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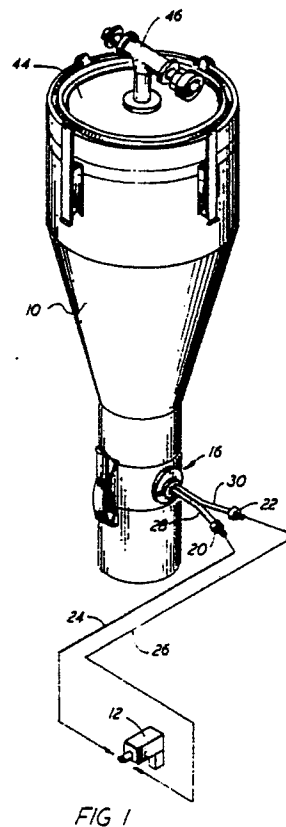
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(54) Multiple outlet powder pickup system for thermal spray guns.

(57) In carrying out the invention, there may be provided a powder pick-up system for thermal spray guns comprising an enclosed hopper for a powder to be thermally sprayed in loose particulate form, a feed gas conduit adapted to discharge a regulated amount of feed gas under pressure into the hopper, a unitary carrier conduit structure powder pickup device having a single carrier gas inlet and a plenum connected to said inlet with a plurality of separate carrier gas bores connected to receive gas from said plenum, separate outlet connections from each of said bores for separate delivery of gas-entrained powder to at least one spray gun, said conduit structure including at least one opening through a wall thereof from each of said bores into the interior of said hopper for picking up powder therefrom.



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MULTIPLE OUTLET POWDER PICKUP SYSTEM FOR THERMAL SPRAY GUNS

This invention relates to a powder pickup and feeding system for thermal spray guns.

Background of the Invention

Thermal spraying, sometimes also referred to as flame spraying, involves the heat-softening of a heat-fusible material, such as a metal or ceramic and the propelling of the softened material in particulate form against a surface to be coated to which the heat-fusible material bonds. A flame spray gun is usually used for this purpose and the heat-fusible material may be supplied in powder form to the gun. The powder is of quite small particle size, e.g. below about 100 mesh U. S. Standard screen size, and as small as one micron, and is difficult to meter and control.

A flame spray gun normally utilizes a combustion or plasma flame to effect melting of the powder, but other heating means, such as electric arcs, resistance heaters or induction heaters can also be used, alone or in combination. In a powder-type combustion flame spray gun, the carrier gas for the powder can be one of the combustion gases or compressed air. In a plasma flame spray gun the carrier gas is generally the same as the primary plasma gas, although other gases such as hydrocarbons are used in special cases.

To obtain high quality coatings, it is necessary to accurately control the rate of the powder fed through the gun and to maintain the rate constant for a given set of spray conditions. The fine powder used is very difficult to handle and to feed with any uniformity into a carrier gas.

In some applications of thermal spraying, it is important to provide powder by means of a carrier gas through more than one conduit, the multiple conduits being fed to a single spray gun or to separate spray guns to provide a greater flow rate of powder for coating, or to provide for concurrent application of the coating at different positions on the article to be coated. One of the most important requirements for such a system is that the powder flow through the multiple conduits must be substantially equal.

Under prior practice, when there has been such a need, it has been common to simply provide a complete duplication of powder feed apparatus, including separate supply hoppers, with a single powder pickup device in each hopper. With such an arrangement, it is difficult to provide for equal flows. To try to provide equal flows, and to reduce the complexity of the apparatus, it is advantageous, if possible, to provide for a single

hopper with multiple powder pickups and delivery conduits associated with that one tank. Various efforts have been made to provide such a powder feed structure. For instance, see U. S. Patent 3,826,540 issued to Frederick K. Jensen and U. S. Patent 4,262,034 issued to Dennis Andersen and U. S. Patent 4,582,254 issued to Anthony J. Rotolico. However, in each of these systems, the entire powder feed hopper and associated structure is completely different from a corresponding hopper and structure which is adapted for a single powder pickup. Thus if single powder pickup is desired all but one pickup tube may be removed, but this can result in uneven wear of the pickup orifices by the powder; i.e., greater wear of the one remaining in use; and, therefore, uneven pickup rate when the multiple pickups are again installed.

It is an important object of the present invention to overcome each of the above-mentioned problems and to achieve the advantages of assured matching of the multiple sets of conduits in a multiple outlet powder pickup system from a single hopper.

Another object of the invention is to provide for greater convenience and economy and simplicity in multiple outlet powder pickup systems by providing a unitary multiple outlet powder pickup element structure having a plurality of separate carrier gas bores which is interchangeable with a single bore powder pickup within a powder delivery tank structure designed for a single conduit.

Another object of the invention is to provide an improved powder pickup system incorporating a carrier conduit structure having a single carrier gas inlet and an interior plenum connected to a plurality of separate carrier gas bores for delivery to separate outlet connections.

Another object of the invention is to provide a multiple bore powder pickup element structure which provides matched pickups with closely spaced inlets in order to assure balanced delivery of powdered coating materials.

Further objects and advantages of the invention will be apparent from the following description and the accompanying drawings.

Summary of the Invention

In carrying out the invention, there may be provided a powder pick-up system for thermal spray guns comprising an enclosed hopper for a powder to be thermally sprayed in loose particulate form, a feed gas conduit adapted to discharge a regulated amount of feed gas under pressure into

the hopper, a unitary carrier conduit structure powder pickup device having a single carrier gas inlet and a plenum connected to said inlet with a plurality of separate carrier gas bores connected to receive gas from said plenum, separate outlet connections from each of said bores for separate delivery of gas-entrained powder to at least one spray gun, said conduit structure including at least one opening through wall thereof from each of said bores into the interior of said hopper for picking up powder therefrom.

Brief Description of the Drawings

Figure 1 is a perspective view of a preferred embodiment of the invention including a schematic showing of two conduits to carry a supply of gas entrained powder through to a thermal spray gun.

Figure 2 is a side view, partially in section, of the embodiment of Fig. 1.

Figure 2A is an enlarged sectional detail of the lower portion of the apparatus of Fig. 2 illustrating details of a unitary carrier conduit structure powder pickup device which forms a part of the invention.

Figure 3 is an enlarged top view, partly in section, of the powder pickup device as illustrated in Figs. 1, 2 and 2A.

Figure 3A is an end view showing further details of the entrance end of the powder pickup device of Fig. 3.

Figure 4 is an enlarged top view, partly in section, of a modified embodiment of the powder pickup device of Fig. 3.

Description of Preferred Embodiments

Referring more particularly to Fig. 1, there is shown a powder pickup system for thermal spray guns which includes an enclosed hopper 10 for powder to be thermally sprayed in loose particulate form by a spray gun schematically illustrated at 12. The system is provided with gas under carefully controlled pressure and with carefully controlled flow rates by gas delivery and control apparatus, not shown. Such apparatus may be combined with other controls for the spray gun 12.

Figure 2 is a side view, partly in section, of the system of Fig. 1. As shown more clearly in Fig. 2, the system includes a feed gas conduit connection, indicated at 14, which is adapted to introduce a regulated amount of feed gas under pressure into the hopper 10.

Included in the system is a unitary carrier conduit structure powder pickup device 16 which receives carrier gas from a single carrier gas inlet 18, as shown in Fig. 2. As shown most clearly in Fig. 1, the unitary carrier conduit structure 16 includes separate outlet connections, indicated as 20 and 22 for separate delivery of gas entrained powder to a spray gun indicated schematically at 12 through extended conduits indicated schematically at 24 and 26. The separate outlet connections are preferably from separate tubes 28 and 30 which define separate bores for the separate delivery of gas entrained powder.

Figure 2A is an enlarged detail view showing a cross section of the lower housing of the hopper structure 10 of Figs. 1 and 2.

As shown more clearly in the sectional views of Figs. 2 and 2A, the tubes 28 and 30 extend through a flanged hub 32 and into an inlet coupling 34. The entire unitary carrier conduit structure fits within a housing bore, and the inlet coupling 34 includes a ring seal 36 which provides a gas-tight seal with the interior surface of the housing bore. The seal 36 and the axial end face of the inlet coupling 34 and the walls of the housing bore together form a plenum for the supply of gas under pressure from the single inlet 18 to both of the carrier gas bores of the tubes 28 and 30. The structure of the inlet coupling 34 is more clearly shown in Figs. 3 and 3A and described further below in connection with those figures.

Each of the tubes 28 and 30 includes an opening through the tube wall, as indicated at 38 in tube 28 and 38A in tube 30 for the introduction of gas entrained powder from the hopper.

As shown in Figs. 2 and 2A, the hopper structure preferably includes a porous disk-shaped member 40 at the gas inlet to the bottom of the hopper from the inlet connection 14 to diffuse the feed gas into the hopper and to block backflow of powder into the feed gas conduit in the absence of feed gas flow. The feed gas supplied through the inlet 14 and the porous member 40 fluidizes powder in the bottom part of the hopper, preferably fluidizing only a portion of the powder near openings 38 and 38A. A part of that fluidized powder is aspirated through the wall opening 38 into the bore of the tube 28. It will be understood that an opening corresponding to opening 38 is provided in tube 30 (Fig. 3), but tube 30 is not visible in Figs. 2 and 2A, since it is obstructed by tube 28. In order to enhance the movement of powder down through the hopper 10 and the fluidization of the powder, the hopper is preferably provided with a vibrator motor in the bottom of the hopper housing as indicated at 42.

The hopper 10 is preferably provided with a removable cover 44 for convenience in refilling the hopper (Fig. 1). The cover 44 preferably includes a gas inlet fitting 46 through which pressurizing gas may be added at the top of the hopper so that the pressurization of the entire volume of the hopper need not be provided solely from the inlet 14. This speeds up the initial startup of operations after the hopper has been previously depressurized.

Referring more particularly to Fig. 3, there is shown a top view, partially in section, of the unitary carrier conduit structure 16. The respective tubes 28 and 30 are sectioned, and the opening 38 through the bottom of the wall of the tube 28 is clearly shown, as is the corresponding opening 38A in tube 30. The inlet coupling 34 is also sectioned in order to more clearly show the structure of that coupling, and particularly the structure of the axial end face of that inlet coupling. As illustrated in Fig. 3, the two tubes 28 and 30 are securely attached together by the end coupling 34 and the flanged hub 32 to form the unitary carrier conduit structure (powder pickup device).

The inlet coupling member 34 includes an axial end face 48 which is recessed in an axial direction, the end face including an axially extended rim portion 50 to partially define the plenum and to assure a minimum axial dimension for the plenum.

Fig. 3A is a left end view of the structure illustrated in Fig. 3, which more clearly shows the recessed face 48, the rim portion 50 and the bore openings from the face 48 into the respective tubes 28 and 30.

Fig. 3B is an enlarged detail, partly in section, showing the preferred construction of the inlet coupling portion of the powder pickup device of Fig. 3. The undercut tips of the ends of the tubes 28 and 30 extending into the associated recesses in the end coupling 34 permit space for brazing material by which the parts are permanently joined.

The above-described embodiment of a powder pickup device is preferably utilized in conjunction with a powder feed system of the general type disclosed in U. S. Patent 4,561,808 issued December 31, 1985 to Mark F. Spaulding et al for a "POWDER FEED PICKUP DEVICE FOR THERMAL SPRAY GUNS", and assigned to the same assignee as the present application.

Figure 4 is a top view corresponding to the view of Fig. 3 and illustrating a modified embodiment of the unitary carrier conduit structure powder pickup device which incorporates further principles taught in the aforementioned U. S. Patent 4,561,808. In this embodiment, instead of providing a single wall opening in the bottom of each tube, two side wall openings are provided in each tube which are arranged substantially horizontally, as indicated at 52 and 54 for tube 28A, and at 56 and

58 for tube 30A. In accordance with the teachings of the prior above-mentioned patent application, the ports 52-58 are each directed at an acute angle with respect to the axis of the bore. As illustrated in the drawing, the angle of each of the openings 52-58 is slanted back towards the inlet end of the powder pickup device. The angle that each opening port 52-58 makes with the associated axis of the tube is preferably about 45 degrees. The members of each pair of ports are substantially parallel to one another. The separation between the adjacent ports 52-54 and 56-58 is preferably between about one and about ten times the average diameter of the tube bore where the openings intersect with the tube bore.

An additional feature of each tube in accordance with the teachings of the above-mentioned patent 4,561,808 is that there is provided a constricted section of the tube downstream from the inlet ports 52-58. That constriction is indicated at 60 in tube 28, and at 62 in tube 38. Beyond the restricted portions 60 and 62, on the downstream side, each bore increases again in a stepwise manner, to the original bore size, as indicated at 64 and 66. It will be understood that the constrictions 60 and 62 are exaggerated in the drawing of Fig. 4 in order to promote clarity in the presentation of the principles involved.

In accordance with the teachings of the aforementioned U. S. Patent 4,561,808, this arrangement provides for a substantially increased uniformity in powder pickup and delivery, especially with materials which are difficult to feed.

It should be understood that each of the tubes 28,30 and 28A,30A of both embodiments may be relatively thick-walled tubes as illustrated in Fig. 3B, having relatively thicker walls than indicated by the other drawings. The structures are shown with relatively thin walls in the other drawings in order to promote an understanding of the invention and to present the details with greater clarity. The greater wall thickness is particularly important in connection with the embodiment of Fig. 4 since the length of the passages of the ports 52-58 is important in conjunction with the rest of the geometry of the structure in promoting the desired result.

When in use, each of the powder pickup devices (16, 16A) of the invention is firmly secured in the associated hopper housing structure by means of the flange portion of the flanged hub 32. The flanged portion is secured to the hopper body by means such as threaded screw fastenings which are inserted through the openings indicated at 68 and 70 in Fig. 3A. The openings 68 and 70 are purposely positioned at an angle of less than 180 degrees away from one another with respect to the

center of the structure so that it will be apparent to the operator that there is only one correct vertical alignment of the powder pickup device in the assembled position.

Generally each of the powder entrainment openings in tubes 28, 30 and 28A, 30A should open generally downwardly to prevent excessive influence by gravity on the flow, but the orifice opening need not point straight down. It is preferred that the geometric design and arrangement of the orifice be such that there is no gravity flow of the powder through the orifice into the carrier gas stream in the absence of fluidizing gas flow. Thus, in some cases, the orifice can be side-facing or even partially upwardly facing. For example, the orifice can be in a relatively thick tube wall, or can consist of a short length of tube extending sideways to prevent the powder, with its particular angle of repose, from entering the conduit. Alternatively, the openings may be upwardly directed with a shed interpose in spaced relationship above each opening to prevent gravity flow of powder into the openings as described in aforementioned U. S. Patent 4,582,254.

The hopper 10 and the associated housing, including the lower housing portion containing the housing bore into which the powder pickup device is fitted, is very similar to a housing which has been used with a single bore powder pickup device in the past, and this same housing may be employed with a single bore powder pickup device. Accordingly, it is one of the important advantages of the invention that a very simple conversion can be made between a single bore powder pickup system and a multiple bore powder pickup system by interchanging multiple and single bore powder pickup elements in the same hopper structure. The same single inlet connection 18 may be employed with either powder pickup device, and it is only necessary to deal with the change between one and two powder outlets in terms of required changes in powder conduit connections.

Also, since both tubes 28, 30 or 28A, 30A are always used simultaneously, any wear of the holes 38, 38A or 52-58 by abrasive powder will be uniform among the holes. Therefore, uniform power pickup by both tubes can be expected.

Another major advantage of the invention is that the two powder pickup elements formed by the two tubes 28 and 30 are very closely positioned together within the hopper so that they both pick up fluidized powder from the hopper at substantially the same position within the hopper. This leads to substantial uniformity of the mixture of gas and powder in the two conduits. That condition promotes high quality coatings in the operation of the thermal spray gun 12.

While this invention has been shown and described in connection with particular preferred embodiments, various alterations and modifications will occur to those skilled in the art. Accordingly, the following claims are intended to define the valid scope of this invention over the prior art, and to cover all changes and modifications falling within the true spirit and valid scope of this invention.

Claims

1. A powder pickup system for thermal spray guns, comprising:

an enclosed hopper for a powder to be thermally sprayed in loose particulate form;

a feed gas conduit adapted to discharge a regulated amount of feed gas under pressure into the hopper; and

a unitary carrier conduit structure powder pickup device having a single carrier gas inlet and a plenum connected to said inlet with a plurality of separate carrier gas bores connected to receive gas from said plenum, separate outlet connections from each of said bores for separate delivery of gas-entrained powder to at least one spray gun, said conduit structure including at least one opening through a wall thereof from each of said bores into the interior of said hopper for picking up powder therefrom.

2. A system as claimed in Claim 1 wherein the number of separate carrier gas bores provided in said unitary carrier conduit structure is two.

3. A system as claimed in Claim 2 wherein said separate carrier gas bores are defined by separate tubes which are attached together.

4. A system as claimed in Claim 3 wherein said tubes are arranged at the same elevation in a parallel configuration and said opening through the wall of said conduit structure from each of said bores into the interior of said hopper for picking up powder comprises a single hole in the bottom of each tube into the associated bore defined by each tube.

5. A system as claimed in Claim 3 wherein said tubes are arranged at the same elevation in a parallel configuration, and wherein a plurality of openings are provided through the wall of each tube from each of said bores into the interior of said hopper for picking up powder therefrom, said plurality of openings for each tube being arranged between downwardly and substantially horizontally in each tube on the side of each tube opposite to the other tube of said unitary carrier conduit structure.

6. A system as claimed in Claim 5 wherein said plurality of openings in the side of each tube consists of two openings, and wherein said openings extend substantially horizontally and substantially parallel to one another through the wall of the associated tube and at an acute angle to the direction of travel of the carrier gas through the associated tube.

7. A system as claimed in Claim 6 wherein a partial constriction is provided within the bore of each tube downstream from said side openings.

8. A system as claimed in Claim 7 wherein the separation between said openings in each of said tubes is between about one and about ten times the average diameter of the tube bore where the openings intersect with the tube bore.

9. A system as claimed in Claim 6 wherein the acute angles of said openings are each about forty five degrees.

10. A system as claimed in Claim 1 wherein said feed gas conduit is connected to discharge feed gas into said hopper at a position below the normal minimum level of the powder within the hopper.

11. A system as claimed in Claim 2 wherein said hopper includes a lower housing portion, said lower housing portion including a single horizontal housing bore extending therethrough to accommodate said unitary carrier conduit structure, and further including a fluid conduit fitting connected to the inlet side of said housing bore, said unitary carrier conduit structure being adapted to fit into said housing bore and extending across the interior of said lower housing portion, the inlet end of said carrier conduit structure including a sealing means and being adapted to establish a seal with the interior walls of said housing bore and to form and define said plenum in cooperation with the interior of said housing bore and said inlet fitting, the inlet end of said unitary carrier conduit structure including an axial end face, said axial end face including two openings from said plenum into said respective carrier gas bores of said unitary carrier conduit structure.

12. A system as claimed in Claim 11 wherein said axial end face of said inlet end of said unitary carrier conduit structure which contains said openings into said separate carrier gas bores is recessed in an axial direction and includes an axially extending rim portion to partially define said plenum and to assure a minimum axial dimension for said plenum.

13. A unitary carrier conduit structure powder pickup device for use in a powder pickup system for thermal spray guns in conjunction with an enclosed hopper for a powder to be thermally sprayed in loose particulate form, the carrier conduit structure having a single carrier gas inlet

adapted to form a plenum with a plurality of separate carrier gas bores connected to receive gas from the plenum, said conduit structure including separate outlet connections from each of said bores for separate delivery of gas-entrained powder to at least one thermal spray gun, said conduit structure including at least one opening through a wall thereof from each of said bores for opening into the interior of an enclosed hopper for picking up powder therefrom.

14. A carrier conduit structure as claimed in Claim 13 wherein two of said separate carrier gas bores are provided and are defined by separate tubes which are attached together.

15. A carrier conduit structure as claimed in Claim 14 wherein said tubes are arranged to be positioned at the same elevation in a parallel configuration and said opening through the wall of said conduit structure from each of said bores for picking up powder comprises a single hole in the bottom of each tube into the associated bore defined by each tube.

16. A carrier conduit structure as claimed in Claim 14 wherein said tubes are arranged to be positioned at the same elevation in a parallel configuration, and wherein a plurality of openings are provided through the wall of each tube from each of said bores for picking up powder, said plurality of openings for each tube being arranged between downwardly and substantially horizontally in each tube on the side of each tube opposite to the other tube of said unitary carrier conduit structure.

17. A carrier conduit structure as claimed in Claim 16 wherein said plurality of openings in the side of each tube consists of two openings, and wherein said openings extend substantially horizontally and substantially parallel to one another through the wall of the associated tube and at an acute angle to the direction of travel of the carrier gas through the associated tube.

18. A system as claimed in Claim 17 wherein a partial constriction is provided within the bore of each tube downstream from said side openings.

19. A carrier conduit structure as claimed in Claim 14 wherein the inlet end of said carrier conduit structure partially forms and defines said plenum, said inlet end of said unitary carrier conduit structure including an axial end face, said axial end face including two openings from said plenum into said respective carrier gas bores of said unitary carrier conduit structure.

20. A carrier conduit structure as claimed in Claim 19 wherein said axial end face of said inlet end of said unitary carrier conduit structure which contains said openings into said separate carrier gas bores is recessed in an axial direction and

includes an axially extending rim portion to partially define said plenum and to assure a minimum axial dimension for said plenum.

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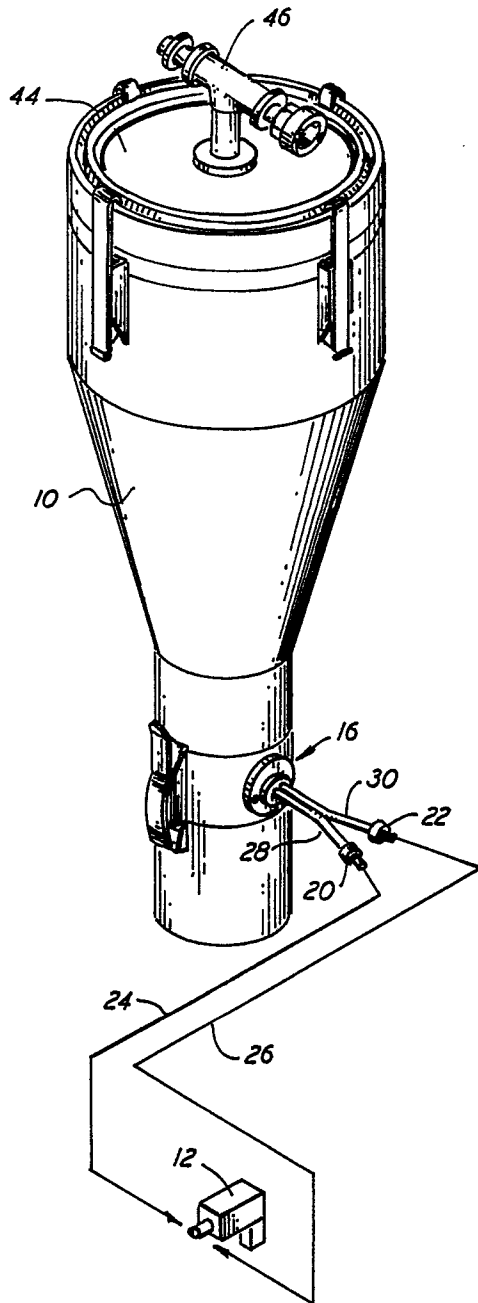


FIG. 1

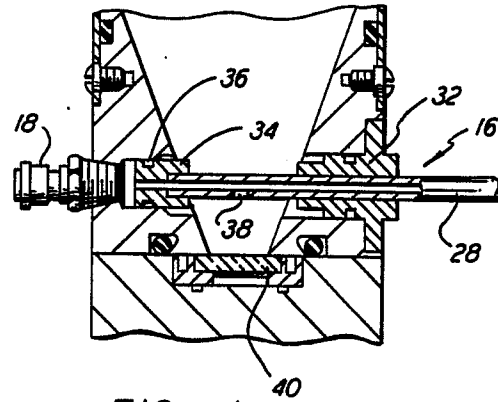


FIG. 2A

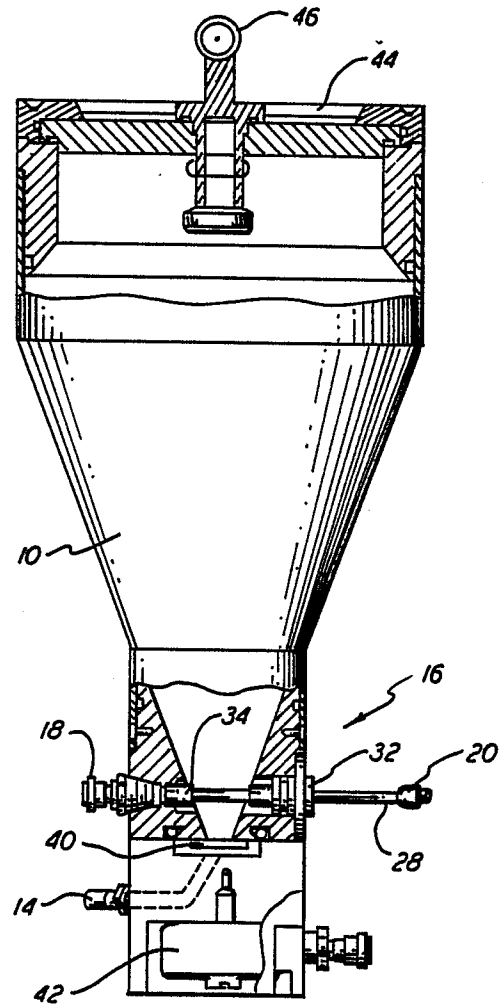


FIG. 2

