerned, but for convenience of expression the intaglio portion of the plates *d d'* will be designated the interior of the mold, it being understood that this term refers to the cavity into which the molten metal is charged.

The pressure chamber *f* is preferably spherical in shape for the threefold purpose of limiting the dimensions thereof, providing the proper clearance for the ladle in turning, and for directing the flow of air adjacent to the bottom thereof so as to avoid a tendency of the air to act indirectly in a

jet upon the molten metal. The chamber *f* is in direct communication with the interior of the mold through a constricted passage way, the dimensions of which will vary with the size and character of the casting to be made, with the metal being cast and to insure the proper application of the air or other fluid under compression to the molten metal. The width of this passage way will under all conditions, however, necessarily be constricted relative to the pressure chamber. In the preferred form of the invention as shown in the accompanying drawings, the passage way consists of an ingate *n* leading directly to the interior of the mold, and a sub-chamber *o* of much greater capacity than the said ingate having a wide mouth, opening into and below the curve of the bottom of the pressure chamber. A graduated passage way between the pressure chamber and the interior of the mold is for the purpose, not only of controlling the flow of metal into the mold and limiting the dimensions of the sprue, but for the further purpose of momentarily checking or retarding the flow of the metal after it is poured, so as to insure the application of the pressure at the proper instant. The enlarged head of the passage way which I have termed the sub-chamber *o*, permits the metal contacting with the sides thereof to set without interfering with the application of pressure to a sufficient volume of metal to fill the mold. In measuring the quantity of molten metal to be used with each casting, allowance must be made for the shell of metal which will be formed in this sub-chamber and in the ingate itself. The sub-chamber *o* is large enough to receive the contents of the ladle and retain it below the pressure chamber in a position where the air currents when admitted to the pressure chamber will pass over same in a manner which will be more fully described hereinafter.

It will be observed that the ingate is unobstructed in any way and that no sprue cutter or other moving part is necessary to insure the production of a perfect casting. This feature is of great importance as when using metals having a high fusing point, a sprue cutter, arranged as it would be, at the point where the temperature would be the highest, could not withstand the ordinary wear and tear of use, and would result in the frequent break down of the machine with the resultant necessity for renewal of parts. The high temperatures would also make it difficult to secure a proper fit, and the warping of the metal in the cutter would make it practically inoperative. In the ordinary up-feed pressure casting machine, a sprue cutter is necessary to close the mold and prevent the portion of the metal forced thereinto under pressure flowing by gravity back to the pressure pot or cylinder. In a machine of the character heretofore described, wherein gravity is utilized in charging, it is not required to provide any means for the purpose above referred to.

Referring more particularly to Fig. 5 of the drawings, I sometimes partially surround the interior of the mold with a channel as *p* which channel is in communication through a duct *p'* with a suction box, or pump, not shown. Leading from this channel are a plurality of shallow ducts p^2 leading to the interior of the mold through which the air in the mold and the pressure chamber may be drawn for the purpose of reducing the pressures in these parts. The expedient of creating a partial vacuum within a mold is old in the art of casting, and I make no claim of invention thereto broadly. In arranging the ducts p^2, however, I not only vacuate the mold but so dispose the ducts with regard to the natural flow of the incoming metal as to direct the flow thereof to special points in the mold where the natural tendency of the metal would be either to pass same, or compress the air within the mold between it and the sides of the mold.

I believe it to be new to direct the flow of metal in the mold by means of a suction or mechanism for creating such, at certain points, and intend to claim such.

Where a mold has a number of moving parts therein, the channel and duct arrangement heretofore described, must be varied to meet the conditions peculiar to said type of mold; but would retain the essential features of the ducts p^2 communicating with a suction box or pump through an intermediate chamber.

In carrying out my method or art or in using my heretofore described apparatus, it is necessary to prevent heat radiation from the metal while it is being conveyed from the melting pot or crucible to the pressure chamber.

A ladle of graphite, fire clay or other similar refractory material would be desirable but as the ladle acts as a deflector and distributer for the air jet such materials would not possess the requisite strength. To obviate this difficulty, I use a metallic ladle, the bowl of which is lined or coated with graphite or fire clay, or both, said insulated lining *r* being molded within said bowl and retained in place by suitable anchors entering holes sunk part way through the metal of the mold. It will be observed that I thus provide a rotary ladle the bowl of which consists of reinforced refractory material, whereby heat radiation from the molten metal is prevented before pouring, and the reinforcement, after pouring, acts to receive and deflect the fluid jet without injury to the refractory lining. The curve of the ladle *q* while on a shorter radius, conforms to that

of the pressure chamber *f* so that the fluid jet as it enters the pressure chamber is deflected against the sides thereof for a sufficient distance to impart thereto a rotary movement so that in case the air should follow the sides of the pressure chamber to the bottom thereof, it will have a direction of flow which would carry it across the sub-chamber where, meeting an air current from other sides, it would pass up into the bowl rather than in a jet upon the metal in the sub-chamber. It will be readily observed that were the metal to project into the pressure chamber in the course of said currents, the air currents would pick up such metal and splash it about the chamber. The ladle *q* has an elongated handle *q'* having thereon a circular shoulder adapted to engage the outside of the pressure chamber adjacent to the bearing *h'*. The handle between said shoulder and the bowl of the ladle is tapered to conform to said bearing.

While the heretofore described apparatus is suitable for carrying out my method or art, it is apparent that said method or art may be carried on in any desired form of apparatus.

In the practice of my said art or method, a measured quantity of metal having been introduced to the pressure chamber in the ladle, and the said chamber and mold closed, and locked so as to withstand the pressures within same, the ladle is overturned and the metal poured in the same manner as is now common in foundry practice, the metal being delivered from the ladle to the constricted passage way between the pressure chamber and the mold, wherein the metal is accumulated and concentrated, substantially simultaneously. The reduced discharge of said passage way will retard or momentarily check the flow of the metal, by gravity, into the mold and at this instant fluid pressure is applied to said chamber, the expansion thereof acting upon the molten metal in the passage way. It will thus be observed that the pressure is applied so as to follow up the metal flowing by gravity into the mold, and that the metal itself forms the only barrier between the pressure chamber and the mold. This insures the charging of the mold under conditions which exclude the compressed fluid from the metal being cast, which compacts the metal slightly, prior to its entrance to the interior of the mold, and which compresses it substantially simultaneously with its entrance to said mold.

By freely venting the mold at certain points or creating a vacuum or partial vacuum throughout the apparatus, by means of ducts leading from certain points of the mold, the direction of the flow of the metal within the mold may be controlled so as to prevent blow holes in the casting or imperfections in the finish due to the setting or chilling of the metal before it entirely fills the mold, by reason of the pocketing of air in the metal or the compression of air between the incoming metal and the sides of the mold.

It will be observed that as heretofore stated, the pressures within the mold and the compression chamber are balanced prior to the application of pressure, and that the pressure, when applied, destroys this equilibrium of pressures with the preponderating pressure within the pressure chamber; and that furthermore, the sole function of the fluid under compression is to accelerate the feeding movement of the metal to the mold and its compression therein when charged, this fluid not having any lifting action.

The detailed mode of operation of this apparatus described is substantially as follows: The sections *d d'* of the mold, and the sections *e e'* forming the compression chamber are separated by raising the lever *k*. This, through the yoke *j* slides the mold plate b^2 on the guide rods *b'*, away from the fixed mold plate *b*. Before actuating the lever *k* it is necessary to disengage the vise *l* from the section *e* of the head. When so opened, the die may be smoked or otherwise coated to protect it from the molten metal, an expedient well known in this art. The ladle *q* is then filled with a predetermined quantity of molten metal, and placed in the pressure chamber *f*, with the tapered portion of the handle in the tapered bearing *h* and the shoulder q^2 abutting against the outside of the head *e e'*. The lever *k* is then lowered to close the plates *b* b^2 and the mold and head sections carried thereby, the said lever and the yoke *j* being on a horizontal center when these parts are closed. If desired any suitable face packing may be provided between the sections of the mold and the head to minimize loss of pressure through leakage. The vise *l* is then swung so as to inclose both sections *e e'* of the pressure chamber head, and the adjustment screw *l'* set so as to clamp the sections of said head together. When a vacuum is used, the mold is then placed in communication with a suction box, or pump in any desired manner, through the duct *p'*, the channel *p* and the shallow duct p^2. This creates a vacuum or partial vacuum within the mold, the pressure chamber and the passage way connecting same. These steps which in practice require only a fraction of a minute, prepare the apparatus for the casting process. The ladle *q* is then quickly overturned by means of its handle *q'* to discharge the molten metal into the sub-chamber *o* and ingate *n*, the refractory or insulating lining of said ladle preserving the condition of the metal while the apparatus is being prepared. When the metal is thus poured, it begins to flow by gravity

into the mold, the graduation of the sub-chamber and ingate, serving to retard this flow or check it momentarily so as to concentrate and accumulate practically the entire bulk of metal between the pressure chamber and the mold. Thereupon the valve g' in the air line g is opened and quickly closed again and air or other elastic fluid under heavy pressure is admitted to the pressure chamber in a jet. The ladle q being completely overturned, is directly in the path of this jet, and serves to deflect it in all directions giving it a direction coinciding with the interior of the pressure chamber. In case the currents thus created follow the walls of the chamber to the bottom thereof, they will meet above the sub-chamber and expand without affecting the surface of the metal therein. The time of application of the pressure will vary relative to the pouring of the metal, with the specific gravity of the metal, its condition, or the alloy being used, and it may be either practically simultaneously with the pouring, or slightly thereafter. This pressure will be applied while the metal is still in the ingate and flowing toward the mold by gravity and it is apparent that the metal itself acts as the only barrier between the pressure chamber and the mold, and offers the only resistance to the pressure. This condition insures an acceleration of the movement of the metal, and no air can penetrate the mass. This mode of operation has the further advantage that no limitation within reason is placed upon the quantity of metal cast at a single operation, such being dependent solely upon the size and strength of the apparatus, the character of the die, and the capability of developing sufficient pressure. As the metal enters the mold, so far as I have been able to determine, it is in a more or less compact stream and is substantially instantly forced to all parts of the mold and compressed and compacted therein by the pressure from the pressure chamber.

I have found that the conductivity of the metal in the mold, sub-chamber and ingate results in the chilling or setting of metal therein practically instantaneously, permitting a quick ejection of a casting, but leaving a quantity of metal within the sub-chamber and the ingate. The action of the pressure, however, is so rapid as to fill the mold from the molten metal not contacting with the metal of the apparatus, leaving a small sprue on the casting which may readily be removed after the casting is ejected. It is apparent, therefore, that the mold should be separable along a line passing through the sub-chamber o and ingate n to permit this sprue to be removed simultaneously with the completed casting.

The casting having been completed as described, the operation of opening the die is repeated, and the ejector mechanism m operated to throw the casting from the mold.

When the jet acts upon the reinforcement of the ladle, it imparts an outward thrust thereto which packs the tapered portion of the handle q' in the tapered bearing h, thus packing the bearing against the high pressure prevailing in the pressure chamber.

By my method or art, and in my apparatus herein described I have successfully cast, alloys rich in copper, and in aluminum, in addition to the so-called white brass, and the ordinary zinc mixtures known as "white metals" and have found that in all metal the castings contain no blow holes or other defects due to the manner of casting same. In fact, the castings show a particularly fine grain, and are more solid and uniform than ordinary sand castings.

The apparatus must be adapted to each mold, and I have found that by varying the direction of the flow of the metal through the ingate I can cast with better results from the same mold. Hence the standard c may be lengthened or shortened to pitch the mold slightly in different directions in the manner heretofore described.

It is not my intention to limit the invention to the precise details as to the method or art, or the construction of the apparatus, as such may be varied without departing from the spirit or scope of the invention. I believe, however, that to cast brass or other high fusing metals successfully, it is essential to utilize both gravity pouring and high pressure substantially as described and that a measured quantity of metal is an essential to this result; and I intend to claim such broadly.

Having described the invention, what I claim as new and desire to have protected by Letters Patent, is:—

1. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of molten metal from within an inclosed chamber into a metallic mold and thereafter forcing and compressing the metal by following it up with an elastic fluid under high pressure.

2. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of molten metal from within an inclosed chamber into a metallic mold and forcing and compressing the metal by subjecting it while it is flowing from said chamber to the mold to an elastic fluid under high pressure.

3. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a constricted passage way leading to a metallic mold, and forcing and compressing the metal

by subjecting it while it is flowing through said constricted passage way to an elastic fluid under high pressure.

4. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a metallic mold, maintaining an equilibrium of pressures within said chamber and said mold while pouring, and destroying the equilibrium of pressures with a preponderating pressure within said inclosed chamber, whereby while the metal is flowing to the mold by gravity its movement is accelerated and it is forced into and compressed in the mold under heavy pressure.

5. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a constricted passage way leading to a metallic mold, maintaining an equilibrium of pressures within said chamber and said mold while pouring, and destroying the equilibrium of pressures with a preponderating pressure within said inclosed chamber, whereby while the metal is flowing to the mold by gravity its movement is accelerated and it is forced into and compressed in the mold under heavy pressure.

6. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of molten metal from within an inclosed chamber into a metallic mold and forcing and compressing the metal by subjecting it while it is flowing from said chamber to the mold to the expansion of an elastic fluid under high pressure.

7. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a constricted passage way leading to a metallic mold, and forcing and compressing the metal by subjecting it while it is flowing through said constricted passage way to the expansion of an elastic fluid under high pressure.

8. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a metallic mold, maintaining an equilibrium of pressures within said chamber and said mold while pouring, and destroying the equilibrium of pressures with a preponderating pressure within said inclosed chamber, whereby while the metal is flowing to the mold by gravity its movement is accelerated and it is forced into and compressed in the mold under heavy pressure by the expansion of an elastic fluid under high pressure.

9. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a constricted passage way leading to a metallic mold, maintaining an equilibrium of pressures within said chamber, said passage way and said mold while pouring, and destroying the equilibrium of pressures with a preponderating pressure within said inclosed chamber, by the expansion of an elastic fluid under high pressure, whereby while the metal is flowing to the mold by gravity its movement is accelerated and it is forced into and compressed in the mold under heavy pressure.

10. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a metallic mold, reducing and maintaining the equilibrium of pressures within said mold and said chamber, and forcing and compressing the metal while it is flowing from said chamber to said mold by expanding an elastic fluid under high pressure in said inclosed chamber.

11. The herein described process, method or art of casting fluid metal consisting of pouring a measured quantity of fluid metal from within an inclosed chamber into a constricted passage way leading to a metallic mold, reducing and maintaining the equilibrium of pressures within said mold, said passage way and said chamber, and forcing and compressing the metal while it is flowing through said passage way to said mold by expanding an elastic fluid under high pressure in said inclosed chamber.

12. In an apparatus for casting fluid metals, the combination of a sectional mold, a head forming a pressure chamber surmounting said mold and adapted to be opened whereby gravity will initiate the flow of fluid metal to said mold, means forming a constricted passage way between said pressure chamber and the interior of said mold, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber and means whereby an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into, and compress it in, the mold.

13. In an apparatus for casting fluid metal, the combination of a sectional mold, a head adapted to be opened forming a pressure chamber surmounting said mold whereby gravity will initiate the flow of fluid metal to said mold, means forming a graduated constricted passage way between said pressure chamber and the interior of said mold whereby metal will be accumulated and concentrated between said pressure chamber and said mold and form a moving barrier between said parts, a receptacle

adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber and means whereby an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold.

14. In an apparatus for casting fluid metal, the combination of a sectional mold, a head forming a pressure chamber surmounting said mold and adapted to be opened, means forming a constricted passage way between said pressure chamber and the interior of said mold whereby an equilibrium of pressures may be maintained in said mold, said pressure chamber, and said passage way whereby gravity will initiate the flow of the fluid metal to said mold through said passage way, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber, and means whereby an elastic fluid under compression may be introduced to said chamber to destroy the equilibrium of pressures within the apparatus with a preponderating pressure within said pressure chamber and follow up the metal, through said passage way and force it into and compress it in, the mold.

15. In an apparatus for casting fluid metal, the combination of a sectional mold, a head adapted to be opened forming a pressure chamber surmounting said mold whereby gravity will initiate the flow of fluid metal to said mold, means forming a sub-chamber opening into and below said pressure chamber and an ingate connecting said sub-chamber with the interior of said mold, said sub-chamber being constricted relative to said pressure chamber and said ingate being constricted relative to said sub-chamber, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber and means whereby an elastic fluid under compression may be introduced to said chamber to follow up the metal through said sub-chamber and said ingate and force it into and compress it in, the mold.

16. In an apparatus for casting fluid metals the combination of a sectional mold, a head forming a spherically shaped pressure chamber surmounting said mold and adapted to be opened whereby gravity will initiate the flow of fluid metal to said mold, means forming a sub-chamber opening into and below said pressure chamber and an ingate connecting said sub-chamber with the interior of said mold, said sub-chamber being constricted relative to said pressure chamber and said ingate being constricted relative to said sub-chamber, a ladle having a bowl conforming to, but of smaller dimensions than, said chamber, means whereby said ladle is pivotally mounted within said pressure chamber and an air line entering said chamber above the pivotal point of said ladle, whereby said ladle after the metal is poured therefrom, becomes an air shield for deflecting the jet and preventing its entering the metal in said sub-chamber, and an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold.

17. In an apparatus for casting fluid metals the combination of a sectional mold, a head forming a spherically shaped pressure chamber surmounting said mold and adapted to be opened whereby gravity will initiate the flow of fluid metal to said mold, means forming a sub-chamber opening into and below said pressure chamber and an ingate connecting said sub-chamber with the interior of said mold, said sub-chamber being constricted relative to said pressure chamber and said ingate being constricted relative to said sub-chamber, a ladle having a bowl conforming to, but of smaller dimensions than, said chamber, means whereby said ladle is pivotally mounted within said pressure chamber and an air line entering said chamber above the pivotal point of said ladle, whereby said ladle after the metal is poured therefrom, becomes an air shield for deflecting the jet and preventing its entering the metal in said sub-chamber, and an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold.

18. In an apparatus for casting fluid metals the combination of a sectional mold, a head forming a spherically shaped pressure chamber surmounting said mold and adapted to be opened whereby gravity will initiate the flow of fluid metal to said mold, means forming a sub-chamber opening into and below said pressure chamber and an ingate connecting said sub-chamber with the interior of said mold, said sub-chamber being constricted relative to said pressure chamber and said ingate being constricted relative to said sub-chamber, a ladle having a refractory lining and a metallic reinforcement covering the outside thereof, and a bowl conforming to, but of smaller dimensions than, said chamber, means whereby said ladle is pivotally mounted within said pressure chamber and an air line entering said chamber above the pivotal point of said ladle, whereby said ladle after the metal is poured therefrom, becomes an air shield for deflecting the jet and preventing its entering the metal in said sub-chamber, and an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold.

19. In an apparatus for casting fluid metals, the combination of a sectional mold, a head forming a pressure chamber surmounting said mold and adapted to be opened, means forming a constricted passage way between said pressure chamber and

the interior of said mold whereby an equilibrium of pressures may be maintained in said mold, said pressure chamber and said passage way whereby gravity will initiate the flow of the fluid metal to said mold through said passage way, means for reducing the pressures within the apparatus, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber, and means whereby an elastic fluid under compression may be introduced to said chamber to destroy the equilibrium of pressures within the apparatus with a preponderating pressure within said pressure chamber and follow up the metal, through said passage way and force it into and compress it in, the mold.

20. In an apparatus for casting fluid metals, the combination of a sectional mold, a head forming a pressure chamber surmounting said mold and adapted to be opened, means forming a constricted passage way between said pressure chamber and the interior of said mold whereby an equilibrium of pressures may be maintained in said mold, said pressure chamber and said passage way whereby gravity will initiate the flow of the fluid metal to said mold through said passage way, means for reducing the pressures within the apparatus, comprising a shallow duct formed in the mold block leading to a definite point or points in the interior of the mold whereby the pressure is reduced at such points, a main channel communicating with said duct or ducts, and means for creating a vacuum within said last mentioned channel, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber, and means whereby an elastic fluid under compression may be introduced to said chamber to destroy the equilibrium of pressures within the apparatus with a preponderating pressure within said pressure chamber and follow up the metal, through said passage way and force it into and compress it in, the mold.

21. In an apparatus for casting fluid metals, the combination of a sectional mold, means for closing and locking the said mold, a sectional head carried by and movable with the sections of said mold respectively, and forming a pressure chamber surmounting said mold whereby gravity will initiate the flow of fluid metal to said mold, supplemental locking means for the sections of said head, and means forming a constricted passage way between said pressure chamber and the interior of said mold, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber and means whereby an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold.

22. In an apparatus for casting fluid metals, the combination of a sectional mold, a head forming a pressure chamber surmounting said mold and adapted to be opened whereby gravity will initiate the flow of fluid metal to said mold, means forming a constricted passage way between said pressure chamber and the interior of said mold, a receptacle adapted to contain a measured quantity of molten metal and to be pivotally mounted within said pressure chamber, means whereby an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold, and means for tilting said mold and said head to control the direction of the flow of metal through said passage way to said mold.

23. In an apparatus for casting fluid metals the combination of a sectional mold, a head forming a pressure chamber surmounting said mold and adapted to be opened, whereby specific gravity will initiate the flow of the fluid metal to said mold, the said head and the walls of the opening thereof having a tapered bearing, means forming a constricted passage way between said pressure chamber and the interior of said mold, a ladle the handle of which is tapered to conform to said bearing and which has a shoulder thereon adapted to engage the exterior of said head, said ladle being adapted to contain a measured quantity of molten metal and means whereby an elastic fluid under compression may be introduced to said chamber to follow up the metal through said passage way and force it into and compress it in, the mold.

In witness whereof, I have hereunto affixed my signature this 11th day of January, 1909, in the presence of two witnesses.

HERMAN H. DOEHLER.

Witnesses:
T. T. WENTWORTH,
GEORGE MCCAY.