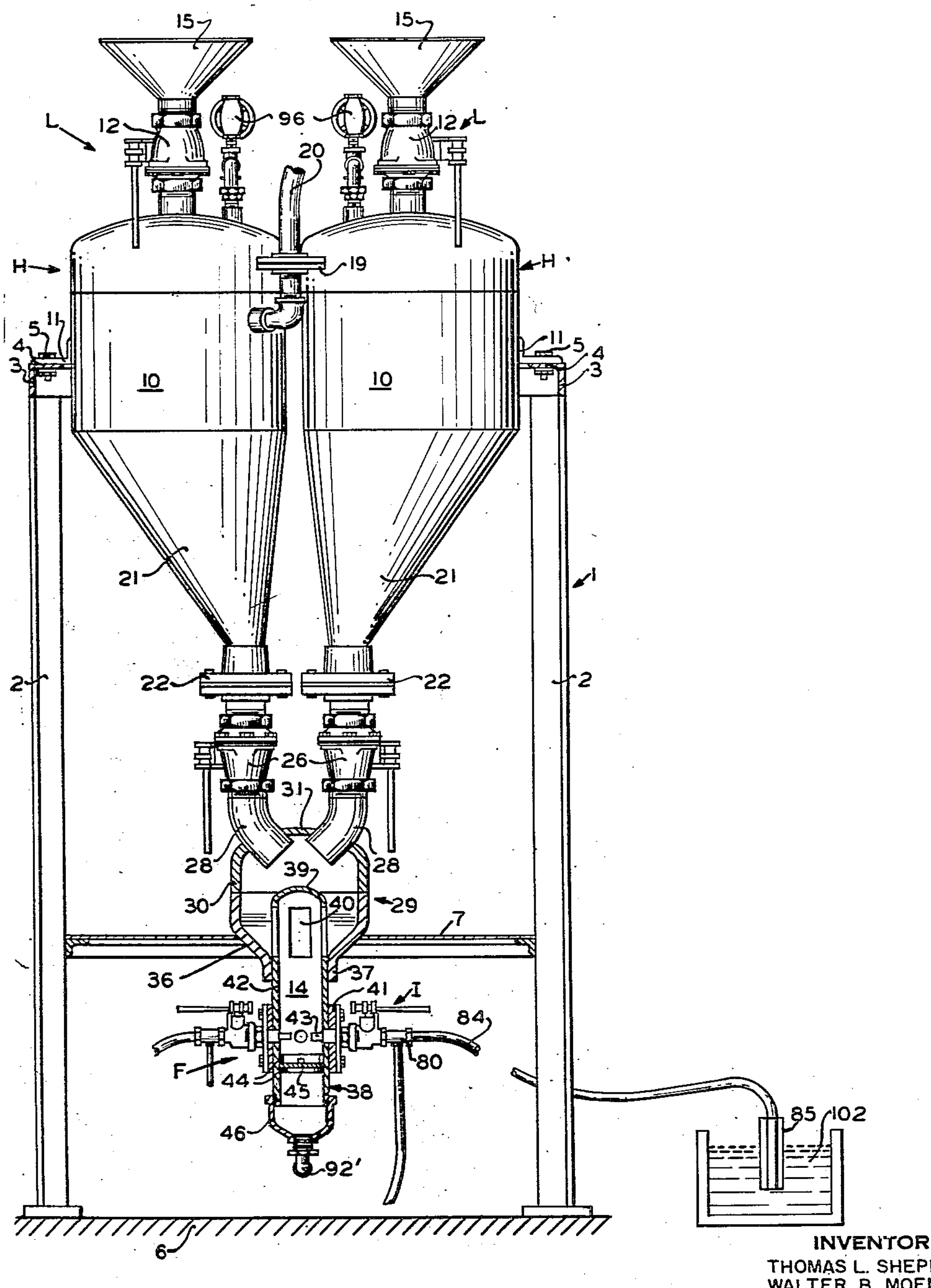
METHOD AND APPARATUS FOR CONVEYING FINELY-DIVIDED MATERIAL

Filed Jan. 20, 1955 3 Sheets-Sheet 1

FIG. 1



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METHOD AND APPARATUS FOR CONVEYING FINELY-DIVIDED MATERIAL

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FIG. 2

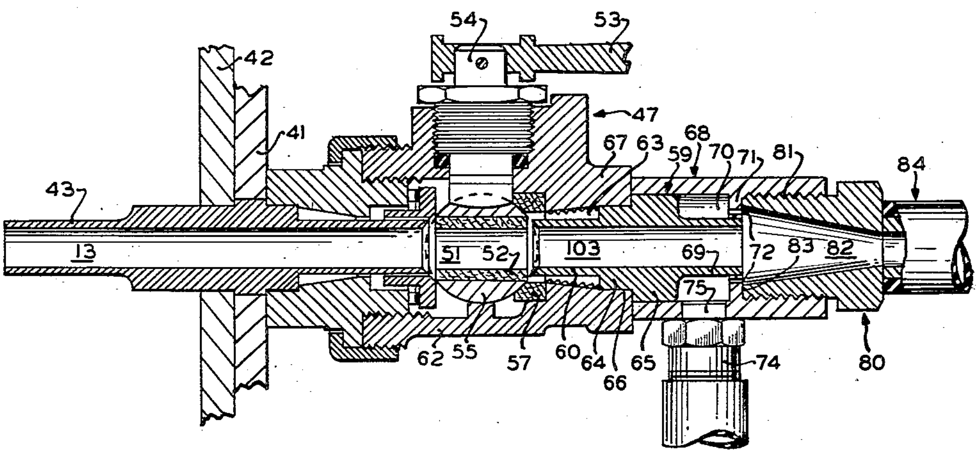
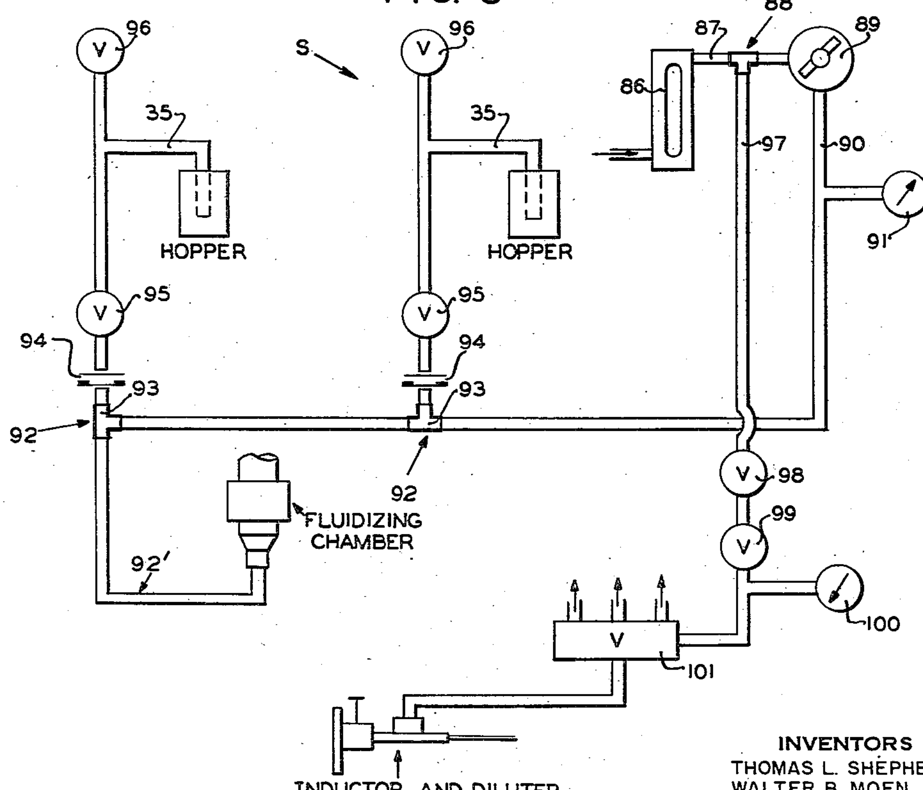


FIG. 3



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METHOD AND APPARATUS FOR CONVEYING FINELY-DIVIDED MATERIAL

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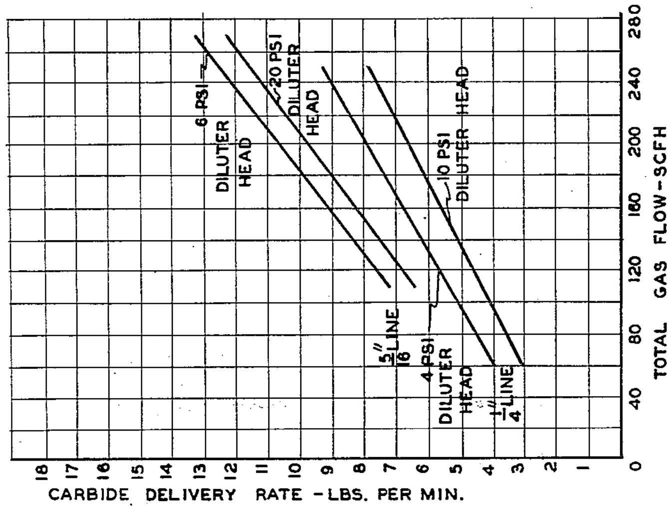

FIG. 6

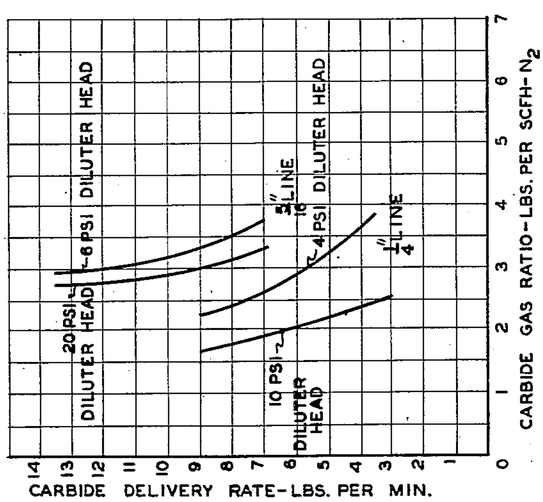

FIG. 5

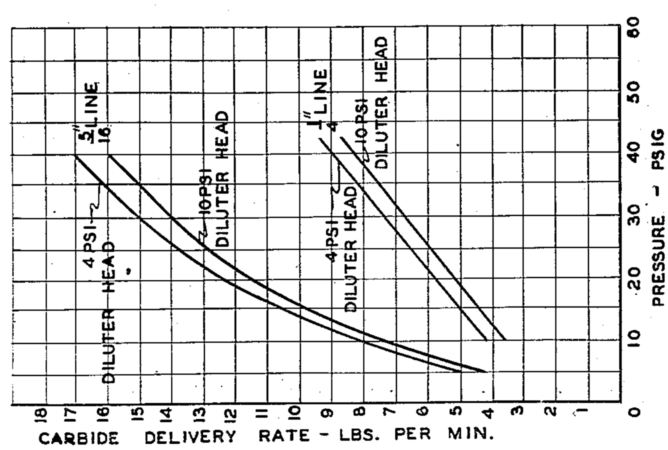

FIG. 4

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METHOD AND APPARATUS FOR CONVEYING FINELY-DIVIDED MATERIAL

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Application January 20, 1955, Serial No. 483,044

9 Claims. (Cl. 75—53)

This invention relates to the transporting of finely-divided material from a hopper through a conveying line to a point of use by means of a carrier gas. It also relates to chemical or metallurgical processes which require a dense, fluid-like, uniform discharge of such material from such a transporting arrangement. The invention particularly relates to the injection of a finely-divided treating material beneath the surface of molten metal, such as the projection of calcium carbide into molten iron beneath the surface thereof in order to effect desulfurization.

In the treatment or preparation of certain metals and metal alloys, it is often desired to effect a chemical or metallurgical reaction or addition between the liquid base metal and various treating agents, such as iron and calcium carbide for desulfurizing. However, the characteristics of these treating agents often are such that they are relatively unreactive even at high temperatures. They are often of a lesser density than the molten metal into which they are to be injected and are frequently very difficult to wet. In order to overcome these difficulties, it has been proposed that the treating agents be reduced to a pulverized state and injected into the molten metal. While pulverizing the treating agent furnishes a greater surface contacting area and reaction zone between the molten metal and the agent, it does, however, introduce a number of injection problems. For example, the agent should be injected into the liquid metal with sufficient force to penetrate metal; and, concurrently, a high ratio of treating agent to carrier gas should be maintained to minimize the entrapment of the agent in the bubbles of carrier gas which are formed when the powder-gas stream is discharged into the liquid metal. The discharging powder-gas stream must be non-pulsating in order to eliminate clogging in the injection tube.

The primary object of the instant invention is to overcome the aforementioned difficulties and to provide a dense, fluid-like, uniform discharge of a stream of finely-divided material and gas from a long conveying line.

It is a further object of this invention to provide an improved apparatus which is capable of continuously conveying large quantities of finely-divided material through a length of tubing at a pre-determined rate and effectively injecting such material beneath the surface of the liquid metal.

A further object of this invention is to provide a method of and apparatus for dispensing finely-divided material wherein a small bed of material is maintained in a fluidized state, withdrawing the material from this portion of the bed and subsequently shielding and diluting it with a gas before moving the stream through a conveying line.

Another object of this invention is to provide a dispensing apparatus for finely-divided material which is capable of injecting the material into molten metal as an uninterrupted stream of a particular agent or as a stream of two successive and dissimilar agents.

Other objects and advantages will become apparent

from the following disclosures taken in conjunction with the accompanying drawings.

Fig. 1 is a vertical elevational rear view of the preferred apparatus partially broken away and in section.

Fig. 2 is a cross-sectional view of the powder inductor and diluter assembly shown in Fig. 1.

Fig. 3 is a schematic diagram of the gas supply and control assembly used with the preferred form of apparatus illustrated in Fig. 1.

Fig. 4 is a graphical representation of the relation between the calcium carbide feed rate and the pressure within the fluidizer for ¼ inch and 5/16 inch supply lines at various diluter heads (the pressure imposed upon the diluter above the fluidization chamber pressure).

Fig. 5 is a graphical representation of the relation between the carbide delivery rate and the carbide to gas ratio for ¼ inch and 5/16 inch supply lines at various diluter heads.

Fig. 6 is a graphical representation of the relation between the carbide delivery rate and the total gas flow for ¼ inch and 5/16 inch supply lines at various diluter heads.

For simplicity the term, powder, will be used at times herein and in the claims and is intended to denote comminuted or finely-divided material of degree of fineness which may be handled by apparatus embodying the principles of the invention.

Referring to Figs. 1 and 3, the fluidizing apparatus shown therein consists essentially of twin loading funnel and valve assemblies L, a pair of powder hoppers H, in parallel arrangement, a fluidizing device F having a multiplicity of powder withdrawal pipes or inductors, diluter assemblies I, and a gas supply and control assembly S.

Now referring particularly to Fig. 1, the fluidizing apparatus shown therein comprises a frame **1**, within which the fluidizing apparatus is vertically mounted. The frame is provided with a multiplicity of legs **2** each secured at their top to a rectangular frame **3** having an inwardly extending flange **4** around its entire perimeter. A second rectangular frame **5** is mounted between legs **2** in a plane subtantially parallel to the floor **6**. This frame is extended rearwardly of the back legs **2** and a platform **7** is mounted thereon to provide a convenient step upon which an operator may stand during the charging operation. To the wall **10** of each of the cylindrical hoppers there are affixed several L shaped brackets **11**. The outwardly extending leg of each of these brackets rests upon the inwardly extending flange of frame **3**, and is secured thereto by bolts **5**.

Ball type loading valves **12** in centrally located vertical pipes atop each cylindrical hopper dome are located below loading funnels **15** which facilitate the loading of the hoppers and minimize spillage of the charging material. A sleeve extending out from the upper portion of each of the cylindrical hopper walls, above the normal upper lever of powder, makes threaded connection with an elbow which retains a pressure safety disc **19** and safety vent tube **20**. The connection from the right hopper does not appear. If at any time the pressure within either hopper exceeds the predetermined maximum of safety, the safety disc will rupture, and the excessive pressure will be vented to the atmosphere away from the normal working area of the operator. Each hopper is designed to contain a hundred pounds of 20 x 0 mesh carbide.

The lower portion of each hopper H depends from the cylindrical hopper wall **10** in an inverted conical-like form **21** and terminates in a flanged coupling device **22**. A second ball type valve **26** makes threaded connection with the flanged coupling **22** and an elbow **28** interconnects these lower ball valves **26** with the distributing powder receiver **29** of the fluidizing device F. Since each hopper H is equipped with an outlet flow valve 26 and since each hopper assembly feeds by gravity to the distribution receiver 29, it can be readily understood that material from either hopper can be used at will without interrupting the flow of the powder gas stream. This can be done by simply manipulating the ball valves 26 located between the hoppers and the distribution dome. In normal operation, one hopper supplies the fluidizing device with powder while the second hopper is being charged, or separate materials are successively fed as required such as carbide and ferrosilicon.

The powder is delivered to the distribution chamber or receiver and subsequently to the fluidizing chamber by means of gravity feed. However as shown in Fig. 3, each hopper is provided with a gas inlet line 35 above the normal upper powder level in order that a metered amount of gas may be supplied to the hopper in order to equalize pressure.

Again referring to Fig. 1 the fluidizing device F is attached to the distribution receiver 29 having a cylindrical main body portion 30 and a hemispherical dome 31. As above mentioned, a pair of powder inlet elbows 28 interconnect the hoppers with the distribution receiver 29. A conical base 36 depends from the cylindrical main body 30 of receiver 29 and terminates in a centrally-located, cylindrical opening 37. A hollow tubular protector and antibridging tube 38 is inserted into the cylindrical opening 37 and is affixed therein such that the closed top 39 of the antibridging device is centrally located within the distribution receiver. The large rectangular powder inlet ports 40 which are provided in the walls of the hollow antibridging device establish the means by which the powder is delivered from the distribution receiver 29 to the bottom of the tubular extension of the antibridging 38 where fluidization of the powder takes place. It is the primary function of the protector 38 to prevent excessive weight above the fluidized bed. A box-shaped sleeve 41 is mounted on the tubular wall 42 extending downwardly from the antibridging mechanism, intermediate the ports 40 and the bottom end of the tubular section 42. The lower part of tubular section 42 forms a fluidizing chamber and the central port acts as a housing to which the powder withdrawal pipes or inductors and diluter assemblies are secured. The four powder inducting conduits 43 extend through box-like sleeve 41 and tubular section 42 and terminate within the fluidizing chamber 14. A pair of snap rings 44 retain a gas diffuser or porous metal disc 45 within, and transversely of, the lower part of tubular section 42 below the powder withdrawal conduits 43. This disc is of such porosity as to permit the uniform transmission of gas therethrough, but of sufficient density to support powder. A reducing coupling 46 connected to the base of the tubular section 42 interconnects the fluidizing chamber 14 by means of a pipe with the gas control and supply assembly S, to be later described.

Referring now to Fig. 2, the powder withdrawal pipes and diluter assembly can be observed in greater detail. Inducting conduit 43 is secured to the box-shaped sleeve 41 mounted on the wall 42 and extends therethrough into the fluidizing chamber. A modified ball valve 47 connects to the outer end of the inducting conduit 43 and has a passage 51 therethrough of essentially the same diameter as that of the passage 13 through the inducting conduit. In order to achieve this result, a bushing 52 has been inserted in the passage of the ball 55 to reduce its diameter to the desired size. By this means, the highly preferred smooth conveying line is achieved. A valve handle 53 mounted upon the upper portion of the valve stem 54 provides a means whereby the valve stem, the ball, and the bushing may be rotated to a closed position. In this position, the passage 51 through the bushing 52 extends transversely of the inducting conduit passage 13 and an annular resilient sealing ring 57 provided rearwardly of the ball and bushing engages the ball in such manner as to establish a gas tight seal therebetween. A slide or gate valve having the same size passage could be used in place of ball valve 47.

Each of the four diluter devices 59 has a central passage 103 therethrough of essentially the same diameter as that of the inducting conduit passage 13 and the bushing passage 51. The inwardly extending nozzle 60 of the diluter's main body 59 is of such length as to terminate at the ball 55 so that, when the ball is rotated to a closed position, a seal is formed between the nozzle orifice and the ball. Intermediate the ends of the diluter's main body 59, there are provided a pair of stepped cylindrical flanges 64 and 65, the first of which engages a recess 66 located in the neck 67 of the valve housing and the second of which abuts the neck of the housing and is affixed thereto. A second nozzle 69 of lesser external diameter than the internal diameter of the diluter sleeve 68, hereinafter described, is provided at the extremity of the diluter's main body 59 and forms an annular passage 70 with the diluter sleeve. The diluter sleeve 68 is essentially a tubular mechanism internally threaded at its outer end and provided with an annular flange 71 disposed centrally and extending inwardly. This flange surrounds and is affixed to the end of the outwardly extending nozzle 69 so that the outer faces of the nozzle and flange are flush. An inlet hose coupling 74 mounted on the diluter sleeve 69 is axially aligned with the gas inlet port 75 in the sleeve and thereby establishes a passage through which the diluter gas may be supplied to the annular passage 70. Horizontal passageways or orifices 72 in flange 71 connect the annular passage 70 and the frusto-conical or outwardly converging passage 82. Diluter passages 72 are annularly and uniformly disposed around the nozzle 69 so that a diluter gas is peripherally introduced as an annular-like envelope surrounding in parallel relation the fluidized stream leaving passage 103. Such peripheral shielding and dilution not only helps to maintain a continuous non-pulsating powder-gas flow stream but also eliminates clogging and prevents turbulence sometimes caused by other type diluting mechanisms. In the diluter, it is to be noted that the surrounding of the dense fluidized stream with a layer of diluting gas whose velocity is substantially in excess of that of the fluidized stream tends to prevent contact between the solid particles and the wall of the conveying conduit and, in addition, promotes the acceleration and smooth flow of the solid particles in the desired direction of motion. Further a more homogeneous dilution is achieved in less time.

The inner end of the double male pipe union 80 having the converging passage 82 at its inner end engages the internally-threaded socket 81 of the outer part of the diluter sleeve and abuts the flange 71 transversely outward of orifices 72. Frusto-conical passage 82 is of somewhat greater cross sectional area at the flange-abutting rim 83 than the powder gas flow passages 13, 51 and 103. At the transverse flange 71 of the diluter sleeve, the gas from the annular ring of diluter gas passageways 72 can be visualized as maintaining a continuous uniform passage for the fluidized stream. The cross sectional area of this frusto-conical passageway 82 is continuously diminished from ⅝ of an inch diameter at the rim 83 towards the center of the fitting until it acquires the same cross sectional area as that of the normal powder flow passages 13, 51, and 103, heretofore mentioned, which are $\frac{5}{16}$ of an inch in diameter. A flexible hose 84, as shown in Fig. 1 and through which the powder-gas stream is moved and transported makes connection with the outer part of the pipe union 80 at one end and the injection tube 85 at the opposite end of the hose.

In the schematic diagram of Fig. 3, the gas supply and control assembly is shown and comprises a gas inlet tube for supplying gas at a predetermined pressure of about 150 p. s. i. g., a flowmeter 86, and a gas outlet line 87. To this outlet line there is secured a connecting T 88 one branch of which leads to a gas pressure regulator

89, a gas supply line 90, a gas pressure gauge 91 which indicates the gas pressure being supplied to the fluidizing chamber. Regulator 89 serves also as a valve by backing off the adjusting screw. A pair of connecting T's 92 are stationed in the gas supply line 90 such that one branch 93 of each T leads to a metering orifice union 94, and a globe valve 95 and then branches to the quiescent powder hopper H and to a pressure vent valve 96. The other branches of these T's 92 are so connected as to establish an uninterrupted passage from the line regulator to the fluidizing chamber via pipe 92'. A single source of gas is used to operate the entire unit since the second branch of connecting T 88 acts as the gas supply line for the diluter assembly. This branch comprises a gas supply line 97 having globe and needle valves 98 and 99, a pressure indicating gauge 100, and a selector valve block or multi-valved manifold 101 by which the gas may be channeled to the desired diluter assembly I.

In operation, the unit is connected to any pressure-regulated source of gas supply which is suitable for the use to which the powder is to be put. Nitrogen is preferred for calcium carbide injection. With all valves and regulator 89 closed, the pressure within the hoppers is reduced to atmospheric. The loading ball valves 12 at the top of the hoppers shown in Fig. 1 are then opened to permit the charging of the hoppers with the desired treating agent. After the charging of the hoppers has been completed and the loading ball valves 12 are closed, it is then determined from which hopper the desired treating agent will be withdrawn and its respective delivery ball valve is opened to permit the feeding of such material from that hopper to the distribution receiver 29 by gravity. While all diluter selector valves mounted in the selector valve block 101 are still in a closed position and after opening valves 95 and opening and adjusting regulator 89, the diluter shut-off valve 98 and diluter needle valve 99 are opened and adjusted to the approximate diluter operating pressure by reference to gauge 100. The pressures may be obtained from a predetermined operating curve. The diluter selector valve which controls the flow of gas to a particular diluter is then opened allowing purge gas to flow therethrough into the flexible conveying line 84 shown in Fig. 1 and thereafter to be discharged from the injection tube 85. Feed control valve 47 is still closed at this stage. With the purge gas flowing through the powder conveying line and injection tube, the diluter needle valve 99 is readjusted to obtain the proper diluter operating pressure. Subsequently the injection tube is lowered into the molten metal bath 102. The feed control or conveying line valve 47 illustrated in Fig. 2 which is positioned between the fluidizing chamber and the diluter is then opened and the powder-gas stream is injected beneath the surface of the molten metal. When the charge from the initial hopper has been depleted, or if at any time it is desirable to introduce a different treating agent from the other hopper, the operator merely closes the delivery ball valve of the hopper which is then in operation and simultaneously opens the delivery ball valve of the other hopper. After treatment has been completed, the conveying line valve 47 is closed and the injection tube is removed from the molten metal bath. Gas from the diluter is permitted to flow during withdrawal. When the injection tube has been removed from the said bath, the toggle valve in the selector block 101 is closed thus completing the operation. It is to be noted that the gas or stream in the injection tube always is such as to prevent molten metal from entering the injection tube passage. If the unit is to be shut down for an extensive period of time, the source of gas supply should be shut off and the hoppers vented to the atmosphere through vent valve 96.

From the foregoing detailed operating procedure and the structural description, it is believed apparent to one skilled in the art that the calcium carbide powder (obtained from a quiescent hopper) in the fluidizing chamber 14 becomes the particles of a small fluidized bed, extending up to the level of the withdrawal inductors, formed by the nitrogen uniformly admitted by the gas diffuser 45. During injection or a similar operation, the gas-powder at the top of the fluidized bed is withdrawn as a dense fluid-like stream through withdrawal pipes 43 and moves to the diluter. At the diluter, extra gas is added peripherally to the stream. This uniform addition from the orifices 72 in the outwardly converging conduit is in near-parallel relation to the axis of flow and surrounds the fluid-like stream. This manner of adding gas or shielding is believed to reduce the frictional drag between the stream and the downstream conveying line for an appreciable distance. This also thins the stream, that is makes it less dense. The foregoing combination assures uniform feeding of particles to the conveying passage and a uniform, less-dense stream in the remainder of the conveying passage results whereby non-pulsating feeding results. Pulsating feeding cannot be tolerated since metal would tend to flow up the injection tube and plug the tube. It is to be appreciated that the residual pressure in the tube from the fluidizing chamber and diluter, when injection is being done, exceeds the pressure which is necessary to overcome the hydrostatic pressure head of the molten metal between the surface of the metal and the bottom of the injection tube.

Figs. 4, 5, and 6 illustrate by graphical means the relation between particular conditions existing during the dispensing operation and the carbide delivery rate related thereto. Fig. 4 illustrates the relationship between the carbide delivery feed rate and the fluidization chamber pressure for ¼ inch and 5/16 inch I. D. supply lines (25 feet long) at various diluter pressure heads. The diluter head being that value of pressure which is imposed upon the diluter above the fluidization chamber pressure. It can be noted from the curves pertaining to the ¼ inch delivery line that an increase in the diluter pressure head from 4 p. s. i. g. to 10 p. s. i. g. effects a decrease of carbide delivery rate of approximately ¾ pound per minute at all fluidizer pressures.

As shown by the curves illustrated in Fig. 5, the relation between the carbide rate and the total gas flow indicates that an increase in the diluter head pressure results in a decrease of the carbide delivery rate amounting to approximately one pound per minute at any particular gas flow. It is therefore apparent that for any desired carbide feed rate the greatest economy and efficiency of operation can be acquired by maintaining the lowest diluter head pressure possible which will give a non-pulsating discharge.

The curves shown in Fig. 6 which represent the relation between the carbide delivery rate and the carbide-gas ratio clearly show that a higher carbide-gas ratio can be obtained by maintaining a minimum diluter head pressure.

The transporting and injecting features of the instant invention were also incorporated ito a larger unit having a single hopper capable of holding six hundred pounds of carbide or similar treating agents. As above described, it also fluidized only a small quantity of finely-divided material obtained from a quiescent storage hopper and had a diluter for adding gas to the conveying line which can be ⅜ inch, ½ inch, and 1 inch in diameter internally. The higher feed rate desired from this unit necessarily involved scaling up the parts thereof. To increase the versatility, the unit was mounted on a wheeled carriage and had its own supply of gas in the form of horizontally-disposed cylinders. Feed rates more than double that of the apparatus herein illustrated were obtained. Smooth delivery of calcium carbide at the rate of 125 pounds per minute through 25 feet of one inch diameter conveying line was achieved. The hopper was oriented in the vertical position with contents being fed directly into the fluidizing chamber by gravity. From the fluidizer compartment, the material was withdrawn through the withdrawal tube, through the matching passage in the shut-off valve and the diluter into the supply line where it is conveyed to the injection tube. The gas addition by the diluter kept the solid particles in suspension along the length of the supply line. Predetermined feed rates are obtained by adjusting independently the fluidizer and diluter pressures. For the delivery rates desired, two sizes of fluidizing chambers were provided. One had an internal diameter of three inches; the other, four inches. The three-inch chamber permitted feeding of two ½ inch conveying lines, while the four-inch chamber permitted feeding of two 1 inch lines whereby the simultaneous injection of large quantities of materials can be effected in different ladles or the same ladle. The chamber had four supply lines which, as is the case with the illustrated fluidizer, permits the use of conveying lines of various sizes and lengths and simultaneous injection of two ladles or the like.

In operation, after the hopper was loaded as above-described, the manifold regulator pressure on the gas supply was set at about 150 p. s. i. g. Then with the diluter shut-off valve closed, the fluidizer pressure regulator was adjusted to the desired pressure which was obtained from a calibration curve and corresponded to a desired feed rate range, whereby the hopper and fluidizer were pressurized. Next the diluter shut-off valve is opened and then the diluter control valve is adjusted to give the desired diluter head, that is, the pressure difference above the hopper or fluidizer pressure. A diluter head of 40 p. s. i. g. was usually preferred. Thereafter, the diluter selector valve was opened to purge the conveying line. With purge gas flowing, the injection tube was lowered into the molten metal bath. Feeding and injecting was begun by opening the conveying line valve located between the fluidizer and diluter. After completion of injection, the conveying line valve was closed and the diluter selector valve was left open until the injection tube was removed from the molten metal.

The 600-pound fluidizer, using a 3-inch fluidizer, fed between 10 and 40 pounds of carbide per minute as the 25-foot conveying lines were varied from ⅜ inch to ½ inch and the hopper pressure varied from 10 to 60 p. s. i. g. with the diluter pressure 40 p. s. i. g. above the fluidizer pressure. With a 4 inch diameter fluidizer chamber and 25 feet of 1 inch line, a smooth delivery of 40 to 125 pounds per minute, at the same head with 5 to 20 p. s. i. g. at the fluidizer, was obtained. Solid to gas ratio varied from 1.6 to 1 to 8.3 to 1 (pounds of carbide per standard cubic foot of gas).

It is also to be appreciated that the instant fluidizer arrangement and diluter can be used with top over bottom hoppers interconnected by a valved pipe. In another embodiment, this arrangement was made and suitable pressurizing and venting means were provided whereby charging from top to bottom could be effected during injection.

It is to be understood that the instant invention, although described with reference to the injection of the calcium carbide or carbide base material (calcium carbide containing magnesium oxide or rare earths) into molten iron, has utility with other powder injection processes, such as carburizing, alloying, and innoculating, and with other metallurgical or chemical processes, such as thermochemical removal of steel with iron powder where the stream is discharged into the atmosphere. The invention is particularly useful when it is desired to project a dense stream of carbide or the like from an immersed injection tube into molten iron or the like.

With the illustrated fluidizer it is to be appreciated that the over-all height is small to permit more convenient installation and charging. Furthermore it is possible and convenient to introduce two different agents as uninterrupted successive streams.

It is to be noted that, with the instant invention, it is not necessary to fluidize a large columnar bed and yet a similar uniform rate of initial feeding is accomplished. It is also to be appreciated that the interior surface of the conveying line will, of course, affect the drag or friction. More friction can be expected from rubber-lined hoses than from copper or brass lines. Equally enlarging the diluter orifices of the diluter used with metal lines permits use of rubber-line hoses and gives smooth delivery.

It is also to be understood that the instant invention is particularly adapted to transport calcium carbide and carbide-base mixtures for the injection thereof beneath the surface of ferrous metal. This finely-divided material should pass a 20 mesh screen (Tyler) and preferably about two-thirds should be retained on a hundred mesh screen. An apparent fluidizing velocity (herein meaning the volumetric flow rate at the density conditions within the fluidizing chamber divided by the cross-sectional area of the chamber) of about 0.2 feet per second is required to hold the calcium carbide in suspension as a fluidized bed. The quantity of gas which moves through the withdrawal tube achieves this minimum apparent fluidizing velocity.

From the foregoing, it is apparent that the instant invention provides an improved pneumatic conveyor which is especially adapted to fluidize a small quantity of finely-divided material such as calcium carbide and to hold it in suspension while conveying it through 25–50 feet of small diameter tubing or hose. Flexibility in locating, when treating molten metal and the like under various conditions, results. Huge quantities of gas are not required since dense phase fluidization is accomplished. Pulsating flow, plugging of the injection tube, and limited feed rates are not encountered. A smooth bore from the fluidizer to the injection tube is highly desirable. The density of carbide, the particle size and surface character of the carbide, as well as the plugging of the injection tube, were significant factors which handicapped prior, known fluidizers used in the coal industry. The instant provision for adding extra gas to the conveying line smooths the flow and provides sufficient exit velocity from the injection tube. Using a small fluidization chamber (feed from a quiescent storage hopper) avoids recirculation of gas and the costs resulting therefrom. The pressure of diluter gas upstream of the diluter orifice appreciably exceeds the pressure in the carbide-gas stream. The introduced extra gas also thins the stream and it is believed provides temporarily a friction reducing shield around the stream. Clogging of the diluter orifices should be prevented by proper operating procedure such as described. The instant invention is especially adapted for dense phase fluidization of calcium carbide and carbide base additives wherein a gas to solid ratio (cubic feet of gas STP per pound of carbide) of about ¼ to 2 is desired.

In summary, it is to be noted that the instant invention incorporates the steps of feeding carbide from a quiescent hopper by gravity to a small-diameter fluidization chamber, fluidizing the carbide with a gas to form a fluidized stream which contains all of the fluidizing gas, withdrawing the fluidized stream, peripherally adding extra gas to the fluidized stream and conveying the gas through a conveying line to an injection tube. It is also to be noted that the surrounding diluting gas also serves as a pick-up or accelerating gas since it is at a substantially higher velocity than that of the fluidizer stream.

It is to be understood that the embodiment of the invention herein can be modified in some respects without departing from the invention as defined in the following claims.

We claim:

1. The method of moving a finely-divided material into and through a small extended conduit; said method comprising establishing a small fluid-like bed of said material by introducing a gaseous medium up through said material, withdrawing a stream of said fluid-like material from said fluid-like bed, adding uniformly a gaseous medium to the periphery of said withdrawn stream after said

step of withdrawing, said step of adding being done so that the second gaseous medium joins the periphery of said stream in near-parallel relation to the flow direction of said stream and so that said gaseous medium has a velocity appreciably in excess of said stream.

2. The method of uniformly feeding powder and moving it through a conveying line as a dense non-pulsating fluid-like stream comprising establishing a small fluidized bed by uniformly introducing a gas upwardly into said bed, withdrawing a powder-gas stream from said bed at a rate such that the rate of gas withdrawal corresponds to the rate at which gas is introduced into said bed, introducing uniformly a second gaseous medium to the periphery and in near-parallel relation to the flow-direction of said powder-gas stream whereby said stream is surrounded by a substantially non-turbulent envelope of gas, and then moving the stream through a conveying line.

3. Apparatus for pneumatically moving finely-divided material through a small conduit comprising a hopper having a bottom opening, a small fluidizer device connected and arranged with respect to said bottom opening in said hopper so that finely-divided material can move by gravity from said hopper into said fluidizer, said fluidizer having a small chamber and means adjacent the bottom of said chamber for uniformly feeding a gaseous medium upwardly through said chamber, said fluidizer having a small withdrawal conduit of uniform internal diameter extending into said chamber at a location spaced appreciably above said means for uniformly feeding a gaseous medium, said conduit being connected to a peripheral diluter device, said peripheral diluter device having an outwardly converging passage, said converging passage having the upstream part thereof slightly larger than the interior of said withdrawal conduit and having the downstream part thereof the same diameter as the diameter of said withdrawal conduit, and said upstream part of said converging passage having passages therein for uniformly adding a gaseous medium to said converging passage, said passages being constructed and arranged to add in the direction of flow said gaseous medium in a near-parallel relation to the axis of said converging passage and at the periphery of said passage, and said diluter having means for attaching a small, smooth-bored conveying line thereto.

4. The apparatus according to claim 3 and further including an antibridging device in the bottom of said hopper.

5. The apparatus according to claim 3 and further including a valve in the connection between said withdrawal conduit and said diluter device.

6. The apparatus according to claim 3 and further including a gaseous medium supply arrangement for feeding gas to said fluidizer and to said diluter, and said supply arrangement including separate pressure regulators and flow control valves for said fluidizer and said diluter.

7. Apparatus for supplying finely-divided material to a plurality of material-consuming devices, said apparatus comprising a gas-tight container for material, a fluidizer having a small chamber connected to said container so as to receive said material from said container by the action of gravity, said fluidizer having a gas diffuser in the bottom thereof for uniformly-dispersing a gas upwardly, said chamber having a plurality of short, opposed withdrawal conduits uniformly extending into said chamber at the same level and spaced a short distance above said gas diffuser, each of said withdrawal conduits being connected to a peripheral diluter having a conveying passage, said diluter being adapted to add a gas to said conveying passage so that the gas moves in the direction of flow and in uniformly surrounding relation to the flow, said diluters having gas control valves which are independent of each other and independent of the gas supply to said fluidizer.

8. Apparatus for moving finely-divided material comprising at least two hoppers which are gas-tight and arranged side-by-side, a valved conduit leading from the bottom of each of said hoppers to a receiver, said conduits being arranged to feed finely-divided material to said receiver by gravity, said receiver having an antibridging device having ports in the bottom of said receiver, and a fluidizer device having a small chamber in communication with ports in said antibridging device.

9. The method of injecting powdered material beneath the surface of molten metal by means of a conveying line and an injection tube comprising establishing a molten quantity of metal, establishing a small fluidized bed of powdered material, withdrawing fluidized material from said bed thereby forming a fluidized stream, diluting said stream by adding uniformly a second gaseous medium to the periphery and in near-parallel relation to the flow-direction of said fluidized stream whereby said stream is surrounded by a substantially non-turbulent envelope of gas, moving said diluted stream through said conveying line and said injection tube and injecting it into said molten metal, and maintaining the pressure in said injection tube at a value sufficient to prevent molten metal from entering said tube.

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