Feb. 27, 1934. H. EMERY ET AL 1,948,653

SEMIPERMANENT MOLDING APPARATUS

Filed March 14, 1932 3 Sheets-Sheet 1

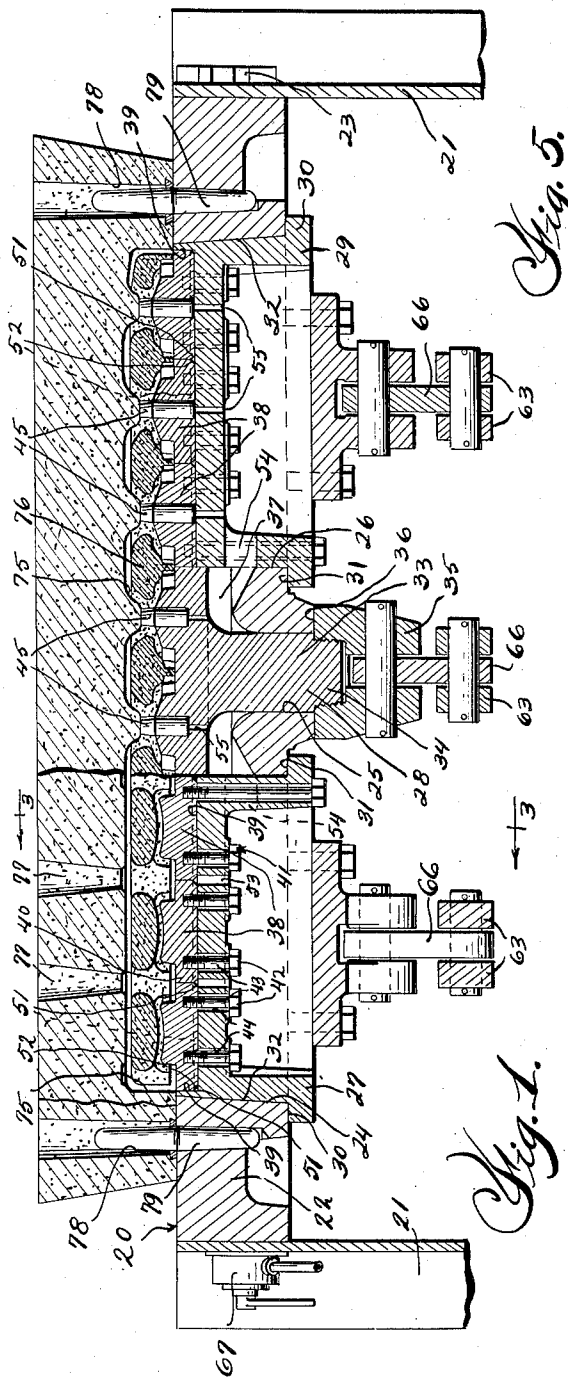


Fig. 1.

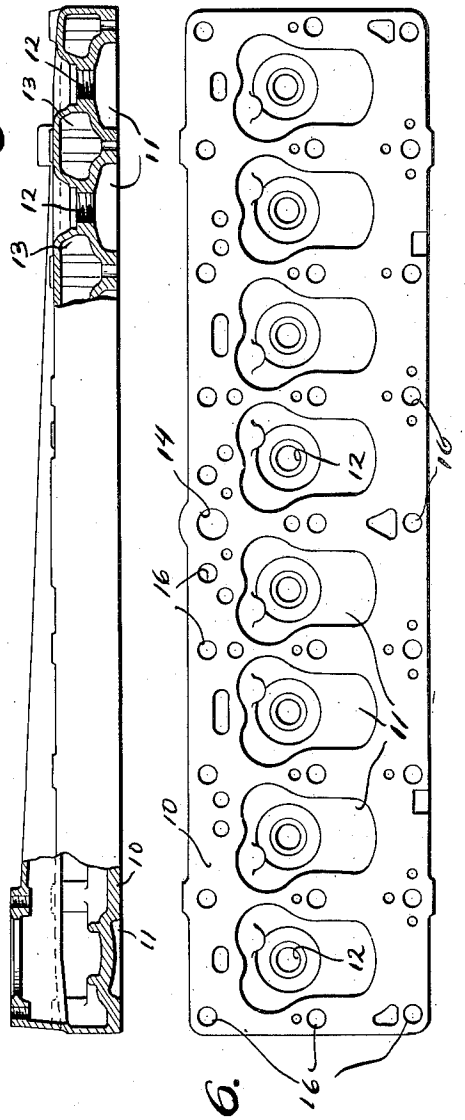


Fig. 6.

Inventors
Howard E. Emery
Andrew Irvine
Arthur T. Bateman

By Whittemore, Hulbert & Whittemore, Belknap
Attorneys

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SEMIPERMANENT MOLDING APPARATUS

Filed March 14, 1932 3 Sheets-Sheet 2

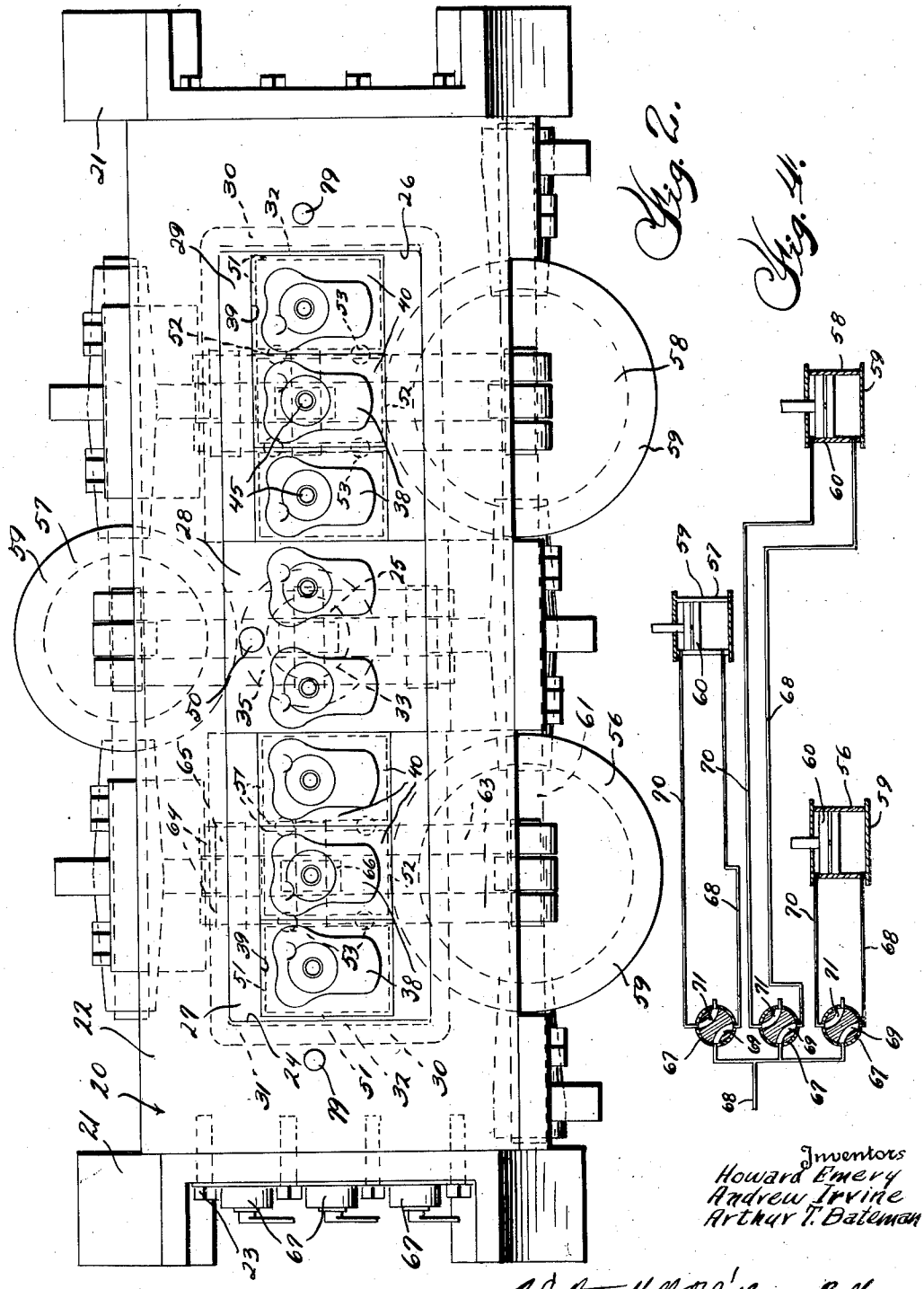


Fig. 2.

Fig. 4.

Inventors
Howard Emery
Andrew Irvine
Arthur T. Bateman

By Whittemore, Hulbert & Whittemore Belknap
Attorneys

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SEMIPERMANENT MOLDING APPARATUS

Filed March 14, 1932 3 Sheets-Sheet 3

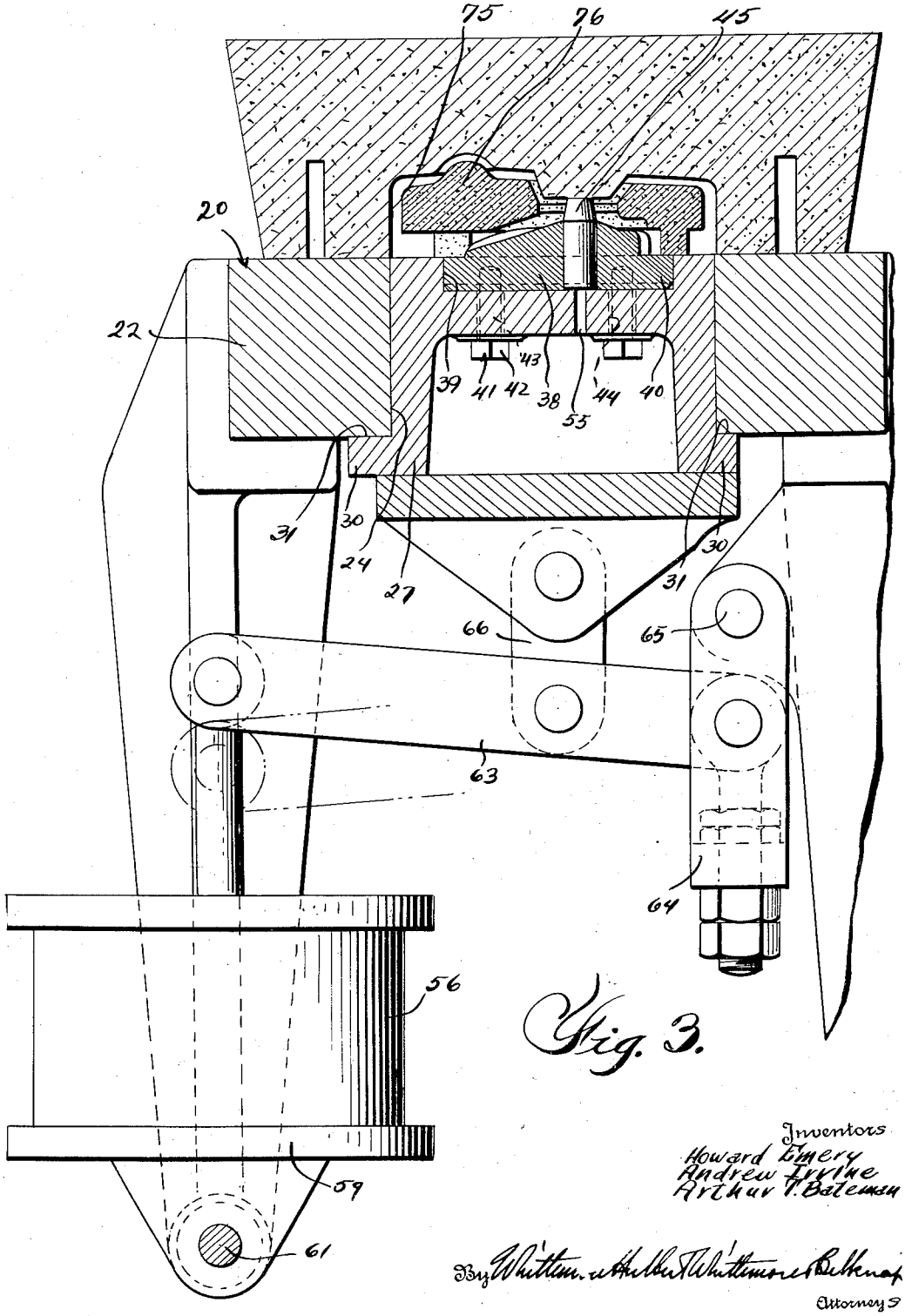


Fig. 3.

Inventors
Howard Emery
Andrew Irvine
Arthur T. Bateman

By Whittemore, Hulbert & Whittemore & Belknap
Attorneys

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SEMIPERMANENT MOLDING APPARATUS

Howard Emery, Andrew Irvine, and Arthur T. Bateman, Detroit, Mich., assignors to Bohn Aluminum & Brass Corporation, Detroit, Mich., a corporation of Michigan

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8 Claims. (Cl. 22—126)

This invention relates generally to molds and refers more particularly to semi-permanent molding apparatus.

Although the molding apparatus about to be described may be advantageously employed for fastening numerous types of castings formed of various different metals, nevertheless, it is particularly applicable for use in the manufacture of cylinder heads for internal combustion engines wherein it is especially desirable to not only form each of the combustion chambers of the head of uniform predetermined volume, but at the same time to form the head of a metal having relatively high thermo-conductivity.

While the advantages derived by forming a cylinder head of metal having relatively high thermo-conductivity and by fashioning the combustion chambers in the head of accurate predetermined size are well recognized by the trade, nevertheless, considerable difficulty has been experienced in the commercial production of such heads, especially where the length of the latter is such as to require a relatively great volume of metal in the formation of the same. Much of the difficulty heretofore experienced in manufacturing cylinder heads of the above type may be attributed to the low melting points of metals having a relatively high thermo-conductivity and the extremely low pouring temperatures which causes the castings to freeze or solidify at a relatively high rate. Thus, it will be apparent that unless extremely efficient venting means is provided, the gas or vapor occulted in the molten metal is trapped in the latter resulting in a porous casting. Moreover, the rapid freezing and high crystallization of metal alloys such as aluminum has a greater tendency to produce shrinkage cracks in the casting which are obviously objectionable.

The present invention contemplates eliminating the foregoing difficulties by providing improved molding apparatus capable of forming relatively large aluminum alloy castings free from porosity, shrinkage cracks and draws.

Another object of this invention resides in the provision of molding apparatus capable of forming the entire floor of a cylinder head including the combustion chambers therein from a permanent mold section. The foregoing materially increases the commercial value and acceptability of the cylinder head since it not only insures forming the combustion chambers therein of uniform predetermined size without the necessity of machining the same, but also serves to increase the density of the casting at the critical portions thereof by chilling the same.

Another advantageous feature of this invention which contributes materially to the adaptability of the molding apparatus for fashioning relatively long castings resides in the provision of a permanent mold section comprising a plurality of metal core members capable of being periodically withdrawn from the mold subsequent to the pouring operation so as to provide unobstructed solidification of the casting and thereby eliminate any tendency for the latter to crack.

A further object of the present invention resides in the novel means provided herein for venting the permanent mold section of the apparatus so as to insure rapid escape of all of the gas occulted in the molten metal and thereby eliminate porosity in the casting.

In addition to the foregoing, the present invention contemplates providing the permanent mold section aforesaid with a plurality of independent chills having portions forming the mold cavity corresponding to the combustion chambers and being readily detachably secured in place independent of each other so as to permit separately adjusting the same and thereby insure the formation of combustion chambers of accurate predetermined volume irrespective of slight inaccuracies which may occur in the apparatus.

The foregoing as well as other objects will be made more apparent as this description proceeds, especially when considered in connection with the accompanying drawings, wherein:

Figure 1 is a longitudinal sectional view through a molding apparatus constructed in accordance with this invention;

Figure 2 is a plan view of the construction shown in Figure 1 with the upper mold section removed;

Figure 3 is a cross sectional view taken substantially on the line 3—3 of Figure 1;

Figure 4 is a diagrammatic view illustrating the mold actuating means;

Figure 5 is a side elevational view partly in section of a cylinder head casting of the type for which our improved molding apparatus is designed to produce;

Figure 6 is a bottom plan view of the cylinder head shown in Figure 5.

For the purpose of illustration, we have shown our improved molding apparatus as employed in the manufacture of one-piece cylinder heads for multi-cylinder internal combustion engines of the water-cooled type. Inasmuch as the specific

embodiment of the invention illustrates molding apparatus especially designed for forming internal combustion engine cylinder heads, reference will be made first to the particular construction of head adapted to be produced by our improved molding apparatus. As shown in Figures 5 and 6, the cylinder head casting is of the conventional water-cooled design and is preferably formed of metal having a relatively high thermo-conductivity such as aluminum alloy. The cylinder head is provided with a flat bottom face 10 having a plurality of combustion chambers 11 extending upwardly therefrom and corresponding in number to the number of cylinders of the engine for which the head is designed. The combustion chambers 11 may be of any suitable design, but are of accurate predetermined size so that when the head is assembled upon a cylinder block, the volumetric efficiency of each cylinder of the engine will be substantially the same as the remaining cylinders, thereby materially increasing the efficiency of engine performance. In accordance with the usual practice, the upper walls of each of the combustion chambers are provided with openings 12 therein for receiving the conventional spark plugs (not shown) and the portions of the casting surrounding the spark plug openings and combustion chambers are cored out as at 13 to form suitable water jackets. In addition to the foregoing, the head is further provided with an opening 14 therethrough intermediate the ends thereof for receiving the distributor shaft (not shown) of the engine. Provision is made for clamping the head to a suitable cylinder block by forming a plurality of suitably spaced openings 16 through the head for receiving the usual studs.

Referring now more in detail to the particular construction of the apparatus shown herein for forming the head previously described, it will be noted that this apparatus comprises a table 20 having supporting leg portions 21 and having a rectangular metallic top section 22 secured to the upper ends of the legs 21 as at 23. The top section 22 in the present instance is provided with three openings 24, 25 and 26 therethrough for respectively receiving the metal cores 27, 28 and 29. The aforesaid metal cores are mounted for independent reciprocation within their respective openings and are fashioned in such a manner that when the same are in their uppermost positions, the top surfaces thereof lie in a common plane with the top surface of the table section 22. Upward movement of the end cores 27 and 29 is restricted by means of marginal flanges 30 extending laterally from the lower ends of the cores and forming continuous shoulders 31 for engaging the bottom surface of the table surrounding the openings therethrough. The shoulders 31 are accurately determined with respect to the top surfaces of the aforesaid cores so that when the latter are in their uppermost positions shown in Figure 1, the top surfaces thereof will lie in a common plane with the corresponding surface of the table 22.

The center core 28 differs in construction from the end cores, but is accurately located with respect to the latter and table in substantially the same manner previously set forth in connection with the end cores 27 and 29. In detail, the central core is provided with a cylindrical portion 33 reciprocably mounted within the opening 25 and having a reduced threaded portion 34 at the lower end thereof for detachably receiving a collar 35. The collar 35 is fashioned to provide an annular shoulder 36 similar to the shoulders 31 hereinbefore described in that it serves to engage the bottom surface of the portions of the table surrounding the opening 25 therethrough to limit upward movement of the core. The upper surface of the center core is located within a recess 37 in the table and the outer sides thereof slidably engage the adjacent inner sides of the core members 27 and 29 so as to form in effect a continuation of the latter when all of the cores are moved to their uppermost position as shown in Figure 1. Inasmuch as the accuracy of the resulting casting depends to a large extent upon the metal cores, it is essential to compensate for the slight clearances necessary to provide a sliding fit between the aforesaid cores and the openings in the table through which the same extend. The foregoing is accomplished herein by correspondingly tapering the outer walls 32 of the cores 27 and 29 and the adjacent walls of the openings within which the latter reciprocate. The aforesaid walls taper upwardly and inwardly so that as the core members 27 and 29 are moved upwardly within their respective openings in the table, the former have a tendency to shift laterally inwardly toward the adjacent sides of the center core member 28. The arrangement is such that when the core members are in their operative positions shown in Figure 1, the combined length of the same will conform exactly to the desired length of a cylinder head casting irrespective of the clearances provided between the core members and table.

In order to form the combustion chambers in the cylinder head casting of uniform predetermined dimension, a plurality of chills 38 are provided corresponding in number to the number of combustion chambers in the head. In the present instance, the cylinder head is shown as comprising eight combustion chambers and accordingly, the molding apparatus is provided with eight of the chills 38. In detail, each of the core members 27 and 29 are provided with a recess 39 in the upper face thereof of sufficient dimension to receive three of the chills 38, while the remaining two chills of the apparatus are formed integral with the central core member 28. The chills 38 on the end core sections of the apparatus are provided with marginal flanged portions 40 located within the recesses 39 substantially flush with the top surfaces of the core members and having the adjacent edges thereof in contacting relation. The arrangement is such that the upper surfaces of the flanged portions 40 of the chills cooperate with each other and with the upper surfaces of the core members to form the bottom face of the cylinder head casting surrounding the combustion chambers. The chills 38 on the end core members, as well as the chills formed integral with the center core member, are formed with upwardly extending portions accurately spaced from each other in accordance with the desired spacing of the combustion chambers in the cylinder head casting and exactly conforming in shape to the combustion chambers.

As shown particularly in Figure 1, each of the chills on the end core members are detachably secured to the latter independent of each other by means of suitable stud bolts 41 having head portions 42 engaging the under surface of the core members and having shank portions 43 extending through enlarged openings 44 formed in the core members and threadedly engageable with the chills to clamp the same to the upper

surfaces of the recesses 39 in the core members. By securing the chills on the end sections in the manner previously set forth, the same may be readily replaced when desired and slight relative adjustment of the chills is rendered possible. For example, if it is found that the height of one of the chills varies with respect to the remaining chills, the former may be removed and each shimmed up or a cut taken off the bottom surface thereof depending upon whether the same is lower or higher than the remaining chills. On the other hand, slight inaccuracies in the lateral spacing of the chills may be readily overcome by removing one or more of the chills and suitably machining the abutting sides thereof. In this connection, it is to be noted that the enlarged openings through the end core members provide for relatively adjusting the chills to compensate for the above machining operations.

From the foregoing, it will be observed that when the core sections 27, 28 and 29 are in their uppermost or operative positions shown in Figure 1, the same cooperate to form a permanent mold section capable of fashioning the floor or bottom face of the cylinder head casting including the combustion chambers. The formation of the bottom face of the cylinder head casting from a permanent mold is obviously desirable since it not only provides for increased density of the casting where strength is most needed, but also minimizes machining of the casting.

Inasmuch as each of the combustion chambers in the casting is provided with a threaded spark plug opening, it is also desirable to form this opening during the molding operation and for accomplishing this result, a permanent core 45 is provided upon each of the chills 38 at a point corresponding to the location of the spark plug openings in the combustion chambers. The permanent cores 45 are in the form of pins having the lower end portions thereof sleeved within openings formed in the chills and having the upper end portions projecting above the chills and suitably tapered. By employing a permanent core for the spark plug openings in the casting, the metal surrounding these openings is chilled providing for obtaining stronger threads in the casting for receiving the usual spark plugs.

A great many cylinder heads as now commercially produced are provided with openings therethrough intermediate the ends thereof for receiving the distributor shaft of the engine and since this shaft is constantly rotating at relatively high speeds, it is essential to provide a wear resisting bearing for the shaft. The problem of providing an efficient bearing for the accessory shaft is perhaps more prevalent in cylinder head castings formed of relatively light alloy metals such as aluminum or the like, and for accomplishing this result in the present instance, a metallic core 50 is provided on the permanent mold section at a point determined in accordance with the position of the hole in the cylinder head casting. The core 50 is preferably in the form of a pin having a portion sleeved within an opening in the permanent mold section and having another portion projecting upwardly a sufficient distance beyond the adjacent surface of the permanent mold section to form the desired opening through the cylinder head casting. The core 50 functions to chill the metal surrounding the opening for the accessory shaft through the cylinder head casting, and, as a consequence, increases the density of the metal in proximity to the aforesaid opening.

In order to provide a commercially satisfactory cylinder head casting, it is necessary that the latter be free from porosity, and, as previously stated, one of the objects of this invention resides in the novel means for insuring the escape of all of the gases occulted in the molten metal prior to solidification of the latter in the mold. Efficient venting of the mold cavities through the permanent mold section is accomplished herein by providing openings in the permanent cores establishing communication between the mold cavities and the atmosphere. In detail, the lower marginal edge portions of the chills 38 on the end core members 27 and 29 are chamfered as at 51 and cooperate with each other and portions of the end core members to form continuous chambers 52 around each of the chills 38 on the latter core members. The chambers 52 establish communication between suitable vents 53 formed in the end core members and the joints between the latter and side edges of the chills 38. The arrangement being such as to provide for the ready escape of the gases in the molten metal downwardly through the permanent core section to the atmosphere. Efficient venting of the mold cavity opposite the permanent center core 28 is effected between the side edges of the latter core and the recess 37. In this connection, it is to be noted that the recess 37 communicates with the atmosphere through openings 54 formed in the inner walls of the end core sections 27 and 29 as shown particularly in Figure 1 of the drawings. The latter openings, in addition to providing for the escape of the gases flowing into the recess 37, also functions to provide for the passage of heat to the recess 37 for preheating the center core section 28. In order to facilitate venting of the mold cavities and at the same time prevent blowing of the metal in the vicinity of the permanent spark plug cores 45, additional vents 55 are formed in each of the chills 38 with the upper ends communicating with the recesses within which the permanent cores 45 are sleeved and the lower ends communicating with the atmosphere. The foregoing venting arrangement is so exceedingly free and effective that practically no gases are occulted in the molten metal during the pouring operation, with the result that the casting is substantially free from porosity.

Another advantageous feature of the present invention which, as previously stated, contributes materially to the commercial production of cylinder heads formed of a metal having relatively high thermo-conductivity and having a plurality of combustion chambers therein resides in the provision of a permanent mold section permitting unobstructed solidification of the molten metal, with the result that the casting will be free from shrinkage cracks. The foregoing is accomplished herein by providing means for periodically and selectively lowering the permanent mold core members 27, 28 and 29 from their operative positions shown in Figure 1. In other words, the arrangement is such that various portions of the permanent mold section may be withdrawn from the mold independent of each other. In detail, we provide separate actuating means for each of the relatively movable core members of the permanent mold section capable of being controlled from a convenient position by a single operator. Inasmuch as the illustrative embodiment of the invention features a permanent mold section composed essentially of three relatively movable core members, we provide three fluid actuated devices 56, 57 and 58 operatively connected re-

spectively to the permanent cores 27, 28 and 29 of the permanent mold section. The aforesaid fluid actuated devices, while capable of operation independent of each other, are identical in construction in that each is provided with a cylinder 59 mounted upon the table for pivotal movement and having a piston 60 arranged therein for reciprocation relative thereto. As shown particularly in Figure 2, the fluid actuated devices 56 and 58 are disposed upon one side of the machine and are pivotally mounted upon a shaft 61 suitably supported from the table, while the fluid actuated device 57 for the center permanent core member 28 is positioned upon the opposite side of the table intermediate the devices 56 and 58. Each of the pistons 60 in the cylinders 59 is pivotally connected at the upper end thereof to a suitable link 63 which in turn extends transversely of the table for pivotal engagement with the lower end portions of a suitable bracket 64 having the upper end pivotally supported upon the side of the table opposite the devices as at 65. The links 63 are pivotally connected to the lower ends of suitable links 66 having the upper end portions thereof pivotally connected to the permanent core members 27, 28 and 29. The foregoing arrangement is such that upward movement of the pistons within the cylinders 59 causes a corresponding upward movement of the aforesaid permanent mold members through the intermediary of the linkage hereinbefore described. In this connection, it is to be noted that the operative connection between each of the pistons and the permanent core members is such as to provide for unobstructed vertical reciprocation of the latter members.

In order to permit independent actuation of each of the fluid actuated devices, we provide a three-way valve 67 for each of the devices. As shown in Figure 2, the valves are conveniently located upon one side of the machine and communicate with a source of fluid supply 68 shown in Figure 4. Each of the valves 67 also communicates with the interior of their respective cylinders at points above and below the pistons 60 in the latter. As shown in the diagrammatic view Figure 4 of the drawings, the arrangement is such that when the passage 69 of each valve establishes communication between the fluid supply line 68 and the cylinder below the pistons, the latter will be moved upwardly by the fluid under pressure causing the cylinders to exhaust the fluid above the pistons through the passages 70 communicating with the cylinders above the pistons, and, in addition, effects an upward movement of the core members in the manner previously set forth. When, on the other hand, the valves are rotated 90° from the positions thereof shown in the diagrammatic view, the passages 71 therein establish communication between the source of supply and upper ends of the cylinders to the conduits 70, thereby causing the pistons, and, accordingly, the permanent core members, to move downwardly. During the interval of downward movement of the pistons as set forth above, the passage in the cylinders below the pistons communicates through the valve with the atmosphere so as to provide for exhausting any fluid in the cylinders below the pistons. As will be observed from the foregoing, each of the valves are provided with a separate operating handle so as to permit actuating the same to operate the fluid devices independent of each other. By reason of the foregoing, it will be apparent that the permanent core members may be periodically withdrawn from the mold, thereby eliminating any danger of breaking the mold incident to the drawing operation and at the same time permitting unobstructed crystallization of the molten metal.

Cooperating with the permanent mold or drag section aforesaid in forming the cylinder head casting is a cope section preferably formed of baked sand with the desired mold cavity 75 therein. The cavity 75 is fashioned to cooperate with a dry sand core 76 in the assembled position of the cope section with the drag section to form the outer wall portions of the cylinder head casting as well as the water jackets in the latter. A plurality of riser openings 77 are also suitably formed in the cope section of the mold, which, in addition to cooperating with the highly porous body of the baked sand cope section to vent the mold cavity, also serves to insure the delivery of the maximum amount of metal at the points in the casting which are later drilled to form the stud bolt openings therethrough. The cope section is further provided with openings 78 adjacent opposite ends thereof for receiving pins 79 extending upwardly from the table 20 of the permanent mold section so as to accurately locate the cavities in the cope section relative to the permanent core members of the drag section.

Referring now to the operation of the molding apparatus and assuming that the permanent core members 27, 28 and 29 are in their operative positions shown in Figure 1, it will be noted that after the same have been thoroughly cleaned and pre-heated to the proper temperature, a suitable sand core 76 is accurately positioned upon the permanent mold section. A cope section similar to the one previously set forth is then positioned upon the permanent mold section in the manner shown in Figure 1, whereupon molten metal is poured into the sprues (not shown) formed in opposite ends of the cope section. The mold is then allowed to set a predetermined length of time depending upon the particular conditions, and then the permanent core members 27, 28 and 29 are periodically lowered to withdraw the same from the mold cavities. Upon withdrawing the permanent core members from the mold, the latter is removed from the table 20 and the operation repeated.

While in describing the present invention we have illustrated a particular form of mold, it will be understood that the improvements involved herein are applicable to various forms of castings and can be carried out in various ways other than those set forth, and, accordingly, reservation is made to make such changes as may come within the purview of the accompanying claims.

What we claim as our invention is:

1. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers therein, comprising a permanent mold section having a member provided with an upper surface corresponding to a portion of the lower plane surface of the head and formed with a recess therein, a plurality of chills having portions located within the recess flush with the upper surface aforesaid of the member and having other portions extending above the latter surface corresponding to the combustion chambers in said head.

2. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers therein, comprising a permanent mold section having a member provided with an upper surface corresponding to a portion of the lower

plane surface of the head and formed with a recess therein, a plurality of chills having portions located within the recess flush with the upper surface aforesaid of the member to provide extensions of the latter surface and having other portions extending above the said upper surface corresponding to the combustion chambers in said head, and means providing for adjustment of the chills relative to each other.

3. Molding apparatus for forming engine cylinder heads having combustion chambers therein, comprising a support, a permanent mold section having end core members mounted upon the support for relative vertical sliding movement and having chills extending upwardly from said members corresponding to the end combustion chambers in said head, a core member interposed between said end core members for sliding movement relative to the latter and having chills corresponding to the remaining combustion chambers in the head, and means for actuating said core members permitting relative movement thereof in a direction to withdraw the same from the mold.

4. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers therein provided with spark plug openings, comprising a permanent mold section having a plurality of chills corresponding to said combustion chambers and having openings therethrough communicating with openings in the chills to provide for escape of the gases occulted in the molten metal during the pouring operation, and a permanent core extending upwardly from each of said chills and having portions sleeved within recesses formed in said chills in communication with the openings therein.

5. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers therein, comprising a permanent mold section provided with a plurality of chills having laterally extending flanges at the base portions thereof and having upwardly extending portions corresponding to the combustion chambers in said head, means for accurately positioning the chills relative to each other with the adjacent edges of the flanges thereon in engagement, and passages in said permanent mold section communicating with the joint between adjacent chills to provide for venting the mold.

6. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers in one face thereof, comprising a metallic drag member, a metallic member mounted for reciprocation relative to said drag member and having a plane surface extending transverse to the direction of reciprocation, a plurality of independently removable chills having portions forming the combustion chambers in the face aforesaid of the head, means independently securing said chills to the plane surface of said reciprocable member and means for reciprocating said latter member.

7. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers in one face thereof, comprising a metallic drag member, a metallic member mounted for reciprocation relative to the drag member, a plurality of independently removable chills having projecting portions forming the combustion chambers in the face aforesaid of the head and having plane surfaces around said projecting portions, means independently securing said chills to the reciprocable member with the edges of adjacent plane surfaces of the chills in abutting relation whereby the plane surfaces cooperate to form the plane face of the head between the combustion chambers, and means for reciprocating said latter member.

8. Molding apparatus for forming an engine cylinder head having a plurality of combustion chambers in one face thereof, comprising a metallic drag member, a metallic member mounted for reciprocation relative to said drag member and having a plane surface extending transverse to the direction of reciprocation, a plurality of independently removable chills having portions forming the combustion chambers in the face aforesaid of the head, means independently securing said chills to the plane surface of the second named member, said means being variably engageable with the latter member to permit accurate assembly of the chills thereon, and means for reciprocating said second mentioned member.

HOWARD EMERY.
ANDREW IRVINE.
ARTHUR T. BATEMAN.