

Jan. 27, 1970

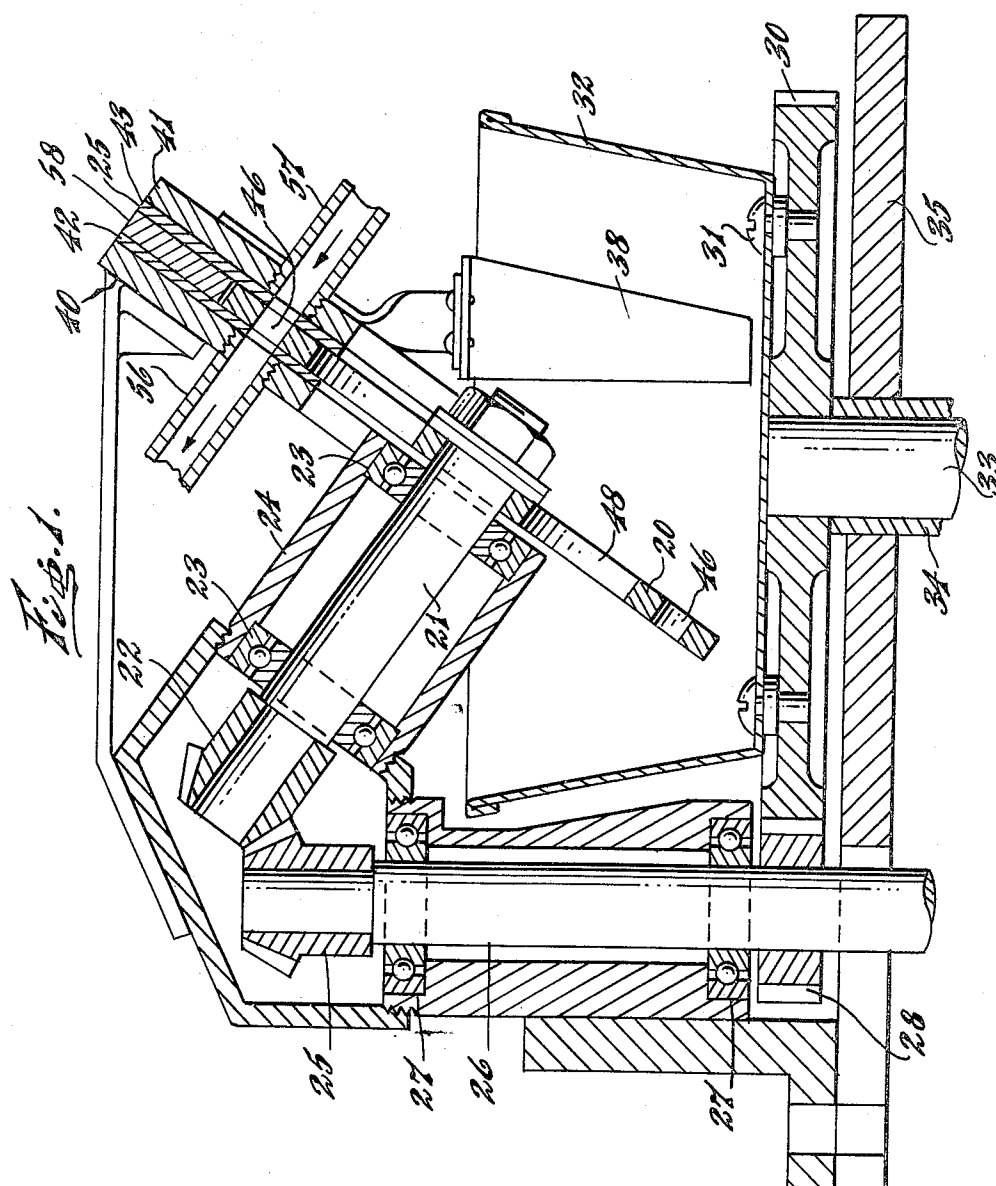
R. D. COLINET

3,492,050

FEEDER FOR NONFLOWING POWDERS

Filed Oct. 15, 1968

5 Sheets-Sheet 1



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FEEDER FOR NONFLOWING POWDERS

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5 Sheets-Sheet 2

Fig. 2.

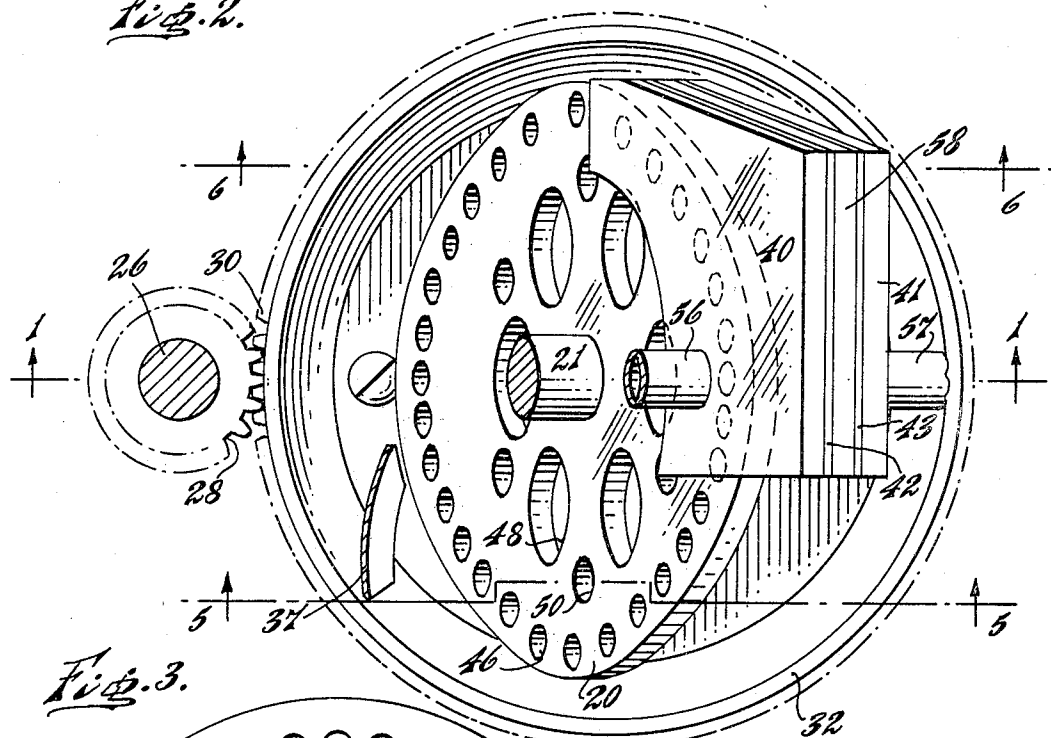


Fig. 3.

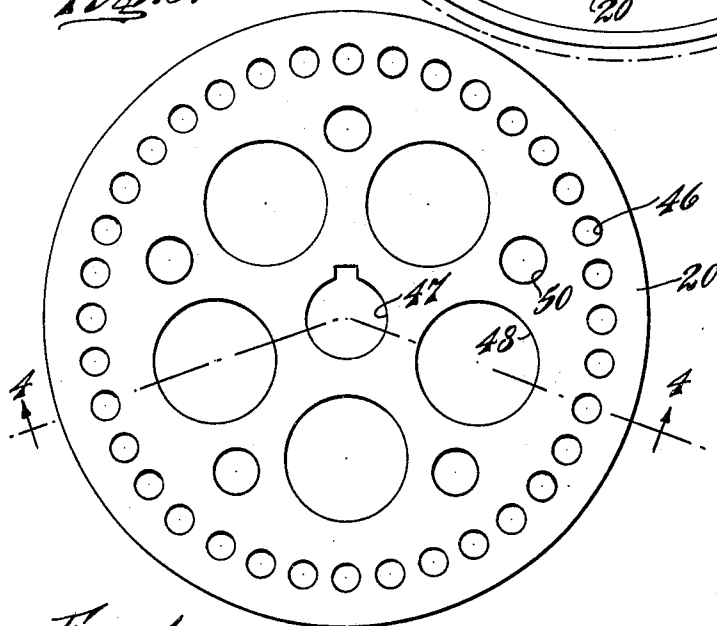


Fig. 4.



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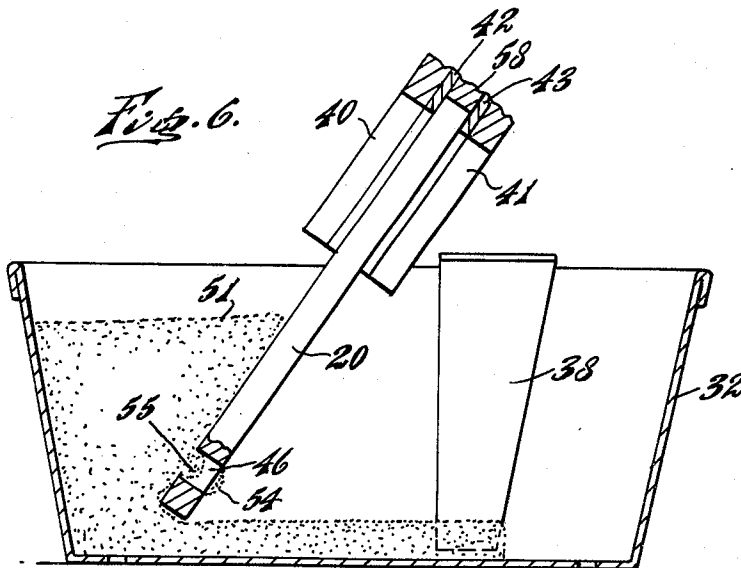
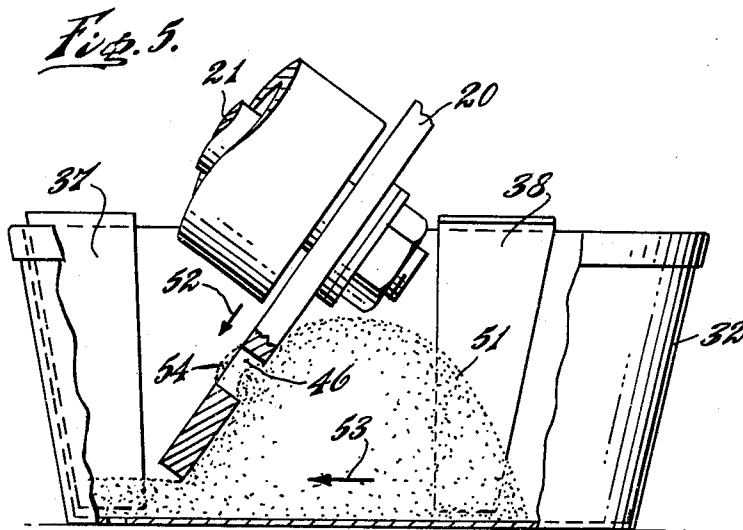
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FEEDER FOR NONFLOWING POWDERS

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5 Sheets-Sheet 3



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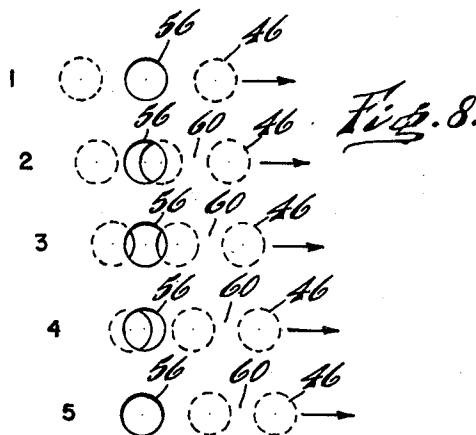
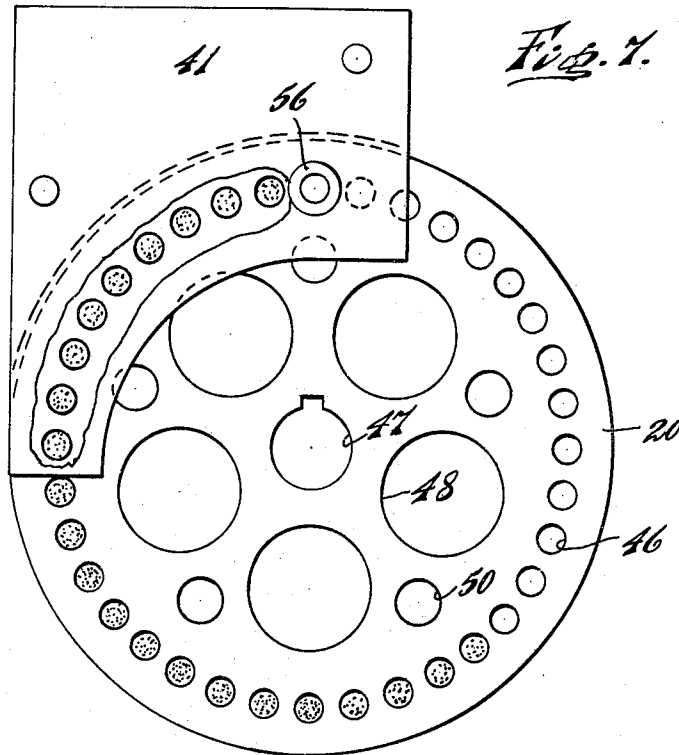
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FEEDER FOR NONFLOWING POWDERS

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5 Sheets-Sheet 4



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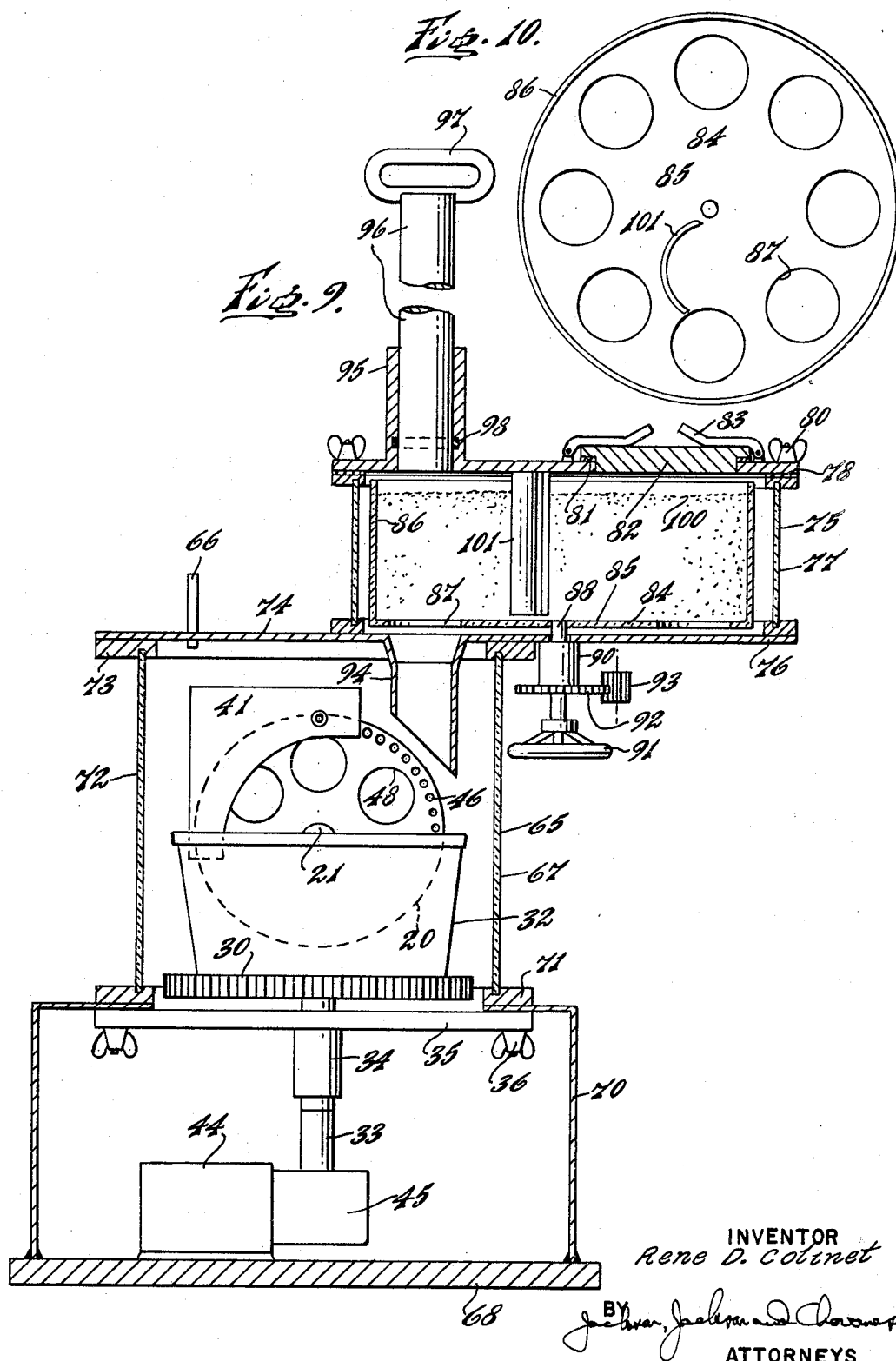
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FEEDER FOR NONFLOWING POWDERS

Filed Oct. 15, 1968

5 Sheets-Sheet 5



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3,492,050

FEEDER FOR NONFLOWING POWDERS

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16 Claims

ABSTRACT OF THE DISCLOSURE

A feeder for nonflowing powders including a container for the powder, a disc submerged in the powder and having transverse holes distributed around it, means for turning the disc on an axis displaced from the vertical, means for turning the container to cause powder to enter the holes from both faces of the disc, shear plates on opposite sides of the disc removing excess of powder, a discharge opening which sequentially cooperates with the holes, and means for projecting a gas flow through the holes and into the discharge opening. The holes are equally spaced and the space between holes in less than their diameter so that the gas flow is uninterrupted. A gas-tight casing surrounds the feeder and includes an air-locking section, means for sealing the air-locking section from the section surrounding the container and the disc, and means for feeding powder from the air-locking section into the container.

DISCLOSURE OF INVENTION

Numerous devices have been proposed and built to deliver or feed a steady stream of continuous solid particles starting with a mass of such particles in contact with each other within a container, box, package or similar loose aggregation. The separation and removal of such particles for constant delivery is relatively easy when the particles are of sufficient size and weight to dissociate freely from one another, by gravity action, but the present invention is concerned with powders which behave much differently.

The present invention deals with extremely fine powders of submicron range (a micron is 0.001 of a millimeter or 0.001 of 0.039 inch) in materials which adhere to themselves even when substantially dry and not compressed except under their own weight. An example of such a powder is common wheat flour used in baking bread or pastry. Other examples of such powder are titanium dioxide, alumina, or zirconium oxide, extremely fine, as used for example in hot spraying with a plasma torch. These powders do not run down an inclined support, do not pour freely from the neck of a bottle, and do not pour out of an orifice of a hopper or a funnel, but tend to cling to the walls of containers, and even form arches across opposite sides of a hopper, behaving in this respect quite differently from free-flowing powders.

One very effective way to break this togetherness is to vibrate the mass, but this does not produce a measurable output which is constant in relation to time.

In spraying processes such as hot spraying with a plasma torch, where such powders must be atomized and carried to the torch as a free suspension in a moving gas having sufficient speed to prevent them from settling anywhere in their passage through a hose, it is further required that output or delivery to the plasma torch or gun be very constant in terms of number, weight or volume of particles in a small unit of time, repeated as long as the material remains available in the feeding device.

When gas is mentioned herein it is intended to include any suitable gas in which the powder might be borne,

2

including the inert gases such as argon, and helium, and also air, nitrogen, carbon dioxide, and any other suitable gas which may be employed.

A purpose of the present invention is to improved mechanism for feeding nonflowing powders and to obtain a more uniform output.

A further purpose is to permit refilling a powder reservoir without interrupting or altering the delivery of the powder to the plasma torch or other point of use.

Another purpose is to protect the powder from alteration by air (oxidation) or by humidity (packing or sticking) from the moment the powder is loaded into the device until it leaves as a suspension in a gas stream.

A further purpose is to gently agitate the entire mass of powder without compressing it, to prevent segregation when the powder consists of several different ingredients which may have different specific weights, different grain sizes, different shapes of grains, or some combination of these features.

The device of the present invention operates upon the principle of separating from the mass a precise small volume of loose powder, enclosing it for protection and to prevent leakage until it is to enter the gas stream, and then blasting it by a gas jet which will add this new increment of powder to the gas stream. Successive volumes follow the first volume with overlapping blasts (no interruption) and so on as long as powder remains available in the device.

FIGURE 1 is a central vertical section through the device of the invention, including the container and disc, but omitting the gas-tight casing, the section being taken on the line 1—1 of FIGURE 2.

FIGURE 2 is a plan view of the device of FIGURE 1, partly in section.

FIGURE 3 is a detail side elevation of the disc of the invention.

FIGURE 4 is a section of FIGURE 3 on the line 4—4.

FIGURE 5 is a vertical section of FIGURE 2 on the line 5—5.

FIGURE 6 is a vertical section of FIGURE 2 on the line 6—6.

FIGURES 5 and 6 show how powder enters opposite sides of the holes in the disc.

FIGURE 7 is a fragmentary side elevation looking toward the disc and the shear plates, showing how the powder which has entered both ends of each hole is sealed and carried to a gas blasting stream.

FIGURE 8 is a stepwise diagram of the relation of successive holes in the disc to the discharge opening, illustrating that the gas flow is uninterrupted due to lack of obstruction at any time.

FIGURE 9 is a central vertical section of the feeder of the invention surrounded by a gas-tight casing, showing how the nonflowing powder can be replenished without interruption of feeding, or contamination or loss of gas pressure.

FIGURE 10 is a top plan view of FIGURE 9, showing only the auxiliary container.

Referring to the drawings, a wheel or disc 20 is keyed onto a shaft 21, the shaft also carrying a bevelled gear pinion 22 and being journaled on antifriction bearings 23 held in a housing 24.

Another bevel gear pinion 25 mounted on a suitably vertical shaft 26 meshes with the pinion 22. The shaft 26 is journaled in antifriction bearings 27 in the housing, and also carries a spur gear pinion 28 which meshes with a larger gear 30 which is centered and attached as by bolts 31 to a round container 32. The gear 30 is mounted on a vertical shaft 33 which is journaled on a sleeve bearing 34, supported on a plate 35 removably mounted by screws 36 on a casing to be described.

The disc 20 fits into the container 32 as best seen in FIGURE 1 so that portions of the discs are in contact with powder in the container on both sides of the plane of axes 21 and 26 as later explained. The disc 20 allows large clearance all around within the container to permit flow of powder under motion of the container.

Extending into the container, and supported from the housing 24 above, are two stationary plows 37 and 38, each of which is directed to deflect powder toward the center of the container as the container turns. The plows are supported ultimately by brackets from housing 24. On either side of the upper portion of the periphery of the disc are placed shear plates 40 and 41 which resiliently press against both faces of the disc 20. In order to achieve the resilience and maintain smoother contact with the disc 20, the plates 40 and 41 are lined with rubber sheets 42 and 43.

When the shaft 26 is rotated by a crank or preferably by a motor 44 through a speed reducer 45, both the disc 20 and the container 32 rotate in unison but at different speeds. In the preferred form shown in the drawings, the disc 20 turns four times as fast as the container 32.

FIGURES 3 and 4 best show the detail of construction of the disc 20. Near its circumference is a row of holes 46 which are arranged in a circle around the axis of the disc, the holes 46 all being of identical size and identically spaced. The holes 46 preferably extend straight across transversely from one side to the other of the disc and act as measuring pockets for the powder. Located toward the center opening 47 is a series of larger holes 48 and 50 which do not participate in measuring the powder but relieve pressure by permitting powder to flow through these larger holes from one side of the disc to the other. While other shapes of pockets might be used, it is considered preferable that the holes 46 be cylindrical and that their axis be parallel to the shaft 21.

In FIGURE 5 is shown a mass of powder 51 introduced into the container 32 at a level approximately the center of the disc 20, while the disc 20 is rotating in the direction of the arrow 53. Due to the combined rotation of the powder 51 packs and presses gently against the underface of the disc 20 in the portion of the disc which is penetrating into the powder mass in the container. The powder 32 thus penetrates into the rim holes 46 as suggested at 51, but does not normally fill such holes 46 entirely at this point because of the nonflowing character of the powder and the low pressure produced because of the escape of powder through relief holes 48 and 50 in the disc 20, and also escape of powder between the disc 20 and the wall of the container 32. As the holes 46, only partially filled, move along with the rotation of the disc at the lowest point, deep into the container 32, all further filling stops because the holes 46 and the powder 32 are now moving in parallel directions. It should be noted that the upper portion of the disc 20 has lost all contact with the powder and is therefore bare in the portion where the holes 46 move downward.

Now as shown in FIGURE 6, the particular hole 46 under study has moved with the disc to a position on the opposite side of the plane of axes 21 and 26 where the primary pressure of the powder on the disc will be against the other side of the disc. The stationary plow 37 deflects the powder adhering to the outer wall of the container 32 toward the center, and this deflected powder is caused by the rotation of the container to strike against the upper face of the disc 20 in its portion which is moving upward. The holes 46 begin to be filled from the upper face of the wheel, as shown at 55, completing the penetration which was begun from the underface of the wheel as explained in reference to FIGURE 5. This double filling action produces complete filling of the holes 46 even with nonflowing material, as proved experimentally using holes of $\frac{1}{4}$ inch diameter and $\frac{1}{4}$ inch length. The second plow 38 later deflects the powder following the outer wall

of the container 32 back to the center, in position where it will strike the underface of the disc once again.

Now as shown in FIGURE 7 the holes 46 which are filled to or beyond the brim move further upward and in between the shear and sealing plates 40 and 41, these plates or their rubber linings shearing off the excess of powder on both faces of the disc 20. In addition any later fallout or leakage of powder from the holes 46 is prevented until the holes reach the top of the wheel and line up with a discharge opening 56 which is connected to a discharge hose to the plasma torch or the like and a cooperating inlet gas opening 57 on the other side of disc 20 and in line with discharge opening 56. The diameters of the discharge opening and the inlet gas opening should be at least as large or the same size as the holes 46. The inlet opening 57 in the simplest form of the invention is connected with a source of pressurized gas such as air, argon or nitrogen. In order to maintain the shear plates properly spaced, a spacer plate 58 is provided between the linings of the shear plates 40 and 41 having desirably approximately the same thickness as the thickness of the disc 20. The shear plates, rubber sheets and spacer plate are united by bolts, not shown, and supported ultimately from the housing 24.

As noted in FIGURE 8, the spacing 60 between the holes in the disc is desirably smaller than the common diameter of the holes and the gas discharge opening 56 and the gas inlet opening 57. Therefore, as shown by the five progressive positions in FIGURE 8, the gas flow through the discharge opening is never interrupted. Instead, powder is carried away by the gas in a continuous stream without noticeable pulsation or momentary loss or reduction of pressure which would otherwise cause settling of the powder in the discharge opening 56 or the hose connected thereto.

The output of powder expressed in units of volume per unit of time, even for very small units of time, remains constant as long as the speed of rotation of the disc remains unchanged. As powder is transferred continuously from the container 32 to the gas suspension stream, it soon becomes necessary to refill the container 32. This could, of course, be done manually with a spoon, a conveyor belt or otherwise, without interrupting the operation of the disc 20. In many cases, however, it is desirable to avoid prolonged contact between the powder and the surrounding air, where oxygen or humidity may be objectionable. For this purpose it is very important in some cases to enclose the feeder in a gas-tight enclosure 65, as shown in FIGURE 9, which can preferably be filled with a neutral gas and provided with transparent walls for easy inspection.

There is a second good reason for such a gas-tight enclosure. Some of the gas introduced in the gas inlet 57 may escape through the seal between the disc 20 and the plates 40 and 41 and this may cause a fine mist or fog of submicron particles which float in and around the container 32, obstructing the view. One very good way to avoid this leakage is by shortening or removing the inlet tube 57, leaving only the aperture through which it extends through plate 41, and also leaving the discharge conduit 56 unchanged and introducing the gas under pressure into the gasproof enclosure 65 as by an inlet connection 66. Now the discharge passage 56 is the only escape route for gas-suspended particles from the enclosure and the fog is eliminated. Thus the enclosure as shown includes a first part 67 having a base 68, a lower housing 70, containing parts concerned with the drive, a connecting ring 71 which supports the plate 35 through bolts and wing nuts 36, an upper housing 72 suitably of a transparent material such as a plastic, a top ring 73 and a cover 74 suitably of transparent plastic.

Above the parts just described, there is an air-locking enclosure 75 which aids in refilling without loss of pressure. This can be accomplished as shown in FIGURE 9 notwithstanding that the nonflowing powders do not obey

the law of gravity when the particles are in contact with side walls. The air-locking casing 75 has a bottom 76, a suitably transparent side wall 77 and a cover 78 attached by screws and wing nuts 80 and having a filling opening 81 closed by a cover 82 having a rubber gasket 82 and held in place by spring fastenings 83.

Within the air-locking casing 75 there is an auxiliary container 84 having a bottom 85 and side walls 86 and preferably made of transparent material such as a plastic. The bottom has as best seen in FIGURE 10 a ring of identical feeding openings 87 extending around its circumference, equally spaced. The auxiliary container 84 is rotatably supported on a shaft 88 journaled at 90 in the bottom of the air-locking casing, turned by a hand wheel 91 and having keyed thereon a spur gear 92 which indexes one notch at a time by engagement with a spring detent 93 as well known in the art, acting from the casing.

At a position above the container 32, and in line with one of the feeding openings 87, there is a sealing and discharge tube 94 extending downward and in precise registry with it in the top of the upper enclosure 75 there is a plunger cylinder 95 of approximately the same diameter, in which operates a plunger 96 manipulated vertically by a handle 97 and sealed by a gasket 98.

With the auxiliary container 84 filled with non-flowing powder 100 and indexed to bring a mass of powder below the plunger, the plunger is moved downward through the cooperating feeding opening 87 in the bottom of the upper container and through the sealing and discharge tube 94 to project a quantity of powder into the container 32.

Then the plunger is retracted to the position shown in FIGURE 9 and the auxiliary container is indexed one notch to bring the next hole 87 into line with the plunger. As this occurs, the plow 101 supported from the cover 78 tends to feed powder to fill the void left by the last charge of powder removed from the upper container, the plow 101 being supported from the cover and remaining stationary.

When it is desired to fill the auxiliary container, this can be accomplished by moving the plunger 96 forward until it closes the sealing and discharge tube 94, then opening the charging opening 81, adding more powder and closing the charging opening. If desired to avoid blow-back, the space in the air-locking enclosure can be swept with a protective gas at the desired superatmospheric pressure by raising the plunger 96.

In operation of the device as shown in FIGURE 9, the plunger 96 is first pushed down into sealing and discharge tube 94, and then the cover 82 is removed and the auxiliary container 84 is filled with powder.

Next the cover 82 is replaced and sealed tight and the plunger 96 is raised into the plunger cylinder 95 to the position shown in FIGURE 9. A hole is left in the powder by retracting the plunger.

Next the hand wheel 91 is turned one notch bringing powder under the plunger. Then the plunger is pushed all the way down and it forcibly feeds powder into the container 32. The feeding can be repeated many more times than the number of holes 87 in the bottom 85 of the auxiliary container because rotating the upper container 84 throws powder from the center outward due to the plow 101 and refills the cavities left by the retracted plunger so that more powder can be expelled.

Variations in design of the device as described are intended to be included within the invention insofar as they are functionally equivalent. For example, it is immaterial whether the disc 20 is on an inclined axis rather than a horizontal axis as long as the shaft 21 is short enough so that it does not reach the outer wall of the container and can be driven as by a chain or by gearing above the rim of the container 32. It is, however, preferable to use the inclined position of the shaft 21 as shown so that the drive will not be subject to as much abrasion from the powder.

Likewise, it will be evident that it is not critical in the

present invention whether the height of the container 32 is as shown or whether the container is shallower, with the disc 20 turning on a horizontal axis, in which case the shaft 21 can extend over the rim of the container. This form, however, is not preferred because powder may then easily be lost over the rim of the container 32.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A feeder for nonflowing powder comprising a container for the powder having an axis, a disc at least partially submerged in the powder within the container and engaging the powder on both sides of the disc, said disc having transverse holes distributed around its circumference, means for turning the disc on an axis which is displaced from the vertical, means for turning the container about its axis, whereby powder enters the holes from one face of the disc and also enters the same holes from the opposite face of the disc, shear plates on opposite sides of the disc removing excess powder extending beyond the holes, a discharge opening cooperating sequentially with the holes after the excess of powder has been sheared off, and means for projecting a gas flow through the holes and into the discharge opening.

2. A feeder of claim 1, in which the holes are equally spaced, spacing between the holes is substantially narrower than their diameter, and the gas flow into the discharge opening is uninterrupted.

3. A feeder of claim 2, in which the speed of the disc is greater than the speed of the container.

4. A feeder of claim 3, in which the container turns on a vertical axis and the disc turns on an axis inclined to the vertical.

5. A feeder of claim 4, in which there are additional holes in the disc toward the center of the disc with respect to said holes first mentioned, acting to relieve pressure on the disc.

6. A feeder of claim 5, in combination with stationary plow means in the container deflecting powder toward the center thereof.

7. A feeder of claim 6, in combination with a gas-tight casing around the feeder, there being gas at elevated pressure therein.

8. A feeder of claim 7, in which the gas-tight casing comprises a first section surrounding the disc and the container, an air-locking section, means for sealing the air-locking section from the first section and refilling powder into the air-locking section, and means for feeding powder from the air-locking section into the container.

9. A feeder of claim 8, in which the air-locking section comprises an auxiliary container having perforations in the bottom, and plunger means aligning with the perforations for pushing increments of powder through the perforations and into the container in the first section.

10. A feeder of claim 1, in which the speed of the disc is greater than the speed of the container.

11. A feeder of claim 1, in which the container turns on a vertical axis and the disc turns on an axis inclined to the vertical.

12. A feeder of claim 1, in which there are additional holes in the disc toward the center of the disc with respect to said holes first mentioned, acting to relieve pressure.

13. A feeder of claim 1, in combination with stationary plow means in the container deflecting powder toward the center thereof.

14. A feeder of claim 1, in combination with a gas-tight casing around the feeder, there being gas at elevated pressure therein.

15. A feeder of claim 1, in which the gas-tight casing comprises a first section surrounding the disc and container, an air-locking section, means for sealing the air-locking section from the first section and refilling powder into the air-locking section, and means for feeding powder from the air-locking section into the container.

16. A feeder of claim 15, in which the air-locking section comprises an auxiliary container having perforations at the bottom, and plunger means aligning with the perforations for pushing increments of powder through the perforations and into the container in the first section.

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