

Aug. 20, 1957

C. E. BIENIOSEK ET AL.
METHOD OF INJECTING FLUIDIZED POWDERS FOR
METALLURGICAL TREATMENT
Filed May 3, 1954

2,803,533

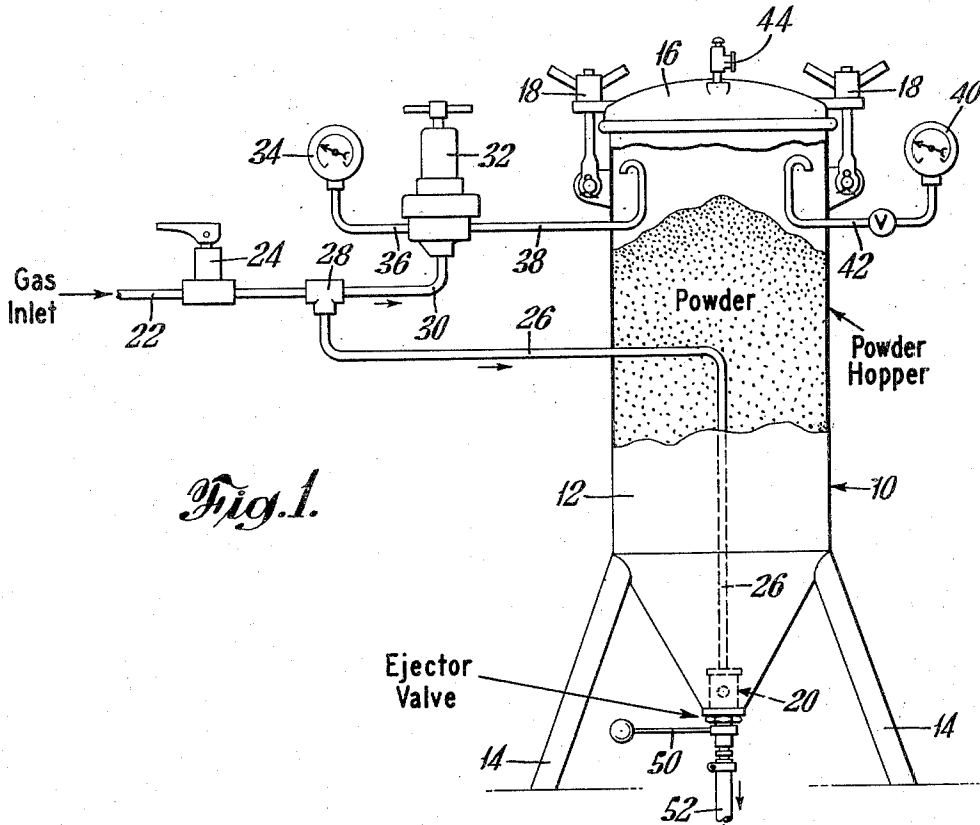


Fig. 1.

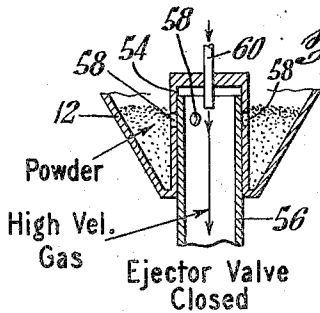
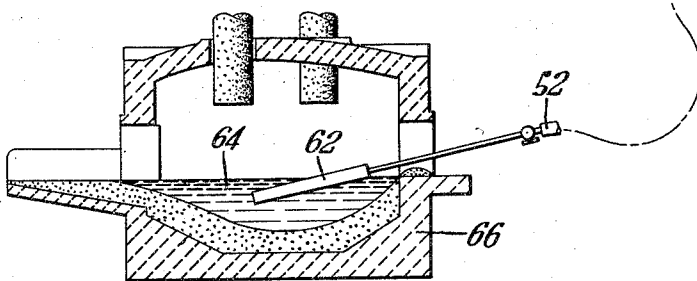


Fig. 2.

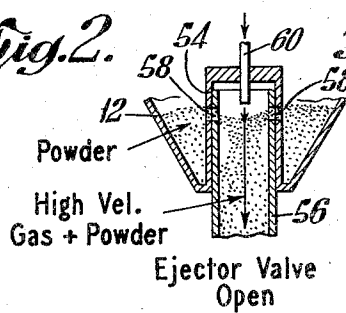


Fig. 3.

INVENTORS
CHESTER E. BIENIOSEK
HOMER C. BARNES, JR.
GEORGE P. DAHM
BY
William F. Mesinger
ATTORNEY

1

2,803,533

**METHOD OF INJECTING FLUIDIZED POWDERS
FOR METALLURGICAL TREATMENT**

Chester E. Bieniosek, Jersey City, Homer C. Barnes, Jr.,
Fayson Lakes, and George Paul Dahm, Roselle, N. J.,
assignors to Union Carbide Corporation, a corporation
of New York

Application May 3, 1954, Serial No. 427,308

10 Claims. (Cl. 75—53)

The present invention relates to a method of injecting fluidized powders into molten metals for accomplishing the metallurgical treatment of such metals.

Heretofore, it has long been desired to provide an effective method for injecting fluidized powders into molten metals at an easily controllable powder feed rate and powder-to-gas ratio. Additionally, it has long been desired to provide such a method wherein the powder feed rate is controlled by other than the gas feed rate alone. Many types of powder injecting methods employing vibratory powder dispensing have been proposed for controlling the powder feed rate. In addition to complicating the method by requiring an electrical energy source for the vibratory apparatus, such methods have left something to be desired in the uniformity of powder dispersion in the fluidized powder stream.

Accordingly, it is the prime object of the present invention to provide a simple and efficient method of fluidizing powders and injecting the as-formed fluidized powders in molten metals to accomplish the metallurgical treatment of such metals.

Other aims and advantages of the present invention will be apparent from the following description and appended claims.

In the drawing:

Fig. 1 is a schematic elevational view, partly in section, of apparatus suitable for performing the fluidization and injecting method of the invention;

Fig. 2 is a sectional view of the ejector valve of the dispenser of Fig. 1 with the valve in the closed position; and

Fig. 3 is a sectional view of the ejector valve of the dispenser of Fig. 1, with the valve in the open position.

In accordance with the present invention, a method is provided for fluidizing powdered solid material and injecting the resultant fluidized powder into molten metals for accomplishing the metallurgical treatment of such metals. The method comprises maintaining a quantity of such powder in a closed container under a controllable regulated pressure of inert gas, feeding this powder under the regulated pressure into a stream of inert fluidizing gas (of high velocity relative to the powder feed rate) to form a fluidized stream of such powder, introducing the fluidized stream of powder through an injection tube into the molten metal to be treated, and correlating the controllable regulated pressure with the powder feed rate desired to the fluidized powder stream, while maintaining the pressure in the injection tube at a value at least greater than that required to prevent molten metal from rising within the injection tube.

It has been found that, by feeding a quantity of powdered material under a controllable regulated pressure into a stream of inert gas, great control can be maintained over the powder feed rate to the resultant stream of fluidized powder. Upon the selection of the powder feed rate desired to the stream for maximum performance of the metallurgical treatment, the value of the corresponding

2

regulated pressure required for the attainment of such powder feed rate can be readily determined.

One embodiment of apparatus which may be utilized for performing the method of the present invention is shown in the appended drawing. As there shown, a powder dispenser 10 is provided comprising a closed container 12, legs 14, a removable cover 16 engaged by lock screws 18, and an ejector valve 20. Such a dispenser is described in detail and claimed in patent application Serial No. 427,307, entitled "Powder Dispenser" and filed concurrently herewith. Powder is charged in dispenser 10 by removing cover 16. Ejector valve 20 positioned in the lower portion of container 12 serves to fluidize the powder in a stream of inert gas.

Inert gas is supplied to the apparatus through conduit 22, containing quick acting valve 24, and line 26, which passes into container 12 and communicates with ejector valve 20. T-connection 28 is provided in conduit 22 and serves to supply a portion of the incoming inert gas through conduit 30 to regulator 32. Gauge 34, in conduit 36, serves to indicate the outlet gas pressure from regulator 32. Conduit 38 carries the regulated gas to the upper portion of closed container 12. In this manner, the interior of powder-containing closed container 12 is maintained at a regulated pressure of inert gas. Gauge 40 in line 42 indicates the value of such regulated pressure and safety valve 44 is provided in cover 16 to relieve the pressure should it exceed a safe value.

Powder ejecting valve 20 is controlled by lever 50 the position of which determines whether or not powder will pass from container 12 through valve 20 to outlet conduit 52 in the gas stream.

Powder ejector valve 20, described in detail in co-pending application Serial No. 427,307, comprises a hollow stationary outer member 54, secured to the base of closed container 12, and a hollow rotatable inner member 56 mounted in outer member 54 and axially aligned therewith. Both members are provided with a plurality of radial holes passing therethrough, as shown in Figs. 2 and 3 of the drawing. When inner member 56 is positioned, as shown in Fig. 2, with the holes of inner member 56 not in alignment with those of outer member 54, there is no powder flow through the valve. However, when inner member 56 is positioned, as shown in Fig. 3, with the holes of both members aligned, there is powder flow through passages 58 to the high velocity gas stream passed through the interior of member 56 from gas ejector nozzle 60. Thus, with ejector valve 20 in one position powder is fluidized in the inert gas stream, while with the valve set in another position only inert gas flows from dispenser 10.

Connected to outlet conduit 52 is an injection tube 62, of refractory material such as graphite or the like, for injecting the fluidized powder into molten metal 64 in metallurgical vessel 66 for accomplishing the treatment of the metal.

It has been found necessary to maintain the fluidized powder flow rate at a value sufficiently high to prevent molten metal from backing up and cooling in injection tube 62. It is also necessary to insure that the fluidized powder flow rate is not so high that molten metal will be blown and spattered from the molten pool.

The fluidizing and injection method of the invention has been successfully employed to accomplish many types of metallurgical treating operations. For example, the method of the present invention may be employed to introduce powders, such as calcium carbide, for the desulphurization of irons and steels; to introduce powders, such as magnesium or cerium metal, for upgrading cast irons; and to introduce alloying agents into molten ferrous and non-ferrous metals and alloys. As employed hereinabove, the term "upgrading" refers to that process

by which free graphite in cast iron is transformed from normal flake form to either compacted flake form or to spheroidal nodular form.

A typical metallurgical process is the desulphurization of molten iron. Desulphurization by means of calcium carbide was widely known but was only of academic interest until its introduction into the bath by fluidized injection.

Heretofore the addition of calcium carbide to the bottom of a ladle prior to the filling of that ladle with iron resulted in calcium carbide consumptions greater than 12 lbs. of calcium carbide per 0.010% sulphur reduction per ton of iron treated. Similarly, the addition of calcium carbide to iron on the surface in a runner at a rate compatible with the iron flow rate resulted in consumptions of 8 lbs. calcium carbide per 0.010% sulphur reduction per ton iron. Gas fluidized injection of calcium carbide in accordance with the method of the present invention resulted in consumptions ranging from below 2 lbs. to about 4 lbs. of calcium carbide per 0.010% sulphur reduction per ton iron.

These improved, consistent results are made possible by employing a method resulting in uniformly predictable dispensing characteristics. For example, where the calculated requirement is to add 6.5 lbs. of calcium carbide per minute, it has been found possible to obtain in actual result between about 6.3 and 6.7 pounds of calcium carbide per minute with the method of the invention. With prior art methods the result could have varied between 4.8 and 8.25 lbs. per minute, that is, an approximate error of $\pm 25\%$.

Another example of injection consistency is a series of $3\frac{1}{2}$ min. treatments of 6000 lbs. of cast iron where the resultant amount of injected carbide varied only between 58 and 60 lbs. In contrast, previous methods might result in an undesirable, unpredictable range of 45 to 75 lbs.

A further example of the importance of closely controlled injection is the upgrading of iron by the addition of magnesium alloys. The operation is very critical because of the low boiling point of magnesium. Uncontrolled surges of the magnesium alloy during injection results in poor efficiencies and nonuniformity in the cast product. The dispensing method of the invention makes for improved results. For example, where 9.5 lbs. addition of upgrading mix was required, an actual result of 9.6 lbs. was obtained. Or, where an injected amount of 2.4 lbs. was specified, 2.2 lbs. was obtained.

In an operation employing the method of the invention for lead additions to steel, eighteen ingots were treated on an elapsed time basis. The aim was to introduce 33 lbs. of lead per ingot. Weighing the dispenser before and after the lead injection showed a total 589 lbs. being added which compares very favorably to the 594 lbs. (18 ingots $\times$ 33 lbs./ingot) theoretically required.

It has been found that the fluidizing gas employed in the method of the invention may consist of any gas or mixture of gases inert to the powder and molten metal, such as nitrogen, argon, helium and the like.

What is claimed is:

1. A method for fluidizing solid powder and injecting the resultant fluidized powder stream into molten metals for the metallurgical treatment thereof comprising, maintaining said solid powder in a closed container under a controllable regulated pressure of inert gas; feeding said powder, under said regulated pressure, into a stream of inert gas to form a fluidized stream of said powder; introducing said fluidized stream of said powder into said molten metal to be treated through an injection tube partially immersed therein; and correlating the value of said controllable regulated pressure with the powder feed rate desired to said fluidized powder stream while maintaining the pressure in said injection tube at a value at least

greater than that required to prevent molten metal from rising within said partially immersed injection tube.

2. A method for fluidizing solid powder and injecting the resultant fluidized powder stream into molten metal in accordance with claim 1, wherein said molten metal is selected from the group consisting of iron and iron alloys, said powder is calcium carbide for desulphurization of said selected group metal, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

3. A method for fluidizing solid powder and injecting the resultant fluidized powder stream into molten metal in accordance with claim 1, wherein said molten metal is cast iron, said powder is at least one metal selected from the group consisting of magnesium and cerium for upgrading said cast iron, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

4. A method for fluidizing solid powder material and injecting the resultant fluidized powder stream into molten metal in accordance with claim 1, wherein said powder is an alloying agent, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

5. A method for fluidizing solid powder and injecting the resultant fluidized powder stream into molten metals for the metallurgical treatment thereof comprising, maintaining said solid powder in a closed container under a controllable regulated pressure of inert gas; feeding said powder, by means of said regulated pressure, into a high velocity stream of inert gas whereby a fluidized stream of said powder is formed; introducing said fluidized stream of said powder into said molten metal to be treated through an injection tube partially immersed therein; and correlating the value of said controllable regulated pressure with the powder feed rate desired to said fluidized powder stream while maintaining the pressure in said injection tube at a value at least greater than that required to prevent molten metal from rising within said partially immersed injection tube.

6. A method for fluidizing solid powder and injecting the resultant fluidized powder stream into molten metal in accordance with claim 5, wherein said molten metal is selected from the group consisting of iron and iron alloys, said powder is calcium carbide for desulphurization of said selected group metal, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

7. A method for fluidizing solid powder and injecting the resultant fluidized powder stream into molten metal in accordance with claim 5, wherein said molten metal is cast iron, said powder is at least one metal selected from the group consisting of magnesium and cerium for upgrading said cast iron, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

8. A method for fluidizing solid powder material and injecting the resultant fluidized powder stream into molten metal in accordance with claim 5, wherein said powder is an alloying agent, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

9. A method for fluidizing solid powder in accordance with claim 5, wherein said molten metal is selected from the group consisting of iron and iron alloys, said powder is lead, and said inert gas is at least one gas selected from the group consisting of nitrogen, argon and helium.

10. In the method of forming a fluidized powder stream and injecting the same into molten metals through an injection tube partially immersed in said molten metal for the metallurgical treatment thereof, the improvement which comprises forming said fluidized powder stream by feeding powder under a controllable regulated pressure into an inert gas stream at a point remote from the point of injection to form said fluidized powder stream, con-

veying said fluidized powder stream through conduit means to said injection tube, and correlating the value of said controllable regulated pressure with the powder feed rate desired to said fluidized powder stream while maintaining the pressure in said injection tube at a value at least greater than that required to prevent molten metal from rising within said partially immersed injection tube.

1,968,917
2,181,095
2,485,760
2,502,259
2,577,764
2,577,837
2,692,196

References Cited in the file of this patent

UNITED STATES PATENTS

10 622,419

1,587,600 Nielson ----- June 5, 1926

Soldatoff ----- Aug. 7, 1934
Ness ----- Nov. 21, 1939
Millis et al. ----- Oct. 25, 1949
Hulme ----- Mar. 28, 1950
Hulme ----- Dec. 11, 1951
Zifferer ----- Dec. 11, 1951
Hulme ----- Oct. 19, 1954

FOREIGN PATENTS

Great Britain ----- May 2, 1949