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REAGENT FEEDING APPARATUS

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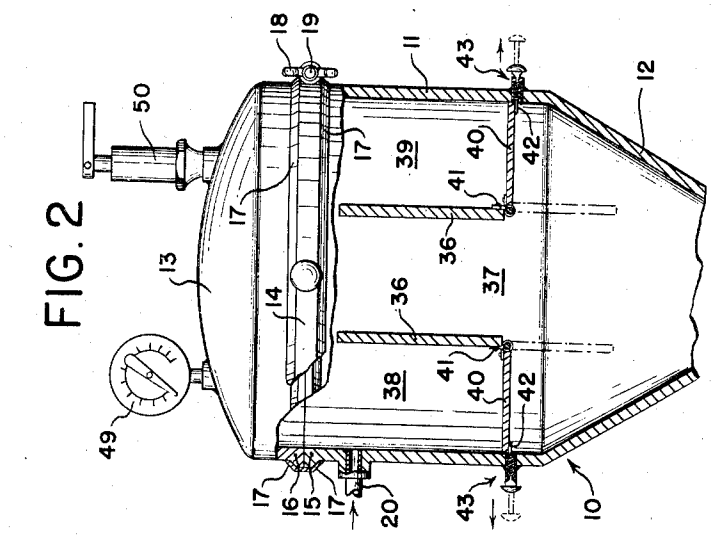


FIG. 2

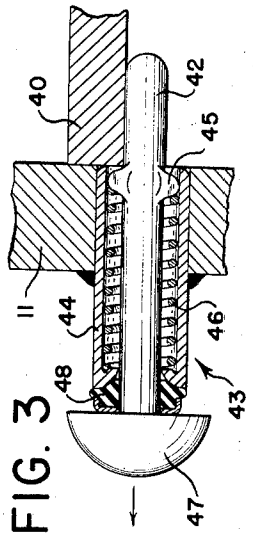


FIG. 3

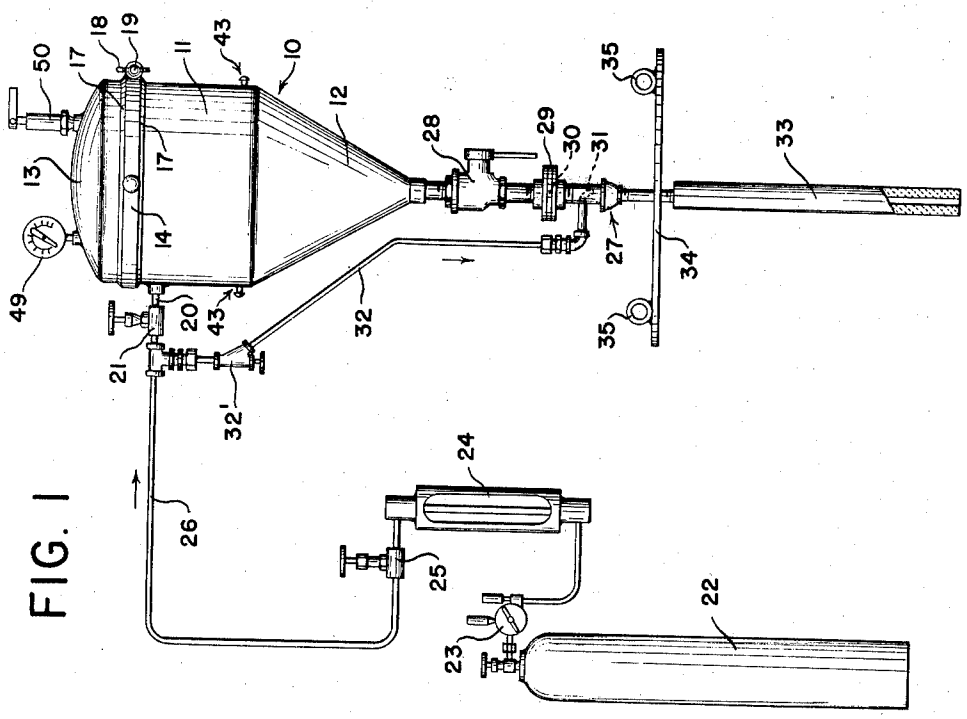


FIG. 1

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REAGENT FEEDING APPARATUS

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2 Claims. (Cl. 266—34)

This invention relates to reagent feeding apparatus, and is particularly directed to the provision of an improved form of apparatus for feeding finely divided solid reagents in successively delivered batches into material to be treated therewith. This application is a continuation-in-part of our prior application Serial No. 430,864, filed May 19, 1954.

Probably the most satisfactory way of introducing a dry pulverulent reagent into molten metal or other similar material to be treated is to feed a flowing stream of the reagent in admixture with a carrier gas into the molten metal or other material. The carrier gas is necessary because dry pulverulent reagents do not flow readily by themselves. Moreover, in treating molten metals it is generally best to introduce the reagent at a considerable distance beneath the surface of the melt. This necessitates feeding the reagent under a pressure sufficient to overcome the hydrostatic head of the molten metal, and the development of such pressure is most conveniently accomplished by forming a flowing stream of the reagent in a carrier gas under pressure.

Not infrequently the treatment of molten metals and the like requires introducing several successive batches of dry solid reagents. For example, in the treatment of molten cast iron, it is often desirable to introduce first a desulfurizing agent such as calcium carbide, and then a nodulizing agent such as a granulated alloy containing magnesium. Moreover, it is sometimes desirable that the added reagents be incorporated in rapid succession just prior to casting. Heretofore the introduction of two or more successive batches of treating reagents into the molten iron has necessitated opening the reagent feeding apparatus after the first batch of reagent has been delivered into the molten metal, recharging the apparatus with the new reagent, and then feeding the new reagent into the molten metal. Alternatively, the use of two separate reagent feeding devices has been necessary. With the first of these alternatives a considerable interlude necessarily occurs between the feeding of the successive batches of reagent; and with the second alternative the apparatus requirements are undesirably complex.

The present invention provides an improved form of apparatus by which finely divided or granular solid reagents may readily be fed into molten metal or other material to be treated. The new apparatus provides for easy and effective incorporation of the solid reagent in the flowing gas stream, and for insuring that the gas solid mixture will begin to flow promptly when desired and will continue to flow in a stream of proper density for so long as desired. Moreover, the invention provides apparatus by which a plurality of batches of dry pulverulent reagent may be delivered successively into molten metal or other material to be treated, and by which the successive batches of reagent may be delivered one after the other with little or no lost time between them.

The new apparatus comprises a pressure-tight feed hopper, and means for introducing gas under superatmospheric pressure into said hopper. A feed conduit is connected with the hopper for conducting the solid reagent into the molten metal or other material to be treated. In a preferred form of apparatus according to the invention, the interior of the hopper is divided by one or more partitions into two or more compartments, one of the compartments being a main compartment connected with the feed conduit, and the others being auxiliary compartments. The bottom of each auxiliary compartment is closed by a bottom closure which is normally held in the closed position. Closure-release means which extend to outside the hopper and which are operable from outside the hopper are provided so that the bottom closure can be opened and the contents of the auxiliary compartment can be discharged without releasing the gas pressure from the hopper.

A feature of the invention is the provision of an orifice plate in the feed conduit, by which the flow of reagent through the feed conduit is controlled. The apparatus also preferably includes a by-pass conduit by which gas under pressure can be admitted directly to the feed conduit without passing through the hopper. Valve means in the by-pass conduit provide for proportioning the amount of gas that flows into the hopper relative to the amount that by-passes it.

The new apparatus is prepared for use by closing the bottom closures and charging batches of different reagents, or successive batches of the same reagent, into the several compartments of the feed hopper. In using the apparatus, the contents of the main compartment are first discharged through the feed conduit into the material being treated, and thereafter the contents of the auxiliary compartments may be discharged in succession by successively operating the closure-release means for the bottom closures of the auxiliary compartments. Since it is unnecessary to release the gas pressure from the feed hopper, or to recharge it, each time a new batch of reagent is to be fed into the molten metal, the successive batches may be fed rapidly one after another with a minimum time delay between them, and with a minimum of manipulations.

The foregoing and other features of the invention are described in greater detail below with reference to the accompanying drawings, in which—

Fig. 1 is a general view of a preferred embodiment of apparatus according to the invention;

Fig. 2 is a fragmentary view, partially in cross section, of the feed hopper shown in Fig. 1; and

Fig. 3 is an enlarged view, in cross section, of the catch and catch release means for the bottom closures of the auxiliary compartments shown in Fig. 2.

The apparatus shown in Fig. 1 comprises a feed hopper **10** having a cylindrical body **11**, a conical bottom section **12**, and a removable cover **13**. The cover **13** is held in pressure-tight engagement with the hopper body by means of a clamp ring **14**. The body and cover are formed with annular flanges **15** and **16**, respectively, and the clamp ring is formed with sloping sides **17** which engage correspondingly sloped surfaces of the flanges **15** and **16**. A wing nut **18** threaded on a clamp screw **19** is provided for drawing the clamp ring **14** tightly about the flanges **15** and **16**, and thereby securing the cover **13** tightly against the hopper body **11**. By loosening the wing nut, the clamp ring **14** may be disengaged from the flanges **15** and **16**, thus permitting the cover **13** to be removed.

Means comprising a gas inlet pipe **20** are provided for admitting gas under pressure to the interior of the hopper **10**. A valve **21** is provided to control the admission of gas through the pipe **20**. The source of gas under pressure is shown in the drawings as a conventional gas cylinder **22**, from which the gas passes through

a pressure regulator valve 23, a flowmeter 24, a shut-off valve 25, and a gas supply line 26 to the valve 21.

A reagent feed conduit 27 is connected to the bottom section 12 of the feed hopper. A reagent flow control valve 28 is provided to control the outflow of material from the hopper 10 through the feed conduit. While any desired form of reagent flow control valve may be employed, it is preferable to use a type of valve which in the open position affords an unobstructed passage through the feed conduit.

An orifice plate 29 is advantageously inserted in the feed conduit 27 to control the rate of flow of reagent therethrough. The orifice plate 29 advantageously is simply a circular plate in which a centrally located orifice hole 30 of desired size is formed. The orifice plate may be mounted by clamping it between the engaging components of a conventional pipe union. With such mounting it is a simple matter to remove the orifice plate and replace it with another having a different size orifice hole whenever it is desired to change the rate of flow of reagent through the feed conduit.

Provision is made for delivery of a current of carrier gas into the feed conduit 27, advantageously adjacent the discharge side of the orifice plate 29. To this end a gas inlet nozzle 31 extends into the interior of the feed conduit. The nozzle 31 is connected by a hopper by-pass pipe 32 to the gas supply line 26, and inside the feed conduit it is configured to direct the current of gas in the direction the reagent is to flow. A needle valve 32′ is connected in the by-pass pipe 32, in order to regulate the amount of gas that enters the feed conduit 27 directly relative to the amount that flows through the hopper. By suitably adjusting the needle valve 32′ (and the valve 21), sufficient gas is directed into the hopper to insure discharge of the contents of the hopper against the hydrostatic head of the molten metal or other material into which they are delivered.

The lower end portion 33 of the feed conduit, in the form of apparatus shown in the drawings, is intended to be inserted into molten metal to be treated with reagent from the feed hopper. Accordingly this lower end portion 33 must be of refractory material, or at least must be protected with a refractory covering. For purposes of treating molten cast iron or equivalent cast metals, a heavy-walled tube of graphite advantageously constitutes the lower end portion 33 of the feed conduit.

A support plate 34 is advantageously welded or otherwise attached to the feed conduit 27. In the form of apparatus shown in Fig. 1, the support plate 34 is designed to rest on the upper edge of a ladle of molten cast iron, with the refractory lower portion 33 of the feed pipe extending to a point below the surface of the molten metal in the ladle. Pipe couplings 35 are welded to the upper surface of the support plate, and serve as brackets into which short lengths of pipe can be screwed to provide carrying handles for the feed conduit and feed hopper assembly.

The interior of the feed hopper 10 is divided by two or more partitions 36 into a main compartment 37 and two or more auxiliary compartments 38, 39. The partitions 36 advantageously are arranged so that the interior of the conical bottom section 12 of the hopper is included in the main compartment 37.

A bottom closure gate 40 is fastened by a hinge 41 to each partition 36. When in the raised positions shown in solid lines in Fig. 2, the bottom closures form bottoms for the auxiliary compartments 38 and 39. A catch pin 42 is provided to hold each bottom closure gate 40 in its raised position. Catch release means 43 project to the outside of the feed hopper 10, in order to permit releasing the bottom closures 40 from outside the hopper.

A simple form of catch release is shown on an enlarged scale in Fig. 3. In this form, the catch pin 42 is mounted in a sleeve 44 which extends through and is welded to the body 11 of the feed hopper. The pin 42 is formed with an upset enlargement 45, against which a compression spring 46 presses. The outer end of the pin 42 is provided with a button head 47, and a sealing washer 48 surrounds the pin 42 adjacent the head 47. The compression spring 46 urges the pin 42 into the position in which it supports the bottom closure gate 40 in the raised position. In this position the washer 48 prevents escape of gas under pressure through the sleeve 44. The spring 46 is strong enough to overcome the gas pressure which tends to force the pin 42 outwardly through the sleeve. However, by pulling outwardly on the head 47, the catch pin 42 may be withdrawn against the force of the spring 46 from under the bottom closure gate 40, allowing the latter to swing down on its supporting hinge 41 to the open position shown in broken lines in Fig. 2.

The above-described apparatus is employed as follows: It is first prepared for use by releasing the clamp ring 14 and removing the cover 13. The bottom closures 40 can now be raised manually to the closed position, where they are held by the catch pins 42. Dry pulverulent reagents then are loaded into the main compartment 37 and the auxiliary compartments 38 and 39. The reagent which is first to be added to the molten cast iron or other material to be treated is loaded in the main compartment 37, and the reagents which are to be added later are loaded into the auxiliary compartments. Then the cover 13 is replaced and secured tightly in place by the clamp ring 14.

With the reagent flow control valve 28 closed, the gas inlet valve 21 is opened to admit gas under pressure into the interior of the feed hopper. The needle valve 32′ is adjusted to regulate the flow of gas into the feed conduit through the by-pass pipe 32, relative to the gas flow into and through the hopper 10, to secure the desired rate of flow of reagent from the hopper. A pressure gauge 49 advantageously is mounted on the cover 13 to show the pressure within the feed hopper, and a safety valve 50 is also mounted on the cover to protect the feed hopper from too high an internal gas pressure.

The apparatus next is brought into position over the ladle of molten cast iron or other material to be treated. Then with the gas line valves 25 and 21 opened, the reagent flow control valve 28 is thrown to the open position. Thereupon the reagent contained in the main compartment 37 flows through the feed conduit, in admixture with the gas entering through the nozzle 31, into the material to be treated. The size of the orifice hole 30 in the orifice plate 29, in combination with the setting of the needle valve 32′, regulates the rate at which the reagent flows through the feed conduit. For an orifice hole of given size, the rate of flow of reagent from the hopper may be adjusted over a considerable range by means of the needle valve 32′. Gas under pressure continues to enter the hopper through the valve 21 to assist in delivering the dry reagent from the feed hopper.

When all of the reagent contained in the main compartment 37 has been discharged through the feed conduit, the reagent flow control valve 28 may if desired be closed. One of the catch release mechanisms 43 is then operated to release the bottom closure gate 40 which is engaged thereby, and the bottom closure thereupon drops under the force of gravity and the weight of the reagent above it to the open vertical position shown in broken lines in Fig. 2. The reagent in the auxiliary compartment above the released bottom closure thus is delivered into the conical bottom section 12 of the feed hopper. This reagent is then discharged, when the valve 28 is opened, through the feed conduit 27 in the same manner as the reagent which originally occupied the main compartment 37. When reagent from one of the auxiliary compartments 38 has been passed through the feed conduit, the

above-described operations may be repeated to similarly deliver the batch of reagent contained in the other auxiliary compartment **39**.

It is of course not necessary that the reagent flow control valve **28** be closed after each batch of reagent has been delivered through the feed conduit. It can be kept open throughout the time required for delivery of all batches, and the successive batches may be delivered in rapid succession. If, however, it is desirable to allow some time to elapse between the delivery of each batch of reagent through the feed pipe, this may be accomplished either by closing the valve **28** between reagent deliveries, or by waiting an appropriate length of time before operating the catch release to allow the next batch of reagent to be discharged from the auxiliary compartment in which it is contained.

The above-described reagent feed apparatus is simple in construction and reliable in operation. It has been found in actual use to provide a very convenient means for introducing controlled amounts of dry pulverulent reagent, at the optimum rate and in the correct sequence, into molten cast iron, and to do so with a minimum of manipulative difficulties.

It is of course apparent that various design modifications can be made in the above-described apparatus without departing from the invention. For example, instead of hinged swinging-gate bottom closures as particularly shown and described, sliding gate valves may be used to close the bottoms of the auxiliary compartments. These compartments may themselves be in the form of hoppers within the main hopper itself, rather than flat-bottomed compartments of the type shown in the drawing. To make the apparatus more rugged and leak-tight, the cover may be welded in place, rather than being removably secured to the hopper vessel **10**, and small access ports with screw covers can then be provided to allow for introducing reagent into the various compartments in the vessel. Many other possible modifications will occur

to skilled designers and can be made without departing from the scope of our invention.

We claim:

1. In apparatus of the character described for feeding finely divided solid reagent into molten metal, a pressure-tight feed hopper, a valve connected to said hopper for starting and stopping the flow of reagent from said hopper, a feed conduit connected to said valve for delivering the reagent beneath the surface of the molten metal, an orifice plate having a flow-controlling orifice formed therein and interposed in said feed conduit, means for introducin ggas under pressure into said feed hopper, a nozzle for introducing a current of gas directly into said feed condiut and below said orifice plate, said nozzle having its outlet positioned to direct the gas discharged therefrom longitudinally of the feed conduit in a direction away from the orifice plate, and a valve for controlling the admission of said gas into said feed hopper.

2. In apparatus as set forth in claim 1 including at least one partition dividing the interior of the said hopper into a main compartment and at least one auxiliary compartment, a bottom closure for closing the bottom of said auxiliary compartment, and closure-release means extending outside said hopper, whereby said bottom closure may be opened to discharge the contents of the auxiliary compartment without releasing gas pressure from the hopper.

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