April 28, 1931. J. C. DAVIS 1,802,706

CAR WHEEL MOLD

Filed Aug. 20, 1926

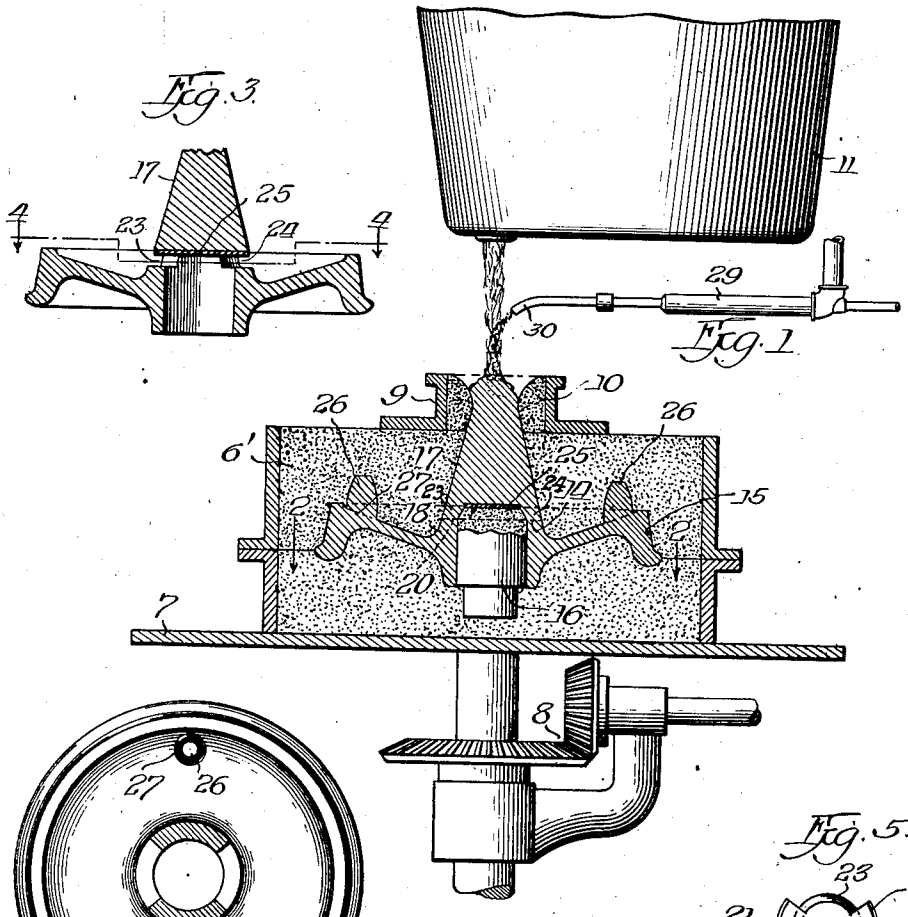

Fig. 1

Fig. 3

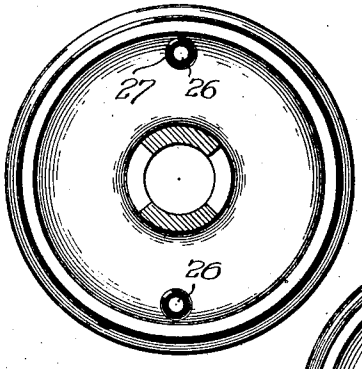

Fig. 4

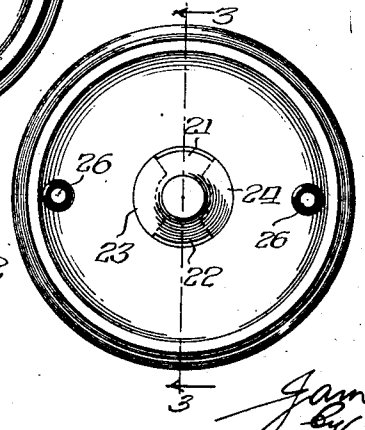

Fig. 2

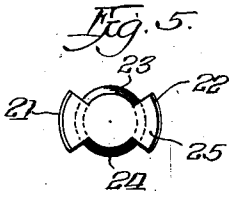

Fig. 5

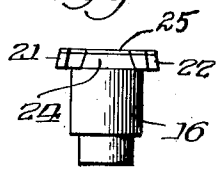

Fig. 6

Witness:

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Patented Apr. 28, 1931

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UNITED STATES PATENT OFFICE

JAMES CAREY DAVIS, OF CHICAGO, ILLINOIS

CAR-WHEEL MOLD

Application filed August 20, 1926. Serial No. 130,542.

My present invention relates to the art of casting metal, and to improved means and methods of producing castings which are not only smooth, and clean, in that they are free from pits or holes or from entrained dirt such as sand, dross, slag and the like, but are notably solid and dense particularly along lines of crystallization or solidification of differential character.

Pits, holes, dirt and the like involve roughness, flaking, shelling and a consequent cutting action, since they cannot readily be machined out, irregularities and other obvious imperfections with an incident intolerable great manufacturing cost due to high scrap loss of the castings discarded on account of the inavailability for the purpose contemplated. Other causes for imperfections and inability to procure the maximum densification are results of the contraction or shrinkage of the solidifying metal and where the portions are subject to differential contraction, there is great likelihood of strains, and uneven density, causing consequent unequal strength of the casting and where the casting has a wearing surface, there results uneven wear of the casting.

Some defects attendant to casting have to some extent been overcome by casting in rotary molds and as regards this general method, my prior Patents: 727,103, May 5, 1903; 767,928, Aug. 16, 1904; 1,192,044, July 25, 1916; 1,193,670, Aug. 8, 1916; 1,581,790, April 20, 1926; have to a marked degree succeeded in procuring even distribution of the metal in the casting. But these and other processes known to me have failed in consistently attaining the requisite solidity and density in the castings and insuring a constant run of castings which are both of the solidity and density sought for, but at the same time free from insuperable peripheral imperfections such as foreign matter, shelling, irregularities of contour and unevenness of wear which are intrinsic and more than merely superficial and so involve actual rejection of the product.

In my application Serial Number 46,254, filed July 27, 1925, I have described a new process, apparatus and resultant product for the manufacture of castings, which has so markedly increased the efficiency of the results obtained by the prior practice as to be well nigh perfect.

The invention I herein describe, briefly, involves a new process and apparatus for supplying an ancillary quantity of moulten metal to the casting, preferably by supplying sinking heads at the periphery of the casting and I further may rotate the same at such speeds to forcefully condense the casting at the peripheral portions and forcefully feed such ancillary quantity to the casting.

While this process is remarkably successful with a melt of certain degree of purity, I found that there is a tendency for an undue amount of shrinkage at portions having a minimum amount of compression, due to the centrifugal force of rotation or diminished amount of metal and consequent diminished fluid pressure head and where the amount of dross, gases or materials of lower specific gravity are comparatively high in quantity, there is a tendency for the collection of these materials at the axial portion or that portion which forms the hub of the car wheel. These impurities and gases and this undesirable low pressure head upon the mold at the axial portion, which is followed by shrinkage in setting, tend to cause a weakness of the metal at the hub portion due to their collection at this point and consequently not only cause failure in practice but involve an additional amount of labor in finishing the article to a stage which, in some cases, result in total loss thereof, as the article is fit only for rejection and reuse by remelting.

Where I have attempted to overcome this difficulty, by assisting the rate of flow of the metal through the gate by diminishing any tendency to adhesion to the side walls thereof and when pouring the same through the "fit" portion of the car wheel, I have found that the centrifugal force of distribution is insufficient to overcome the defects, particularly at portions of the casting where the ready interchange of metal is prevented, due to the shape of the pouring gate and the core and also due to the fact that the supply of metal is greater

from portions of the casting itself rather than from the excess of metal provided at the pouring gate, and also due to the fact that the paths of flow of excess metal are more direct to the body portions of the casting than to the marginal portions and that upon subsequent setting and shrinkage, the marginal portions of the hub develop flaws due to shrinkage cracks as well as collecting the gases, dross and similar materials.

It will be appreciated that castings of high quality, the attainment of which is one of my present objectives, are useful for many purposes, but are not only of utility but practically essential for a number of uses, such as for example, car wheels, and other structures more or less analogous in certain characteristics.

I have found that I can procure substantially perfect castings, particularly car wheel castings, of unusually dense character whose integrity is uninterrupted by flaws such as cracks, holes, insufficiency of metal, sand, dirt, slag and dross, and free from peripheral and marginal imperfections such as foreign matter, gas holes, shelling, irregularities of contour and shrinkage cracks and that I am able to cut down the losses in manufacture, owing to avoidance of production of useless but expensive castings which have to be broken up and remelted at a loss; that I may obtain such castings at higher centrifugal speeds of rotation of the casting apparatus, and also procure greater perfection at the portions of the casting which have lower momentum, such as the web or hub portion, if the pouring of the metal, particularly at the hub portion, is accomplished marginally, peripherally, directly, rectilinearly, ultimately and without disturbing the core usually provided for the hub "fit" and also if the radial component of force due to rotation is augmented by a higher gravitational component by eliminating the factors due to frictional contact of the metal with the sides of the mold, particularly with the walls of the pouring gate.

I have further found that I may introduce by centrifugal force or otherwise an excess supply of the metal at those portions of the casting where substantially vertical or transverse walls increase the frictional contact of the metal to such an extent as to prevent ready radial movement and also at those axial portions having a minimum amount of fluid pressure head where there is a tendency for loss of metal due to differential setting thereof, by increasing the readiness of flow of metal to such portions.

I have still further found that I may obtain, in a very simple manner, a fullness of supply of metal at all portions including the hub and at the same time where I use a rotating mold have sufficient metal, as well as densify the periphery of the entire casting at high speeds of rotation, if the pouring is accomplished at the marginal portions of the hub as the ultimate pouring step, and furthermore may obtain forced feed of the excess metal necessary to maintain a completely filled mold conducive to best casting results, particularly where I use a rotating mold at higher speeds of rotation, by forming the pouring gate with converging walls tending to augment the distribution of the metal by an added gravitational component in an amount greater than that encountered by frictional contact with the walls of the mold, particularly the pouring gate, the supply being at the marginal portion of the hub in a direction substantially rectilinear and without disturbing the core ordinarily provided for forming the "fit".

My invention further has for an object thereof the provision of a mold for casting, for example, car wheels, which includes pouring the metal, particularly the hub portion, marginally, ultimately and rectilinearly; the provision of a mold for casting car wheels which includes supplying moulten metal to the hub portion thereof substantially parallel to the axial line of the casting so that all portions thereof, particularly the marginal portion of the hub, will have a ready supply of excess metal and during setting of the metal all portions will be free from attenuation, avoiding thereby shrinkage cracks as well as the accumulation of undesirable constituents, such as gases, slag, dross and other impurities tending to form non-uniform and unsound castings; the provision of a method for casting car wheels which includes pouring moulten metal into a mold directly and rectilinearly so that when rotated to obtain the benefit of densification of the metal due to centrifugal force, the gravitational force due to an excess amount of material will be an additive component to the centrifugal force of rotation; the provision of a method for casting car wheels which includes pouring moulten metal into a mold and directly diverting portions of the stream to marginal portions, at which point attenuation during shrinkage is likely to occur.

The invention still further has for an object thereof the provision of a method for casting car wheels which includes introducing moulten metal into a mold to impart centrifugal motion to the metal to force it outwardly to the confines of the mold, including provision to supply excess material at all portions of the mold as the densification occurs and to compensate at all portions for shrinkage due to attenuation by providing an additional component of force other than that due to the centrifugal force, particularly at the axial portions where the frictional contact with the walls of the mold would tend to produce "hanging" of the metal in the mold and result in an insufficient supply of metal at these portions.

The invention still further resides in the provision of a process for casting, preferably in a rotating mold, to obtain a casting varying in density and composition between the peripheral and the axial portions, means being provided to permit the ready interchange of materials so as to eliminate impurities and remove the same from the casting to that portion forming the waste or excess and whereby where an alloy may be formed at different portions of the body of the casting, the alloying constituents being positioned only at the desired points without restriction due to the configuration of the mold.

The invention includes as a further object thereof the provision of casting apparatus particularly suitable for forcefully feeding moulten metal to the mold and where a mold is used having a configuration which would normally cause the moulten metal fed thereto to hang or move away from portions of the casting under conditions used for feeding moulten metal thereto, means being provided to overcome any deficiency of metal by supplying an excess of metal at all portions, particularly at the portions adjacent to the hub and at marginal portions thereof.

The invention includes as a further object thereof the provision of casting apparatus suitable for rotary casting including a pouring gate and ancillary means such as a sinking head for receiving moulten metal for the formation of a casting therein, the pouring gate and the sinking head being formed to supply metal in an amount tending to overcome any deficiency due to hanging of the metal in contact with the walls of the mold by forming the same so as to include an additional component of force, preferably gravitational, during rotation, the pouring gate and/or the sinking head being formed with walls divergent towards the body of the mold and preferably supplying a quantity of metal to the marginal portions of the hub from the pouring gate.

The invention still further includes as an object thereof the provision of a casting apparatus including a core member so associated with moulten metal supply means arranged to facilitate the separation of any excess metal normally retained in the metal supply means, said core member further including means to deflect moulten metal without disturbing the configuration of said core member at that portion where the stream of metal directly strikes said core.

The invention has for another object thereof the provision of a casting, for example, a car wheel, obtained in a rotary casting apparatus and of uniform progressive variation in density from the peripheral portion towards the axial portion and which has substantially every portion thereof free from defects due to attenuation of the metal in setting and from the accumulation of foreign and objectionable matter, such as gases, slag, dross and the like.

In the attainment of the objects and advantages above set forth, in the avoidance of the objections and disadvantages mentioned, and in accomplishing certain ends and gaining certain benefits which will below be pointd out or clearly appear, I have provided the constructions illustrated in the accompanying drawings which for purposes of convenience, as before suggested, are adapted for the production of a car wheel such as one made of steel which is solid, dense, hard and resistant and consequently of excellent wearing qualities at the peripheral or tread portion and may be relatively softer toward the center and therefore more tough and less apt to fracture.

In these drawings, it will be observed that

Figure 1 is a side elevation partly in section of a rotary casting apparatus;

Figure 2 is a plan view of the casting taken in the direction of the arrows shown on line 2—2 of Figure 1.

Figure 3 is a section taken on a line 3—3 of Figure 2.

Figure 4 is a plan view taken on a line 4—4 of Figure 3.

Figure 5 is a plan view of a core member assembly;

Figure 6 is a side elevation of the core member shown in Figure 5.

Referring to the drawing it will be observed that I may employ a mold, such as for a car wheel, which is preferably mounted upon a support 7 which is rotatable by means of a suitable driving mechanism indicated generally at 8. The mold 6 is provided with a pouring spout or funnel 9 having a refractory lining 10 for directing into the mold moulten metal from the ladle 11 or the like. The pouring spout is connected with a pouring gate which is a truncated cone having its major base 14 connected with the mold cavity or form 15, about a core member 16 which will be hereinafter described.

The major base of the truncated cone aforementioned is preferably positioned to supply moulten metal to a marginal portion of the main body of the mold and where the body is concentric with the central portion of the casting, it is preferred that this base portion be of substantially equal diameter as that of the hub portion of the car wheel so that the angular walls 17 are continuous with the walls defining the hub 18. The pouring gate of truncated-cone shape forms a passage to the main body of the mold about the core member 16 as at the annular portions indicated at 20. Preferably, however, this passage is divided so as to render the excess metal usually found in the pouring gate after the pour has been completed readily separable and for this reason the core member is provided with flanged portions 21, 22, leav-

ing metal passages therebetween numbered 23, 24. For forming these portions and for deflecting the metal from the core 16 and to prevent any disturbance of the core member by contact therewith of the flowing metal, I provide a shield portion 25 preferably a metal plate, formed of a general shape including the flanged portions 21, 22, which serves to offer resistance to the stream of moulten metal as it enters the cavity intermediate the casting mold, preferably adjacent the rim portion. Where I cast a car wheel, near the tread portion thereof I provide ancillary chambers, sinking heads or risers, 26, in the cope 6', which are preferably substantially truncated-cone shaped, that is, they have divergent walls and a mouth portion 27 at the base connected with the main body of the mold during the pouring operation. In the resultant casting, these sinker heads 26, 26 are duly removed during the finishing operation of the casting and before it is put into use. Similarly any excess metal in the pouring gate is also removed from the main body of the casting and where I have provided the core member with flanges 21, 22 the removal of this portion of excess metal will be facilitated as attachment of this excess portion to the main body of the mold is with metal which has flowed in the passages 23, 24.

In the production of a wheel of uniform composition, I preferably employ moulten steel having a specification of 0.25 to 0.50 per cent carbon and 1.25 to 2.0 per cent manganese, which may be introduced in the furnace, though it will be understood my present improvements are available for the production of wheels having varying composition by graduating the addition of the modifying material as can be accomplished readily by introducing it between the ladle and the mold in a manner such as outlined in my aforementioned patents or my application above mentioned.

The moulten metal is poured into the mold 15 through the pouring gate and as such mold fills, the ancillary mold cavities 26, 26 are also filled. The metal filling in throughout the mold cavity 15 enters the same through the passages concentric with the top of the core member 16 and where I have divided this concentric portion the metal enters through the passages 23, 24.

It will be observed that the metal flows to the casting in a direction substantially parallel to the axial line of the mold and that the metal flows thereto rectilinearly and directly in an unrestricted manner, the hub portion being filled at its marginal portion, which is the ultimate or final pouring step. During the pouring operation, the mold may be rotated but I prefer to rotate the mold after the pouring is completed, the rotation being effected until the casting is solidified. Preferably I include an amount of moulten metal in the pouring gate in excess of the amount necessary to fill the mold. This excess of metal, particularly where I use high speeds of rotation, serves as an additional fluid pressure head upon the metal in the mold. This additional component varies as the walls become more divergent with higher speeds of rotation. Where I position the mold as shown, this excess metal increases the pressure of the metal on the mold, due to the gravitational component.

From experience I have ascertained that if the mold 15 remains stationary I cannot infallibly attain a degree of solidity and density in the casting desired by me but that by utilizing a rate of rotation of say 25 to 100 revolutions per minute, centrifugal motion is imparted to the moulten metal to such an extent that the metal filling the sinker heads 26, 26 serves to completely fill the outermost parts of the mold and the excess metal in the pouring gate additionally serves to densify the metal at the hub portion as it acts upon the marginal portion of the hub at the passages 23, 24.

For certain purposes to further densify the moulten metal in the casting I may impart rotation above the speeds of revolution above mentioned to obtain a highly densified metal wherein the casting is completely filled and I am enabled not only to prevent the formation of holes and secure a solid and clean casting, free from entrapped gases, loose sand, slag, dross and the like but am also enabled to attain, in addition, complete solidity and marked degree of density at all portions of the casting, particularly at the hub portion, at which point the metal solidifies, free from attenuation or shrinkage cracks.

Where I have found that speeds of rotation intermediate the lower limits mentioned will cause the metal to frictionally engage the face of the mold, particularly those portions near the axis which are arranged transverse to the axis of the mold, so as to hang therein or fail to readily move towards the periphery of the casting, I have found that the metal accumulating in the pouring gate 10 will by reason of the sides or wall thereof being angular, characteristic of the sides of a truncated cone, that the component of the centrifugal force and that due to gravity will force the metal downwardly towards the main body of metal in the mold and thence outwardly radially. In this way, whatever metal ordinarily would have a tendency to hang on or rise away from the metal in the main body of the mold, will be forced into the mold and disengaged from the transverse portions of the mold or those portions offering the greatest amount of frictional contact.

I have also found that by forming the pouring gate as aforementioned, during ro-

tation the metal will not hang or rise away from the main body of the metal in the mold and give the deceptive appearance of the mold being completely full. For this reason I may operate my process at centrifugal speeds not previously available, and obtain densification of the casting in a manner not heretofore attainable, while at the speeds ordinarily used the excess metal in the pouring gate will serve as additional pressure to the main body of moulten metal and act as an additive force during rotation.

It will thus be observed that by this process there will be no attenuation during solidification between that part of the metal in the casting which has the highest degree of momentum imparted to it, and that portion having a lower centrifugal force nearer the hub or axis which is more readily affected by frictional engagement with the mold face. Thus assurance is had that the web and hub portions are completely filled during solidification.

For certain purposes, particularly where it is desired to feed to the stream of moulten metal a modifying agent forming varying alloys with the metal in the main body of the mold so that varying characteristics will be obtained in accordance with uses to which the wheel is to be submitted, I may modify my process by including during the pouring step the addition of a modifying element such as manganese of other ingredient having desirable properties when alloyed with steel. This modifying element may be added directly to the ladle 11 or between the ladle 11 and the mold 15 but for the purpose of introducing and incorporating most perfectly and commingling and distributing most thoroughly the modifying element into the stream of flowing metal, I make use of an ejector 29 and nozzle 30 so that the modifying element may be drawn or otherwise forced into the flowing stream of moulten metal.

By the process as above practiced, added modifying ingredients will be positioned at predetermined portions of the casting in an unrestricted stream and will be fully as effective at the desired points without adhering to intermediate portions of the walls of the mold, in that the passages to the mold are rectilinearly disposed and continuous with the walls of the pouring gate.

It will thus be observed that by the combined effects of the pouring gate and the ancillary chamber, a forceful feeding of the metal to the casting will be assured and more forcible as the speeds of rotation are increased. While this process is adaptable for use with "chills" in the rim of the mold for procuring densification with a high degree of success and which I consider within the scope of my invention, the preferred form of my invention contemplates the omission of chills so as to permit the free movement of materials of varying density, that is the entrapped gases, sand dirt, slag, dross and the like may find their way to the central portion of the mold, whereas the purified metal will be forced to the confines or periphery of the mold. And while I contemplate rotating my mold during the pouring operation, I prefer particularly in the casting of car wheels to first fill the mold and then rotate, having found that in this manner there will be no scouring or displacement of the mold, particularly where a sand mold is used, and in this manner also I obtain the benefits derived by using a mold that is completely filled.

Inasmuch as I preferebaly make use of centrifugal force, the extent to which the benefit thereof is attained obviousy depends in part upon the rate of revolution imparted to the mold 15 and in part to the time interval through which such movement is continued.

It is believed that the operation of my present invention and various applications of its use will be understood by those skilled in the art without further detailed description.

For certain purposes and in certain of its phases, it may be employed in connection with stationary molds, in intermittently rotated molds, in continuously rotated molds, and in molds rotated at predetermined times, and equally the modifying material may be introduced at various points or under various conditions, or both, all according to the prospective uses of the castings produced.

In the claims, where I have used the expressions "pouring the hub portion marginally", "marginal portions of the hub" or "marginal portions of the wheel" I mean to include by the term "marginal" the extreme lateral dimensions taken at any point of reference in a horizontal plane and where I make reference to "pouring marginally", it is contemplated that the molten metal flows preferably from such reference point from the source in a direction towards the extreme peripheral dimensions from the axial line rather than vice versa.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent, is:—

1. In a rotary casting apparatus for car wheel castings, a mold provided with a pouring gate, the walls thereof being divergent and continuous with the hub forming portion of the mold, to supply the metal directly to the marginal portion of the hub along the walls thereof, whereby when the mold is rotated at or above rotating speeds which would normally cause the metal to hang to the walls of the pouring gate or move away from portions of the casting, the hub forming portion of the mold will be completely supplied with the molten metal to and in-

cluding the full marginal portions of the hub.

2. In a rotary casting apparatus, a car wheel mold formed with a pouring gate adapted to supply said casting with excess metal at rotating speeds which would normally cause the metal to hang to the walls or move away from portions of the casting adjacent the axial portions, said pouring gate being formed with walls divergent towards the body of the mold and continuous with the outlines thereof, to keep said axial portions completely supplied during rotation of the apparatus at the said rotating speeds.

3. In a rotary casting apparatus, a car wheel mold provided with a pouring gate adapted to supply said casting with an excess metal at rotating speeds which would normally cause the metal to hang to the walls or move away from portions of the casting adjacent the axial lines, said pouring gate being provided with walls divergent towards the hub forming portion of the mold and having passages continuous therewith to keep said portions completely supplied adjacent the marginal portions of the hub during rotation at the said rotating speeds.

4. In a rotary casting apparatus, a mold provided with a pouring gate, an ancillary sinking head for receiving moulten metal for the formation of the casting therein, said sinking head and pouring gate being formed with walls divergent towards the main body of the mold, the pouring gate being adapted to supply metal gravitationally to all portions of the hub during rotation.

5. In a rotary casting apparatus, a mold provided with a pouring gate, an ancillary sinking head for receiving moulten metal for the formation of the casting therein, said sinking head and pouring gate being formed with walls divergent towards the main body of the mold, the pouring gate being arranged to completely fill all portions of the hub during rotation.

6. In a rotary casting apparatus, a mold provided with a pouring gate, an ancillary sinking head for receiving moulten metal for the formation of the casting therein, said sinking head and pouring gate being formed with walls divergent towards the main body of the mold, the pouring gate being arranged to directly and gravitationally supply metal to the hub at the marginal portions thereof during rotation.

7. In a rotary casting apparatus, a car wheel mold provided with a pouring gate, an interiorly disposed ancillary sinking head closed to the atmosphere for receiving moulten metal for the formation of a casting therein disposed near the periphery of the wheel, said sinking head and pouring gate being formed with walls divergent towards the main body of the mold and formed of a size relative to each other and to the main body of the casting to maintain the mold completely filled during rotation.

8. In a rotary casting apparatus, a car wheel mold provided with a pouring gate, an interiorly disposed ancillary sinking head closed to the atmosphere for receiving molten metal for the formation of a casting therein disposed near the periphery of the wheel, said sinking head and pouring gate being formed with walls divergent towards the main body of the mold and formed of a size relative to each other and to the main body of the casting to maintain the mold completely filled during rotation and to maintain an excess at a marginal portion of the hub.

9. In a rotary casting apparatus, a car wheel mold provided with a centrally disposed pouring gate, said gate being formed with walls divergent towards the main body of the mold and substantially continuous with the outlines of the hub forming portion thereof at the maximum divergence and arranged to be of a size relative to the main body of the casting to include a quantity of molten metal to maintain the mold completely filled during rotation and maintain an excess of metal at the marginal portions of the hub free from attenuation of the metal retained in the hub and intermediate portions between the pouring gate, at centrifuging speeds.

10. For use in a rotary casting apparatus, a car wheel mold including a pouring gate and a hub core member associated therewith, the pouring gate being divergent towards the hub forming portion of the mold and having substantially continuous outline and direct gravitational connection with said hub forming portion for the flow of metal from the pouring gate to the hub forming portion, said hub core member being arranged to facilitate the separation from the body of the casting of the excess metal normally retained in the pouring gate after complete pouring of the casting and comprising a deflecting plate immediately above the hub core member at that portion where the molten metal directly strikes said core member in flowing from the pouring gate.

11. In a rotary casting apparatus arranged to cast car wheels varying in density and composition between the axial portions and the peripheral wearing surface, the combination which includes a rotatable car wheel casting mold, molten metal supply means therefor including means to intermittently feed alloying ingredients for selectively forming in said casting an alloy steel of predetermined characteristics at predetermined portions, varying from the composition of the main body of the casting, a gate associated with said car wheel casting mold formed with walls divergent substantially continuously from the inlet to the hub forming portion of the mold whereby the metal and the alloy-

ing ingredients will flow in an unrestricted stream to the predetermined portions of the casting, free from adherence to the walls of the mold and the gate.

12. For use in a rotary casting apparatus, of a car wheel mold, a pouring gate and hub core member associated therewith, said hub core member being arranged to divert molten metal poured through said gate, through a plurality of passages to the hub forming portion of the mold, the center line of said passages of the gate being at right angles to the angle of repose assumed by the molten metal in the main body of the mold at centrifugal speeds of rotation of the casting apparatus.

13. A device of the character described comprising in combination, a car wheel casting mold mounted for rotation on a vertical axis, and having a metal receiving cavity at the hub thereof, said cavity being formed to provide the hub of said wheel and extending thereabove with continuous walls with said hub forming portion, to provide a combined sinking-head and pouring gate said sinking-head and pouring gate having wall portions diverging from top to bottom.

14. A device of the character described comprising in combination, a car wheel casting mold mounted for rotation on a vertical axis, and having a metal receiving cavity at the hub thereof, said cavity being formed to provide the hub of said wheel and extending thereabove with continuous walls with said hub forming portion, to provide a combined sinking-head and pouring gate said sinking-head and pouring gate having wall portions diverging from top to bottom, and a core in said hub forming portion of said cavity to form a center opening in said wheel hub.

In testimony whereof, I have hereunto signed my name, this 13th day of August, 1926.

JAMES CAREY DAVIS.