June 27, 1939. J. R. BURNS 2,164,228

PHOSPHORUS CHARGING METHOD AND APPARATUS

Filed Feb. 16, 1938 2 Sheets-Sheet 1

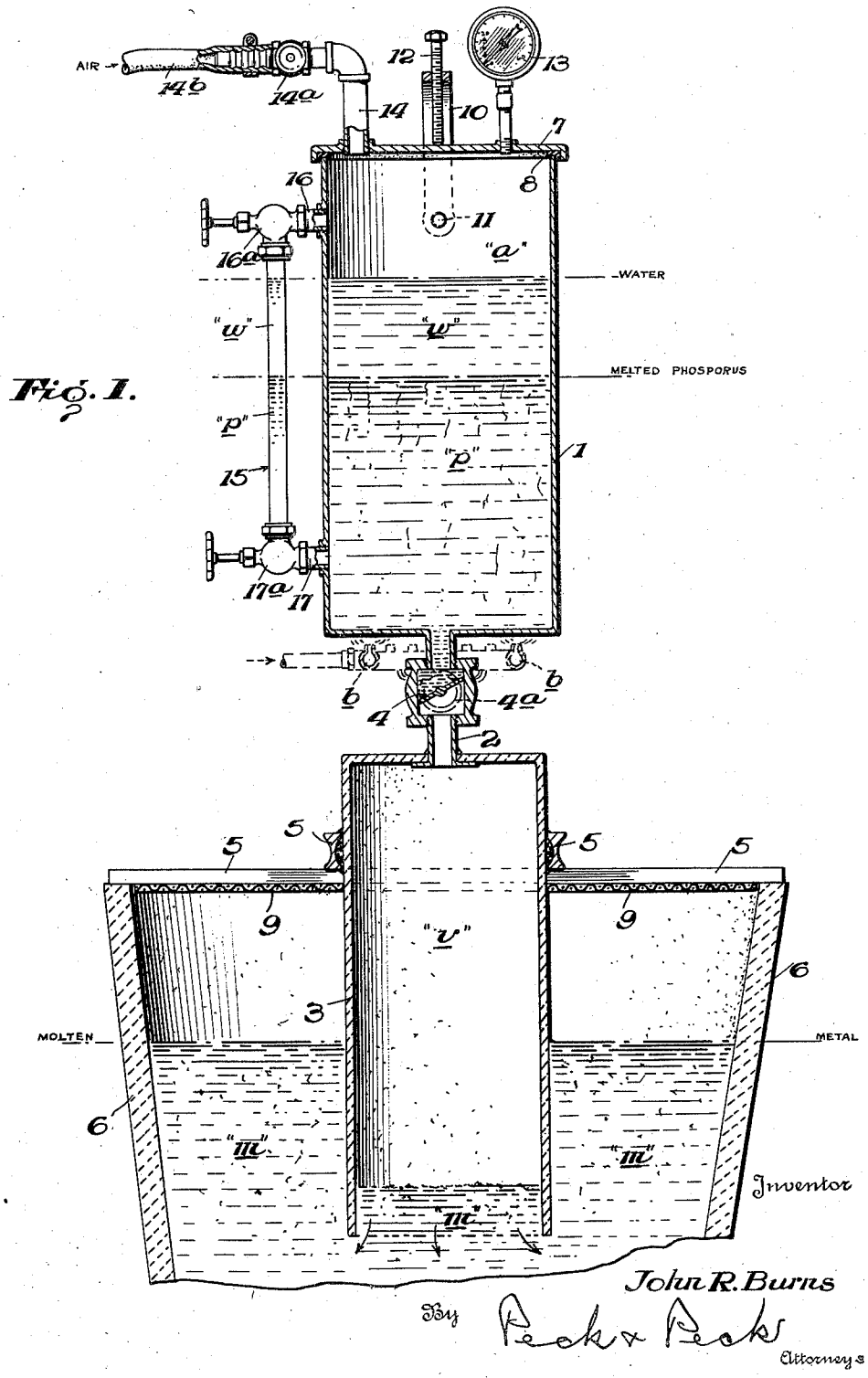


Fig. 1.

Inventor

John R. Burns

By Peck & Peck

Attorneys

June 27, 1939. J. R. BURNS 2,164,228

PHOSPHORUS CHARGING METHOD AND APPARATUS

Filed Feb. 16, 1938 2 Sheets-Sheet 2

Fig. 2.

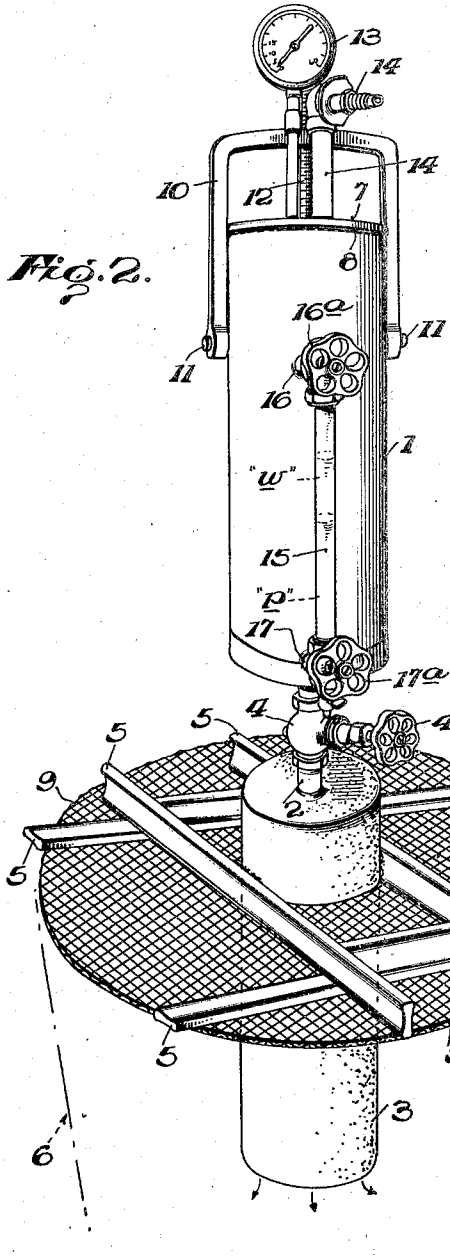
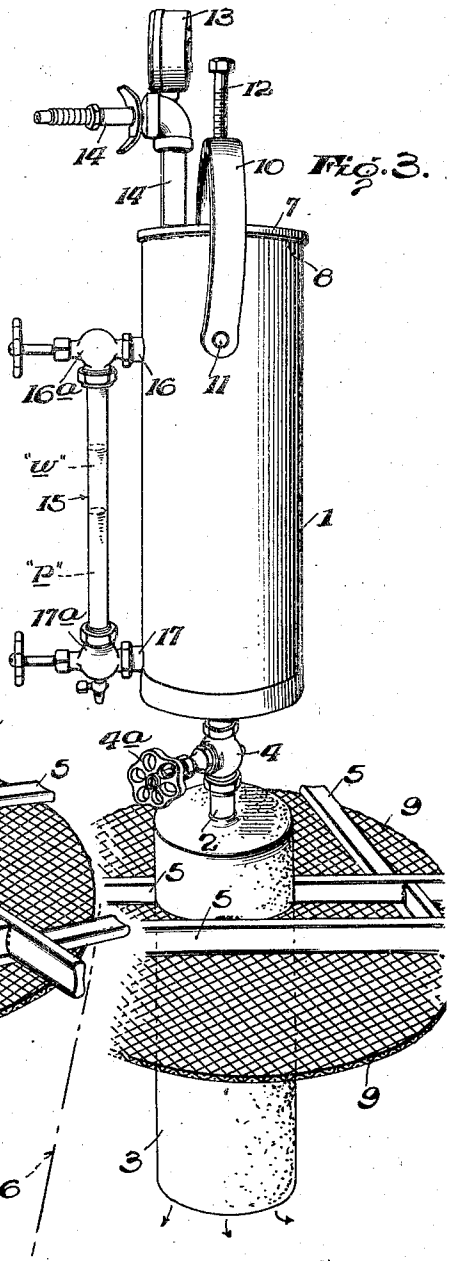


Fig. 3.



Inventor

John R. Burns

By Peck & Peck

Attorneys

Patented June 27, 1939

2,164,228

UNITED STATES PATENT OFFICE

2,164,228

PHOSPHORUS CHARGING METHOD AND APPARATUS

John R. Burns, Powell, Ohio

Application February 16, 1938, Serial No. 190,847

11 Claims. (Cl. 266—34)

This invention relates to a phosphorus charging method and apparatus, and particularly concerns the art of producing phosphoric materials or alloys; and the objects and nature of the invention will be understood by those skilled in the art, in the light of the following explanations of steps and procedure followed in the practice of my method of handling and charging reagents, such as phosphorus, into molten material, and in the light of the following description of the accompanying drawings illustrating what I now believe to be the preferred embodiment of apparatus for carrying out my method, from among other forms, structures, arrangements and constructions within the spirit and scope of the invention.

The yellowish, or so-called "yellow," phosphorus of commerce is not stable in light and air, is highly inflammable, taking fire in air somewhere about 93° F., melting at approximately 111° F., and boiling at approximately 554° F. This element is exceedingly difficult to handle with safety and economy, particularly when charging or introducing the same into molten metal or other materials as in the production of phosphoric materials, or alloys, such as phosphor-bronze, phosphor-copper, etc.

Those implements and methods, now employed with which I am familiar, for charging or injecting the phosphorus into the molten metal in open-top pots or crucibles are uncertain, and wasteful in action, and dangerous to those contacting the phosphorus, as well as dangerous to the attendants and operatives, not only because of lack of manual control of the conversion of the phosphorus to the gaseous state, but also because of the lack of possibility of control or regulation of the charging or injecting rate and quantity of phosphorus being introduced into or to contact with the molten metal, with molten metal projected or flying from the pots, as the result, due to explosions within the molten metal in the pot caused by the too quick rapid conversion of bodies of solid phosphorus to the gaseous state, or by the too rapid injection of too much gaseous phosphorus into the molten metal.

It is an object of this invention to provide a method of and means for the economical, safe, and manually-controlled introduction of yellow phosphorus, into molten material or metal, in the production of alloys or phosphorized materials, with the end in view of minimizing the dangers and difficulties hereinbefore recited.

A further object of the invention is to maintain the supply of raw material, the solid phosphorus, out of contact with the atmosphere; namely, sealed from air, while being converted to the flowable liquid state, and to control or regulate the flow of the liquid phosphorus, to a zone of high temperature wherein said liquid is converted into gas for final operative contact with the molten material or metal.

A further object of the invention is to maintain the supply of raw material, the solid phosphorus, in a substantially stable condition totally immersed in a body of liquid such as water, and thereby sealed from contact with the outer air, while reducing the said submerged phosphorus to the liquid state, for feeding to the molten metal in the pot or crucible.

A further object of the invention is to protect the supply of solid phosphorus by submerging the same in a body of water for heating and reduction to the liquid state, and to feed the liquid phosphorus from the water to the high temperature zone of the molten metal, under manual control, by fluid pressure applied to the surface of said body of water, and to convert the phosphorus into the gaseous state by the high temperature of said zone, and to discharge said gaseous phosphorus into the body of molten metal below the surface thereof.

And a further object of the invention is to provide apparatus for injecting or introducing phosphorus, while in the gaseous state, into molten material or metal in a pot or crucible for phosphorizing the same, and wherein the supply of solid phosphorus will be maintained submerged within and below the surface of a body of water, while being reduced to the liquid state, and wherein provision is made for the application of fluid pressure to the surface of the body of water for forcing the liquid phosphorus therefrom under manual control and regulation, to the high temperature zone of the body of molten material for reduction to the gaseous state.

And a further object of the invention is to provide a mobile apparatus, adapted to be transported from one crucible of molten metal to another, for phosphorizing the metal in such pots, and to provide such apparatus with a water and phosphorus chamber wherein to maintain the supply of solid phosphorus submerged below the surface of a body of water, and wherein the phosphorus is to be melted by the application of heat, and from which the liquid phosphorus is to be fed to the pot of molten metal.

And a further object of the invention is to provide certain novel combinations, features, structure and arrangements for the production of a

highly advantageous and improved apparatus for charging molten materials and metals with phosphorus.

With the foregoing and other objects in view which will be developed by the following description, my invention consists in certain novel method steps, and in certain novel combinations, constructions, and features, more fully and particularly hereinafter explained and specified.

In the accompanying drawings, forming a part hereof:

Fig. 1 is a somewhat diagrammatical longitudinal section, showing an example of an embodiment of the invention applied to a pot or crucible containing molten material to be charged, the yellow phosphorus being shown in a fluid or melted condition covered by the sealing body of liquid such as water, the valve for regulating and controlling the discharge of melted phosphorus to the vaporizing and discharge nozzle shown projecting down into the molten mass to be charged, being shown in its tightly closed position, in readiness for "cracking" to initiate the charging operation, suitable heating means, such as a usually removable gas burner, to heat the retort for melting the phosphorus, usually before application of the charging apparatus to the crucible, being indicated by dotted lines.

Fig. 2 shows the charging apparatus of Fig. 1, partially in perspective.

Fig. 3 also shows said apparatus from a different angle, partially in perspective.

The particular construction illustrated by the drawings merely as one example, from among others, of an embodiment of the invention, is in the form of a mobile charger or injector, adapted to be handled and transported as a unit, from one crucible or pot of molten material to another, so that the molten contents of a number of crucibles, can be successively charged and phosphorized. However, I do not wish to limit all features of my method and apparatus invention to such a mobile unit.

In the example shown, this unit includes a phosphorus-melting upright retort or vessel **1**, of strong usually steel or iron construction that provides an interior vertical chamber of a capacity to receive the charge of solid phosphorus, usually commercial yellow phosphorus in the form of "chunks" or pieces, and the charge of liquid, such as water, in volume sufficient to completely cover and submerge the solid phosphorus, and to provide a compressed air space within the chamber above the water level in the chamber.

A rigid strong vertical tubular liquid-phosphorus iron or steel offtake pipe or connection **2**, leads from the lower end or bottom of said chamber through and depends from the bottom end head of retort **1**, and at its lower end extends through the top end head of and discharges into the interior of a vertically elongated hollow phosphorus-vaporizing and discharge nozzle or retort **3**, open at its lower end for discharge of the phosphorus vapor into the molten material into which the nozzle is adapted to extend. This nozzle **3**, is composed of suitable refractory material capable of withstanding the high temperature of the molten metal or other material into which it is intended to be partially immersed. Usually this nozzle is composed of substantially the same material that is employed for the construction of crucibles.

The offtake pipe or hollow connection **2**, is preferably rigid with both the otherwise closed lower head of the retort **1**, and the otherwise closed top head of the nozzle **3**, and this offtake pipe **2**, preferably maintains the nozzle **3**, spaced a substantial distance from the lower end head of retort **1**, preferably with the retort and nozzle in longitudinal alinement.

The normal capacity or internal diameter of offtake **2**, is relatively quite small or restricted with respect to the internal cross sectional dimensions of the retort and nozzle. This offtake **2**, is provided with any suitable adjustable means, preferably, manually controlled and actuated, by which the passage through the offtake can be closed, and/or opened to any desired capacity between completely closed position, and completely opened or full capacity position.

For example, I show a valve **4**, for this purpose, located within the offtake pipe, and provided with an exterior accessible handle **4a**, by which the valve can be moved and set at any desired position, as above outlined, to shut off or regulate the flow of liquid phosphorus from the bottom of the chamber within the retort to the interior of the nozzle. The portions of this regulating valve exposed to contact with the phosphorus, are preferably composed of some material, such as iron or steel, inert to phosphorus.

The mobile charging unit, as above outlined, is preferably provided, as a part thereof, with a suitable support or rest, as for example, the strong metal laterally projecting opposite side supporting feet or rails **5**, arranged exteriorly of the nozzle, and fixedly secured thereto, preferably at opposite sides thereof near its upper end. These supporting feet, are adapted to rest, for instance, on diametrically opposite portions of the top edge of the pot or crucible **6**, containing the molten material, such as metal *m*, with the nozzle depending centrally from such support, the required distance down into the molten mass in the pot or crucible.

The elongated upstanding retort **1**, is provided with a top closure or removable top head **7**, normally closing the otherwise open top of the retort through which the retort is charged with the required volume of sealing liquid and the charge of solid reagent, such as phosphorus. This closing head **7**, can be of any suitable construction, and can be rendered applicable to and removable from the retort by any suitable means. For instance, merely as an example, I show a rigid strong removable closure head **7**, more or less of disk-like form, adapted to fit down on the top edge of the barrel or body wall of the retort, preferably against an asbestos or other suitable sealing gasket **8**, resistant against heat, and fluid, etc. This gasket will be clamped and compressed between the head and wall edge to provide a seal tight against liquid and pressure escape.

The removable top head or closure, can be removably secured to the body or barrel of the retort to form a tight seal, in any suitable manner or by any suitable means, although in the particular example shown, I happen to provide a swingable yoke **10**, straddling the removable top head or closure, with its legs depending at diametrically opposite sides of the retort body and coupled thereto by alined transverse pivot trunnions **11**. The transverse top portion of the yoke, is formed with a vertical screw threaded hole, through which the vertical closure contacting and clamping screw **12**, extends and is longitudinally movable by rotation to contact and tightly clamp the closure head to the retort to tightly seal the retort charging opening, and by rotation in the opposite direction to release the yoke for lateral

swinging, freeing the closure head for removal.

The retort is preferably provided with means for the introduction of fluid pressure, such as air under pressure, into the air space at the upper end of the chamber within the retort, and also with an exterior gage to show the air pressure within said space.

For instance, I can provide an exterior visible pressure gage or indicator **13**, supported by the top closure head of the retort and having its air tube opening through the closure head to the air space within the retort.

Also, the attachment to receive the pressure tube from a suitable source of air under pressure, and deliver the same into the air space within the retort, can, if so desired, be carried by and open through the removal closure head. For instance, I show rigid air pipe **14**, fixed to and opening through the closure head and at its upper end provided with a coupling nipple and means for attachment of the pressure air supply pipe *14b*, and also providing a shut-off and controlling valve *14a*.

The retort is provided with an exterior visible indicator to show the water level, and also the liquid phosphorus level, in the retort. For instance, a water glass or tube **15**, can be provided for this purpose carried by top and bottom tubular fixtures, the top fixture **16**, opening into the air space within the retort, and the bottom fixture **17**, opening into the liquid phosphorus space at the lower portion of the interior of the retort. As usual, each fixture is, preferably, provided with a valve *16a*, or *17a*, whereby the passages within the fixtures can be opened or closed.

Even in carrying on my instant method, the operative through inadvertence, accident or mistake, might feed the phosphorus too rapidly or in too great volume into the molten metal and thus cause explosions therein or too violent and excessive boiling or agitation thereof with resulting upward spraying or discharge of globules or particles of molten metal from the crucible, with possibility of injury to closely adjacent operatives. I hence provide a horizontally-disposed shielding screen **9**, having a centrally disposed vertical opening more or less closely receiving the depending nozzle **3**, that extends downwardly therefrom the necessary distance into the molten metal in the crucible, although I do not wish to so limit all features of my invention. This shield **9**, is located above that surface area of the molten metal in the crucible, that surrounds the nozzle **3**, and that is more or less adjacent thereto, without necessarily covering or shielding the entire top surface area of the molten mass in the crucible. The possibility of excessive boiling and spraying of molten metal, under the above recited circumstances, occurs in the molten metal adjacent to and surrounding the nozzle **3**. Hence, although I happen to show this screen **9**, in area approximately the same as the area of the top surface of the molten material *m*, yet in some instances the screen can be of relatively smaller size, to extend over this danger zone, leaving opportunity for the operative to insert a stirring implement into the crucible through the uncovered space surrounding the shield **9**. This shield can be secured to and carried by the supporting base or standard **5**, of the charging unit, so as to be applied to the crucible by and removed therefrom with the unit. Under some circumstances, the shield can be separate from the unit, and independently applied to, removed from, and supported by the crucible.

This fine screen **9**, can be composed of a reticulated metal sheet, or a wire screen-like sheet, say, of approximately ⅛" or ¼" mesh, so that the gases pass therethrough, while obstructing passage of spraying molten metal, to protect the adjacent operatives from burns and injury.

In carrying out my method, I preferably proceed as follows, namely—

While the melting retort **1**, is maintained in its normal upright position with the cut-off and regulating valve **4**, tightly closed against liquid flow or leakage, and with the pressure air flow through pipe *14b*, cut off, the closure end head **7**, is removed from the retort, thereby opening the top of the retort for charging the interior chamber thereof. Thereupon, the retort is approximately, but not completely filled with the sealing liquid to be employed, such as, preferably, clear water ("*w*", Fig. 1). The quantity of water with which the retort is charged should be sufficient to completely cover and submerge the said phosphorus charge to be added, and leave a substantial depth and layer of water over the phosphorus after the phosphorus has been reduced to liquid, see Fig. 1. The volume of water with which the tank is charged should also be sufficiently less than the full capacity of the retort, to leave the compressed air space *a*, Fig. 1, between the water level and the retort top.

When the retort has thus received its charge of sealing water, the water level in the retort, will appear through the transparent glass tube **15**. When charging the retort, the water flows into the tube **15**, through the bottom fixture **17**.

The next step, is to charge the water filled retort with the supply of solid so-called yellow phosphorus. Where the commercial product, yellow phosphorus, is employed, the solid "chunks" or pieces of phosphorus, are removed from the tight container in which packed and delivered, to the predetermined measured weight or volume required for the phosphorizing work to be performed, and dropped into the water in the retort, and become wholly submerged therein.

The retort is now charged with the supply of phosphorus wholly submerged in and covered by the sealing liquid, and hence the retort is now closed and tightly sealed against air and liquid escape, by the application and securing of the closure head **7**, as hereinbefore described.

External heat is now applied to the tightly closed and sealed and charged retort at sufficiently high temperature, to melt the contained submerged phosphorus, and reduce the same to a flowable liquid condition. The liquid phosphorus, maintained in such condition precipitates or settles in the offtake pipe **2**, above the closed regulating valve therein, and to the bottom of the retort, displacing the water which thereupon forms a protective layer or body on the fluid level surface of the body of liquid phosphorus, as shown by Fig. 1, wherein, *p* is the body of liquid phosphorus; *w*, the protecting covering body of water; and *a*, the pressure air chamber above the body *w*, of water.

During the transition of the phosphorus from the solid to the liquid state, the liquid phosphorus, gradually enters the fixture **17**, and the glass tube **15**, displacing the water previously therein, until, when the phosphorus has been completely reduced to flowable liquid condition, the transparent tube **15**, will show the level of liquid phosphorus in the retort and also the depth and level

of the covering body of water, as appears by Fig. 1.

The exterior phosphorus melting temperature should be controlled to prevent water and phosphorus vaporizing temperatures within the retort.

The phosphorus melting temperature can be applied to slowly and gradually melt the phosphorus, and maintain the same in liquid condition, by an exterior preferably removable, gas burner *b*, indicated by dotted lines Fig. 1, or by a blow torch, steam jacket, electrical heating means, or otherwise.

When the water glass **15**, shows by its displayed levels of the water and liquid phosphorus, in the tank, that the phosphorus therein, has been completely and wholly reduced to the desired flowable liquid state, and there should be certainty as to this, the charging unit is removed from the heating means, or vice versa, and said unit is transported to the open-top crucible or pot containing the body of molten material such as metal, to be phosphorized. The unit is dropped onto the crucible **6**, with its supporting base **5**, resting on the top edge of the crucible, and with its shield **9**, arranged over the surface of the molten metal "*m*", Fig. 1, surrounding and adjacent the nozzle **3**, and with the lower discharge end of the nozzle **3**, depending the required distance down into the molten metal, say from two to six inches, approximately, below the surface of such metal.

The usually flexible pressure air hose **14***b*, is then coupled to pressure air inlet fixture **14**, that leads into the air space "*a*", or if said flexible pressure air hose **14***b*, remains coupled to the fixture **14**, air pressure of fifteen to twenty pounds per square inch, more or less, is then established in the air space *a*, and thus approximately maintained throughout the following operation of charging the molten metal with the desired quantity or volume of phosphorus from the charging unit.

The regulating valve **4**, is then "cracked" cautiously, and slowly, and carefully opened, and thereupon the pressure in the retort on the covering sealing liquid therein, gradually forces a small quantity of liquid phosphorus from the retort through offtake pipe **2**, past the valve, and into the phosphorus vaporizing chamber *v*, within the nozzle **3**, and above the level of the molten metal that extends up in said nozzle from the open bottom discharge end of the nozzle.

The liquid phosphorus discharged therefrom by the air pressure within the retort, falls from offtake pipe **2**, onto the surface of the molten metal in the nozzle, and is thereby quickly converted into vapor or to a gaseous state. There exists within the vaporizing space within the nozzle, a high temperature zone, approximately a zone of the temperature of the molten metal, which is sufficiently high to vaporize the phosphorus. The pressure within the nozzle thus generated as the flow of phosphorus into the nozzle continues, plus the pressure existing within the retort, is sufficient to depress the molten metal level in the nozzle, and force the discharge of gaseous phosphorus from the open discharge end of the nozzle into the mass of molten metal exteriorly of the nozzle and cause agitation thereof to the extent necessary to enable the molten metal to absorb and take up the phosphorus, and this agitation of the molten metal by the action of the gaseous phosphorus discharged thereinto, can be supplemented if necessary and desirable, by the operation of a stirring implement in the hands of an attendant.

The charging unit, is of sufficient weight, or can be so anchored, as to prevent the pressure within the nozzle and against the surface of the molten metal, from lifting the unit and carrying the nozzle up from the molten mass.

The phosphorus is thus thoroughly mixed with and distributed throughout the mass of molten metal, to effect the desired phosphorization thereof, and this without explosions within the molten mass and consequent splashing and spraying molten metal to the exterior of the crucible, caused by too sudden discharges of too much phosphorus into the molten mass. The rate and quantity of phosphorus discharge from the retort, is under the constant control of the operative by manipulation of regulating valve **4**.

During the phosphorization process, the phosphorus should be fed into the nozzle in such volume and at such a rate as to maintain but a mild, but not violent boiling action within the molten metal mass.

The operative by constantly observing the molten mass in the crucible, determines whether the phosphorus is being fed too fast or too slowly. If the boiling or agitation is too violent, or if flames momentarily appear on the surface of the molten mass, too much phosphorus is being discharged into the mass or the phosphorus feed is too rapid, and the operator thereupon manipulates the regulating valve to reduce the rate of feed, or momentarily stops the feed. When bursts of flame continue to appear on the surface of the molten mass, even when the phosphorus is very slowly fed in reduced volume, the molten mass has reached the state of phosphorus saturation, and the valve **4**, should be operated to tightly close the offtake pipe **2**.

When the desired percentage of phosphorus has been introduced into the molten metal in the crucible, the valve **4**, is tightly closed, and the charging unit is removed from the crucible, and placed at rest with the retort in a vertical position. If phosphorus remains in the retort, the lower end of the nozzle is inserted in a body of water, in any suitable vessel, to seal the nozzle discharge, and is thus maintained in this position with the nozzle outlet sealed, until the charging unit is to be again inserted in molten metal, for phosphorizing the same.

In charging the retort, sufficient water should be placed therein to show an inch more or less in the water tube **15**, depending of course on the amount of phosphorus to be added, as the phosphorus, both in the solid and the liquid form, must be fully covered by water.

In charging the retort with phosphorus, the phosphorus chunks should be broken from the supply mass or body, under water and quickly transferred to the water in the retort.

The operation of heating the charged and sealed retort, to melt the phosphorus, should be carried on slowly and gradually, to avoid sudden application of high temperature and quick melting and expansion.

Before application of the nozzle to the molten metal, the operative should be certain that there is no moisture within the nozzle, and that the vaporizing chamber therein is thoroughly dry and that the valve **4**, is in position tightly closing offtake pipe **2**, and that all of the phosphorus in the retort is in melted condition and has settled into pipe **2**, on the valve **4**, and has displaced all of the water from the valve and the offtake pipe.

During the phosphorizing operation, the operative not only constantly closely observes the condition of the molten mass in the crucible, but also

observes the air pressure gage and the liquid phosphorus level as disclosed by the glass tube 15, and always tightly closes the offtake pipe 2, by manipulation of the regulating valve 4, before the liquid phosphorus is even approximately exhausted from the retort 1, preferably before the liquid phosphorus disappears from the glass tube 15, to absolutely avoid any possibility of water passing from the retort into the offtake pipe.

The presence of the sealing water covering the yellow phosphorus in the liquid chamber or retort 1, during the step of reducing the solid phosphorus to the fluid or liquid condition by heat, prevents the formation of phosphorus vapor and the consequent possibility that the yellow phosphorus might be converted into so-called red phosphorus. In other words, the sealing water holds the temperature of the submerged phosphorus to approximately 212° F. which is well below the phosphorus boiling point.

While in the hereby disclosed specific example of one embodiment of my invention, I describe water as a sealing fluid, yet I desire to cover my invention for use with any other sealing fluid, and molten masses, for which my invention is or may be adapted.

Desiring to protect my invention both specifically and generically, as fully and completely as is legally possible, what I claim is:

1. A unit for charging a molten mass with phosphorus, embodying a liquid phosphorus receiving and vaporizing discharge nozzle providing an internal vaporizing chamber for the free downward passage of falling liquid phosphorus, and open at its lower end, the discharge end of which is adapted to extend down into the molten mass to be phosphorized with a surface area of said molten mass exposed in said chamber; in combination with a normally-closed water-bath and phosphorus melting-elongated retort providing an internal space for a charge of solid phosphorus submerged in a water bath, said retort adapted to be heated to melt said solid phosphorus for settling in said bath to provide a supply of liquid phosphorus covered by the displaced water in the retort, said retort being elevated and normally fixed with respect to said nozzle with said nozzle depending substantially therefrom during a charging operation; the vaporizing chamber of said nozzle being in direct outer-air-excluding communication with the liquid phosphorus containing space of said retort to directly and vertically receive liquid phosphorus dropped therefrom onto said molten mass surface; and manually controlled valve means for opening and closing said communication and for regulating the rate of direct liquid phosphorus flow into said nozzle.

2. A unit for discharging vaporized phosphorus into a molten mass, comprising a normally-closed solid-phosphorus-melting water-bath retort internally providing a chamber for a charge of solid phosphorus submerged in a sealing water bath with a space over the water bath, said retort adapted to be heated for melting said solid phosphorus in said bath for settling therein to provide a supply of liquid phosphorus covered by the displaced water; a visible liquid level indicating tube at one end in normal open communication with said space over the water bath, and at the other end in normal open communication with the lower portion of said chamber occupied by the water bath or by the liquid phosphorus, to normally visibly indicate the water bath level before the phosphorus is melted, and after the melting and formation of the liquid phosphorus supply, to visibly indicate both the level of the liquid phosphorus and the level of the displaced water in said tube; in combination with means extending from said retort and providing an outer-air-excluding passage from the liquid phosphorus containing portion of said retort chamber for directly receiving liquid phosphorus therefrom for vaporization and discharge into the molten mass; and valve means for starting and stopping said liquid phosphorus discharge flow and for regulating the rate of said flow into said passage.

3. An apparatus for charging phosphorus into a molten mass, comprising a normally-closed retort providing an internal chamber to receive a charge of solid phosphorus submerged in a water bath, said retort adapted to be heated for melting the phosphorus to settle in the chamber and provide therein a supply of liquid phosphorus covered by the displaced water; means to visibly indicate at the exterior of said retort the level of said water bath before complete melting of the solid phosphorus, and after the complete melting of the phosphorus, to visibly indicate the level of the liquid phosphorus supply and the depth of the displaced water, to thereby indicate when the charge of solid phosphorus has been completely melted; in combination with means operatively associated with the retort and leading therefrom and providing a normally closed internal liquid phosphorus passage from the supply of liquid phosphorus in the retort, including a liquid phosphorus vaporizing portion having an end discharge adapted to be submerged in the molten mass to be phosphorized; and manually actuated and controlled means for opening and closing said passage and for regulating the rate of flow of liquid phosphorus thereinto from said retort.

4. In an apparatus for charging phosphorus into a molten mass, the combination of a sealing-water-bath and solid-phosphorus-melting normally closed retort providing an internal water bath chamber to receive a charge of solid phosphorus to be sealed by the bath, said chamber providing a space above the water bath level for liquid-phosphorus-ejecting pressure fluid, said retort adapted to be heated to melt the phosphorus submerged in the water bath for settling therein to provide a supply of liquid phosphorus covered by the displaced water; with vertically-disposed means normally fixed with respect to said retort and providing a depending internal liquid phosphorus passage directly from the liquid phosphorus in said retort, including a liquid phosphorus vaporizing chamber having an end discharge for insertion into the molten mass to be phosphorized; said passage and chamber formed for the free downward movement of the falling liquid phosphorus to the surface of the molten mass in said end discharge; and manually actuated and controlled valve means for starting and stopping and regulating the rate of liquid phosphorus flow from said retort into said passage.

5. A portable unit for charging phosphorus into a molten mass, including in combination, a normally-closed elevated water-bath and solid phosphorus-melting retort for melting a charge of solid yellow phosphorus sealed therein from contact with the air, and provided with a normally-closed restricted vertical bottom outlet for gradually dropping liquid phosphorus therefrom; manually controlled means for starting and stopping and for regulating the volume of falling

liquid phosphorus; and a phosphorus-vaporizing and discharge nozzle depending from said retort and providing a relatively large vertical passage in outside-air-excluding continuation of said outlet to receive the liquid phosphorus falling therefrom, and permit free downward passage of the falling liquid phosphorus therethrough, while the discharge end of the nozzle is immersed in the molten mass to be phosphorized, and thereby vaporize said liquid phosphorus and discharge the same into said mass.

6. In the method of phosphorizing a molten mass, those steps which comprise gradually melting a charge of solid yellow phosphorus while immersed in a bath of inert sealing fluid in a closed chamber to provide a supply of liquid phosphorus covered by the displaced fluid; and then gradually flowing liquid phosphorus only from said supply in said chamber under manual regulation and control directly into a charging nozzle while the outlet of said nozzle is immersed in and below the surface of said molten mass, whereby the heat of the molten mass vaporizes the liquid phosphorus in the nozzle and the pressure thus generated within the nozzle drives the phosphorus vapor from the nozzle into the molten mass below the surface thereof.

7. In the method of phosphorizing a molten mass, those steps which consist in immersing a charge of solid yellow phosphorus in a sealing water bath in a chamber; then tightly closing said chamber; then gradually reducing said solid phosphorus to flowable fluid form by the application of heat until the flowable liquid phosphorus has settled into a supply of liquid phosphorus in said closed chamber covered by the water bath; supplying pressure in said chamber above the liquid bath; and then gradually releasing liquid phosphorus from said body within said chamber under manual control, into the vaporizing chamber of a charging nozzle while the outlet end of said nozzle is immersed in said molten mass and its chamber exposed to the high temperature of said molten mass, whereby the liquid phosphorus is thereby vaporized within said chamber and driven from the nozzle into the molten mass.

8. The method of charging a molten mass with phosphorus, that comprises, dropping liquid phosphorus under releasing and stopping control and volume regulation, directly from a confined supply of melted flowable yellow phosphorus sealed by a water bath from contact with the air, and under ejecting pressure, and delivering such discharged liquid phosphorus into the liquid-phosphorus-vaporizing heat zone of said molten mass while said liquid phosphorus is confined and excluded from air contact, and discharging the thus vaporized and confined phosphorus into said molten mass below the surface thereof.

9. A yellow-phosphorus-melting and molten-mass-charging unit, comprising a sealing-liquid-bath and phosphorus-melting retort providing an upwardly elongated interiorly unobstructed normally sealed chamber of capacity to receive a sealing liquid bath and a charge of solid yellow phosphorus submerged in said bath for melting and an air space above said bath; means providing a restricted outlet from the bottom of said chamber for dropping liquid phosphorus only from said chamber, and manual means for opening and closing said outlet and controlling the liquid phosphorus volume dropping therefrom; in combination with a vaporized phosphorus discharge nozzle normally rigid with and substantially depending from said retort, and providing an interiorly unobstructed liquid phosphorus vaporizing chamber open to the discharge outlet of said nozzle and substantially in longitudinal alinement with said liquid phosphorus outlet to directly receive the liquid phosphorus from said outlet and permit free downward passage of the falling liquid phosphorus to the molten mass surface exposed in said chamber, when said nozzle is immersed in the molten mass.

10. A mobile unit for charging yellow phosphorus into a molten mass, comprising a depending discharge nozzle providing an internally unobstructed longitudinal liquid phosphorus receiving and vaporizing chamber of relatively large cross-sectional dimensions for the free downward passage of falling liquid phosphorus, said chamber being open at its lower end for discharge of vaporized phosphorus into the molten mass, whereby a surface area of the molten mass will be exposed in said chamber when the discharge end of said nozzle is immersed in the molten mass; in combination with a sealing liquid bath and solid-yellow-phosphorus-melting retort, normally rigid with and arranged above said nozzle and providing an upwardly elongated interior retort chamber for a sealing liquid bath and the solid yellow phosphorus submerged therein, said retort chamber open at the top for reception of said liquid bath and the solid phosphorus to be submerged therein, and provided with a top head for uncovering and tightly sealing said open top; said retort chamber provided with a restricted liquid phosphorus bottom discharge for dropping liquid phosphorus only directly from said retort chamber into said vaporizing chamber of the nozzle and onto said surface area of the molten mass, and a manual control for closing and opening said discharge and controlling the volume of liquid phosphorus dropping therefrom.

11. A unit for charging yellow phosphorus into a molten mass, comprising a normally closed upstanding retort for a supply of flowable fused yellow phosphorus covered by sealing liquid bath with a fluid pressure space above the bath; means to constantly, exteriorly and visually indicate the falling level of said supply of liquid phosphorus during a molten mass charging operation; said retort being provided with a manually controlled restricted exit from the bottom of said supply for dropping liquid phosphorus directly therefrom in restricted controlled volume; in combination with a depending discharge nozzle having a vaporized-phosphorus-discharge open end adapted to be immersed in said molten mass with a surface area of said mass exposed therein, said nozzle providing a longitudinal laterally enlarged chamber-forming passage leading to said open end and in substantial alinement with said exit to directly receive the falling phosphorus therefrom for dropping therethrough onto said area of the molten mass surface, said passage being internally unobstructed for the free downward movement of the falling liquid phosphorus and for the vaporization thereof and discharge into the molten mass under the pressure thereby generated in said chamber.

JOHN R. BURNS.