

Sept. 1, 1953

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METHOD AND DEVICE FOR VISUAL OBSERVATION
OF DENSE-PHASE SUSPENSIONS
Filed Dec. 6, 1951

2,650,562

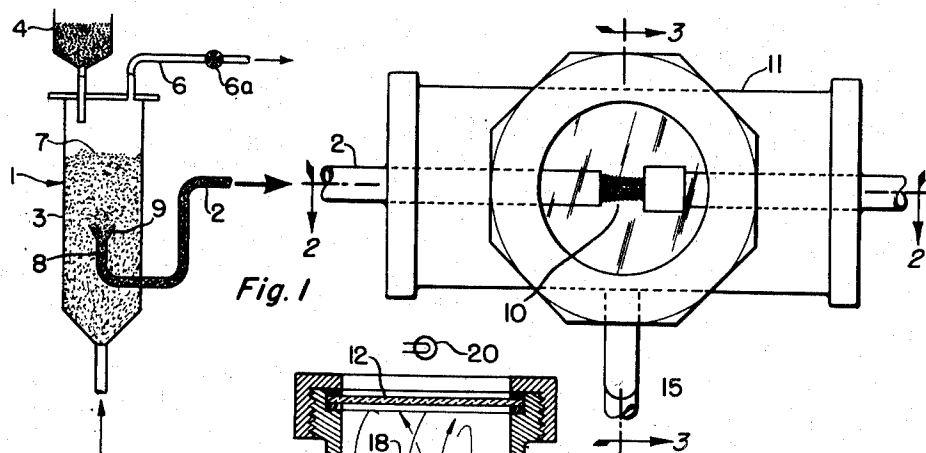


Fig. 1

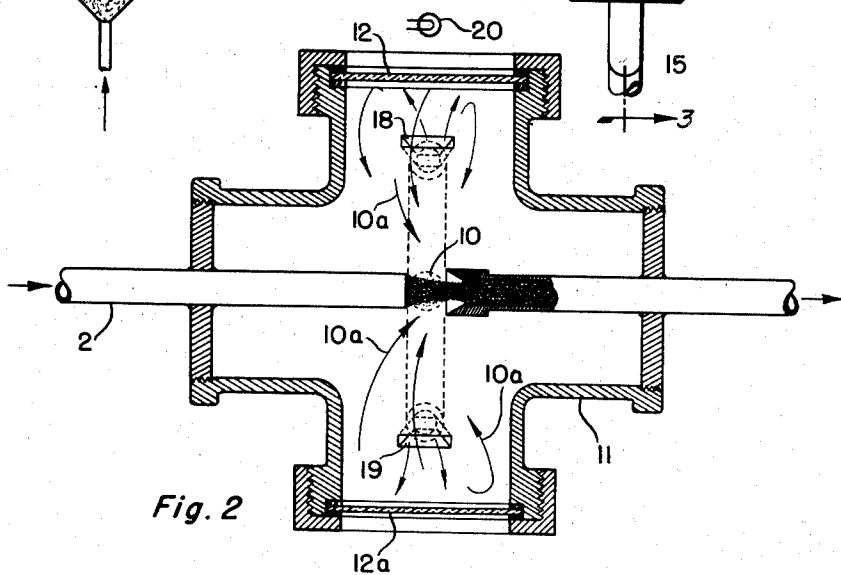


Fig. 2

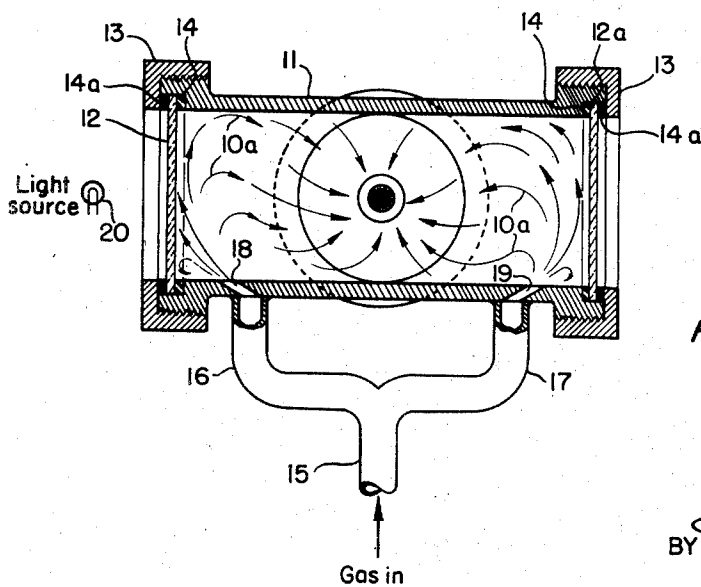


Fig. 3

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2,650,562

METHOD AND DEVICE FOR VISUAL OBSERVATION OF DENSE-PHASE SUSPENSIONS

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Application December 6, 1951, Serial No. 260,296

6 Claims. (Cl. 116—117)

(Granted under Title 35, U. S. Code (1952), sec. 266)

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The invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without payment of royalties thereon or therefor.

This invention is concerned with a method and device for permitting visual observation of a dense phase, solids-in-gas suspension flowing through a conduit.

In the pneumatic conveying of pulverant materials it is often desirable to have some means for visually observing the flow of the material through the conveying conduit. In ordinary methods of pneumatic conveying, where the solids-in-gas suspension is relatively dilute (having a solids:gas volume ratio of the order of 1:100), and where the suspension flows at a relatively high velocity (75 feet per second, for example), it is usually possible to readily observe the flow through the conduit merely by providing a transparent section therein. Even when conveying materials such as pulverized coal, which tend to deposit an opaque film upon the walls of the conveying conduit, the turbulence and scrubbing action of a relatively high velocity suspension tends to keep the walls clean and makes visual observation possible through a transparent section of the conduit.

It has been found however, that when employing dense phase suspensions (having a solids:gas volume ratio of the order of 1:4 to 1:8, for example) which move at relatively low velocities (8 feet per second, for example), it is often difficult to observe the flow of the solid material through a transparent section of the conduit. The low velocity and lack of turbulence in the suspension makes it rather difficult to detect any movement in the suspension even when the walls of the conduit remain clean. When conveying a material such as pulverized coal, the difficulty is exaggerated since the conduit walls tend to become coated with a film of coal particles.

It is the principal object of the present invention to provide a convenient and reliable method for visually observing a dense phase solids-in-gas suspension as it flows through a conveying conduit. Ancillary objects of the invention will be apparent from the description which follows.

In accordance with the invention it has been found that visual observation of a dense-phase suspension flowing through a conduit may be obtained by providing a relatively small gap in the conduit and continuously flowing an extraneously supplied gas stream through this gap into the

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conduit at a velocity sufficient to prevent disentrainment or separation of solid material at the gap. With such an arrangement, the dense phase suspension will be clearly visible as an opaque cylinder bridging the gap in the conduit.

To carry out the foregoing method, the section of the conduit including the gap is enclosed in a gas-tight housing which is provided with at least one transparent wall to permit visual observation of the interior thereof. A gas stream from an external source is directed into the housing at such a rate that the gas velocity through the gap into the conduit is sufficient to prevent the solids from separating from the suspension as it crosses the gap. Preferably, the incoming gas stream is jetted against the transparent wall, or walls of the housing to prevent the accumulation thereon of relatively small amounts of solids which may become disengaged from the suspension.

For a better understanding of the invention, reference is now made to the accompanying drawings, wherein:

Fig. 1 is a side elevation of a device constructed in accordance with the invention, together with a semidiagrammatic illustration of an apparatus for supplying a dense-phase solids-in-gas suspension; and,

Fig. 2 is a section taken on line 2—2 of Fig. 1; and,

Fig. 3 is a section taken on line 3—3 of Fig. 1. Referring now particularly to Fig. 1, the reference numeral 1 refers generally to a device for supplying an extremely dense phase, solids-in-gas suspension to a conveying conduit 2. The device comprises a closed vessel 3 which is charged with a finely-divided solid material, such as pulverized coal, from a hopper 4. A gas stream is introduced into the bottom of the vessel and is passed upwardly through the finely-divided material at a velocity so adjusted that the mass of finely-divided material is converted into the so-called "fluidized" condition. Most of the fluidizing gas stream is withdrawn from the top of the vessel through line 6 and may either be vented to the atmosphere, or if desired, recirculated to the bottom of the vessel. A minor portion of the fluidizing gas stream flows out of the vessel through tube 8 as carrier gas for the suspension.

In the so-called fluidized condition, which results when the linear velocity of the gas stream passing upwardly through the mass of finely-divided solid material is within a rather critical range, the individual particles of the mass be-

come suspended, as it were, in the fluidizing gas stream, but do not become entrained therein. The mass as a whole resembles a liquid at its boiling point, and as a matter of fact possesses many of the properties of a liquid; it has a definite, though turbulent upper surface (indicated by the numeral 7 in the drawing); exerts a pseudo-hydrostatic pressure on the walls and bottom of the vessel in which it is contained; and likewise has many of the flow properties of a liquid.

The range of gas velocities over which "fluidization" occurs depends chiefly upon the density and size of the individual particles. With coal pulverized to a size through about 100 mesh, fluidization occurs at superficial linear gas velocities of from .08 to .3 foot per second, for example. Below this range, the particles in the vessel remain in the settled state; while above this range the particles become entrained in the gas stream and are carried out of the vessel.

One outstanding characteristic of the so-called fluidized suspension is that it contains an extremely high concentration of solids. The solids:gas volume ratio, is ordinarily of the order of from 1:4 to 1:8. For a material having a density equivalent to that of coal, such suspensions contain from 98% to 99% by weight of solids.

In order to deliver this extremely dense phase suspension to the conveying conduit 2, an upright tube 8 is provided having an opening within the fluidized mass in the vessel 3. The fluidized suspension flows into the open end of tube 8 in much the same way as a liquid flows into the open end of a pipe. The pseudo-hydrostatic pressure exerted by the head of fluidized material above the opening provides energy for driving the suspension through the conveying conduit 2. Preferably, this driving force is supplemented by maintaining a superatmospheric pressure within the vessel 3 by creating any desired back pressure in the vessel by suitable adjustment of back pressure valve 6a in line 6. A funnel shaped deflector 9 is disposed around the open end of the tube 8 to provide a settling zone adjacent the opening. The foregoing method for supplying a dense-phase suspension to a conveying conduit is described in more detail in copending application Ser. No. 103,502, filed July 7, 1949, for Method of Feeding Coal or Other Pulverized Solids to a Zone of Utilization by Charles W. Albright et al.

In order to permit visual observation of the dense phase suspension flowing in conduit 2, a relatively small gap, indicated by the reference numeral 10 is provided in the conduit. The portion of the conduit including the gap is enclosed in a gas-tight housing 11. In the embodiment shown, the housing 11 is constructed in a manner similar to a pipe cross, each arm of which has an inside diameter substantially larger than the conveying conduit 2. The conveying conduit 2 passes through one arm of the cross, with the gap 10 located at the center of the cross. The other arm of the cross is provided at both ends with transparent or translucent windows.

Referring to Figures 2 and 3, it can be seen that in the embodiment shown, two glass windows 12 and 12a respectively are provided, held in place by internally threaded retaining members 13, which are threaded onto an externally threaded portion of the housing 11. Gaskets 14 and spacing ring 14a provide a gas tight seal.

A gas stream, supplied from an external source, is introduced into the housing 11 by line 15. As can be seen most clearly in Figure 3, line 15 divides into lines 16 and 17, which in turn supply

a gas stream to each of the slots 18 and 19 provided in the bottom of the housing 11. As can be seen in Figure 3, the slots 18 and 19 direct the entering gas stream against the transparent windows 12 at a glancing angle. The gas stream, sweeping over the windows 12, serves to prevent the accumulation of finely-divided solid material, a small amount of which may become disengaged from the suspension as it crosses the gap.

The gas stream introduced into the housing flows into the conveying conduit 2 through the gap 10 as indicated by the arrows 10a in the drawings. This serves to prevent the disengagement of any substantial amount of the solids in the suspension as the suspension crosses the gap. It has been found that when no auxiliary gas is introduced into the housing 11, or when the amount of gas introduced into the housing is insufficient to maintain a certain minimum velocity in the gap, the solids separate from the suspension at the gap at such a rate that the housing quickly becomes filled with disentrained solids, eventually plugging conveying conduit 2. While a small amount of solids may be disengaged at the gap when operating in accordance with the invention, the accumulation of solids in the housing is prevented by the sweeping effect of the gas stream introduced through line 15. Stray particles are re-entrained in this gas stream and carried back into conveying conduit 2.

The minimum gas velocity through the gap 10 which is necessary to prevent substantial disentrainment of the solids at the gap will vary somewhat from system to system depending upon such factors as the size of the gap, the dimensions of conduit, and the particular type of solids-in-gas suspension employed.

In one particular instance, employing a coal-in-air suspension at a system pressure of 130 p. s. i. a. and having a solids-to-gas ratio of about 23 lbs. of coal per SCF gas, flowing at a rate of about 10 feet per second through a conveying conduit having an inside diameter of about 0.368", and in which the length of the gap was .045", it was found that it was necessary to supply a gas stream to the housing 11 at such a rate that the linear velocity of the gas through the gap was about 1.5 feet per second, in order to prevent substantial disentrainment of the solids at the gap. It is to be understood, of course, that gas velocities through the gap greater than the minimum required may be employed.

While the size of the gap is not particularly critical, it is preferable that it be kept relatively small. In most cases, for conveying conduits having an inside diameter of about .25 to .5 inch, a gap length of from about .045 to .6 inch will generally be found suitable. The larger the gap, of course, the greater amount of extraneous gas must be introduced into the conveying conduit in order to maintain the minimum required gas velocity through the gap. Thus, where it is desired to dilute the suspension flowing through the conduit as little as possible, the minimum gap size should be chosen which will still permit clear visual observation of the suspension as it crosses the gap. In this regard, a gap length as little as .045 inch has been found satisfactory.

It is clear, of course, in the embodiment shown, that direct observation of the suspension as it crosses the gap may be had through the transparent windows 12. By providing a light source 20 (Fig. 3) adjacent to one of the windows to illuminate the interior of the housing, observation, of course, is facilitated. If desired, one of

the windows, such as window 12a may be constructed of a translucent material such as frosted glass for example. With this type of arrangement, and with a light source illuminating the conduit from the opposite side of the housing, the shadow of the conveying conduit 2 together with the shadow of the suspension crossing the gap 10, is cast upon the translucent window 12a. In this way, the suspension may be observed without looking directly into the housing.

If desired, an automatic device may be provided for detecting stoppage in the flow of the suspension. A photoelectric cell, for example, may be positioned at the opposite side of the housing 11 from the light source. Ordinarily, light from this source would not reach the cell because of the opaque suspension crossing the gap. If a stoppage occurred, light reaching the photoelectric cell would cause it to become activated and operate a signal of some sort to warn of the stoppage.

The invention has been found to be particularly useful in providing a means for visually observing the flow of dense phase suspensions of finely-divided coal. In one particular application in which the invention has been used, the dense phase coal suspension is fed into a gasification reactor where it is converted by the action of steam and oxygen into a mixture of carbon monoxide and hydrogen. In such an application, it has been found convenient to introduce the necessary oxygen needed in the gasification zone into the housing 11, whence it flows through the gap 10 into the conveying conduit 2. In this way, one of the necessary reactants is mixed with the coal before it is introduced into the coal gasification chamber and at the same time the necessary gas is introduced into the housing 11 to prevent separation of the coal from the suspension as it crosses the gap.

It is to be understood that the above description, together with the specific examples and embodiments described, is intended merely to illustrate the invention, and that the invention is not to be limited thereto, nor in any way except by the scope of the appended claims.

We claim:

1. A method for visually observing the flow of a dense phase solids-in-gas suspension through a conduit comprising the steps of causing the dense phase suspension flowing through said conduit to jump a relatively small gap in said conduit, flowing an extraneously supplied tributary gas stream into said gap at a velocity sufficient to prevent separation of solids from said suspension at said gap, and visually observing the flow of said suspension as it crosses said gap.

2. A method for visually observing the flow of a dense phase solids-in-gas suspension through a conduit comprising the steps of enclosing a section of the conduit in a gas-tight housing, providing a relatively small gap in said conduit within said housing, flowing a gas stream into

said housing at a rate sufficient to prevent separation of solids from said suspension at said gap, and visually observing the flow of said suspension as it crosses said gap.

3. A method for visually observing the flow of a dense phase solids-in-gas suspension through a conduit comprising the steps of enclosing a section of the conduit in a gas tight housing having at least one transparent wall to permit visual observation of the interior thereof, providing a relatively small gap in said conduit within said housing, flowing a gas stream into said housing at a rate sufficient to prevent separation of solids from said suspension at said gap, directing the gas stream flowing into said housing against said transparent wall so as to effectively dislodge solid material accumulating thereon, and visually observing the flow of said suspension as it crosses said gap.

4. A device for visually observing the flow of a dense phase solids-in-gas suspension through a conduit comprising a gas-tight housing surrounding a relatively small gap in said conduit, said housing having at least one transparent wall to permit visual observation of the interior thereof, and means for admitting a gas stream into said housing so as to prevent solids from accumulating on said transparent wall.

5. A device for visually observing the flow of a dense phase solids-in-gas suspension through a conduit comprising a gas-tight housing surrounding a relatively small gap in said conduit, said housing having at least one transparent wall to permit visual observation of the interior thereof, and means for directing a gas stream into said housing against the inner side of said transparent wall so as to effectively dislodge solid material accumulating thereon.

6. A device for visually observing the flow of a dense phase solids-in-gas suspension through a conduit comprising a gas-tight housing surrounding a relatively small gap in said conduit, said housing having a pair of light transmitting walls disposed on opposite sides of said gap, a light source adjacent one of said light transmitting walls for illuminating the interior of said housing, and means for directing a gas stream into said housing against the inner sides of said light-transmitting walls so as to effectively dislodge solid material accumulating thereon and thereby to permit the observation of said solids-in-gas suspension as it crosses said gap.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,124,575	Zimmer	Jan. 12, 1915

FOREIGN PATENTS

Number	Country	Date
662,623	Germany	July 18, 1938