June 14, 1960 M. K. WELLS ET AL 2,940,142

MOLD ASSEMBLY

Filed March 31, 1958 4 Sheets-Sheet 1

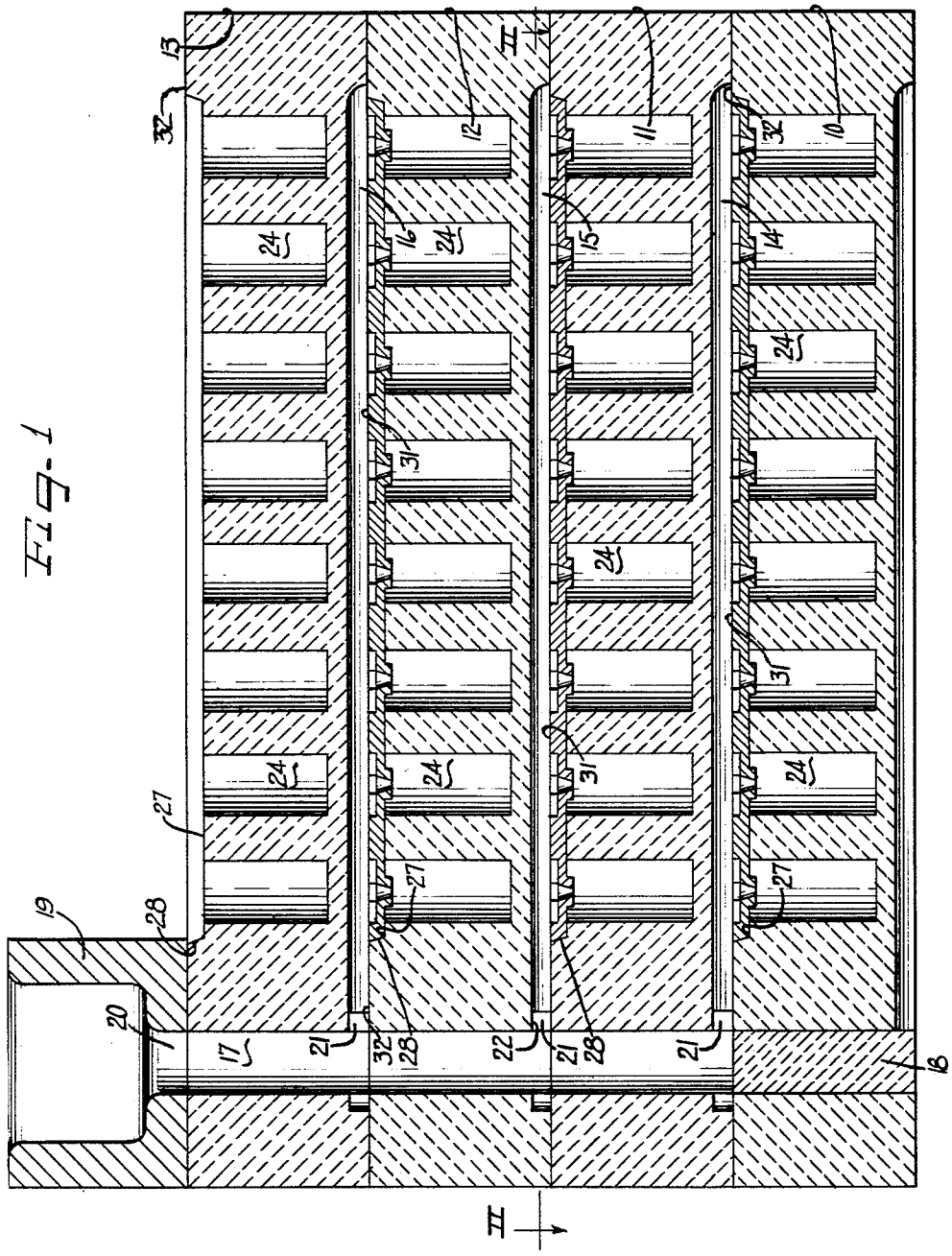


Fig. 1

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MOLD ASSEMBLY

Filed March 31, 1958 4 Sheets-Sheet 2

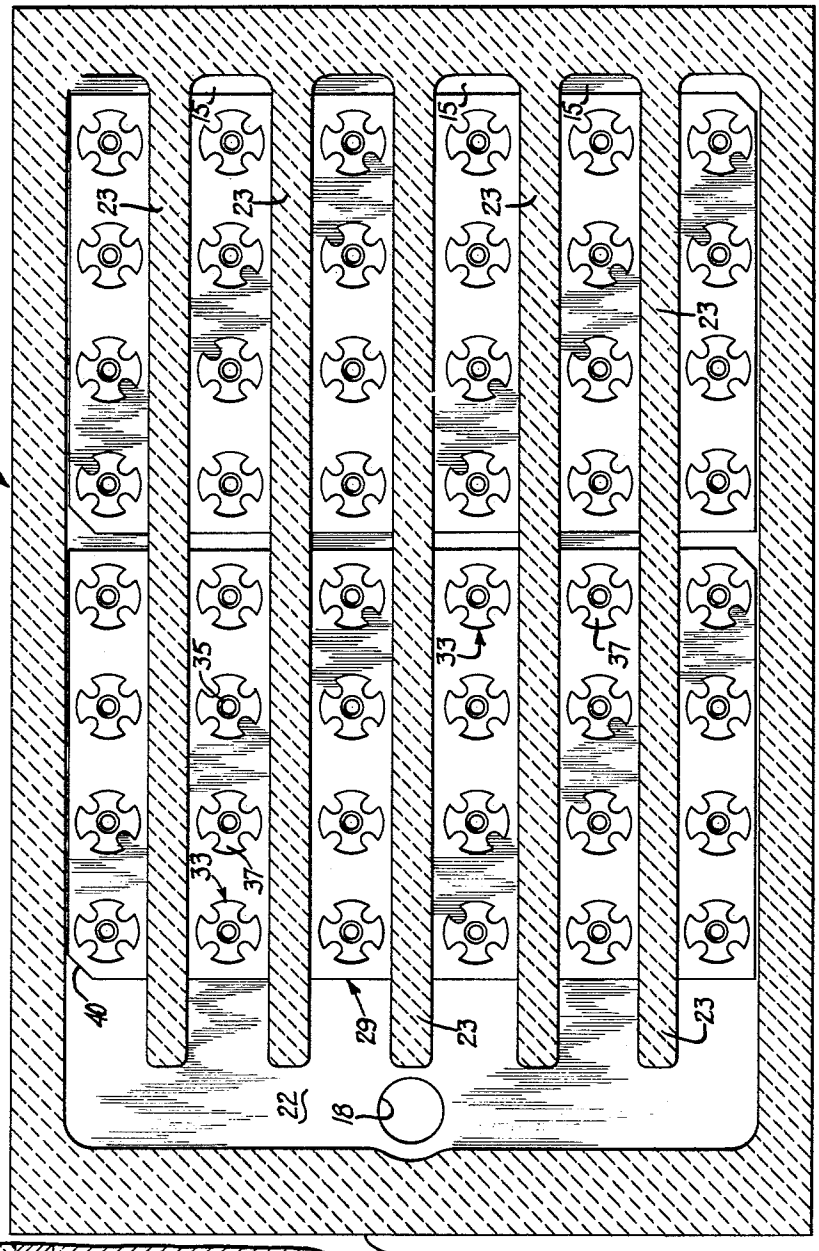


Fig. 2

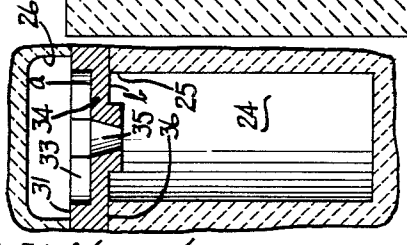


Fig. 5

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MOLD ASSEMBLY

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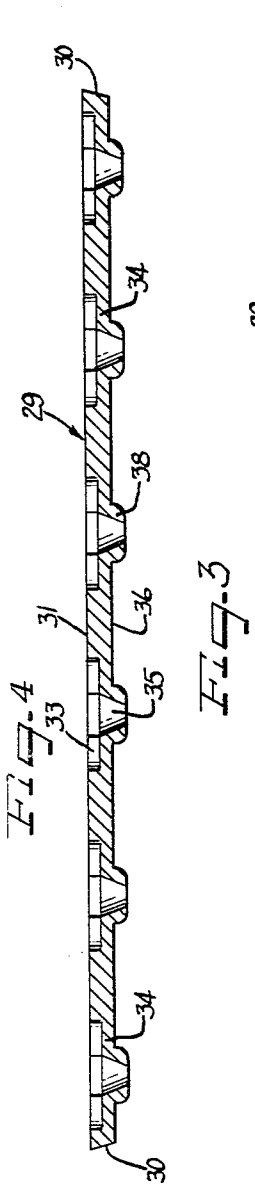


Fig. 4

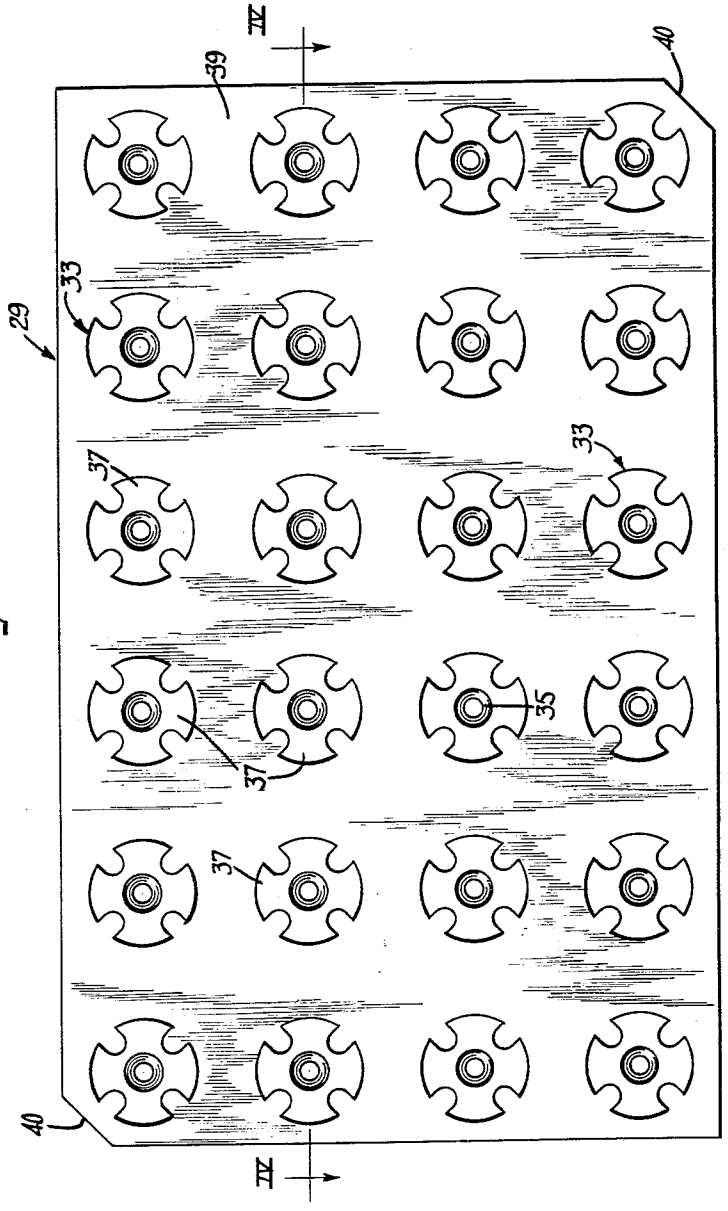


Fig. 3

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MOLD ASSEMBLY

Filed March 31, 1958 4 Sheets-Sheet 4

Fig. 6

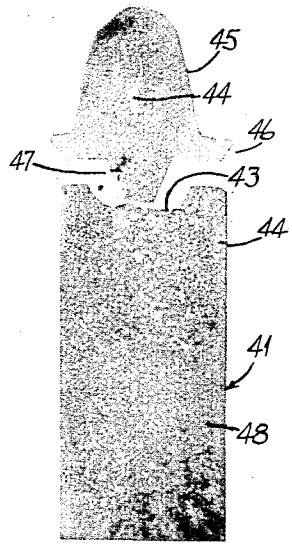


Fig. 7

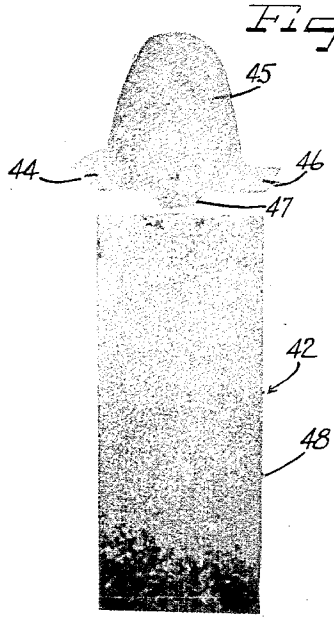


Fig. 8

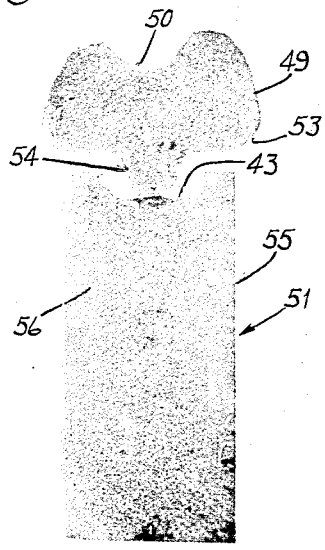
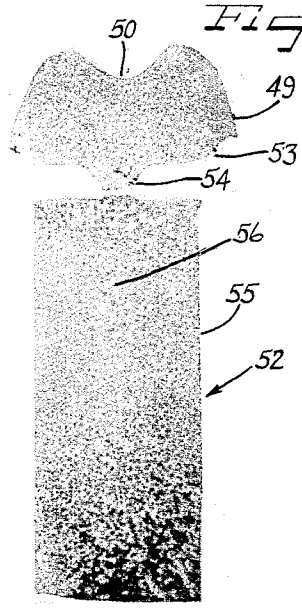


Fig. 9



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2,940,142

MOLD ASSEMBLY

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Filed Mar. 31, 1958, Ser. No. 725,103

5 Claims. (Cl. 22—130)

The present invention relates broadly to the production of castings, and is more particularly concerned with a novel casting method and mold assembly of proven utility in the manufacture of valve lifter castings.

Valve lifter castings have heretofore been produced by cope and drag molding methods, or stack molding practices. However, several disadvantages are associated with the particular techniques customarily employed. First, separate machines are normally required to produce the drag and cope sections, and many rather elaborate individual patterns must be provided. Second, the stem and button forming the inlet to the mold cavity are subjected to substantial abrasive action each time a mold is made, and frequent replacement of the worn stems and buttons is therefore necessary. Third, should it be desired to provide a stack mold having three productive layers, it is necessary to produce seven cheek or individual mold sections, and this is obviously costly in both manpower and metal yield. As a fourth disadvantage, relatively large center ingates are by custom employed in an endeavor to produce castings free from internal shrinkage defects, and such ingates require special handling of the castings in order to remove the gate stub remaining after the casting is broken from the runners. In addition, special equipment must be utilized to effectively perform this task. Fifth, the use of a relatively large ingate permits foreign material to flow directly into the mold cavity, and further, since the customary ingate covers a substantial area of the end of the casting, there frequently results internal shrinkage and an inverse chill condition in the center of the casting near the ingate. Difficult machining and poor tool life frequently result from the chill condition, and excessive internal shrinkage is productive of scrap castings after machining.

It is therefore an important aim of the present invention to provide a method of casting and a mold assembly therefor which avoid the objections and disadvantages of the prior art structures and processes.

Another object of this invention is to improve and simplify the molding techniques and the equipment for use therewith in the casting of metal articles having uniform hardness throughout the casting gate end to facilitate machining and other mechanical operations in the finishing of the casting to produce such articles.

A further object of the invention is to provide a valve lifter or tappet produced from a hardenable iron composition by the use of novel casting techniques insuring a desirable metallurgical structure in the casting and finished tappet.

A further object of this invention lies in the provision of a stack mold assembly wherein there is positioned between the individual mold sections a novel core member which facilitates the casting break-off at the junction of the casting and ingate and substantially entirely eliminates chilling of the casting at the gate end.

A still further object of the invention is to provide a method of casting hardenable iron articles in which a

stream of molten metal is flowed along a horizontal path, portions of said stream collected and diverted through a downwardly convergent heat conductive path into substantially the center of the mold cavity to fill the same.

Other objects and advantages of the invention will become more apparent during the course of the following description, particularly when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

Figure 1 is a vertical sectional view of a stack mold assembly embodying the principles of our invention;

Figure 2 is a sectional view taken substantially along the line II—II of Figure 1;

Figure 3 is a top plan view of a sand core member forming a part of our invention and illustrated in Figures 1 and 2;

Figure 4 is a sectional view taken substantially along the line IV—IV of Figure 3;

Figure 5 is an enlarged, fragmentary, sectional view illustrating the arrangement of a single mold cavity and a portion of the core member providing an entrance thereto;

Figure 6 is a reproduction of a photomacrograph of a sectioned and etched casting as produced by the method of our invention; and

Figures 7, 8 and 9 are reproductions of photomacrographs of modified forms of solid castings, sectioned and etched, also formed in accordance with the teachings of this invention.

The stack mold assembly of our invention includes a plurality of identical mold sections. As illustrated in Figure 1, the typical stack mold assembly comprises a bottom section **10**, which constitutes the drag mold, a plurality of intermediate sections, constituting cheek molds **11** and **12** which are superimposed upon the drag mold **10**, and an upper mold section **13** which is superimposed on the upper cheek mold **12** and constitutes the cope mold. Each section is provided on its underside with a plurality of spaced, parallel, horizontal runners, generally referred to by the reference numeral **14**. The runners on the cheek molds **11** and **12** are designated, respectively, as runners **15** and **16**. Each of the mold sections is also provided with a vertically extending bore, which when the mold sections are assembled in stacked relation (Figure 1), is in alignment with the bores in the other sections to provide a downsprue **17**. The corresponding bore in the drag mold **10** is closed by means of a filler or stop-off core **18**, and a pouring cup **19** is positioned on the upper surface of the cope mold **13** with its lower spout **20** in alignment with the downsprue **17**. The under surface of each of the cheek molds **11** and **12** and of the cope mold **13** is transversely recessed, as at **21**, to provide a common header **22** for the sets of casting runners **14**, **15** and **16**. As best shown in Figure 2, the casting runners such as the casting runners **15**, are separated by integral, downwardly extending portions **23** of the particular mold section in which the casting runners are formed.

All of the mold sections **10**, **11**, **12** and **13** are formed of green sand by any suitable means known to the foundry art, and are identical in form and construction so as to be interchangeable. Each of such mold sections is a productive part of the mold assembly, in that each is provided with a plurality of mold cavities **24** arranged in parallel rows in alignment with and wholly within the outline in plan of the area of the cross runners **14**, through which the molten metal flows by gravity into said cavities. The cavities **24** are here shown as being right cylindrical in form, with their axes vertical, but it will be understood that other shapes of mold cavities

may be employed. It is pertinent to note that when the mold sections are assembled, each tier of mold cavities lies below and wholly within the lateral and longitudinal confines of the cross runners **14**, **15** or **16** as the case may be, with the upper open ends **25** of said mold cavities **24** equi-spaced from each other and from the lateral walls **26** (Figure 5) of each of said cross runners. The symmetrical arrangement shown in the drawings is important to insure the proper flow of molten metal or alloy to the respective cavities, and also to insure substantial uniformity of dimensional relationship between each of the cross runners and each of the mold cavities which they serve.

Each of the cheek molds **11** and **12**, and the drag mold **10**, is provided with recessed upper surfaces, indicated generally at **27**, to provide rectangular recesses having tapered lateral and end walls **28**. A novel core member, indicated generally by the reference numeral **29** (Figures 3 and 4) is adapted to be received in each of the recesses so formed to rest against the surface **27** with its lateral edges conformingly sloped, as at **30**, to conform with and abut against the tapered edges **28**. Each of said core members comprises a rectangularly shaped plate of a thickness equal to the depth of the recess into which it is to fit, with the result that the upper surface **31** of each member **29**, when in place, is flush with the upper surface **32** (Figure 1) of the corresponding mold section.

Since each of the members **29** is identical, only one need be discribed. The members **29** are formed of dry sand, produced in any suitable manner known to the foundry art, by mixing sand with a binder and then baking. Each member **29** is thus of a coarse sand composition. In accordance with the present invention, each of the core members comprises a plate-like body portion **39**, and opposite corners thereof may be beveled, as shown at **40** in Figure 3, to facilitate insertion and removal of the core members **29** from the mold sections.

At a plurality of equi-spaced locations along its upper surface **32**, each core member **29** is cut out or recessed to provide a heat retention zone or relatively shallow core cavity **33** in communication with each of the runners **14**, **15** and **16**. Each heat retention zone is of predetermined depth in order to pre-heat a core portion **34** therebeneath with molten metal prior to the flow of said metal through a novel tapered center ingate **35** surrounded by said core portion and communicating with the mold cavity **24**. As will be pointed out in detail later, a heat retention zone arranged substantially in the manner disclosed not only reduces the quantity of sand between the runners and mold cavities, but makes the distance from the runner to the cavity so short that the ingate **35** cannot solidify until the runner is ready to solidify. Actual practice has shown that the core portion **34** becomes heated instantly from the metal in the heat retention zone **33**, and acts much like additional metal over the casting being formed in the cavity **24**. The gate end of the casting accordingly cools slowly and is self-annealing for a prolonged period, with the result that improved hardness properties are obtained in the casting at the gate end. Substantial improvement in the machineability of the casting is one of the many advantages flowing therefrom.

It has been found that although the shape of the heat retention zone **33** in plan can be varied widely, a definite relationship exists between the depth of the zone and the thickness of the core portion **34** therebeneath. Particularly desirable results have been obtained when the depth of the heat retention zone is approximately the same as the thickness of the core portion measured radially outwardly of its center and between the points *a* and *b* in Figure 5. In other words, and by way of example, if utilizing a core member **29** having a thickness of ¼ inch between its upper and lower surfaces **31** and **36**, as identified in Figure 5, the heat retention **33** is desirably of a depth of ⅛ inch, or one-half the core member thickness. Any substantial increase above the thickness of ⅛ inch between the surfaces containing the points *a* and *b* have been found to produce chilling and increased hardness in the casting gate end.

As indicated, the configuration of the heat retention zone or relatively shallow core cavity **33** may be varied within the skills of those versed in the art. Viewing now Figures 2 and 3, an exemplary shape may resemble a four leaf clover or a Maltese cross, and accordingly, includes a plurality of circumferentially spaced cavity segments **37** receiving molten metal during horizontal passage in the runners **14**, **15** and **16**. As appears in Figure 5, the diameter of the heat retention zone is substantially the same as the diameter of each mold cavity **24**, and is less than the width of each runner.

For the purpose of facilitating handling during subsequent operations of machining and the like, the core portion **34** may be provided on its lower surface with a relatively thicker section **38** generally centrally thereof surrounding the center ingate **35**. In the ultimately produced casting, the upper end accordingly has a centering identification impressioned therein, and this may be employed to receive handling equipment during later processing. However, an identification impression is not required in all instances, and may be conveniently eliminated by use of a uniform thickness core portion without departing from the novel concepts of this invention.

The center ingate **35** contributes importantly to the advantages obtained from the herein disclosed mold assembly, and may be seen to be of relatively short downwardly convergent or tapered configuration. The upper end of the ingate communicates with the center of the heat retention zone **33**, and the opposite end with generally the radial center of the mold cavity **24**. Further, the ingate is disposed centrally of the core portion **34**, and is surrounded throughout its depth by said core portion, or when an identification impression is to be provided, specifically by the relatively thicker center section **38** of said portion **34**. In any instance, however, the depth of the ingate **35** and the thickness of the core portion **34** at the center thereof are essentially the same to provide heated core sand around the ingate during the flow of metal therethrough and prevent premature hardening of the ingate.

It is to be further noted that the ingate is of relatively shorter diameter at its lower end than at the upper end. This is an important feature of the present invention, and many advantages result therefrom. First, casting breakoff at the junction of the casting and lower end of the ingate is facilitated. All previously required gate stub knockoff operations are eliminated since the castings can now be broken off the runners in the shake out operation during sand removal. Second, the relatively small diameter ingate produces a slower filling of the mold cavity, and as a result, foreign material is skimmed from the metal during cavity filling and does not appear in the casting formed. Third, by reason of slower cavity filling, progressive solidification of the casting takes place and center-line shrinkage in the casting is greatly minimized. Center-line internal hard spots caused by inversed chilling are essentially eliminated, and machining operations accordingly greatly facilitated. Tool life is lengthened as a result thereof. Fourth, the 100% gate end rough grinding operations associated with larger ingates are no longer required.

The use of the above-described stack mold assembly for the casting of solid articles will be understood by one ordinarily skilled in the foundry art. With the mold sections assembled as illustrated in Figure 1, metal or alloy of the desired composition and at the desired pouring temperature is poured into the cup **19** to fill the downsprue **17** and be distributed uniformly therefrom through the cross-runners **16**, **15** and **14** from the headers. The individual mold cavities **24** are gravity filled with molten metal from the corresponding cross-runners through the

heat retention zones 33 and center ingates 35. After all the mold cavities have been filled and the poured metal has been allowed to cool sufficiently to permit the removal of castings, the molds are broken, and the runners, heat retention zones, and center ingates broken as a unit from the castings. By reason of the relatively narrow diameter of the center ingate at its junction with the casting, breaking of the ingate 35 from the casting is relatively simply performed, and prior stub removal and rough grinding essentially entirely eliminated.

While any high strength cast iron or iron alloy can be used in the manufacture of tappet bodies to impart thereto desirable wear properties, the following specification covers a hardenable iron suitable for the purpose:

	Percent by weight
Total carbon	3.00 to 3.30
Combined carbon	1.00 to 1.20
Silicon	2.10 to 2.40
Manganese	0.70 to 0.90
Phosphorus	0.20 max.
Sulphur	0.10 max.
Chromium	0.80 to 1.25
Molybdenum	0.40 to 0.70
Nickel	0.40 to 0.70

A hardenable iron alloy of the above analysis is suitably produced in an electric furnace operated in accordance with the best current metallurgical practice to insure good control.

Figures 6 and 7 are reproductions of photomacrographs, one and one-half times magnified, of center gate solid castings having structures at the upper end of the specification range above given and produced in accordance with the teachings of this invention. Figure 6 illustrates a rough casting 41 obtained utilizing a core member 29 of the construction shown in the drawings, while the casting 42 of Figure 7 was produced by means of a core member in which the relatively thick center core section 38 was eliminated. Accordingly, the essential distinction between the structures of Figures 6 and 7 is the presence of an identification impression 43 in the casting of the former figure. The core member employed in obtaining the castings of both Figure 6 and Figure 7, however, featured a tapered center ingate and a heat retention zone as earlier disclosed.

It may be seen from Figures 6 and 7 that the castings produced possess a very desirable macrostructure in that no substantial concentrations of cementite, indicated by the light areas 44, are present. Thus, in the casting runner 45, heat retention zone 46, center ingate 47, and body portion 48 of each of the castings 41 and 42, a substantially uniform macrostructure is present. Rockwell hardness readings were obtained on castings as produced by the method of this invention, and it was found that a substantial improvement in hardness values, particularly in the casting gate end, were obtained utilizing a core member 29 provided with a heat retention zone 33 in combination with the center ingate 35. Rockwell "C" hardness values in the upper or gate portion of the casting ranging between 28 and 30 were obtained, while solid center ingate castings formed by customary techniques are characterized by Rockwell "C" hardness values in the range of about 30 to 40. Accordingly, in addition to the other advantages noted above, the gate end of the castings produced by the teachings of the present invention are relatively softer, and the hardness in this region more uniform in various lots of castings. Actual experience has demonstrated that greater tool life is obtained, and there is less down time for tool replacements. Further, less stock or metal removal is required, and there is a more consistent cam face structure from lot to lot.

It is of course not necessary that the runner formation of Figures 6 and 7 be of the precise shape disclosed therein, and a casting runner of somewhat different configuration and yet obtained by practice of this invention is shown in Figures 8 and 9. In the latter views, differing essentially only in the absence of an identification impression 43 in the gate end of the casting of Figure 9, a casting runner 49 of lesser depth is presented having a recess 50 in the top wall thereof. This is of course obtained by provision of a longitudinally extending rib in the runners 14, 15 and 16 along the bottom surface of each mold section 10, 11, 12 and 13. In addition to metal savings and other advantages, the casting runner 49 illustrates the feature of providing a metal mass of greater diameter over the gate end of the casting 51, and particularly, over the periphery thereof to induce slower solidification and improved hardness characteristics.

In other respects, the rough casting 51 of Figure 8 and casting 52 of Figure 9 comprise the features of Figures 6 and 7. A heat retention zone 53 surrounds a center ingate 54 connecting with a casting body portion 55 by a minimum of solidified metal to facilitate breakage therefrom. There are no substantial concentrations of cementite, indicated by the light areas 56, and the hardness values measured in the Rockwell "C" range were less than those obtained by customary casting techniques.

From the foregoing description it will be apparent that our process, using a relatively short tapered center ingate and heat retention zone arranged as disclosed, permits the production of a solid casting having a specific microstructure and cementite distribution pattern and superior machineability. These features of the casting produced by our method are largely the result of the method of feeding the molten metal to the mold cavities, and are particularly due to the provision of a downwardly convergent centergate at one end of which is located a heat retention zone of predetermined depth to adequately condition the core material prior to molten metal entrance into the mold cavity. A substantial increase in the metal yield, as contrasted with conventional centergate mold structures is obtained, and a relatively short center ingate surrounded by a core sand section heated by the heat retention zone substantially eliminates or reduces the amount of centerline internal hard spots or inverse chill often associated with the prior art molds. The relatively small diameter ingate further eliminates the prior art operation of gate stub knock-off, and produces a relatively slower filling of the mold cavity during which foreign material is skimmed from the metal and a progressive solidification takes place.

Our method is applicable to mass production at considerable savings in both material and labor. Additionally, since it is now possible by use of a relatively small ingate and the novel heat retention zone disclosed to form a depression in the gate end of the casting, the casting lends itself well to automatic handling and reduces the manpower required to feed said castings into a machine line in the proper position. In addition, as previously stated, by the production of the herein disclosed casting having a specific metallurgical structure, it is possible to machine the casting into a hollow article much faster and at a lower cost than heretofore possible.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

We claim as our invention:

1. A mold assembly comprising a plurality of mold sections arranged in superimposed relationship and cooperating to provide horizontal casting runners and a plurality of mold cavities of lesser diameter than the width of the corresponding one of said runners and aligned vertically therebeneath within the vertically projected extent thereof, and a relatively thin, plate-like core member removably carried by each of the mold sections except the uppermost, each core member having a plurality of openings therethrough communicating with the corresponding mold cavities directly beneath, the upper end of each of said openings being enlarged and having a diam-

eter substantially equal to the inner diameter of the corresponding mold cavity and the lower end of each opening providing a restricted opening into the open end of the cavity.

2. A mold assembly comprising a plurality of mold sections arranged in superimposed relationship and cooperating to provide horizontal casting runners and a plurality of mold cavities of lesser diameter than the width of the corresponding one of said runners and aligned therebeneath within the extent thereof, and a relatively thin plate-like core member of dry sand removably received in the upper surface of each of the mold sections except the uppermost and essentially flush therewith, each core member having a plurality of individual center ingates in communication with the mold cavities and defining a heat retention zone substantially coextensively overlying the upper end of each of the ingates and having a diameter closely similar to that of the corresponding mold cavity, each heat retention zone being closely spaced vertically from the upper end of the corresponding mold cavity.

3. A mold assembly comprising a plurality of mold sections arranged in superimposed relationship and cooperating to provide horizontal casting runners and a plurality of mold cavities of lesser diameter than the width of the corresponding one of said runners and aligned therebeneath within the extent thereof, and a core member of integral dry sand construction removably received in the upper surface of each of the mold sections except the uppermost and essentially flush therewith, each core member having a plurality of individual center ingates in constricted communication with the mold cavities and defining a heat retention zone substantially coextensively overlying the upper end of each of the ingates and having a diameter closely similar to that of the corresponding mold cavity, the core member further including an integral core section of relatively greater thickness in the central portion thereof disposed below the heat retention zone and circumferentially surrounding each of the center ingates.

4. A mold assembly comprising a plurality of mold sections arranged in superimposed relationship and cooperating to provide horizontal casting runners and a plurality of mold cavities of lesser diameter than the width of the corresponding one of said runners and aligned therebeneath within the extent thereof, and a dry sand core member received in the upper surface of each of the mold sections except the uppermost and essentially flush therewith, said core member having a plurality of individual center ingates in communication with the mold cavities and defining a heat retention zone about ⅛ inch in thickness substantially coextensively overlying the upper end of each of the ingates and having a diameter corresponding to the mold cavity inner diameter, the core member further including an integral core section of relatively greater thickness in the central portion thereof extending into the mold cavity and circumferentially surrounding each of the center ingates to maintain the metal in molten condition during flow therethrough.

5. A mold assembly comprising a plurality of mold sections arranged in superimposed relationship and cooperating to provide horizontal casting runners each of said cheek molds having a shallow recess in its upper surface and having therebelow a plurality of mold cavities of lesser diameter than the width of the corresponding one of said runners and aligned beneath each runner within the extent thereof, and a dry sand core member received in the recessed upper surface of each of the mold sections except the uppermost and essentially flush therewith, said core member having a plurality of individual relatively short center ingates in communication with the mold cavities and defining a heat retention zone of clover shape substantially coextensively overlying the upper end of each of the ingates and provided with a diameter corresponding to the mold cavity inner diameter, the core member further including an integral core section of relatively greater thickness in the central portion thereof disposed below the heat retention zone and circumferentially surrounding each of the center ingates, said core section outwardly of the center thereof and beneath the heat retention zone being substantially the same thickness as said zone.

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