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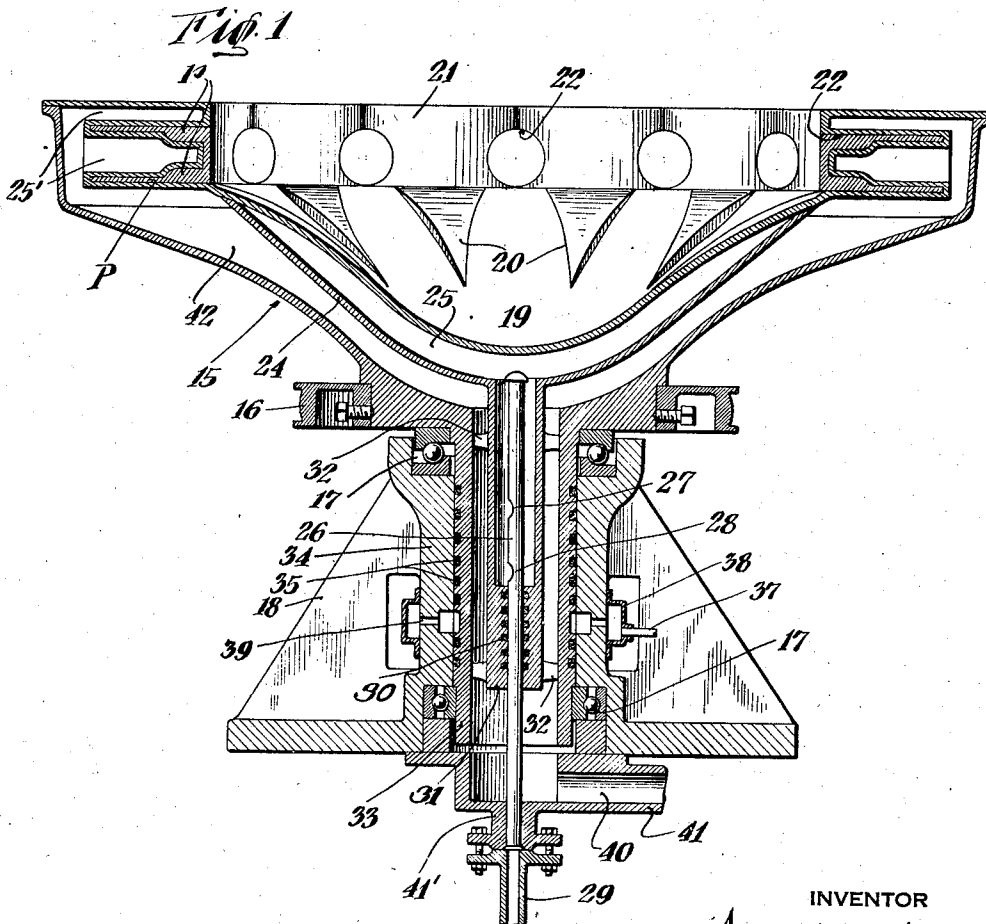
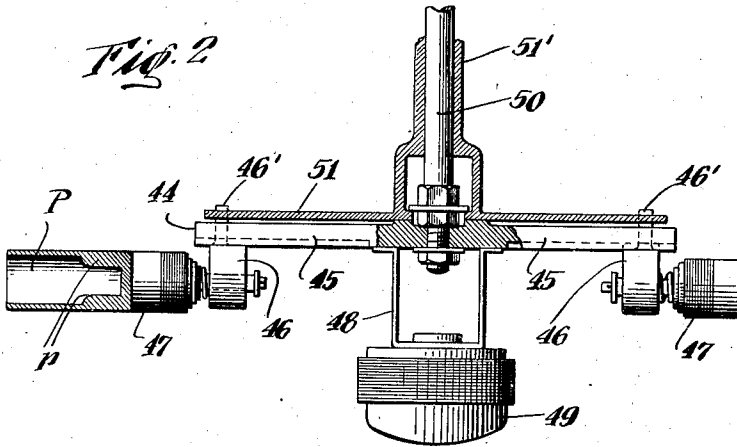
A. M. HENRY

1,997,405

FERROUS METAL CASTING

Filed Feb. 28, 1933

4 Sheets-Sheet 1



INVENTOR

Augustus M. Henry

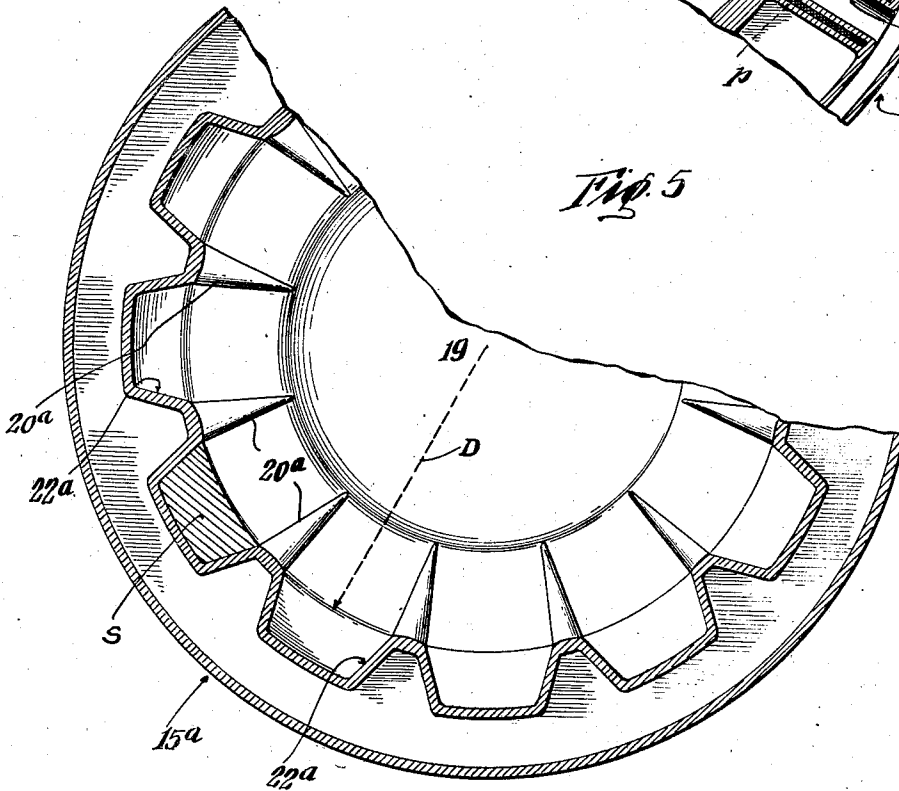
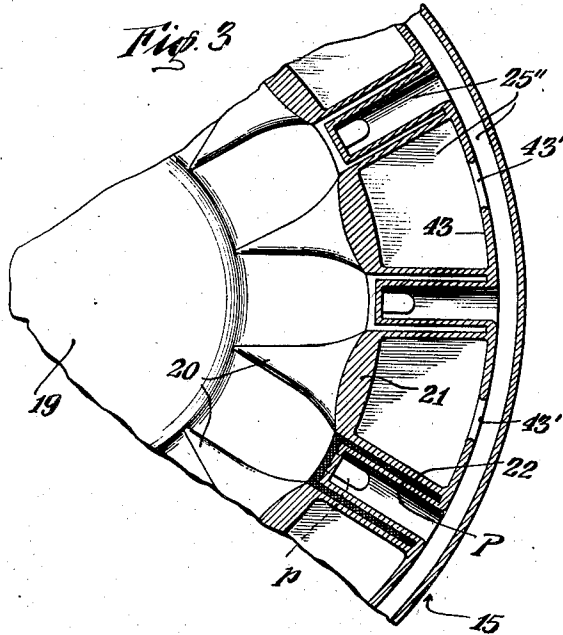
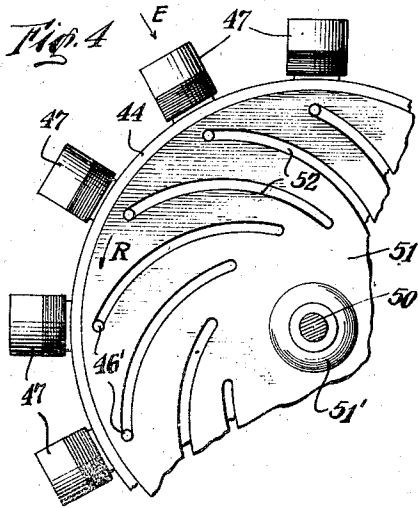
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4 Sheets-Sheet 2



INVENTOR

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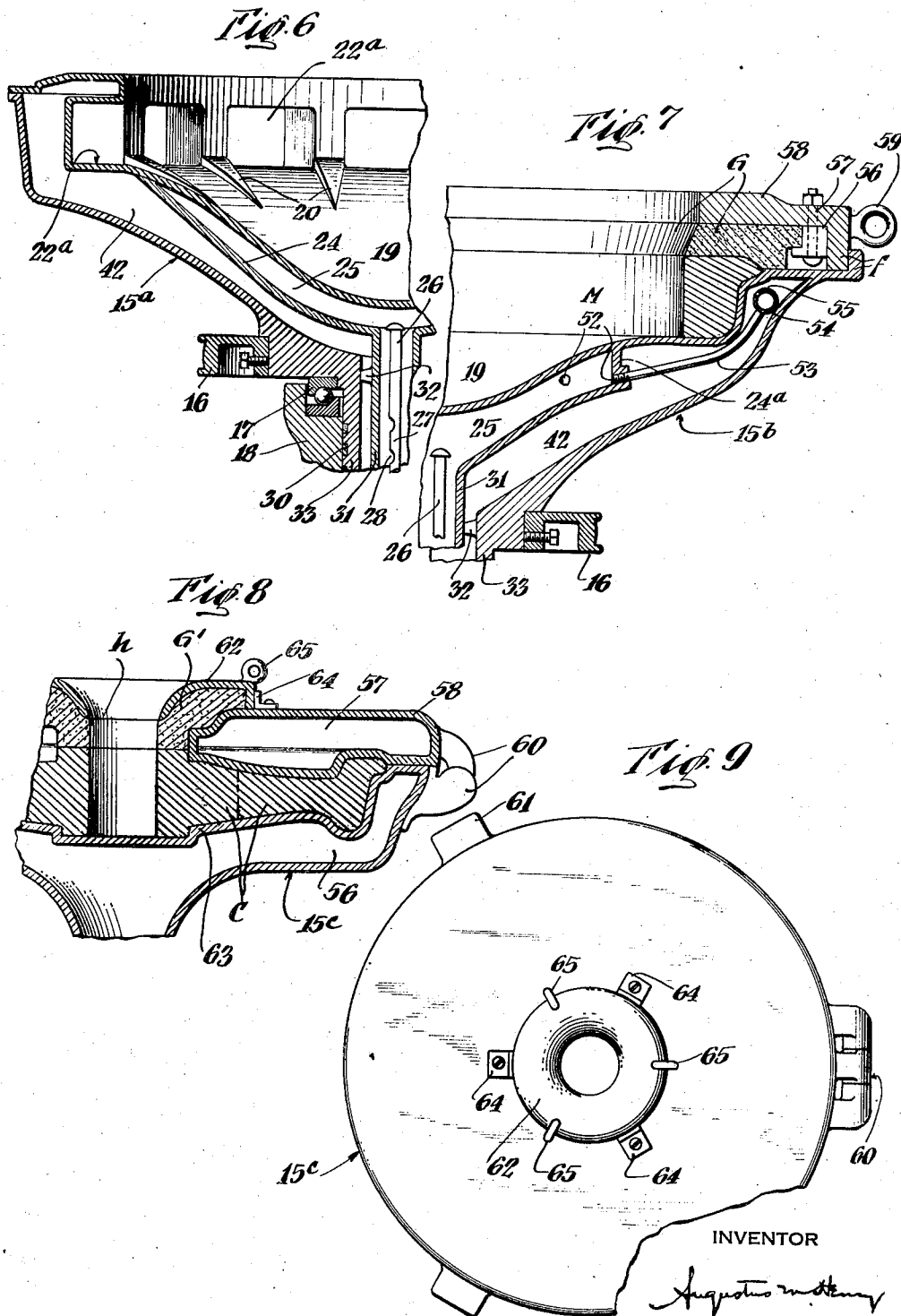
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FERROUS METAL CASTING

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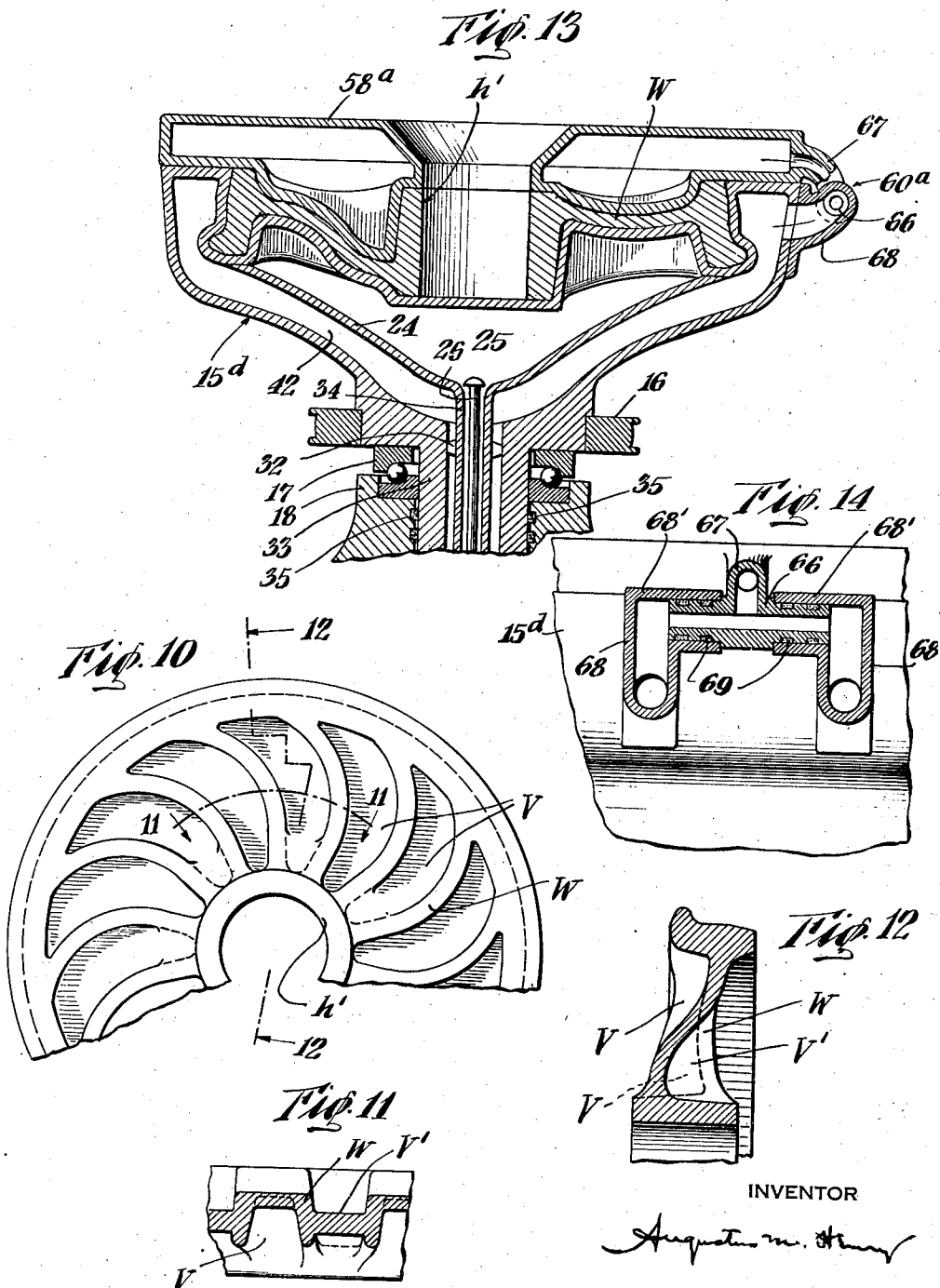
A. M. HENRY

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FERROUS METAL CASTING

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UNITED STATES PATENT OFFICE

1,997,405

FERROUS METAL CASTING

Augustus M. Henry, Brooklyn, N. Y.

Application February 28, 1933, Serial No. 658,893

3 Claims. (Cl. 22-65)

This invention relates to the casting of metals, and is particularly adapted for handling the ferrous metals, even steel. While perhaps most valuable in the art of centrifugal or rotary casting, the invention, or at least all the features thereof, are not to be limited to rotary casting; as will hereinafter become apparent and be definitely and positively emphasized by the language of the appended claims.

The invention has been made with the idea of improving upon and extending the use of mercury and mercury vapor according to the teachings of U. S. patents to Dale Nos. 1,698,624 and 1,698,623 or of any liquid and/or vapor now known or hereafter discovered and capable of employment approximately as mercury and mercury vapor or the like is taught to be used in said Dale patents; with or without the assistance of the teachings of U. S. Patent No. 1,561,924 to the present applicant.

Rotary casting presents, importantly, the possibility of high-speed production of cast articles. But to take advantage of this possibility, to the fullest extent, the mold, by which is meant the mold surfaces of the molding cavity or cavities, must be permanent. In order to attain such permanence, that is, to avoid the use of sand or cement lined molds, which linings require frequent renewal, a metal mold has been attempted to be used. In the case of such a mold, however, there is the danger of chilling the casting where chilling is not desired, or of cold-shotting the casting, or of otherwise obtaining a poor casting. The aforesaid Dale patents teach the use of a metal mold, in combination with the employment, in heat-exchanging relation with such mold, of a vapor such as mercury vapor which can be utilized as an easy controller of the rate of congelation of the molten metal as it is formed into a casting in the molding cavity;—mercury vapor, for this purpose, having the unique advantages clearly set forth in said Dale patents. The aforesaid Henry Patent No. 1,561,924 teaches the use of a mold which has a mold facing present as a preformed block of carbon densely compacted (such, for instance, as is used in making the carbon-electrodes for electric arc lamps or the commutator brushes for dynamos and motors), or an equivalent. The rate of heat conductivity of this carbon or an equivalent is so much closer to that of the foundry sand with which the ordinary foundry flasks are customarily lined, than to that of a metal mold, that the rate of congelation above referred to is held down

sufficiently for the satisfactory casting even of steel.

The present invention has been made, more specifically, with the aims, among others, of providing:

(a) An improved method and apparatus for casting an annular article or a plurality of articles annularly arranged, by the aid of a mold-including spinner rotating about a substantially vertical axis;

(b) An improved method and apparatus for the rotary casting, particularly in the kind of casting machine just alluded to, of an article having a disk-like as well as an annular characteristic, such as, for instance, a piston for an engine;

(c) An improved type of engine piston particularly adapted to be fabricated by the rotary casting method;

(d) An improved method and apparatus for the rotary casting, particularly in the kind of casting machine referred to under (a), of a disk-like object, such as a railroad car-wheel, where the bulk of molten metal to be supplied to form the casting is unusually large compared to the size of the "gate" which must be employed for the supply of such metal; and

(e) An improved type of railroad car-wheel particularly adapted to be fabricated by the rotary casting method.

The invention has various other objects and advantages, and includes other features than those hereinabove mentioned; as will appear hereinafter.

The invention will be more clearly understood from the following description, when taken in connection with the accompanying drawings, illustratively showing embodiments as now preferred of types of apparatus and articles of manufacture according to the invention; in which

Fig. 1 is an axial section, showing the casting machine of an apparatus adapted to cast simultaneously a plurality of annularly arranged objects, here shown as engine pistons of the automobile and airplane type;

Fig. 2 is a similar view, showing the elements of said apparatus which function to extract all said objects simultaneously after they have been cast;

Fig. 3 is a fragmentary top plan view of the casting machine shown in Fig. 1;

Fig. 4 is a similar view of the extracting means shown in Fig. 2;

Fig. 5 is a view similar to Fig. 3, but with the

casting machine arranged to cast simultaneously a plurality of railroad brake-shoes;

Fig. 6 is a view similar to Fig. 1, but showing, fragmentarily, the casting machine of Fig. 5;

5 Fig. 7 is also a view similar to Fig. 1, but showing, fragmentarily, a casting machine for producing at each operation a single article, and that article a rim for a railroad car-wheel;

10 Fig. 8 is also a view similar to Fig. 1, but showing, fragmentarily, a casting machine for producing at each operation a single article, and that article a railroad car-wheel;

Fig. 9 is a top plan view of the machine of Fig. 8;

15 Fig. 10 is a fragmentary side elevation of an improved type of car-wheel;

Fig. 11 is a section taken on the curvilinear line 11-11 of Fig. 10;

Fig. 12 is a section taken on the irregularly stepped line 12-12 of Fig. 10;

20 Fig. 13 is a view similar to Fig. 1, but showing a casting machine for producing the car-wheel of Fig. 10; and

Fig. 14 is a detail, partially in section, of the casting machine of Fig. 13.

25 Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring in detail first to Figs. 1, 2, 3 and 4, a spinner 15 is rotatable about a vertical axis, by power-drive to a pulley 16 fixed on the spinner as shown. The spinner is mounted by ball bearings 17 for rapid and vibrationless rotation within foundation 18.

This spinner at its central upper portion is open 35 to provide a bowl 19, above the latter a plurality of outwardly diverging radially arranged ribs 20, above said ribs a side wall 21, and in said wall a plurality of radially arranged casting pockets 22 arranged alternately with the ribs 20. Within 40 these pockets are inwardly directed, shaped, "core" structures 23. Thereby, when a charge of molten metal, as iron or steel (which will hereinafter be referred to for convenience, as representative of any metal or metals desired to be 45 employed), is dropped into the bowl 19, rotation of the spinner will spread the charge centrifugally and separate the same into substantially equal portions between each pair of adjoining ribs 20, and such charge portions will be forced into 50 various casting pockets, to form simultaneously twelve pistons all like those shown at P in Figs. 1, 2 and 3 and having crank-pin-mounting bosses like those indicated at p in these views.

In order to keep the iron charge delivered to 55 the bowl 19 molten as long as desired, as for instance in operating the machine by starting rotation of the spinner after such charge is in the bowl, or otherwise, the hollow interior of the spinner below the bowl is subdivided by a vapor-tight 60 wall to provide, above a lower chamber herein-after referred to, an upper chamber 25; this chamber 25 for containing a medium, preferably mercury vapor, and hereinafter for convenience called such, which can keep the preferably steel 65 spinner parts at the proper high temperature. For this purpose mercury vapor of the high temperature required is admitted to chamber 25 through a capped tube 26, having a vapor discharge opening 27 and a condensate egress opening 28. This tube is fixed, as is its feeding and 70 relieving conduit 29; there being a labyrinth joint 30 between the tube and a sleeve 31 fixed by spider-arms 32 within a hollow vertical shaft 33 forming the lower part of the spinner. Thus, 75 although the tube is stationary, and sleeve 31

rotates with the spinner, there is no possibility of mercury vapor leakage between the two. Foundation 18 has a long vertical main bearing 34 for this shaft 33, and mounting the ball bearings 17; and between said shaft and said main bearing is a labyrinth joint 35. As a further seal against even the slightest leakage of mercury vapor past said joint 35, an illuminating gas barrier is provided, including a gas inlet pipe 37, an annular gas-tight shell 38 leading from said 10 pipe, ports 39 leading from said shell, and matching grooves served by said ports; these grooves being annular, one inside the main bearing 34 and the other outside the shaft 33.

Shaft 33 is thus a gas-tight bypass around tube 15 26 and sleeve 31 for safely feeding to the interior of the spinner, during rotation thereof at any speed, mercury vapor under varying pressures and consequently under varying temperatures pursuant to the teachings of said Dale patents. The combined inlet and outlet for this vapor is through 20 a passage 40 formed in a casting 41, secured in a suitably gas-tight manner to the bottom of foundation 18, and providing in its dependent portion 41' a gas-tight securing means for the lower 25 end of tube 26. The upper end of the hollow shaft 33 opens into a chamber 42 below the wall 24; this chamber being mainly shaped like a downwardly dished disk but having upper, outer extensions 25' surrounding all the casting pockets 22 30 and their core structures 23, as clearly seen from Figs. 1 and 3—in which latter view there will be noted openings 43' in an annular wall 43 and which openings all around the spinner alternate with the casting pockets 22. These pockets, it will 35 be seen, extend radially between said wall 43 and the annular wall 21.

As soon as a casting operation is completed, that is, as soon as the twelve pistons P are sufficiently set for safe extraction from their molding cavities, 40 rotation of the spinner is stopped, and the extracting apparatus of Figs. 2 and 4 is brought into play.

This apparatus of Figs. 2 and 4 includes a disk 45 44 having twelve pairs of radial tracks on its lower side two of which track pairs are indicated at 45, 46 in Fig. 2. Slidable along each of these pairs of tracks is one of twelve carriages two of which are shown at 46, 46 in Fig. 2. Each of these carriages has offset therefrom, radially of disk 44, one of 50 twelve electromagnets 47. On the bottom middle of the disk 44 is a strap 48 carrying an electromagnet 49 the bottom of which is rounded to correspond more or less to the rotundity of the central part of bowl 19. The disk 44 is raised and 55 lowered by means of a suspending rod 40 to the lower end of which it is secured; this rod desirably being dependent from overhead supporting and controlling means (not shown), as a turntable on an elevator on the travelling carriage 60 of an overhead crane. Loosely sleeving the rod 50 is the hub-portion 51' of a horizontal wheel 51, so that the wheel is rotatable with its hub-portion relatively to the underlying disk 44. Disk 44 has twelve arcuate and generally secantially extended 65 slots 52; each slot receiving an upstanding pin 46' on a different one of the twelve carriages 46.

In using this apparatus of Figs. 2 and 4: The rod 50 is brought into axial alignment with the spinner 15, then said rod is lowered until the center lines of the magnets 47 are in the same plane 70 as the center lines of the casting pockets 22 (at which time the lower end of magnet 49 is just above such scrap or surplus metal as in bowl 19), and then said rod is fractionally rotated, if or as 75

required, to align the center lines of magnets 47 with the center lines of the castings P. Then, through electric circuits not shown, all the magnets are energized; each magnet 47 now seizing a casting P and the magnet 49 seizing such scrap or surplus metal as is in bowl 19. Then, by a suitable means not shown, the hub-portion 51' of wheel 51 is rotated in the direction of the arrow R of Fig. 4, to move said wheel relatively to the disk 44 and thereby retract all the pins 46' to the inner ends of the slots 52. As a result, all the carriages 46, their magnets 47 and the castings P, are moved in the direction of the arrow E of Fig. 4 a sufficient distance simultaneously to extract all the castings from their pockets 22. Thereupon, the rod 50 is lifted to the extent required to raise the whole extraction apparatus and its magnetically held objects and materials above the top of the spinner, and said apparatus is moved to another point in the plant for the removal, as by magnet-deenergization, of said objects and materials.

The new piston P is of the high tensile strength characteristic of centrifugally cast iron, and consequently can be made exceedingly thin-walled and hence of substantially the same weight as a duralumin or other aluminum-alloy or aluminum piston equipped with invar or equivalent struts or inserts. Such a cast iron piston is of high value, due to its own natural correct coefficient of expansion, and due to the elimination of localized points of differential stress and strain set up by invar struts or inserts, there being no such expansion-throttling expedients required.

Referring next in detail to Figs. 5 and 6, there is shown a casting machine of generally the same design and having the same dual vapor supply means and chambers as the machine of Fig. 1; as indicated by the same reference characters employed in both these views. The spinner here is marked 15a. This spinner differs from the spinner 15 of Fig. 1, in that it, the spinner 15a, has its casting pockets 22a shaped as shown so that each will make a separate railroad brake-shoe S, and has ribs 20a somewhat different in form from the ribs 20 of Fig. 1. As in the case of the machine of Fig. 1, twelve castings are made simultaneously; and these castings, after being made, can be simultaneously withdrawn from their casting pockets by apparatus similar to that shown in Figs. 2 and 4.

The new brake-shoe S is of dense, compact metal, and is absolutely free of blow-holes however small, as is characteristic of all centrifugally cast iron; and its frictional characteristics are ideal for braking railroad rolling-stock. Very little if any machining is required, especially if the radius of the line D of Fig. 5 be not excessively different from the diameter of the railroad car-wheel against which the shoe is to be applied in service.

Referring next in detail to Fig. 7, there is shown a casting machine of generally the same design and having the same dual vapor supply means and chambers as the machine of Fig. 1; as indicated by the same reference characters employed in both these views. Here, however, the spinner, which is marked 15b, has a partition wall 24a therein which is somewhat differently shaped from the partition wall 24 of Fig. 1. This wall is provided with apertures 52 therearound, each of said apertures having threaded thereinto the inner end of a pipe-like conduit 53. These conduits extend through the chamber 42, and at their outer ends lead into a continuous ring 54, suitably fixed in place in chamber

42, having spray-holes 55. The chamber 42, in the machine shown, which happens to be for the casting of a car-wheel rim as a single annular object to be formed at each casting operation, extends only part way of the height, all around the spinner, of the casting cavity for such rim, which last is indicated at M. To illustrate an employment according to the present invention of the teachings of the aforesaid Henry Patent No. 1,561,924, the remainder of the casting cavity for this rim M is here provided by gas-carbon or an equivalent, indicated at G. This material G is secured in place, by means of a clamp-ring 56, to a metal top or cover 58 of adequate weight to bear down properly, merely by gravity, on the top of the spinner during a casting operation; said clamp-ring being secured to the top 58 by a suitable number of bolts 57 spaced circumferentially around the ring. In preparing for a casting operation, top 57 is centered precisely and easily on the spinner by interfitting flanges on these two parts as indicated at f. When the casting operation is completed, the top 58 is removed from the spinner by engaging suitable lifting tools, as chain hooks, with three or more equal-weight and equally spaced lift-rings 59. As in the cases of the machines of Figs. 1 and 5, the chamber 25 is for the high temperature mercury vapor for maintaining molten the charge of iron or steel in the bowl 19 pending the dispersal of such charge from bowl 19 by centrifugal force in performing the casting operation, and the chamber 42 is for the mercury vapor for controlling the date of congelation of the casting or castings. The machine of Fig. 7, however, illustrates the utilization of further teachings of said Dale patents; the use of liquid mercury, and in connection therewith the latent heat of vaporization principle, in hastening the rate of cooling of a casting, say after the critical point referred to in said Dale patents has been reached, or otherwise. In the present case, liquid mercury is used in this way to impart a localized chill to a casting. As is well known, often it is desired to chill the tread of a car-wheel or car-wheel rim. In the machine of Fig. 7, this is accomplished, when the rim M has been formed, by injecting liquid mercury through the tube 26 and the sleeve 31 into the chamber 25 to a sufficient extent to allow centrifugal force to spray said liquid upwardly and outwardly of the chamber 25 and under sufficient velocity to force said liquid into and through the conduits 53 and thence into the ring 54 and through the spray-holes 55, which last are directed toward the parts of the rim tread it is desired to chill. To facilitate this liquid injection, the temperature and pressure of the vapor in chamber 25 is desirably considerably reduced. Such sprayed liquid as does not vaporize falls back, as do any condensates thereof, to the interior of hollow shaft 31, and such liquid as is left in conduits 53 or within chamber 25 drains back into sleeve 31 and thence into tube 26 and out of the machine; on stopping rotation of the spinner to remove the casting.

Referring next in detail to Figs. 8 and 9, there is shown a casting machine also including a vertical spinner, marked 15c, similar to those already described; this spinner for casting say a steel car-wheel, marked C. Spinner 15c is mounted for rotation as is the spinner 15 of Fig. 1; mercury vapor being admitted through the spinner sleeve as in Fig. 1, but the tube 26 of Fig. 1 and its appurtenances being omitted. Dur-

ing the pouring of successive charges of metal to make the complete car-wheel, so that the latter is gradually built up from the tread inward, all as hereinafter described, the mercury vapor in chambers 56' and 57' of the spinner is maintained at sufficiently high temperature to hold the metal being cast to the requisite fluidity to preclude any tendency even to cold-shotting. As soon, however, as the wheel is completely thus built up, this same vapor is varied in temperature and pressure to control precisely as predetermined the rate of congelation of the casting as a whole as per the teachings of said Dale patents. Chamber 56' is in the spinner proper, and chamber 57' is in a top or cover 58' therefor. This top is shown as hinged at 60 to the spinner proper, and counter-balancing weights are provided as at 61, 61'. As will be hereinafter described in connection with Fig. 14, this hinge is composed of, and/or associated with, a number of relatively movable parts which are not only hinge parts but also mercury vapor conducting elements made gas-tight by labyrinth joints. Thus the temperature and pressure of the vapor in the chamber 57' will always correspond with the temperature and pressure of the vapor in chamber 56'.

This machine of Figs. 8 and 9 also illustrates another feature of the invention, which is that of gradually inwardly roofing over the casting cavity or cavities in a spinner rotating on a substantially vertical axis as the casting is more and more built up. In the present case, this feature is illustrated in connection with a car-wheel where the permissible final "gate", or input orifice for the molten metal, is an opening of the relatively small diameter of the axle-receiving center hole *h* of such wheel, compared to the diameter of the wheel itself as here shown—that is, where the space defined by such final gate is very small relatively to the bulk of the metal to be poured as a totality during the casting of the entire wheel and before any part of the casting begins to set. Said feature involves the successive additions to the spinner of one or more ring closures of smaller and smaller diameter. In the present case, for example, only one of such closures is illustrated. Such closure here includes a metal annulus 62, suitably securely mounting therein and thereunder a lining of gas-carbon *G'* or an equivalent. When the casting of the wheel has proceeded to the point where a certain part of the molten metal charge has been distributed by centrifugal force within the casting cavity of the spinner, such annulus is applied, and then the remaining part of the charge is applied to the spinner, through the central opening of the annulus. For instance, before the annulus 62 is applied, the car-wheel *C* is built up say to the dot-and-dash line 63, and then the annulus is laid atop the spinner, and the car-wheel completed as shown. While the annulus 62 is being applied, the spindle continues rotation, at least at a speed sufficient to hold the line 63; the annulus being lowered, by suitable overhead apparatus (not shown), so as gently to come to rest on top of the rotating spinner and come up to speed with the latter—whereupon the annulus-holding part of said overhead apparatus (which is desirably rotatably mounted on said apparatus) is released and withdrawn. Now the spinner is again brought up to casting speed, if its rotation has been slowed down below that as a temporary step to facilitate adding the annulus as just described. The annulus, centered by lugs 64 on the spinner, is held

in place by its own weight, during rotation of the spinner. To remove the casting, the annulus is lifted up and away by its eyes 65, the top 58 is swung over and away on hinge 60, and the casting is removed as by dropping an expansion-grapple (not shown) within the hole *h*, expanding the grapple and hoisting out the casting—all this of course after rotation of the spinner has been stopped following completion of the casting.

Referring next to Figs. 10 and 11 and 12, an improved type of railroad car-wheel is shown which has the strength of a double-webbed standard car-wheel yet avoids such a double web. A double-webbed car-wheel requires a continuous annular core between hub and tread, and the holding of such a core in place in a rotary casting machine presents extreme difficulties. However, the equivalent of a double web is obtained in the car-wheel shown in these views by providing a single web which undulates circumferentially of the wheel between hub and tread. Desirably, also, because this gives a better load distribution in service and a more uniform absorption of stresses and strains, these undulations are present as rather distinct corrugations or grooves; and, further toward the same end, these groovings are also desirably arcuate or curvilinear lengthwisely thereof, between hub and tread. As these just-stated preferences are illustrated in the embodiment of car-wheel shown in Figs. 10, 11 and 12, such corrugations or groovings are indicated at *V* and *V'* on opposite sides of the wheel and the single web at *W*.

Referring finally to Figs. 13 and 14, there is shown a casting machine for making such a car-wheel as that shown in Figs. 10, 11 and 12; but having generally the same elements and the same dual vapor supply means and chambers as the machine of Fig. 1, as indicated by the same reference characters employed in Figs. 1 and 13. However, the spinner of Fig. 13, which is marked 15*d*, is, above its interior chambers, considerably like the spinner 15*c* of Fig. 8, including, as it does, a vapor containing top or cover 58*a* and a vapor-passing hinge 60*a*. The casting cavity between the spinner proper and said top is so shaped as to produce the car-wheel of Figs. 10, 11 and 12. Such car-wheel, it will be noted, as an axle-receiving central hole *h'* occupying a space relatively large as compared to the bulk of total metal contained in the completed car-wheel, and so an annulus like the annulus 62 of Fig. 8 is not employed.

Finally, as to Fig. 14, this very clearly shows the details of construction of the hinge 60*a* of Fig. 13. The pintle 66 of such hinge is a T-head on a gooseneck 67 on the cover, said pintle and gooseneck being hollow and the passage in the latter communicating with the hollow interior of the cover; while the accommodating swing-mount for said pintle is made up of a pair of sleeves 68' embracing considerable end-lengths of the pintle, these sleeves forming parts of L-shaped extensions 68 from the spinner proper, which extensions are hollow with their passages communicating with the passage in the pintle and also with the hollow interior of the spinner proper. To prevent gas leakage between the pintle and sleeves, labyrinth joints are provided as indicated at 69, 69'.

As already indicated, and as will be made apparent from the claims following, certain elements and features of the present invention,—notably the new piston as an article of manufacture, the new car-wheel as an article of manufacture, a

molten metal receiving station (such as or analogous to the bowl 19) in combination with a vapor in heat exchanging relation thereto additional to a vapor in heat exchanging relation to the molten metal after the latter has been transferred to its casting cavity, a hinge-connection or a mechanical equivalent between relatively movable vapor-jacketed mold-parts which connection is also a conduit for mercury vapor or the like, and so on,—are not to be limited to centrifugal or rotary casting; but may be used in connection also with stationary or fixed molds, as, for instance, to facilitate the carrying out of what in effect is the die-casting of ferrous metals. This last will be appreciated when it is pointed out that with the fluidity of molten ferrous metals prolonged indefinitely, as is made possible by the present invention, the die-casting of ferrous metals, heretofore deemed practically impossible, presents no more real difficulties than the present-day widely successful die-casting of low melting-point alloys and other metals than iron or steel; especially when it is remembered that in rotary casting the equivalent of a molten-metal-compressing mechanical ram is intangibly present as centrifugal force, and that in fixed-mold casting such a ram, either as a hydraulically operated auxiliary or the like, or as a sufficient excess amount of molten metal to act as a gravity head, is readily employable.

The scope of protection contemplated is to be taken primarily, if not solely, from the appended claims; which are to be interpreted as broadly as is consistent with the prior art.

Having thus described my invention, what I claim, and desire to secure by United States Letters Patent, is:

1. In casting apparatus, the combination of a main mold body, an auxiliary mold body movable relative to said main mold body, a mechanical

connection between said bodies to permit the auxiliary mold body to participate with the main mold body to build up a casting cavity or to be positioned to facilitate removal of the completed casting, a vapor chamber for jacketing each of said bodies, a communication passage between such chambers within said mechanical connection, and means for admitting heated vapor to one chamber and consequently to the other whereby the rate of congelation of the casting may be affected by varying the temperature of said vapor.

2. In metal casting apparatus, the combination with a rotary casting machine having molten metal receiving station and a molding cavity removed from said station, said cavity being spaced from said station outwardly radially from the axis of rotation of said machine whereby centrifugal force acts to transfer molten metal from said station to said cavity during rotation of said machine, of a first vapor receiving chamber in heat transfer relation to said cavity for controlling the congelation of a casting in said cavity, a second and independently served vapor receiving chamber for maintaining molten metal at said station at the requisite fluidity prior to and during transfer of said metal from said station to said cavity.

3. In a rotary casting machine, the combination with a casting machine having a molten metal receiving station substantially at the center of rotation, and a plurality of radially arranged casting pockets all facing said station, each of said pockets for forming a different article; of a mount movable toward and from said station, means carried by said mount for seizing the castings in their cavities, and means for moving such seizing instrumentalities toward said center to withdraw said castings from their pockets.

AUGUSTUS M. HENRY.