May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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Fig. 2

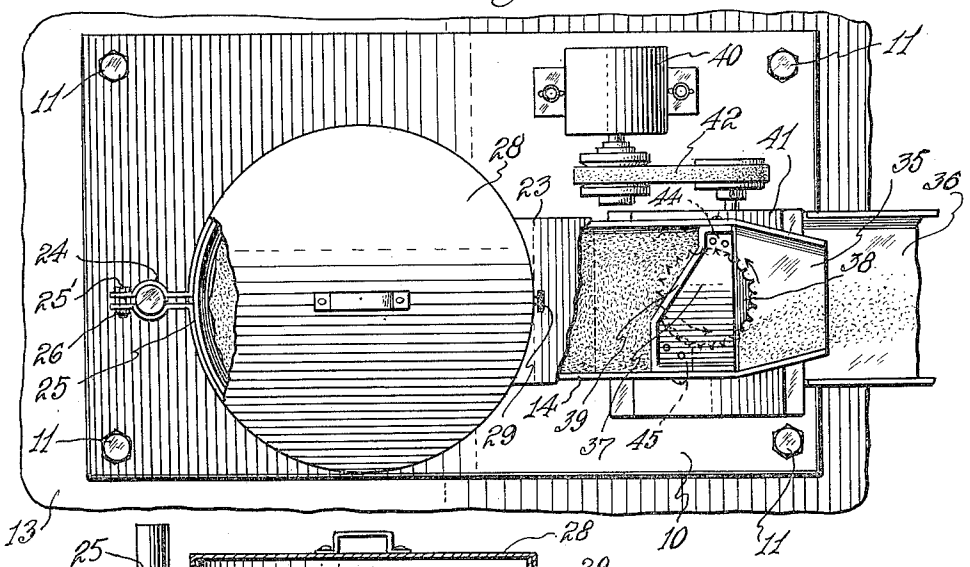
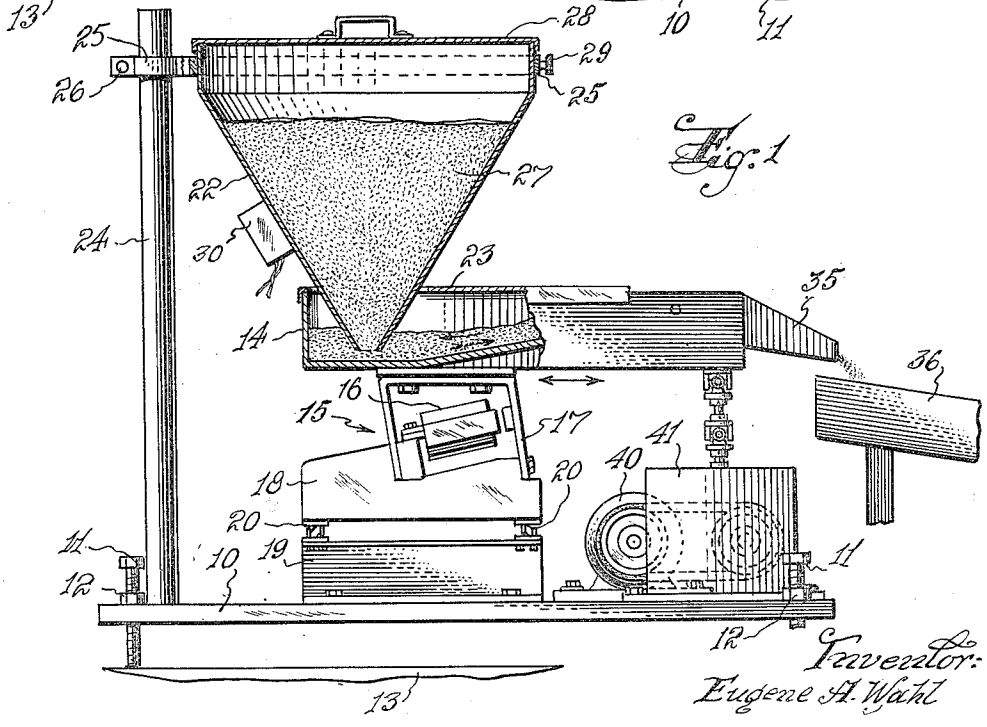


Fig. 1



Inventor:
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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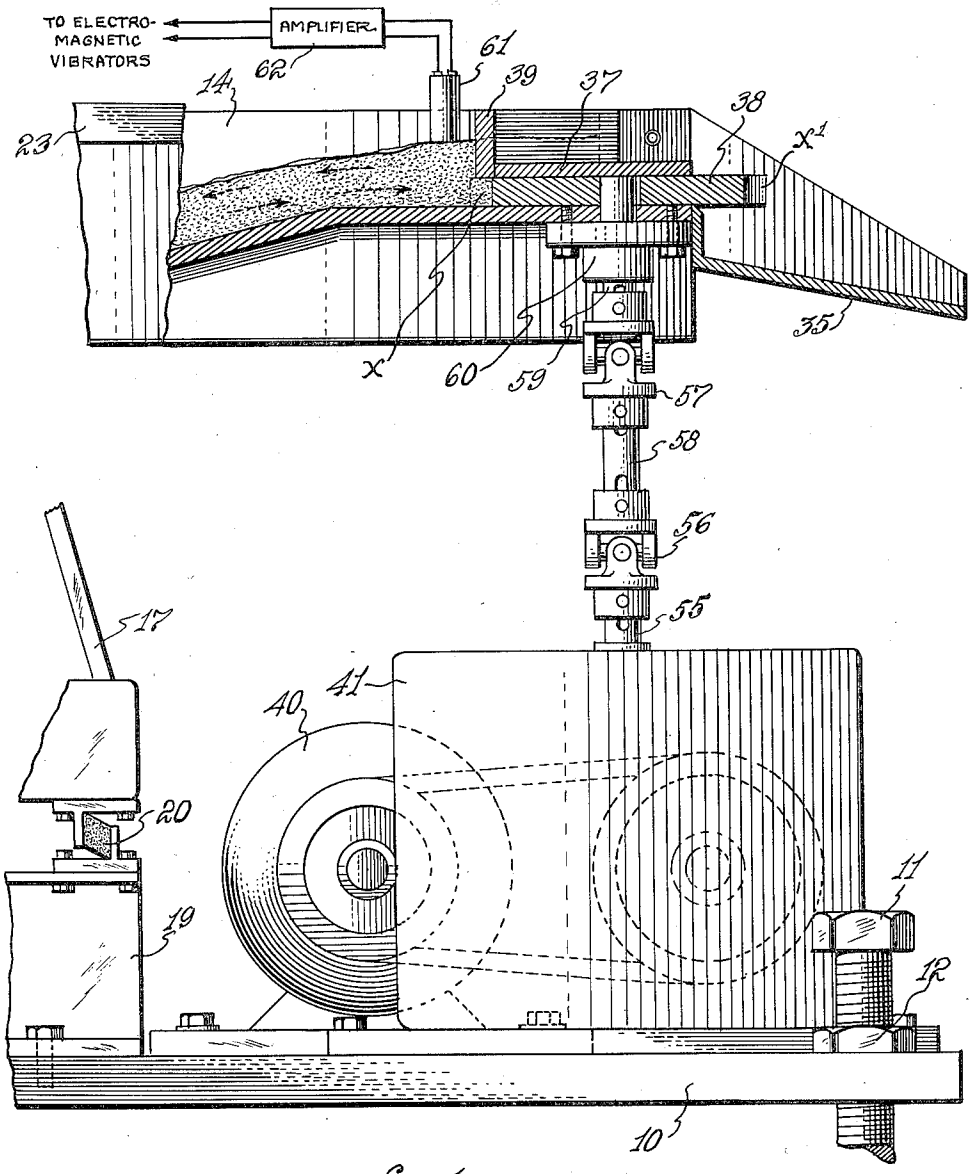


Fig. 3

Inventor:
Eugene A. Wahl

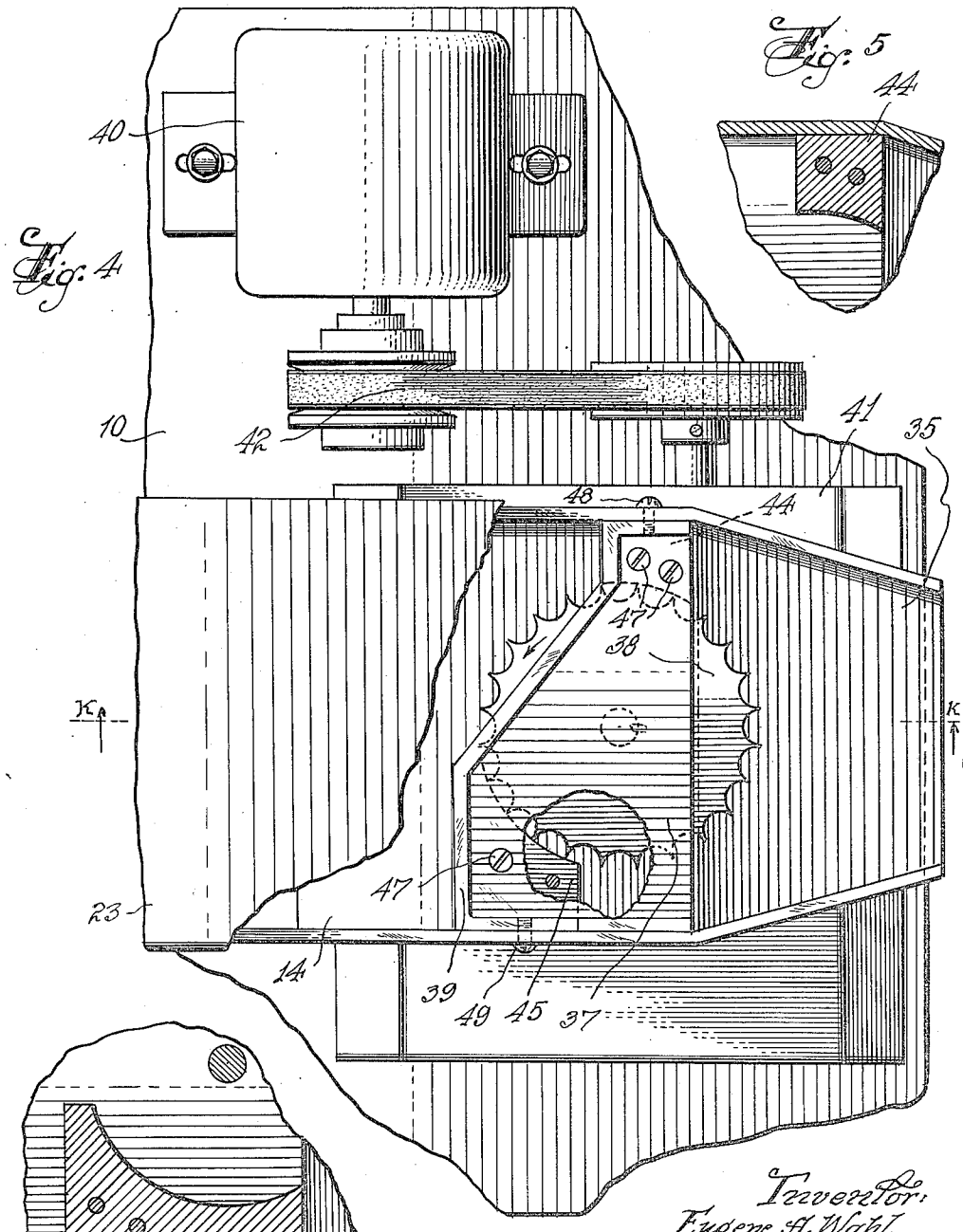
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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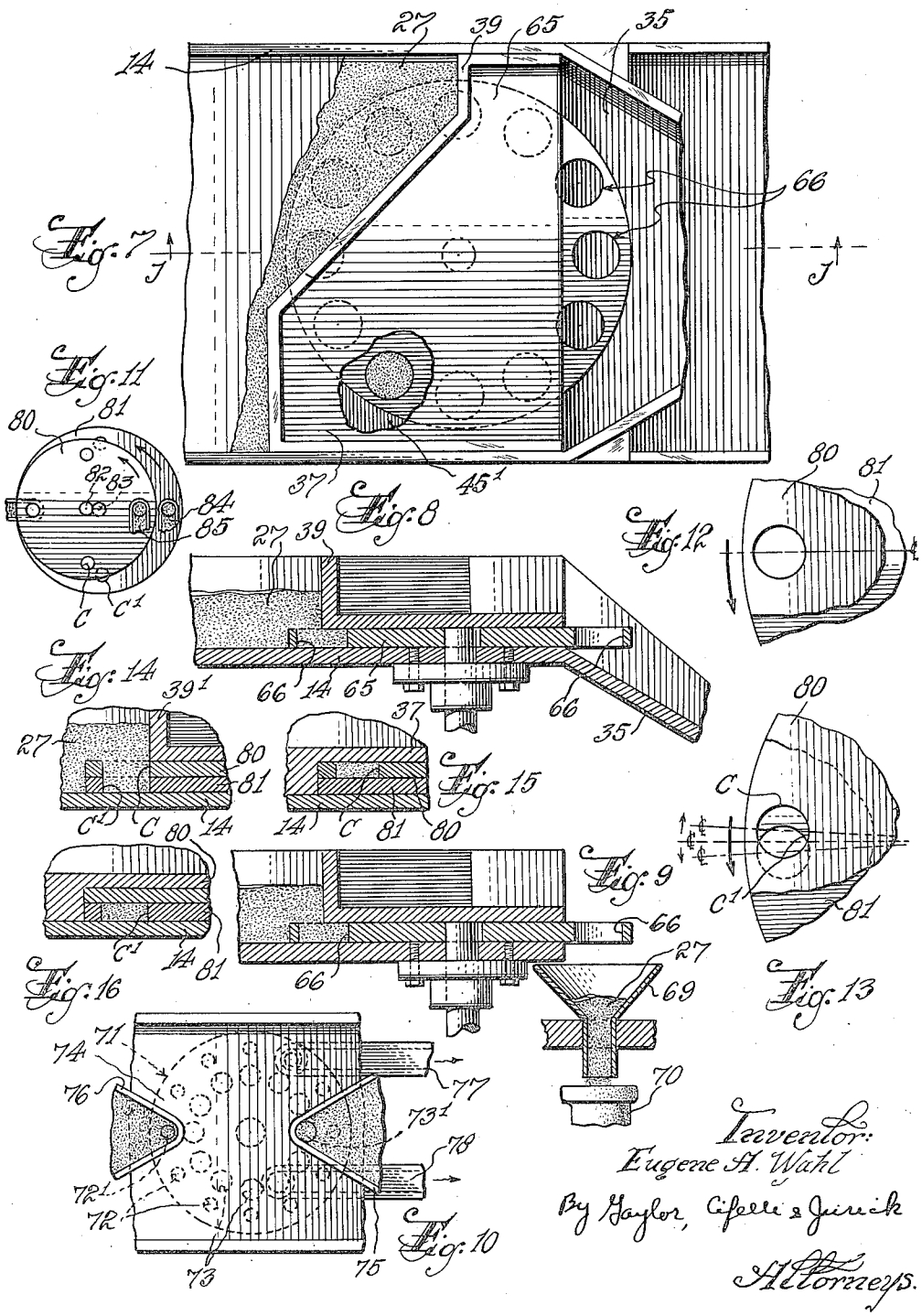
Inventor:
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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POWDER FEEDING MACHINE

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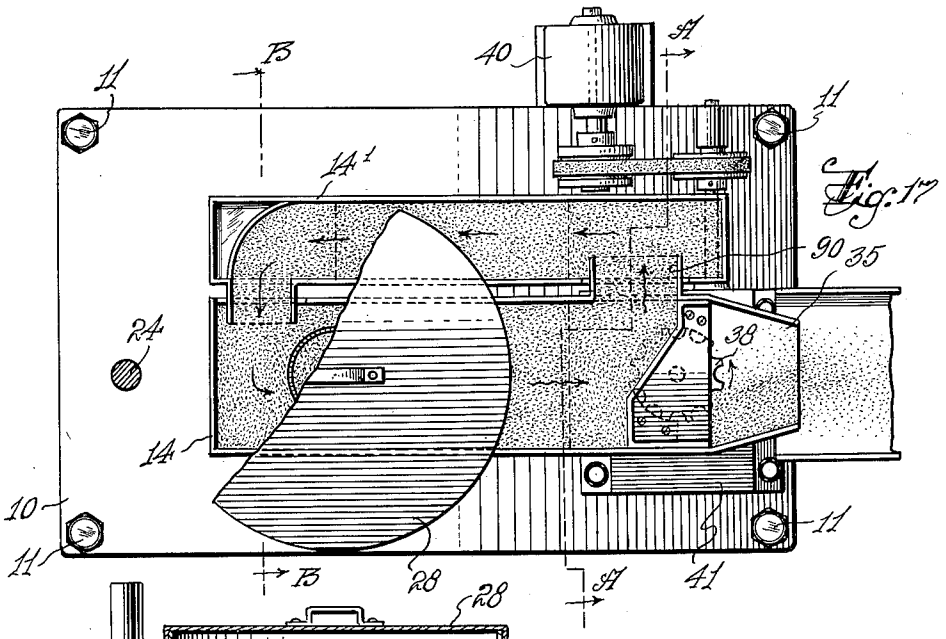


Fig. 17

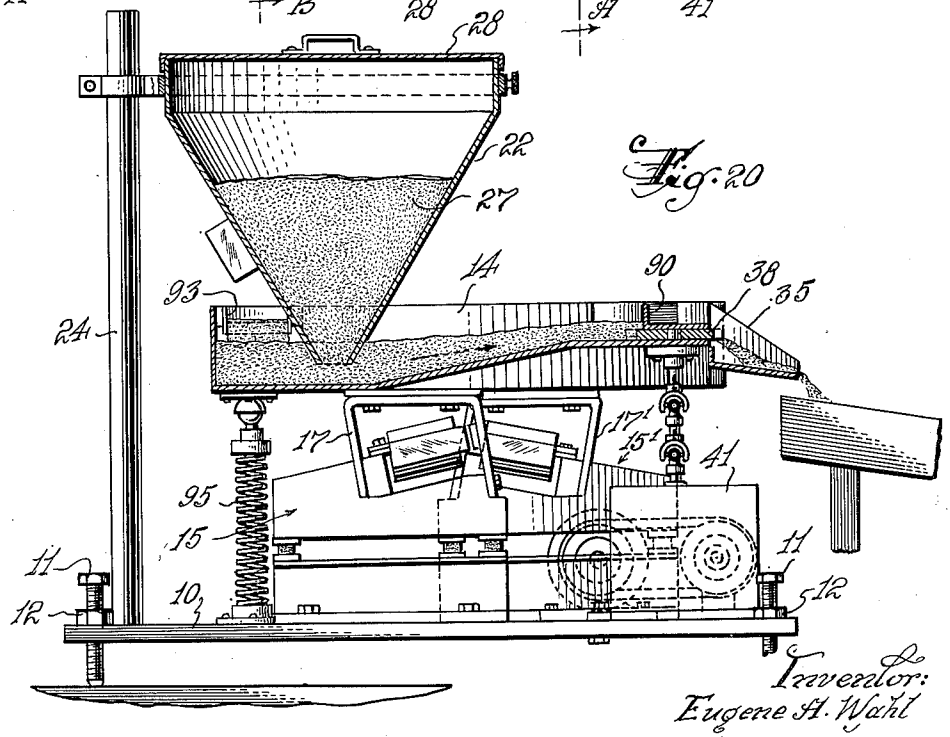


Fig. 20

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POWDER FEEDING MACHINE

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Fig. 22

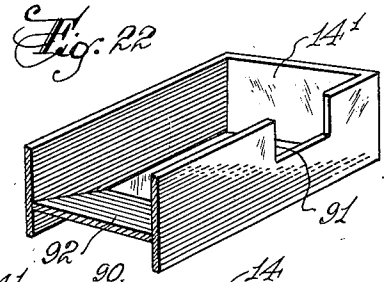


Fig. 18

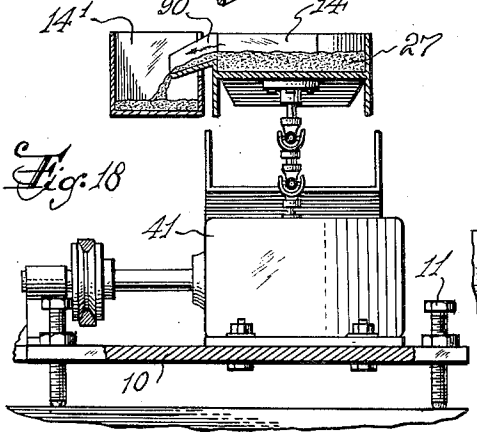


Fig. 19

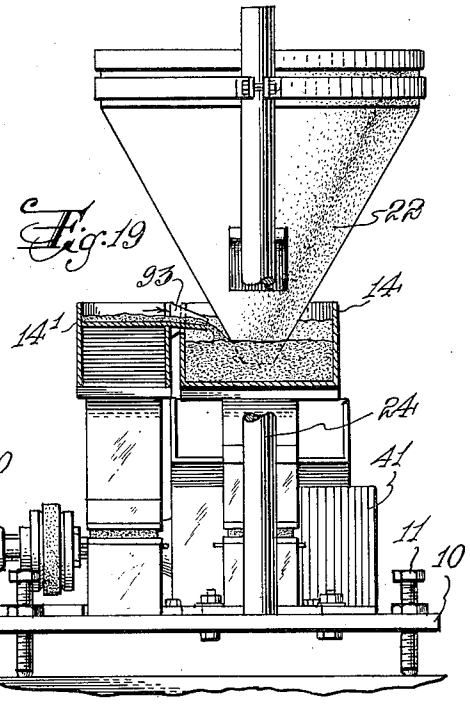
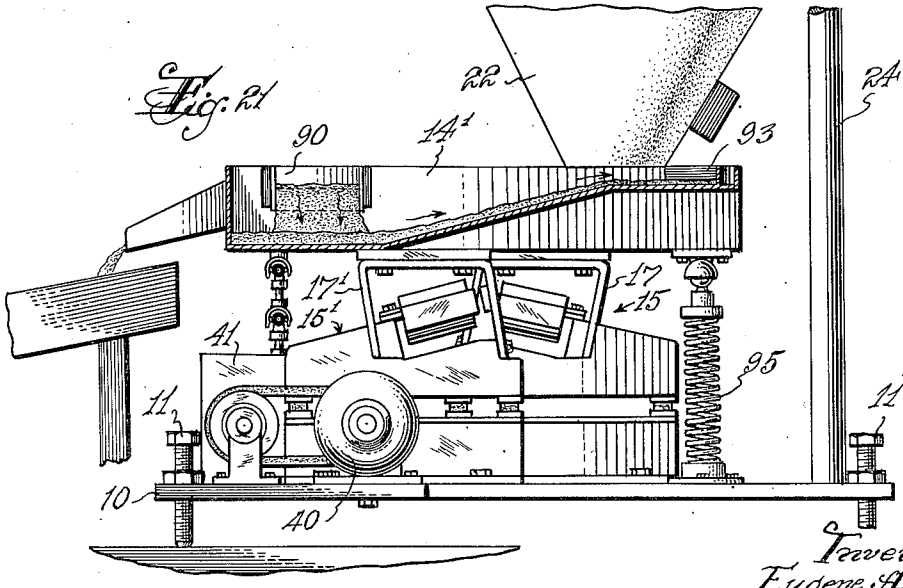


Fig. 21



Inventor:
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POWDER FEEDING MACHINE

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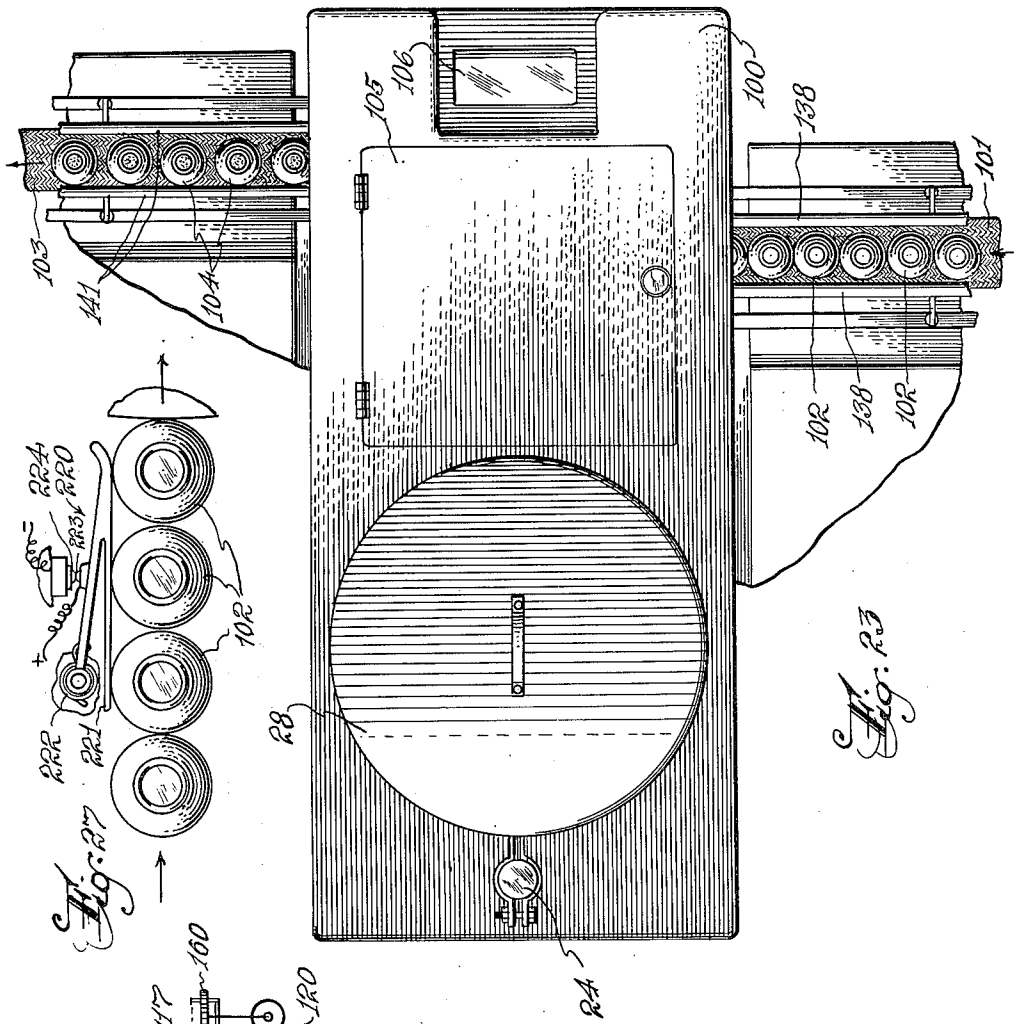


Fig. 23

Fig. 22

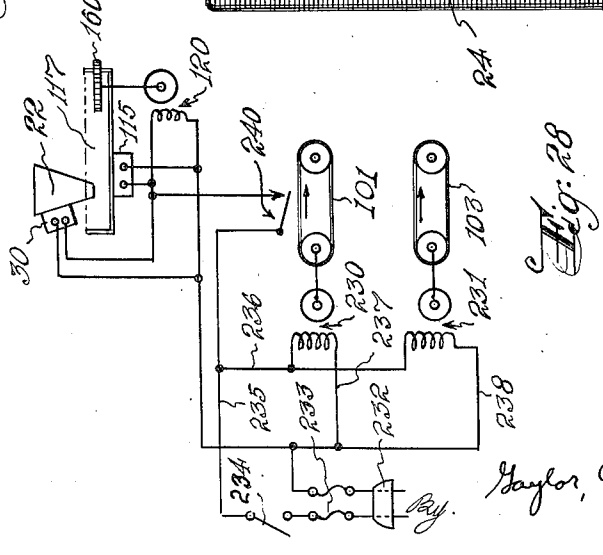


Fig. 28

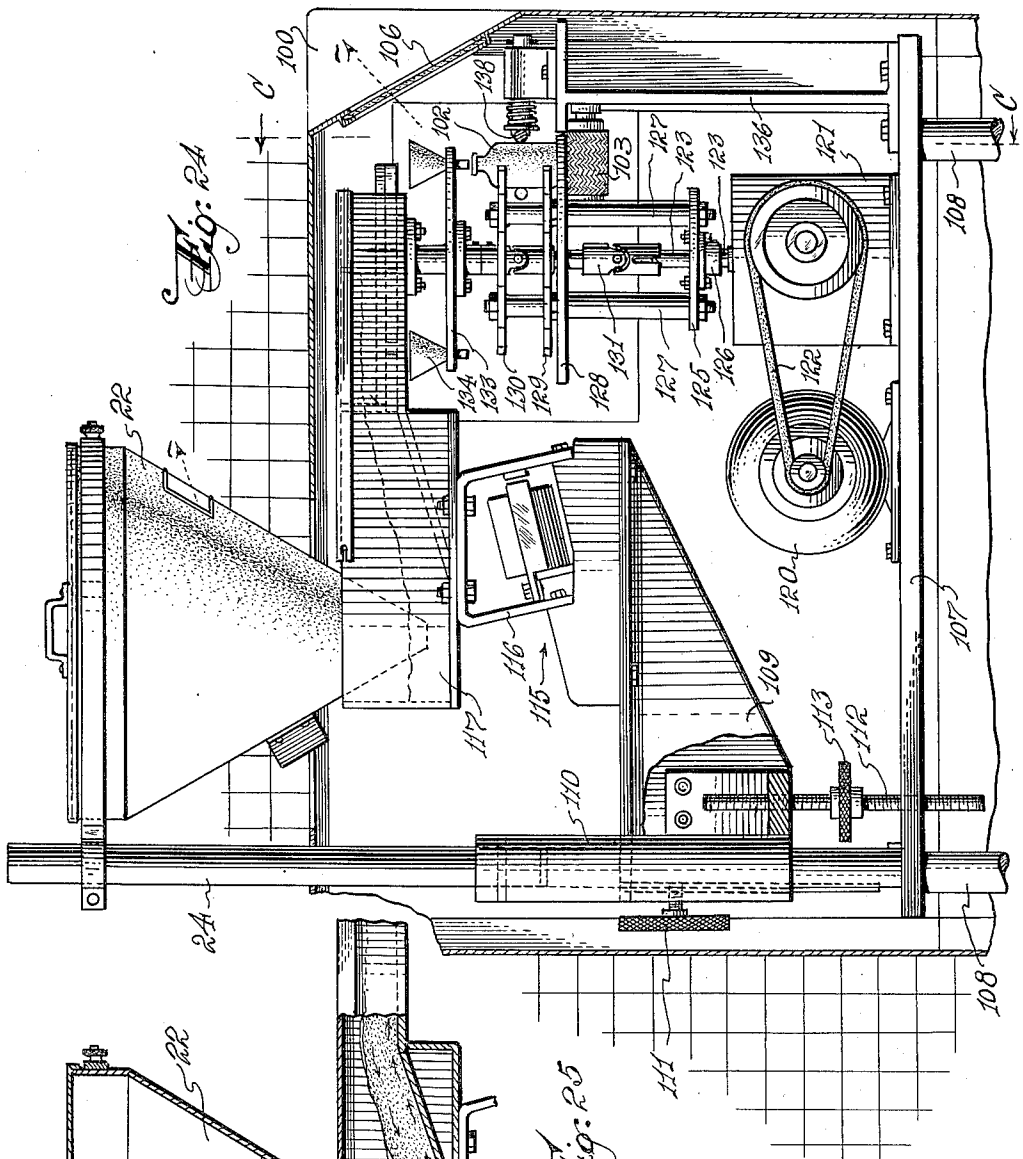
Inventor:
Eugene A. Wahl

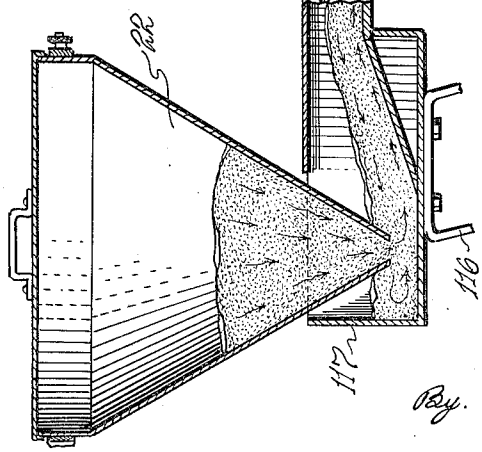
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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Inventor:
Eugene A. Wahl

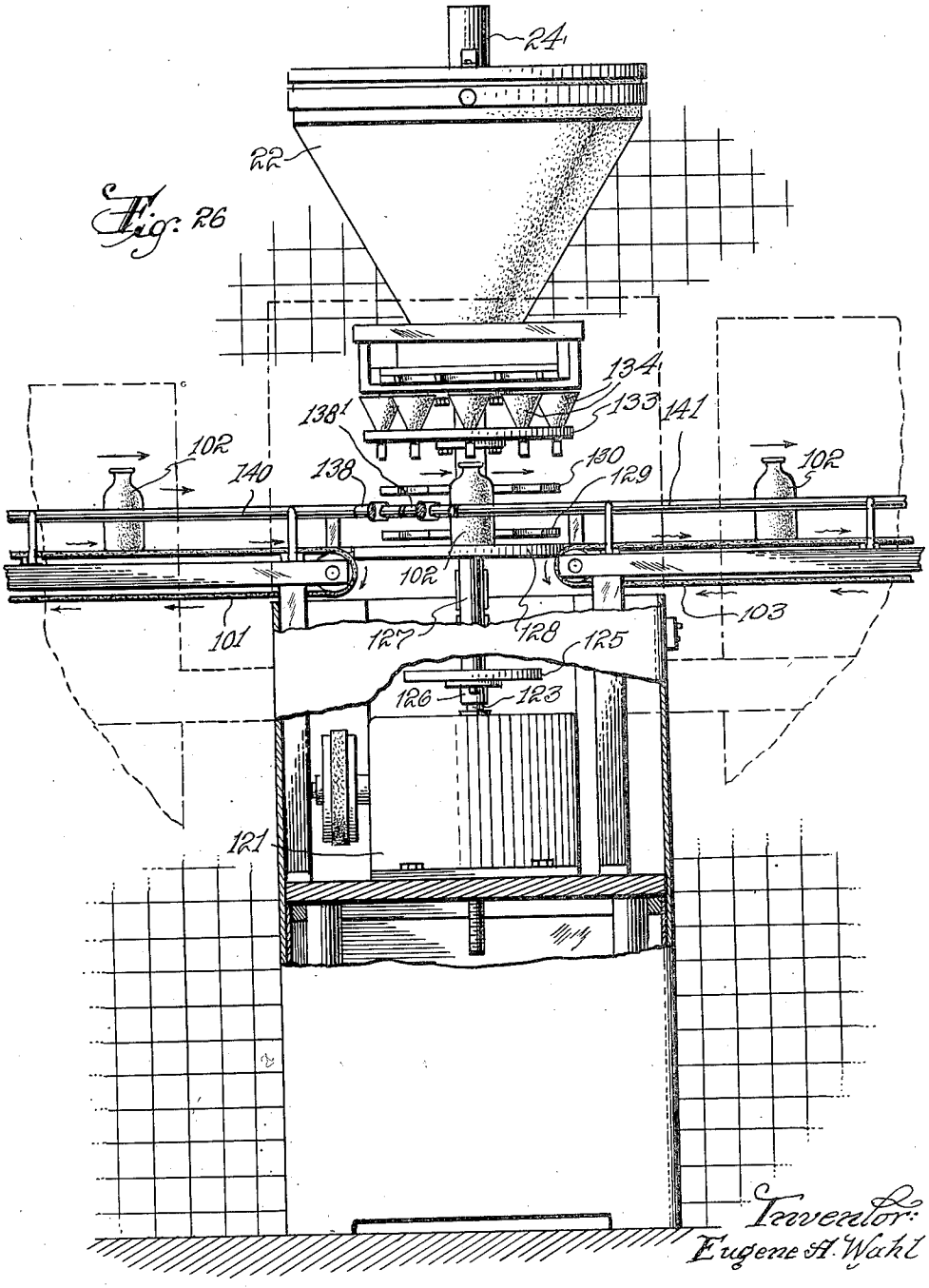
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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Fig. 26



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POWDER FEEDING MACHINE

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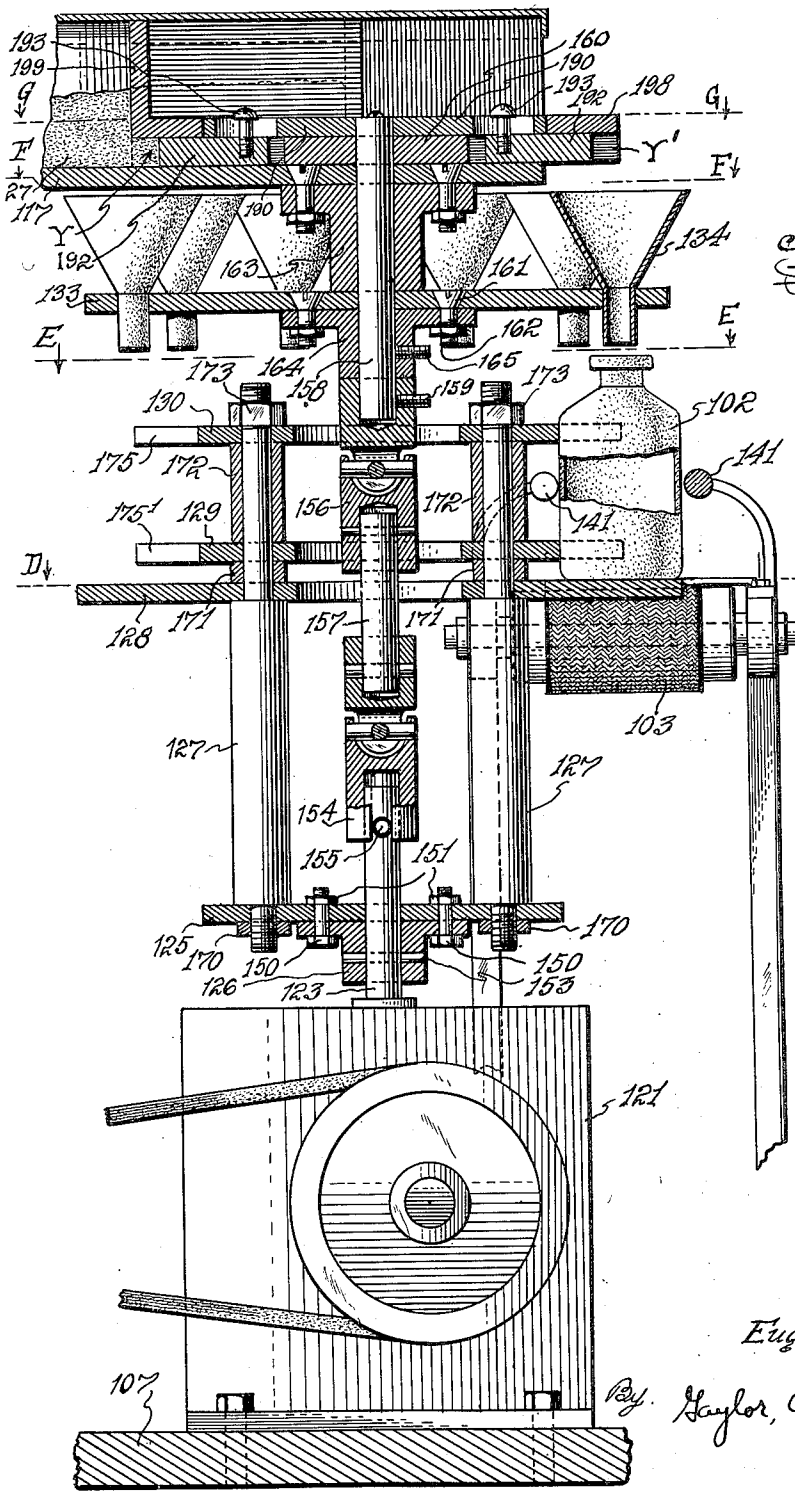


Fig. 29

Inventor:
Eugene A. Wahl

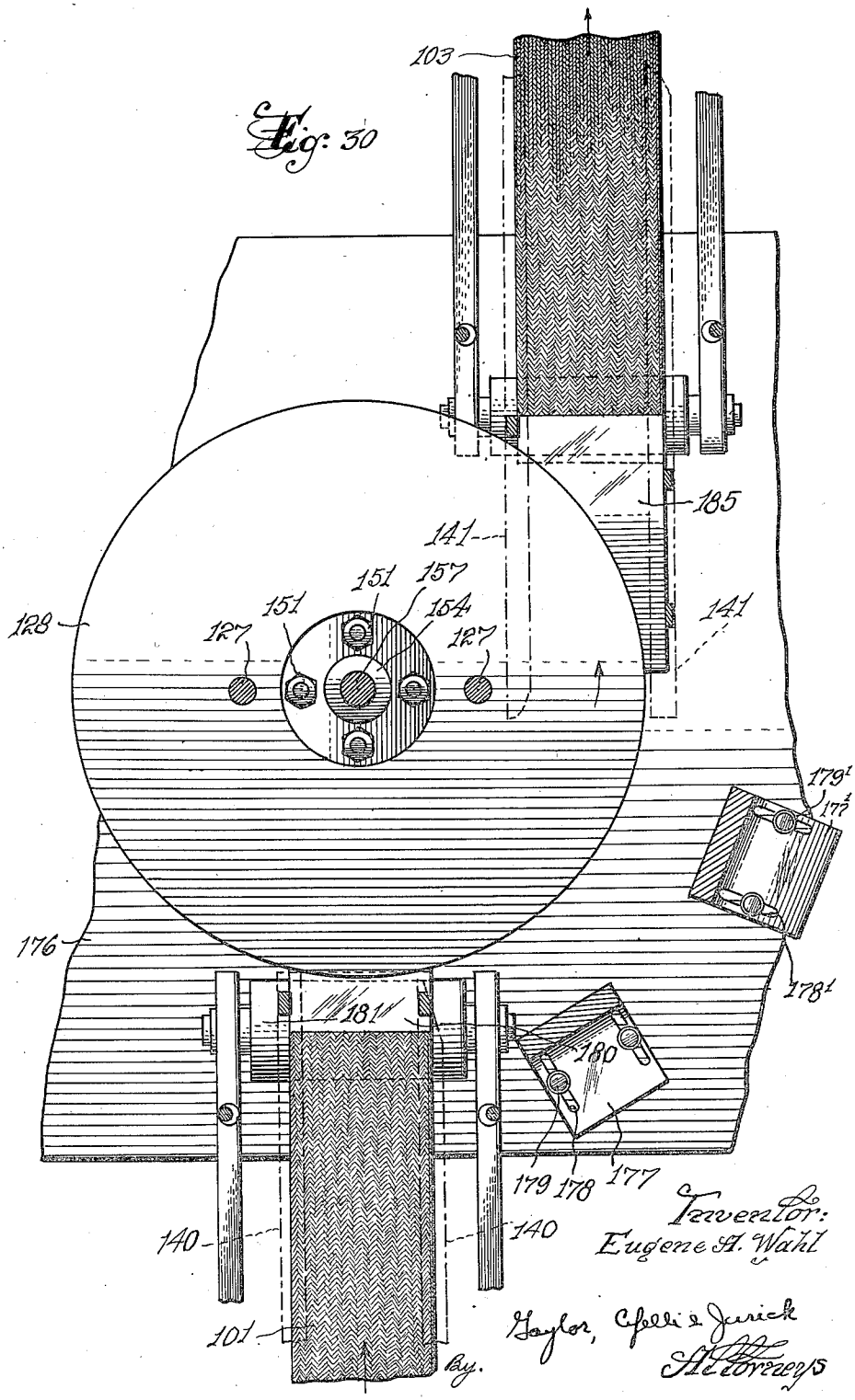
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POWDER FEEDING MACHINE

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Fig. 30



Inventor:
Eugene A. Wahl

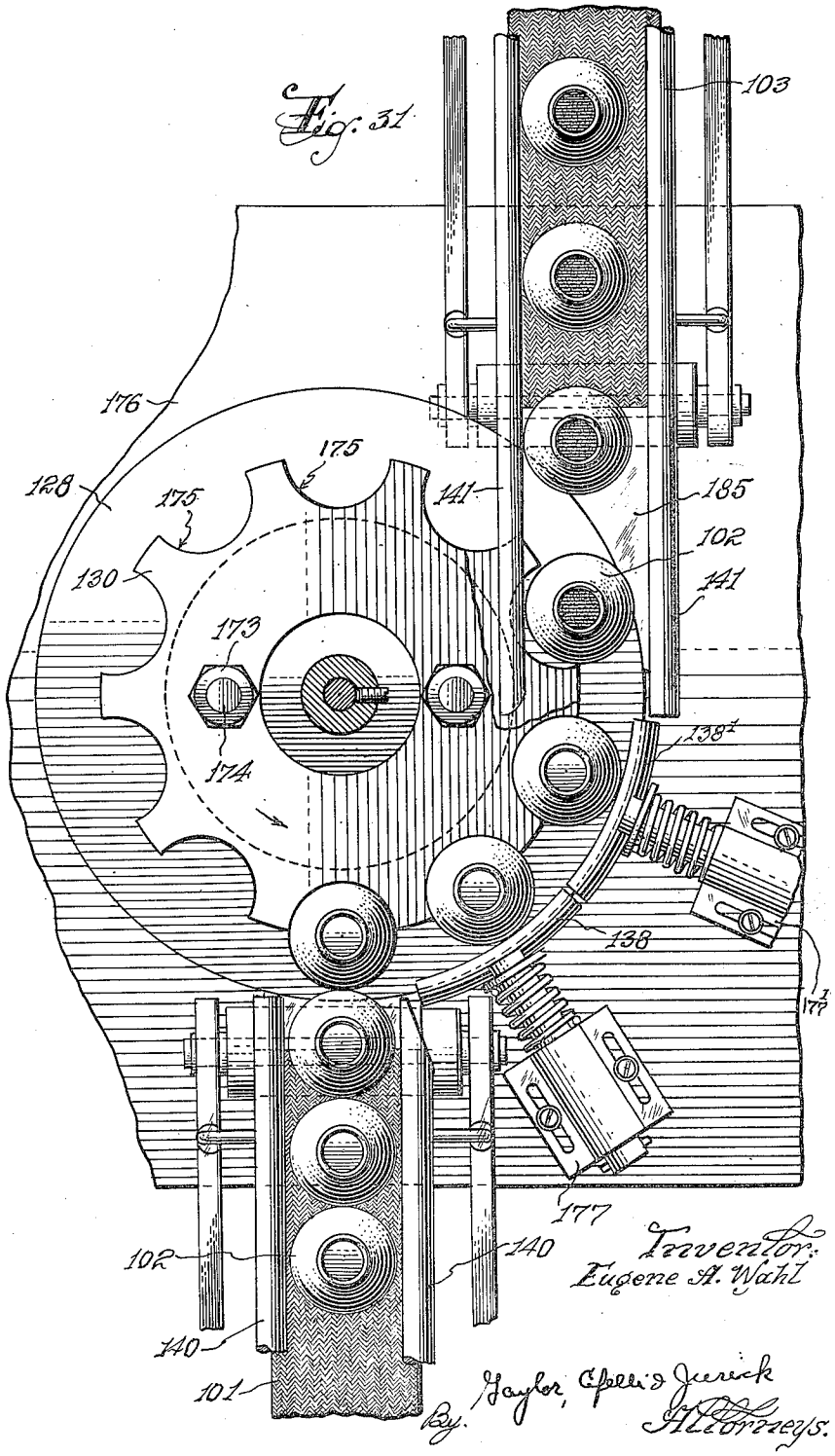
By. Taylor, Cifelli & Jurick
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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Fig. 31



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POWDER FEEDING MACHINE

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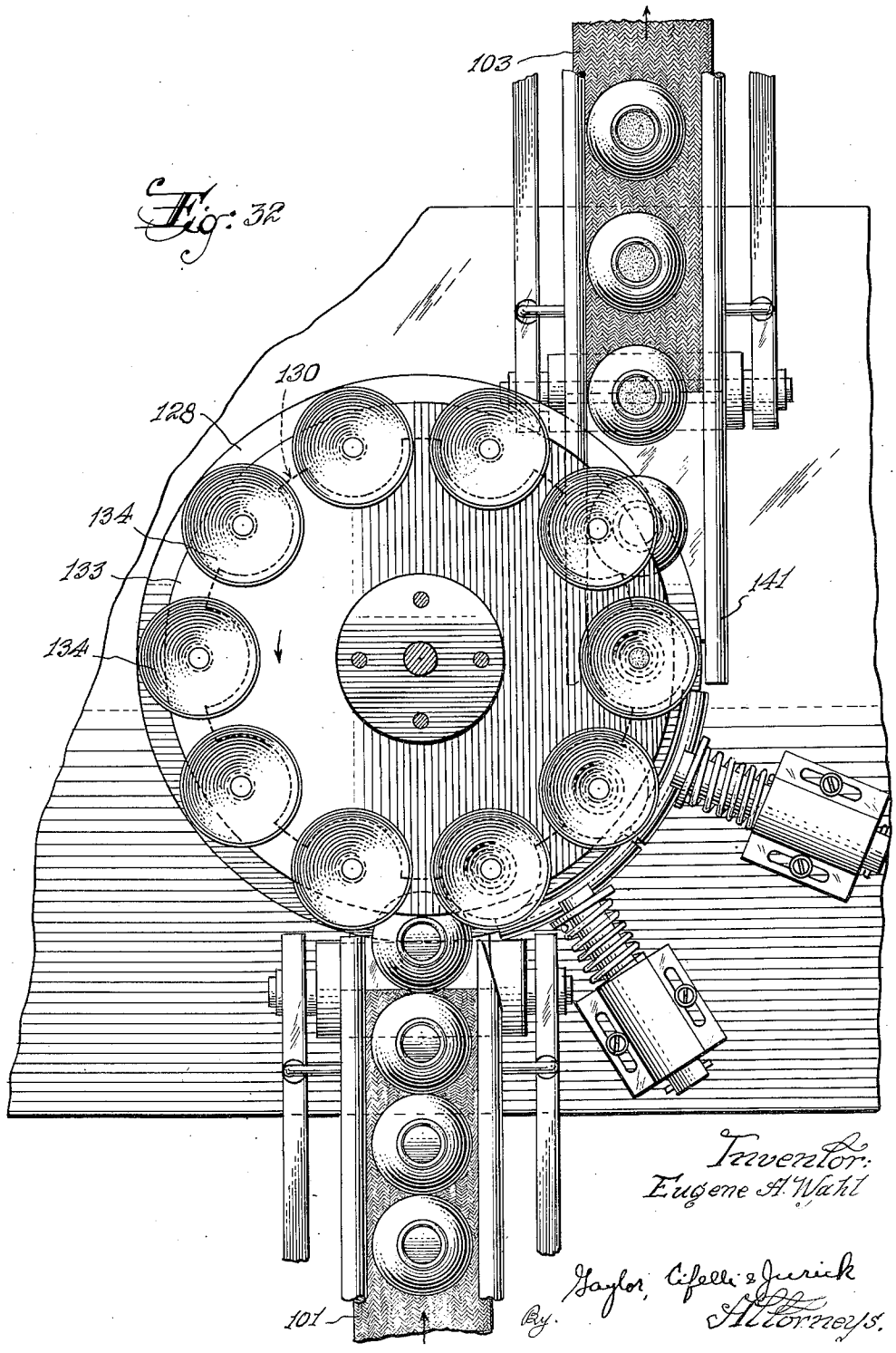


Fig. 32

Inventor:
Eugene A. Wahl

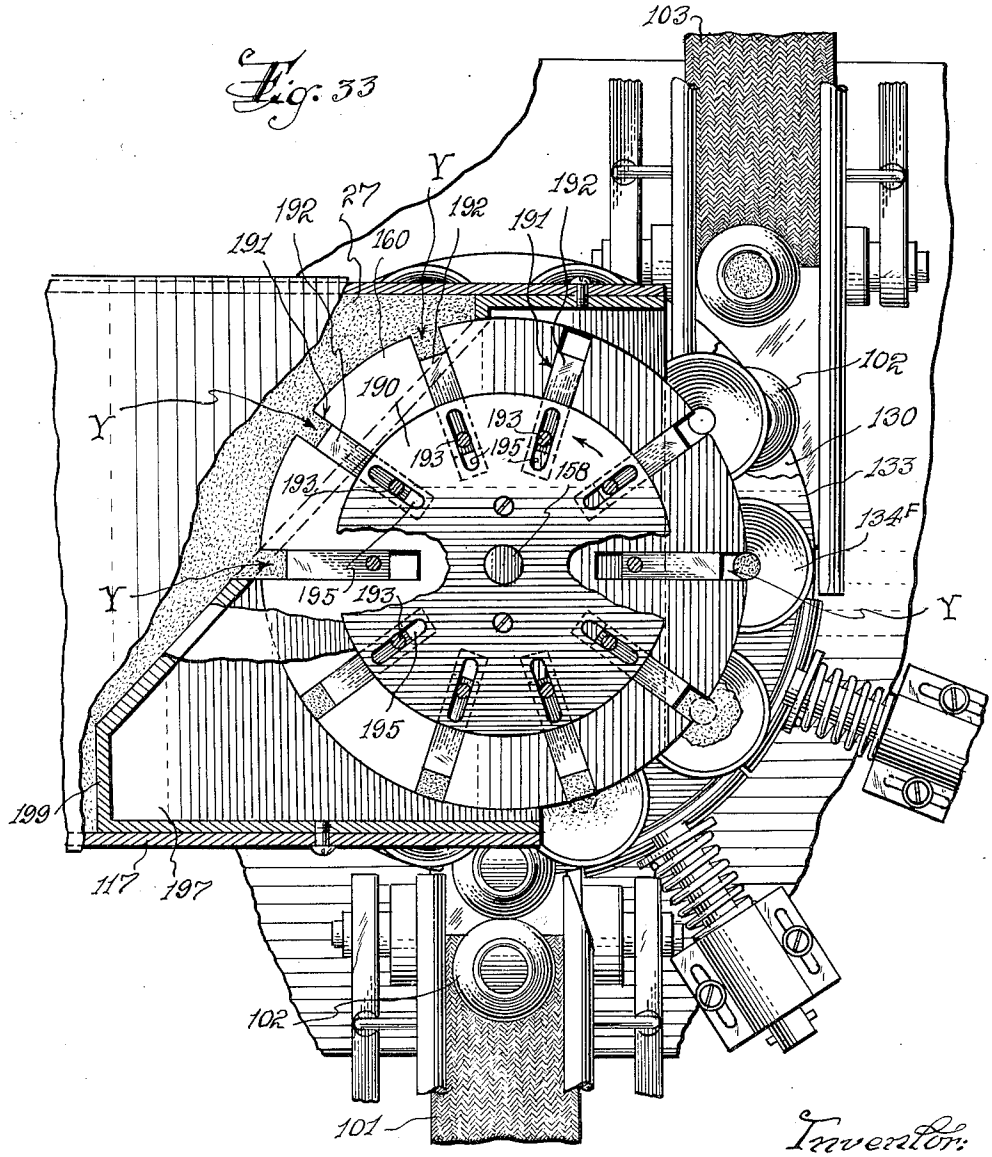
By Taylor, Cifelli & Jurick
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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Fig. 33



Inventor:
Eugene A. Wahl

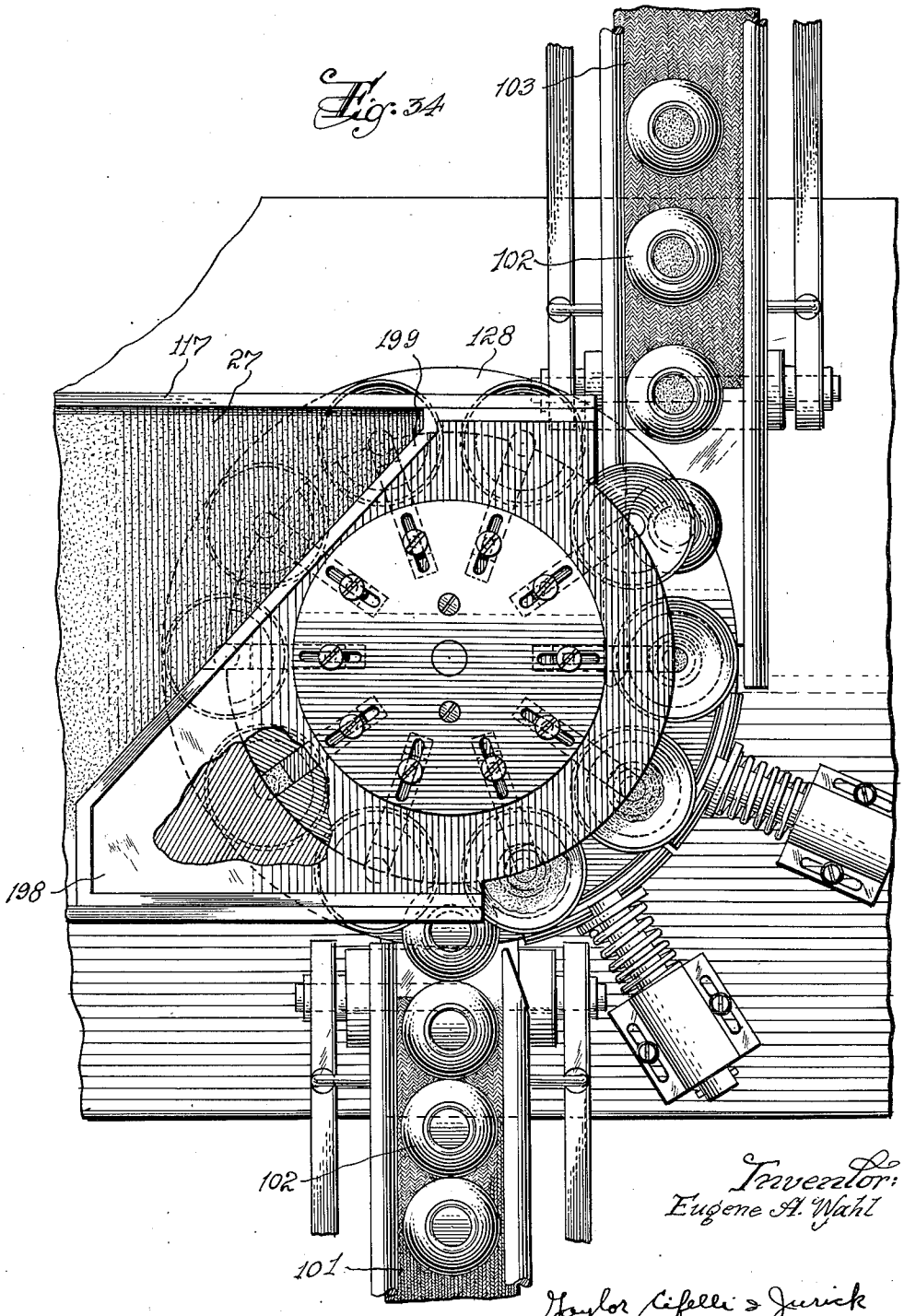
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May 14, 1957 E. A. WAHL 2,792,030

POWDER FEEDING MACHINE

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Fig. 34



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POWDER FEEDING MACHINE

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Fig. 35

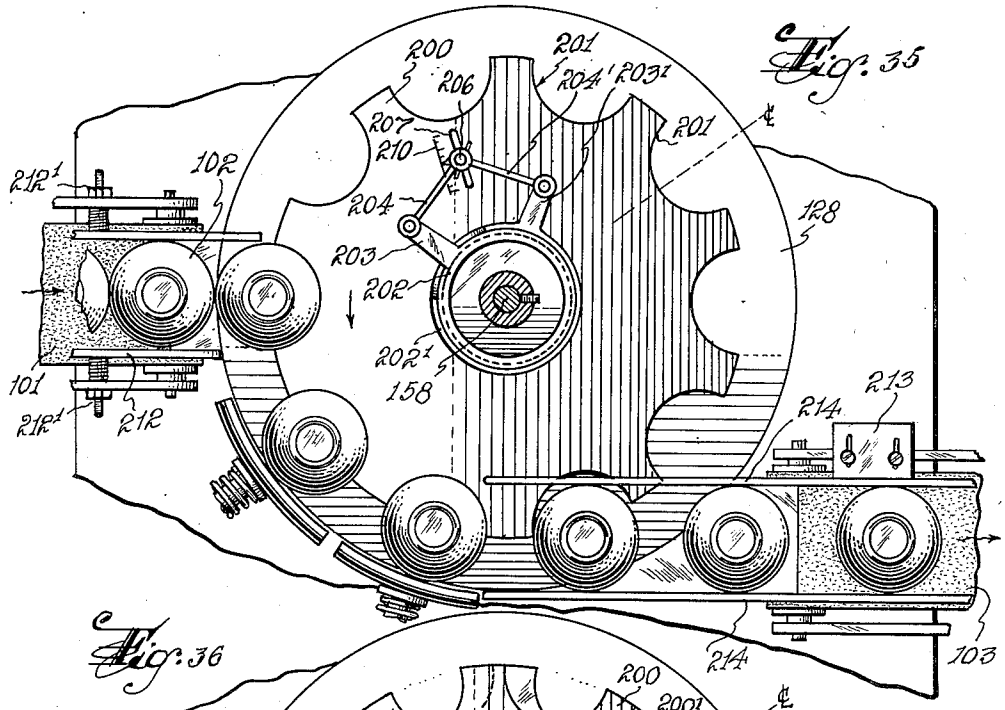
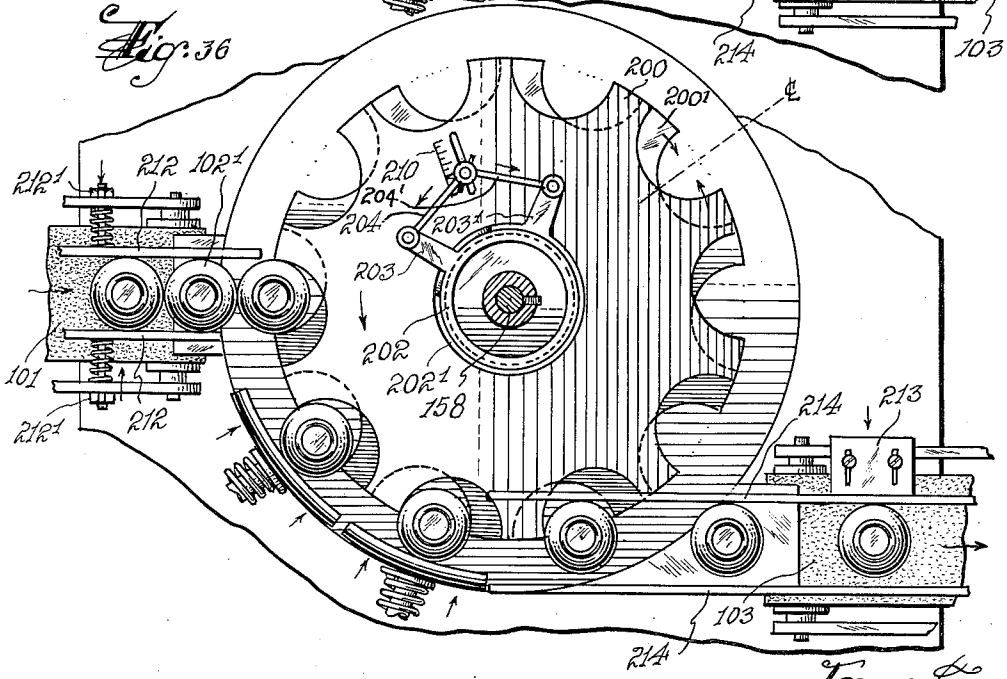


Fig. 36



Inventor:
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Attorneys

United States Patent Office 2,792,030 Patented May 14, 1957

2,792,030

POWDER FEEDING MACHINE

Eugene A. Wahl, Glen Ridge, N. J.

Application March 1, 1954, Serial No. 413,108

35 Claims. (Cl. 141—145)

This invention relates to automatic feeding apparatus and more particularly to a machine of novel construction for continuously feeding precisely measured quantities of a powdered material into a medium or into a container.

Various powder-feeding machines have been provided heretofore. However, such prior machines are of complex construction and, more importantly, are not adapted for uniform operation with powdered materials of widely-different flow characteristics as, for example, free-flowing granular dry powder and sticky amorphous powders. Nor are such prior machines readily adjustable to compensate for the widely varying densities found in powders of the same composition. Still further, the constructions of existing machines are such that they are not adapted for convenient dismantling and reassembly, by unskilled help, for purposes of periodic sterilization as is required particularly in the pharmaceutical field.

An essential feature of my machine resides in a novel arrangement wherein powder from a storage hopper is fed at a predetermined and positive rate to a measuring and dispensing station from which precisely measured amounts of the powder are discharged at a controlled rate. The measured amounts of powder may be discharged directly into a medium as, for example, fluoride salts into a stream of water for control of tooth decay. By provision of a suitable bottle-moving system the discharged powder from the measuring station may be fed directly into bottles at a high rate of operating speed and with a high degree of accuracy.

Machines which are designed to discharge measured or predetermined quantities of powder or granular material directly into a medium at a specified rate are known in the art as dry feeders whereas machines in which measured quantities of powder are fed directly into containers are known as filling machines.

With respect to feeders, those in general use fall into two categories; namely, the volumetric type and the gravimetric type. Present volumetric devices show measuring inaccuracies ranging from 3–15 percent, the principal source of error being the inability of these devices to handle material with varying flow characteristics ranging from free-flowing to sticky conditions often met under varying atmospheric and storage conditions. Also, some materials naturally resist gravitational flow by reason of the fact that such particular materials are sticky under most all conditions of use other than those subject to elaborate control. Consequently, such materials cannot generally be handled by present volumetric feeders. Gravimetric feeders, on the other hand, usually are of more complicated construction and depend upon a weighing belt to control the flow of powder from the supply hopper. Their high cost of construction and operation serve to restrict their use to such operations where greater accuracy is an absolute necessity. However, gravimetric feeders also reflect inaccuracies at times ranging from 2–5 percent. An inherent source of error in such feeders lies in the fact that the absolute dry weight of material

measured out varies as the natural moisture content of the material fluctuates. Such variations often exceed by far the mechanical inaccuracies of the weighing process. Volumetric feeders are much less subject to this kind of error because the volume of moist materials does not change appreciably with moisture loss or pick-up and a given volume of material will more nearly reduce to the same weight of dry material irrespective of moisture content. My novel feeder operates on the volumetric principle and includes numerous features which overcome the disadvantages of prior devices of this class.

A feeder constructed in accordance with my invention is also specifically adapted for use as a powder-filling machine. A majority of machines heretofore employed for filling bottles with powder include either a rotating auger or operate on a differential air pressure system wherein the powder is drawn into a measuring chamber having a fine-mesh screen bottom. In the former case a sticky powder will adhere to the auger and a granular, dry powder tends to overrun the auger when the latter is disposed in the customary vertical position. There occurs, therefore, a wide variation in the quantity of powder discharged from an auger rotating at constant speed. In the case of the differential air pressure machines the screens become progressively clogged with resultant serious volume variations. A powder-filling machine made in accordance with my invention is not subject to the mentioned influences and, therefore, operates at an accuracy far beyond that possible heretofore.

In my co-pending United States patent application, Serial No. 388,543, filed October 27, 1953, I disclose a powder bottle-filling machine which includes a plurality of what may be termed reciprocating measuring chambers associated with a storage hopper. Such measuring chambers transfer precisely-measured quantities of powder from the hopper into the bottles and the machine has an operating accuracy and reliability factor far superior to the auger and pressure-differential machines. The present invention differs from that disclosed in the referenced co-pending application in numerous respects. Primarily, my present invention comprises an arrangement wherein powder from the storage hopper is vibratorily moved along a trough, or chute, to a measuring station. At the measuring station, rotary measuring chambers are filled with powder at one position and at another position such chambers discharge the volumetrically-measured quantities of powder either into a chute for directing the powder directly into a medium or into a funnel for directing the powder directly into a bottle or other container.

An object of this invention is the provision of a powder-feeding machine of simple, straight-forward design, rugged construction, of positive operation and having a high degree of operating accuracy.

An object of this invention is the provision of a powder-feeding machine operating on the volumetric metering principle having a high operating accuracy and adapted for use as a bottle-filling machine for pharmaceutical powders requiring sterile handling.

An object of this invention is the provision of a powder-feeding machine comprising a storage hopper for the powder, a vibratory trough having one end communicating with the hopper opening and the other end communicating with a measuring station, a rotary member at the measuring station and including a plurality of discrete measuring chambers, means to fill the measuring chambers with powder at one position and means to discharge the powder from the measuring chambers at another position.

An object of this invention is the provision of a powder-feeding machine comprising a storage hopper for powder said hopper having a discharge opening at the lower end of an inclined trough, a plurality of measur-

ing chambers at the upper end of the trough, means to vibrate the trough whereby powder discharged from the hopper moves up the trough and into the measuring chambers, automatic means to discharge the powder from the measuring chambers, and means to return an overflow of powder from the upper end of the trough back to the lower end of the trough.

An object of this invention is the provision of a powder-feeding machine of the type wherein powder is fed from a storage hopper into a plurality of measuring chambers for subsequent discharge therefrom at a predetermined rate and including means adjustable to vary the volumetric capacity of the measuring chambers and/or including means to direct the discharge of the powder from the individual measuring chambers at two positions at a predetermined ratio.

An object of this invention is the provision of a powder-feeding machine comprising a storage hopper for the powder, an inclined trough having a lower end spaced from the hopper opening, a rotatable member disposed at the upper end of the trough and including a plurality of measuring chambers, means to vibrate the trough so as to cause the powder discharged from the hopper opening to move up the trough and into the measuring chambers, and means including vibration effective upon rotation of the rotary member to discharge the powder from the measuring chamber.

An object of this invention is the provision of an automatic machine for filling bottles with powder and comprising a storage hopper for the powder, an inclined trough adapted to receive powder from the hopper, means to vibrate the trough so as to move the powder upwardly thereon, a plurality of measuring chambers movable into position to be filled by powder which has been moved up the trough, means to vibrate said measuring chambers, means to move a succession of bottles into bottle-filling association with the measuring chambers, and means to discharge the powder from the measuring chambers into the bottles.

An object of this invention is the provision of an automatic machine for filling bottles with powder and comprising an inclined trough, a storage hopper for powder disposed over the trough and having an opening for discharging powder into the lower end of the trough, a rotatable member at the upper end of the trough and including a plurality of peripherally-spaced measuring chambers, means to vibrate the hopper and rotatable member and the trough whereby powder discharged from the hopper moves up the trough and into the measuring chambers, means for rotating a plurality of bottles in alinement with certain measuring chambers, means to discharge the powder from the filled measuring chambers into bottles aligned therewith, and means to move the filled bottles on to a conveyor belt.

An object of this invention is the provision of a machine for filling bottles with powder and comprising a vibratory trough adapted to receive powder at one end, a plurality of measuring chambers adapted to receive powder at the other end of the trough, adjustable means to vary the capacity of the measuring chambers, means to feed a succession of bottles toward the measuring chambers, means mechanically coupled to the measuring chambers to aline the bottles into individual bottle-filling registry with the measuring chambers, means to discharge the powder from the measuring chambers into the alined bottles and means to remove the filled bottles from the bottle-filling registry position.

These and other objects and advantages will become apparent from the following description when taken with the accompanying drawings illustrating various modifications of the invention. It is to be understood that the drawings are for purposes of illustration and are not to be construed as defining the scope or limits of the invention, reference being had for the latter purpose to the claims appended hereto.

In the drawings wherein like reference characters denote like parts in the several views:

Figure 1 is a side elevation of a powder-feeding machine made in accordance with one embodiment of my invention, certain parts being cut away and others being shown in section to facilitate an understanding of the construction;

Figure 2 is a top view of such machine with parts cut away;

Figure 3 is an enlarged, fragmentary side view of the front end of the feeder with parts drawn in section to show the measuring chamber arrangement;

Figure 4 is an enlarged, fragmentary, top view corresponding to Figure 3;

Figure 5 is a fragmentary view showing one of the end plates having an arcuate side wall cooperating with the rotary wheel forming the measuring chambers;

Figure 6 is a similar view showing a modification of the other end plate which has an arcuate side wall cooperating with the rotary wheel to define the point at which the powder is discharged from the measuring chambers;

Figure 7 is a fragmentary, top view of the front end of the feeder and showing another form of the measuring chambers;

Figure 8 is a sectional view taken along the line J—J of Figure 7;

Figure 9 is similar to Figure 8 but showing an arrangement wherein powder discharged from the measuring chambers is directed into a bottle;

Figure 10 is a fragmentary, top view similar to Figure 7 and showing a modification wherein the rotary wheel includes two sets of measuring chambers for feeding measured quantities of two powders into separate, directing troughs;

Figure 11 is a plan view showing another modification of the multiple measuring chamber arrangement;

Figures 12 and 13 are fragmentary, plan views to illustrate the operation of the arrangement shown in Figure 11;

Figures 14–16 are fragmentary, vertical sections to further illustrate the operation of the arrangement shown in Figure 11;

Figure 17 is, generally, similar to Figure 2 and including a return trough for automatically returning the overflow of powder to the hopper end of the powder-feed trough;

Figure 18 is a sectional view taken along the line A—A of Figure 17;

Figure 19 is a sectional view taken along line B—B of Figure 17;

Figure 20 is a side view, with parts in section, of the machine shown in Figure 17;

Figure 21 is similar to Figure 20 but taken from the opposite side;

Figure 22 is a fragmentary, perspective view of the return trough;

Figure 23 is a fragmentary, top view showing a machine for filling bottles with powder as made in accordance with my invention;

Figure 24 is a side view, with parts in section, of such machine;

Figure 25 is a fragmentary, side view, with parts in section, of the hopper end of the machine;

Figure 26 is essentially a front view of the machine, taken along the line C—C of Figure 24;

Figure 27 is a top view showing a safety switch controlled by the bottles being fed to the filling station, said switch serving to stop the operation of the machine in the event empty bottles are not approaching the filling station;

Figure 28 is an electrical circuit diagram of the bottle-filling machine;

Figure 29 is a fragmentary side view, drawn to an

enlarged scale, of the bottle-filling station with the bottle in-feed conveyor removed;

Figure 30 is a horizontal section taken along the line D—D of Figure 29;

Figure 31 is a similar section taken along the line E—E of Figure 29;

Figure 32 is a similar section taken along the line F—F of Figure 29;

Figure 33 is a similar section taken along the line G—G of Figure 29;

Figure 34 is a top view of that portion of the machine shown in Figure 29; and

Figures 35 and 36 are plan views showing a dual, adjustable disc arrangement to condition the machine for operation with bottles of a given diameter.

Reference is now made to Figures 1 and 2 which are, essentially, a side and top view, respectively, of the basic powder-feeding apparatus. All components of the apparatus are supported in operative relationship on a platform **10** provided with four bolts **11** and cooperating nuts **12** by means of which the platform can be adjusted to a level position on a flat surface **13**. A more-or-less rectangular trough, or chute **14**, is rigidly secured to an electro-magnetic vibrator **15** comprising a solenoid **16** including a soft-iron core spaced from the soft-iron frame, or yoke, **17**. The vibrator frame **17** has its ends secured to a relatively heavy metal block **18** which, in turn, is supported on the sub-base **19** by suitable vibration-absorbing mountings **20**, said sub-base being rigidly secured to the platform by fastening screws. The electro-magnetic vibrator is of conventional construction but I here wish to point out that the trough **14** effectively is supported solely by the vibrator frame **17**, as will be explained in more detail hereinbelow with reference to Figure 3. Consequently, when the vibrator solenoid is energized by a pulsating current the resulting mechanical vibrations of the frame **17** are directly imparted to the trough for purposes explained in detail hereinbelow.

A storage hopper **22** for powder has its discharge opening positioned within, and at one end of, the trough, as shown, the trough cover **23** being provided with a suitable aperture for this purpose. The hopper is supported on the platform **10** by a rigid post **24**, said hopper being secured to the post by a circular band **25** having its ends formed about the post and clamped thereto by a bolt **25'** and cooperating nut **26**. It will be apparent, therefore, that such arrangement affords a ready means for adjusting the vertical position of the hopper relative to the trough to thereby space the discharge opening of the hopper a desired distance from the trough bottom. Such positional spacing of the hopper opening controls the rate of discharge of the powder **27** from the hopper into the trough. The hopper is provided with a cover **28** and the entire hopper may be removed by simply unscrewing the locking screw **29** that is threaded into the band **25** at a point opposite the supporting post **24**. Secured to the outer wall of the hopper is a second electro-magnetic vibrator **30** which, when energized, vibrates the hopper to assure a positive discharge of the powder therefrom.

As shown clearly in Figure 1, the trough **14** has an inclined bottom terminating in a level portion directly beneath the discharge opening of the hopper. If, now, it be assumed the electro-magnetic vibrators **15** and **30** are energized the powder will flow from the hopper into the trough and will be moved up the inclined trough bottom by vibration. The character of the vibrations imparted to the hopper is not critical since any slight amount of vibration will assure a downward flow of powder into the trough. However, the vibrations imparted to the trough, by the vibrator **15**, are such that the entire trough vibrates longitudinally in essentially a horizontal plane, as indicated by the solid arrows placed along the trough bottom. Such trough vibration is not solely and strictly mono-planar but is somewhat elliptical by reason of the

attachment of the vibrator frame ends to the relatively heavy block **18**. Still further, the vibrational movement of the trough is substantially greater in one direction than the other. Specifically, the backward movement of the trough, that is, toward the post **24**, has a velocity component exceeding that of the forward trough movement. Consequently, the powder carried by the lower end of the trough is caused to move up the inclined surface of the trough bottom. I have found that such upward movement of the powder is positive and continuous resulting in a uniform flow of powder from the left end to the right end of the trough and the rate of such powder flow is a function of the frequency and amplitude of the trough vibrations.

If it be assumed that the discharge end of the trough (that is, the right hand end shown in Figure 1) has an unobstructed discharge capacity equal to or exceeding the volumetric flow of the powder up the inclined surface of the trough, the stream of powder on such inclined surface will have a depth dependent upon the amplitude and frequency of the trough vibrations, the size of the hopper discharge opening, the spacing of the hopper end from the trough bottom and the flow characteristics of the particular powder. In any event, the only mentioned variables which cannot be controlled positively are the characteristics of the particular powder. If now, we assume that the discharge end of the trough is partially blocked so that the quantity of powder actually flowing out of the trough is somewhat less than that flowing up the inclined surface, the depth of the powder stream will be increased. I have found that in this case the depth of the powder reaches a maximum value since the upper particles of powder actually flow back down along the inclined trough portion over the upwardly-moving particles proximate to the trough surface. Such simultaneous, opposed movement of the powder is indicated by the dotted line arrows placed into the powder stream, Figure 1. The excess powder, that is, the powder which flows back toward the lower end of the trough increases the depth of the powder around the discharge end of the hopper. Such build-up of the powder reduces the rate at which powder flows from the hopper into the trough. From this it will be seen that the upwardly-inclined vibratory trough arrangement results in what may be termed an automatic feed-back of excess powder and a concurrent control of the rate of discharge of powder from the hopper, highly desirable features in apparatus of this type.

While the arrangement just described is suitable for certain applications which do not require a high degree of precision with respect to the quantity per unit time of powder fed into a medium, I prefer to incorporate an arrangement for volumetrically-metering precise quantities of powder discharged from the trough. In order to relate such metering apparatus to that already described continued reference is made to Figures 1 and 2, although a detailed description thereof will follow with specific reference to Figures 3 and 4. The discharge end of the trough is provided with a downwardly-inclined chute **35** for directing the discharged powder either directly into a medium or into an intermediate trough or chute **36**. It is here pointed out that at the front, or discharge, end of the vibratory trough **14**, the bottom surface thereof is horizontal. Specifically, the trough bottom includes a horizontal lower portion at the hopper, an inclined center portion, and a horizontal upper portion at the discharge end. The passageway of the trough, at the discharge end, is, effectively, completely closed by a plate which has a horizontal portion **37** in smooth contact with the upper surface of a rotary disc **38** and an upwardly directed portion **39** terminating flush with the upper end of the trough walls. The disc **38** has its lower surface in sliding contact with the trough bottom and is rotated by a motor **40** coupled to a reduction-gearing box **41** by the belt **42** and as will be described in more detail hereinbelow. A pair of end plates **44**, **45** having arcuate side walls con-

forming to the diameter of the disc 38 close off the trough on either side of the disc. Thus, the powder from the trough can pass to the discharge chute 35 only along the chambers formed by the peripheral recesses in the disc 38 upon rotation of the latter, it being noted that a portion of the disc extends free and clear over the chute 35.

Inasmuch as Figures 3 and 4 are drawn on separate sheets, it is believed an understanding of the construction and operation of the discharge portion of the trough will be facilitated if the description is restricted to direct attention to only one figure at a time, even though such procedure will entail a certain amount of repetition. Attention, therefore, is first directed to Figure 4 which is a fragmentary view, drawn to an enlarged scale, of the corresponding discharge end of the apparatus shown in Figure 2. The disc 38 is secured to a vertical shaft and when the motor 40 is energized such disc rotates at a constant, predetermined speed in the direction indicated by the arrow thereon. A major portion of the disc is covered by the horizontal section 37 of the plate which has the upturned side walls 39, such plate being held down and secured to the trough side walls by screws 48 and 49. The side plates 44, 45 have a thickness approximately 0.001" greater than that of the disc and each includes an arcuate side wall corresponding to the maximum disc radius. The relatively short plate 44, see also Figure 5, is secured to the trough by screws 47 passing through the trough bottom, and the relatively long plate 45 is similarly secured by the other screws 47. The parts are so dimensioned that the outermost edges of the toothed disc 38 will be in smooth, sliding contact with the arcuate walls of the plates 44, 45 upon rotation of the disc. Inasmuch as the lower surface of the disc is in smooth, sliding contact with the trough bottom and the upper disc surface is in smooth, sliding contact with the bottom of the plate portion 37 it will be apparent that powder can pass from the trough to the chute 35 only upon rotation of the disc, and the quantity of powder so passed depends upon the volume of the disc recesses and the speed of disc rotation. Thus, the individual recesses formed in the peripheral surface of the disc may be termed measuring chambers, each such chamber moving a precise quantity of powder. It should be particularly noted that a portion of the disc extends beyond, to the left of, the offset portion of the vertical wall 39 and into contact with such powder as may be at this end of the trough, and an opposed disc portion extends over the inclined chute 35. The rate at which the powder is moved upwardly along the trough to the discharge end thereof is adjusted so that the depth of the powder substantially exceeds, at all times, the thickness of the toothed disc. Thus, as the individual measuring chambers pass to the left of the offset portion of the vertical wall 39 they will immediately be vibratorily filled by powder. Upon further disc rotation the so-filled measuring chambers effectively are completely closed by the arcuate wall of the side plate 45. Once such measuring chambers pass beyond the right hand end of the plate 45 the powder will vibratorily leave the chambers and, in the case of the Figure 4 arrangement, spread along the bottom of the trough to be vibrated into the chute 35. At this point attention is directed to Figure 6 which illustrates a longer side plate 45'. Specifically, the right hand end of the plate 45' terminates at the point where the inclined chute 35 joins the main trough 14. It will be obvious that in such arrangement the powder will be discharged directly on to the chute 35 from the individual measuring chambers. Alternatively, a similar discharge action will occur in the Figure 4 construction upon rotation of the toothed disc in a clockwise direction. It may be well to here again point out that the the entire trough, including the toothed disc, is vibrated as a unit thereby assuring not only a positive feed of the powder to the measuring chambers but also the discharge of the powder from the measuring chambers to the directing chute and from such chute to a desired point.

Reference is now made specifically to Figure 3 which is an enlarged, fragmentary view of the front end of the apparatus and, essentially, a sectional view taken along the line K—K of Figure 4. The output shaft 55, of the gear box 41, has attached thereto a universal joint 56 which, in turn, is coupled to a second universal joint 57 by the loose-fitting rod 58. The upper joint 57 is attached to a shaft 59 which passes through a flange bearing 60 and is securely fastened to the toothed disc 38 by any suitable means, the flange bearing 60 being secured to the bottom of the trough, as shown. It will be noted that the universal joints are loosely coupled to the associated shafts by means of pins passing through elongated slots formed in the shafts 55, 58 and 59. Thus, the trough may be raised or lowered somewhat relative to the platform 10 without effecting the drive shaft arrangement between the shaft 55 and the disc 38. More importantly, the illustrated drive shaft arrangement does not impede the mechanical vibration of the trough and disc since the trough is not supported by the drive shaft.

As already explained, the vibration of the trough causes the powder to flow in a stream up the inclined portion of the trough bottom and to pile up on the horizontal portion of the trough bottom against the forward edge of the disc and the vertical wall portion 39 of the plate 37. Hence, as the disc rotates, the powder completely fills the individual measuring chambers as they pass beyond, that is, to the left of the wall 39, one such chamber X being visible in the Figure 3 view. Such filled chambers are closed off as they pass by the side plate 45, see Figure 4, and eventually are rotated clear of all obstructions over the inclined chute 35, as shown by the chamber X'. Since the disc rotates continuously and powder is fed to the disc at a rate exceeding the discharge rate of the measuring chambers, it will be apparent that individually-measured quantities of powder are discharged to the chute at a predetermined rate. In the case of a powder-feeder such measured quantities of powder can be directed by the chute directly into a medium as, for example, fluoride fed into a stream of water.

A powder-feeding machine constructed as hereinabove described includes numerous structural and operational features. The machine is of simple, straight forward, rugged construction promoting long, trouble-free operation. Those parts coming into contact with the powder are readily dismantled for purposes of sterilization. Specifically, the hopper is removable simply by unscrewing the fastening screw 29, see Figure 1. The entire trough is removable simply by removing the bolts which secure it to the vibrator frame 17. As will be clear from a study of Figure 3, by making the slot in the shaft 59 open-ended, the disc 38 and the trough may be uncoupled from the drive shaft arrangement by simply raising the trough. By providing an inclined bottom on the trough, between the hopper and the measuring chambers, I provide a positive, controllable flow of powder to the measuring chambers with an automatic feed-back flow of the excess powder. The use of measuring chambers of equal and precise volume content, coupled with the mechanical vibration thereof, assures an exceptionally high degree of accuracy. A machine made as herein described has an operating accuracy of better than one-half of one percent in any range from ounces per hour to tons per hour and such accuracy applies whether checked on a minute-to-minute or hour-to-hour basis. Further, since the mass of the powder in the hopper is disassociated from the measuring function the accuracy of my machine obtains irrespective of the amount of powder in the hopper. Still further, the character of the powder, whether sticky or free-flowing, and the moisture content thereof, do not adversely affect the operation of the machine since such factors are effectively rendered in-

significant by the vibrational filling of the measuring chambers under a substantially-constant head of powder.

In the event my powder-feeding machine is used for a particular application wherein it is desired or necessary to vary the rate of powder fed to a medium over wide limits by control of the rotating speed of the measuring disc it may be advantageous to incorporate an automatic control of the level of the powder passing to the measuring chamber station. Although such level control of the powder may be affected by varying the amplitude and frequency of the electro-magnetic vibrators associated with the hopper an additional level control may be provided as shown in Figure 3. Here, I show a conventional arrangement comprising a vibration sensing head **61** containing a barium-titanate crystal at the lower end. Such crystal is positioned at the level corresponding to the maximum powder level. When the level of the powder reaches the crystal the resulting vibrations imparted to the crystal produce a signal in the input of the amplifier **62**. Such signal can be utilized, by suitable means, to either stop or alter the hopper vibrations thereby stopping or decreasing the delivery of powder from the hopper to the trough.

Befor passing on to the descrpition of other embodiments of my invention I wish to specifically call attention to the fact that the trough is subject only to vibrations generated by the trough vibrator. As shown in Figure 1, the hopper is mechanically isolated from the trough. Any vibrations of the main platform **10** and/or the gear box **41**, see Figure 3, are not transmitted to the measuring disc or the trough by reason of the essentially loose coupling arrangements of the universal points and associated shafts. Still further, and as is clear from Figure 1, the supporting block of the vibrator **15** is vibrationally isolated from the main platform. Therefore, the trough is not subjected to any spurious vibrations. Consequently, the character of the trough vibrations may be controlled and adjusted, without regard to the other factors mentioned, to provide desired flow characteristics of the powder from the hopper to the measuring station and into the measuring chambers.

Thus far, I have described a powder-feeding machine having a single rotatable disc provided with peripheral measuring chambers. I shall now describe other variations of the disc designed for specific purposes.

Figure 7 is a fragmentary, top view of the discharge end of the trough wherein all of the parts are similar to those shown in Figure 4 with the exception of the rotary disc. In this case, the disc **65** is provided with a plurality of uniform, circular holes **66**, preferably, but not necessarily, having centers lying on a common radius of the disc. Since these holes are set in from the disc periphery, and since the disc is disposed flush against the bottom of the trough **14**, the powder can enter the holes only from the top of the disc, as shown more clearly in Figure 8 which is a longitudinal sectional view taken along the line J—J of Figure 7. Such filling of the holes **66**, which constitute the measuring chambers, of the machine, is quick and positive by reason of the vibration of the trough and disc, as already explained. This formation of the measuring chambers offers certain advantages over the peripheral recess formation shown in Figure 4 in that the side boundaries of the measuring chamber are herein fixed and independent of clearance requirements between the rotating disc and stationary side walls **45** and **44**.

In the Figures 7 and 8 arrangement, the powder is discharged from the individual measuring chambers on to the inclined chute **35**. As shown in Figure 9, the inclined chute can be replaced by a funnel **69** for directing the discharged powder into a bottle **70**.

A measuring chamber disc having circular holes therein lends itself to numerous modifications wherein the powder-feeding machine is adaptable for specific applications. One such variation is shown in Figure 10 which is a fragmentary top view of the dispensing end of the machine comparable to that shown in Figure 7. Here the measuring disc **71** is provided with two series of holes, or measuring chambers, specifically the relatively small holes **72** and the relatively large holes **73**, each series of holes having centers lying on a given radius of the disc. The entire upper surface of the disc is covered by a fixed flat plate **74** provided with but two, diametrically-opposite holes. One such hole **72'** corresponds in diameter to the outer series of disc holes and is aligned with such disc holes as the disc rotates. The other hole **73'** is similarly arranged with respect to the larger disc holes. The vibratory trough, which moves the powder from the hopper to the dispensing or measuring chambers, is divided into two, tapered ends **75**, **76** for individually directing the powder to the holes **72'**, **73'** in the cover plate **74**. It will be apparent, therefore, that the powder will be fed into the measuring chambers of the disc as such measuring chambers pass into and out of alinement with the associated feed holes in the plate **74**. At certain points in the arcuate path of the disc holes, the disc rotates clear of the trough bottom and a pair of inclined chutes **77**, **78** are alined with such points. Thus, assuming a counter-clockwise rotation of the disc, the powder is fed into the outer measuring chambers **72** as they pass under the feed hole **72'** and such powder is discharged into the chute **77** when such chambers pass over the chute. Similarly, the powder which is fed into the inner measuring chambers as they pass under the feed hole **73'** is discharged into the associated chute **78**. A machine so designed is adapted to feed different, but precisely-measured, quantities of a single powder to two different points. However, by providing two separate hoppers and associated vibratory troughs, each terminating in the illustrated tapered sections **75**, **76**, different type powders can be fed to the two inclined chutes. The volume per time, or rate of powder feed, to each chute can be the same or different depending upon the number and size of the holes formed in the rotatable disc.

Another construction of the rotary, measuring-dispensing disc is illustrated in Figures 11–16, inclusive. Here, I employ two rotary discs **80**, **81** superposed one over the other as shown in Figure 11. The disc axes are displaced but the discs are rotated at equal speeds by means of a suitable pinion gear coupling together the disc drive shafts **82**, **83**, as is well known in this art. Each disc is provided with a plurality of holes of equal and constant diameter and since the discs are of equal thickness every such hole will have the same volumetric capacity. As the two discs rotate, single holes in each disc will be in precise vertical alinement at the left side of a vertical plane passing through the center of each disc, and such holes will be laterally spaced at the right side of such plane. Bearing in mind the operation of the rotary disc **65**, Figure 7, wherein the disc section to the left of the vertical wall **39** is completely covered by powder, that portion of the discs **80**, **81** (Figure 11) where the two disc holes are in precise vertical alinement would lie to the left of such vertical wall and is similarly covered by powder. This is shown more clearly in Figure 14 which is a fragmentary, central sectional view of Figure 11. Here the alined holes in the upper disc **80** and the lower disc **81** are identified by the letters C, C', respectively. With the trough **14**, disc **80**, **81** and the powder **27** all under constant vibration the alined measuring chambers C, C' become filled with powder quickly and positively. Since these alined chambers have displaced axes of rotation, upon further rotation of the discs the holes C, C' progressively move out of vertical alinement as will be clear from a study of Figures 12 and 13. More specifically, the axis of the two holes C, C' will coincide only on a center line drawn through the individual axis of rotation of the two discs. While the coming into and going out of alinement of the disc holes is progressive and at a varying rate of

speed the powder will start to flow through the upper hole C and into the lower hole C' for some period of time prior to and after the point of exact coincidence. In any case, the vibrating feature assures a complete filling of both holes even when the discs are rotated at a fairly high speed. Referring again to Figure 14, the point at which the filled chambers C, C' fall completely out of alinement will depend primarily upon the relative diameters of the discs and radial disposition of the holes, and in the illustrated construction such point occurs after approximately a 90 degree rotation of the discs. Figures 15 and 16 are fragmentary sectional views taken along two radial planes passing through the centers of the holes C, C'. Thus, Figure 15 is taken along the radial plane passing through the shaft **82** and hole C (see Figure 11) and Figure 16 is taken along the radial plane passing through the shaft **83** and hole C'. In Figure 15, the upper, filled, measuring chamber C is completely closed by the top plate **37** (correspondingly shown in Figure 7) and the lower disc **81** whereas in Figure 16 the lower, filled, measuring chamber C' is completely closed by the upper disc **80** and the bottom of the trough **14**. These filled, measuring chambers remain so closed until they reach a point substantially diametrically opposite to that of precise vertical alinement. At such point the chambers are spaced apart along a common radius of the two discs, as clearly shown in Figure 11, and the contents of each chamber can be discharged into individual chutes **84**, **85** for direction to desired points.

It will be apparent, now, that the dual, measuring-dispensing arrangement just described with reference to Figures 11–16 results in a powder-feeding machine capable of delivering equal precisely-measured quantities of a single powder to two points. Alternatively, the same arrangement can be adapted to supply equal, measured quantities of two different powders to a single point. Specifically, if the two chutes **84**, **85**, Figure 11, be considered as tapered ends of two troughs (similar to the trough ends **75**, **76** of Figure 10) and disposed over the associated discs **80**, **81** the measuring chambers of the two discs can be filled with different powders. Such filled chambers will fall into vertical alinement at the diagonally-opposite point and may be emptied simultaneously into a single directing chute. Broadly speaking, the action in this case is just reverse to that previously described and it is felt the description given is sufficient to convey a clear understanding of the two modes of operation to one skilled in this art.

The various embodiments of a powder-feeding machine hereinabove described all incorporate my novel, vibratory trough for moving the powder from the hopper to the measuring station at a predetermined rate and the precise, volumetric measurement of the powder for dispensing to desired points. I have described the dual-directional flow of the powder up and down the inclined trough providing an automatic overflow protection and the control of powder movement by adjustment of trough vibration. In certain applications of the powder-feeding machine it is desirable to frequently vary the quantity of powder per unit time fed into a medium, such powder-feed variations being related to other factors which vary in accordance with related conditions. More specifically, the rate of powder fed into a medium must be related to other variable factors which may vary minute-to-minute or hour-to-hour. In such cases it is desirable that the powder-feeding machine be responsive to a single adjustment to facilitate conditioning the operation of the machine in direct response to changes in the related factors. Such single adjustment is best and most conveniently accomplished by varying the speed of rotation of the disc carrying the measuring chambers, particularly since the motor speed adjustment can be done manually or automatically by simple means and such motor speed adjustment results in an immediate, corresponding change in the rate of powder discharge. In such cases the rate at which powder is vibrated up the inclined trough must at least be equal to, and preferably exceed, the maximum expected rate of powder discharge into the medium. In such arrangement the rate of powder movement up the trough may be excessive when the speed of rotation of the measuring disc is suddenly reduced to the minimum required value. For this purpose I provide a novel excess-powder, feedback arrangement as will now be described.

Figures 17–22 show the construction of my powder-feeding machine provided with a second vibratory trough which returns the excess powder from the measuring-dispensing station to the lower end of the main trough. Specific reference is first made to Figure 17 which is a top view of the machine corresponding to that shown in Figure 2. In the present case the main vibratory trough **14** is lengthened somewhat to accommodate an end of the return trough **14'** and the drive motor **40** has been moved back as shown. As heretofore described, the powder flowing out of the hopper is moved up the inclined feed-trough **14** to the cover the exposed portion of the rotatable disc **38** having the peripheral measuring chambers and measured quantities of powder are discharged from the measuring chambers directly on to the inclined chute **35**. When the depth of the powder at the disc exceeds a predetermined level the excess powder overflows into the return trough **14'** through the gate **90**. Such overflow action of the powder is best shown in Figure 18 which is a transverse sectional view taken along the line A—A of Figure 17. It is again pointed out that the depth of the powder accumulated at the measuring station is always greater than the thickness of the measuring disc to assure a positive filling of the individual measuring chambers at all times. It is also pointed out that the two troughs **14**, **14'** are reversely disposed to each other, that is, overflow powder from the highest section of the main trough falls to the lowest section of the return trough and such powder is vibratorily raised to the highest section of the return trough to flow into the lowest section of the main trough. The plane of the sectional view shown in Figure 18 is at the forward, or discharge, end of the machine. The excess powder **27**, therefore, flows from the highest section of the main trough **14** into the lowest section of the return trough **14'**, the latter having one side cut out to form the slot **91** for accommodating the overflow gate **90** as shown in the fragmentary, perspective view of Figure 22. Also shown in the Figure 22 view is a portion **92** of the inclined central section of the return trough. Figure 19, on the other hand, is a transverse section taken along the line B—B of Figure 17, that is, at the rear end of the machine and here the powder is shown flowing from the highest section of the return trough **14'** through the gate **93** and into the lowest section of the main trough **14** in the vicinity of the hopper **22**.

The main trough and the return trough are separately supported from the common platform **10** by the individual electro-magnetic vibrators, each such vibrator being vibrationally isolated from the platform by suitable vibration-absorbing mountings as has been described with reference to Figure 1. Figure 20 is a side view of the machine looking toward the main feed trough **14** and Figure 21 is a reverse side view looking toward the return trough **14'** certain parts being shown in section for purposes of description. In each view are shown the electro-magnet vibrators **15**, **15'** having their frames **17**, **17'** respectively secured to the associated troughs **14**, **14'**. An optional spring support **95** is also shown for the return trough **14'**. The vibrational operation of the return trough is identical to that of the main trough. Thus, as shown in Figure 20, powder passes from the hopper opening to the bottom of the main trough **14** and is moved up the trough to the measuring disc **38**. Measured quantities of the powder are discharged to the inclined chute **35** and the excess powder, if any, flows

through the gate 90 into the return trough. As shown in Figure 21, the powder which has been deposited on the return trough 14' is moved up such trough and returned to the main trough through the gate 93. Inasmuch as each trough operates independently of the other there are no interacting cross actions likely to adversely effect the operation of either trough. Once again I wish to point out that the level of the powder at the discharge end of the hopper effects the rate of flow of the powder from the hopper into the trough. This effect takes place in spite of the fact that powder, under vibration, reacts more like a liquid than a solid. Thus, by having the return trough empty into the main trough in the vicinity of the hopper an excess overflow of powder results in a corresponding retarding effect upon discharge of powder to the main trough.

Although Figure 17 includes a rotary measuring disc having peripheral recesses forming the measuring chambers it will be understood that the overflow-return-trough arrangement may be applied to feeders having any of the measuring-dispensing chamber arrangements shown in Figures 7–16.

To this point I have described machines falling into the powder-feeding class. However, the same general arrangement of the vibratory hopper, inclined trough and rotary measuring-dispensing disc are quite readily adapted for an automatic bottle-filling machine. Figure 23 is a top view of such bottle-filling machine. Here are shown the cover 28 of the hopper which is secured to the vertical post 24, a cabinet 100 enclosing the vibratory trough and measuring station, an in-feed conveyor belt 101 for moving a succession of empty bottles 102 to the filling station and an out-feed conveyor belt 103 for removing the filled bottles 104 from the machine to another station, for example, for bottle-capping. A hinged door 105 provides access to the trough and a window 106 permits viewing the bottle-filling operation.

Reference is now made to Figure 24 which is a side view of the bottle-filling machine with the side of the cabinet removed. The operating components of the machine are supported on a base 107 which, in turn, may be supported from a flat surface as by leg-posts 108. As hereinbefore explained, the hopper 22 is adjustably secured to the vertical post 24 having a lower end rigidly affixed to the base 107. A bracket 109 is likewise adjustably carried by the post 24 as by the bearing collar 110 and the thumb screw 111. Vertical adjustment of the bracket is accomplished by loosening the thumb screw and adjusting the toggle screw 112, said toggle screw having reversely-threaded ends and a centrally-affixed thumb-operable wheel 113. The bracket 109 has secured thereto the electro-magnetic vibrator 115 having its vibratable frame 116 securely attached to the bottom of a trough 117. As shown in the fragmentary view of Figure 25, the hopper empties into the lower section of the trough bottom and the powder is vibratorily moved up to the inclined central section of the trough to the measuring-dispensing station. The motor 120 is coupled to the input shaft of a gear-reduction unit 121, by a belt 122, such unit having a reduced-speed output shaft 123. A lower disc 125 is secured to the output shaft 123 as by the coupling flange 126 and said disc has secured thereto a pair of posts 127 carrying the rotatable plates 128, 129 and 130. The latter three plates are provided with central holes through which extends the universal-joint drive shaft 131, the lower end of said drive shaft being coupled to the upper end of the gear-reduction unit output shaft 123 and the upper end being connected to the rotary measuring-dispensing disc disposed within the forward end of the trough 117. The exact arrangement of this portion of the machine will be described in detail with specific reference to Figure 29. At present I merely wish to point out that a disc 133, carrying a plurality of funnels 134, is rigidly secured to the universal drive shaft and that the entire structure supported by the output shaft 123 rotates as a unit. The out-feed conveyor belt 103 is supported by suitable rollers and the upper belt surface is flush with the upper surface of the disc 128 so that a bottle 102 is transferred from the disc (upon rotation of such disc and the associated discs 129, 130), to the out-feed belt. During rotary movement of the bottle it is alined with one of the funnels and at the proper point in the machine operating cycle, the rotary measuring-dispensing disc (within the trough) discharges a measured quantity of powder into the bottle through the funnel. The movement of the bottles, funnels and measuring chambers are all controlled by rotation of the discs and since all discs are directly driven by the shaft 123 absolute operating synchronism is maintained. A spring-backed guard rail 138 prevents outward movement of the bottles as they are rotated on the disc 128. The extent of rotary movement of each bottle as it passes through the powder-dispensing station is approximately 90 degrees.

Reference for the moment is made to Figure 26 which is a fragmentary front view taken substantially along the line C—C of Figure 24. The empty bottles are moved in succession to the bottle-filling station by the in-feed conveyor belt 101. The bottles are rotated through approximately 90 degrees in alinement with the funnels during which time powder is discharged into the bottle, and the filled bottles are then automatically transferred to the out-feed conveyor belt 103 for removal from the machine. A pair of parallel, spaced guard rails 140 maintain the bottles in alinement on the in-feed belt, curved guard rails 138, 138' retain the bottles in proper position during their circular movement through the bottle-filling station, and a pair of parallel, spaced guard rails 141 aline the filled bottles for transfer to the out-feed belt 103.

Reference is now made to Figure 29 which is an enlarged, fragmentary view, with parts in section, showing the construction of the rotary, bottle-filling apparatus. The circular plate 125 is secured to a flange coupling 126, by the bolts 150 and cooperating nuts 151, and the coupling is secured to the shaft 123 as by a pin 153. The shaft 123 extends through a central hole in the plate 125 and is secured to one end of a universal coupling 154 by a pin 155. A second, universal coupling 156 is similarly coupled to the coupling 155 by a short rod 157. The upper end of the coupling 156 is secured to a shaft 158, as by the set screw 159, which shaft passes through a hole provided in the bottom of the vibratory trough 117. A detailed description of the construction, arrangement and operation of the measuring chambers will be given hereinbelow but it is well to here point out that the measuring chamber disc 160 is rigidly secured to the shaft 158 for rotation therewith and that such disc is in smooth, sliding engagement with the bottom of the trough 117 at all points except where powder is to be discharged from the measuring chambers. Secured to the trough 117, as by the screws and nuts shown, is a downwardly-depending bushing 163 provided with a close clearance hole for the shaft 158. A somewhat similar bushing 164 is secured to the disc 133 as by the screws 161 and nuts 162, such bushing 164, however, being secured to the shaft 158 by the set screw 165. Attention is particularly directed to the fact that the shaft 157 and the universal coupling 156 extend through central clearance holes in the disc 128, 129 and 130. Consequently, the mechanical vibrations of the trough are not transmitted to the plates 128, 129, 130 and, importantly, the drive shaft arrangement, including as it does the universal couplings 154 and 155, does not significantly interfere with the trough vibrations. Still, the measuring chamber disc 160 and the funnel-carrying plate 133 are subject to positive rotation by the output shaft 123 of the gear-reduction unit 121. Preferably, the funnels are rigidly affixed to the plate 133 as by welding. It is deemed pertinent to here point out that by simply loosening the single set

screw 159 the entire funnel assembly and measuring disc is removable as a unit with the trough for sterilizing purposes, which feature is very important in the pharmaceutical field in which it is the practice to sterilize daily all machine parts coming into contact with the powder.

Proceeding with the description of Figure 29, it will be noted that the vertical posts 127 are rigidly secured to the plate 125 by means of the nuts 170 operating on the reduced-diameter post ends extending through appropriate holes formed in the plate. The upper ends of these posts are also of reduced diameter forming shoulders to support the disc 128, collars 171, plate 129, bushings 172 and disc 130, the entire assembly being held and secured by the nuts 173. It is apparent, therefore, that the entire assembly carried by the posts 127 rotates as a unit with the funnels 134 even though the driving means for the funnels is subject to transverse flexure by reason of the universal couplings 155, 156. It is this flexing characteristic which eliminates any rigid tie-in between the trough and the rest of the apparatus and permits relatively unobstructed vibration of the trough for the movement of the powder from the hopper to the measuring chambers, the filling of the measuring chambers and the subsequent discharge of the powder from the measuring chambers to the associated funnels. The spaced discs 129, 130 are of identical construction and each include vertically-alined semi-circular, peripheral recesses such as those identified by the numerals 175, 175' in the Figure 29 showing. Such recesses have a diameter conforming to the diameter of the bottles 102 and they serve somewhat as fingers for imparting positive, rotary movement to the bottles as they pass through the bottle-filling operation. Although not clearly evident from the particular showing in Figure 29, as the empty bottles are moved in succession toward the bottle-filling station by the in-feed belt, the leading bottle is transferred to the circular plate 128 and into contact with the periphery of the spaced discs 129, 130. Since such bottle now rests upon the rotating plate 128 and is being pushed toward the disc axis by the succeeding bottles, it tends to rotate about its vertical axis and falls into the plate recesses 175, 175', after which the bottle is subject to positive circular movement through the bottle-filling station and out onto the out-feed belt. This action will become more evident as the description proceeds.

Reference is now made specifically to Figure 30 which is a horizontal section taken along the line D—D of Figure 29. However, included in the Figure 30 showing is a flat plate 176 which serves as a support for certain machine components, said plate being omitted from the Figure 29 showing for purposes of clarity. The plate 176 lies below the circular plate 128 and includes a circular opening to clear the vertical posts 127 shown in Figure 29. Supported by the plate 176 are two, L-shaped brackets 177, 177' provided with elongated slots 178, 178' whereby such brackets are adjustably positionable with respect to the circular, rotary plate 128, as by the screws 179, 179' passing through the slots and into corresponding holes in the plate 176. As will be described in more detail with reference to Figure 31, these brackets support arcuate, spring-backed guard rails which press the bottles toward the axis of the disc 128 as the bottles are moved in an arcuate path through the bottle-filling station. An in-feed dead plate 180 overlies the end portion of the in-feed belt 101 (as such belt moves around the roller 181) said plate having an upper surface flush with the upper surface of the disc 128 and being provided with an arcuate side adapted for sliding contact by the periphery of the disc. Thus, as a succession of bottles is moved toward the rotary disc 128, by the in-feed belt 101, the leading bottle is pushed onto the plate 180 and then slid from the plate onto the rotary disc. The rotary disc then moves the bottle into alinement with the out-feed belt 103. A pair of parallel guide rails 141 (see also Figures 23 and 26) lie in a plane just over the rotary disc from which it is apparent that each bottle, moved by the disc, will push the preceding bottles over the out-feed dead plate 185 and onto the out-feed belt 103. Once a bottle is transferred to the belt 103 it is moved by such belt to a desired point as, for example, a bottle-capping machine. It may be well to here point out that the action of filling the bottles with powder takes place during the time the bottle is moved in a circular path on the rotary disc 128. It is also pointed out that the plane through which the section of Figure 30 is taken discloses the universal coupling 154, shaft 157 and the nuts 151, all visible through the central hole in the rotary disc 128, see also Figure 29.

Reference is now made to Figure 31 which is a horizontal section taken along the line E—E of Figure 29. In this plane are clearly shown the guard rails 140 overlying the in-feed belt 101 and the guard rails 141 overlying the out-feed belt 103. It is particularly to be noted that the upper disc 130, provided with the semi-circular, peripheral recesses 175, is of a smaller diameter than the circular plate 128. As described hereinabove, two such cut-out plates (see plates 130 and 129 in Figure 29) are provided in fixed, spaced relationship with the corresponding semi-circular recesses, or notches, in vertical alinement. These two, recess-carrying plates and the bottle-supporting plate 128 rotate as a unit. Thus, as the leading bottle on the in-feed belt is pushed onto the bottle-supporting plate 128 it may fall directly into the vertically-alined peripheral recesses in the discs 130, 129 or its vertical wall may rub against the outermost peripheral surface of such discs. In the latter case, the bottle will almost immediately fall into the alined recesses by reason of the rotation of the discs and pressure from succeeding bottles. Once the first bottle has so-fallen into position succeeding bottles can be made to fall directly into the associated recesses by properly spacing the recesses with due regard to the bottle diameter and speed of rotation of the discs. In any event, the precise character of the bottle movement from the in-feed belt into the recesses is not important as such action is not critical and a machine constructed as shown is capable of positive operation at a high rate of speed. Once the bottle is in position on the supporting plate 128 it is moved in a circular path toward the out-feed belt 103. During such circular bottle movement the bottle is firmly retained within the disc recesses by the spring-backed, arcuate guard rails 138, 138' such rails being supported by the brackets 177, 177' as has already been described. After receiving its charge of powder the bottle moves between the guard rails 141, the inner such rail serving as a stop to prevent continued rotary movement. Just beyond this point each bottle will push the preceding bottles over the dead plate 185 and onto the out-feed conveyor belt 103. It is apparent that each bottle is securely held in vertical position and moved by a positive force throughout a major portion of its circular path of travel between the in-feed and out-feed belts. Again I point out that the bottle-filling operation takes place while the bottle is so moved.

Reference is now made to Figure 32 which is a horizontal section taken along the line F—F of Figure 29. The plane of the view shows the circular plate 133 carrying the funnels 134 which are in vertical alinement with the semi-circular, bottle-receiving recesses formed in the periphery of the underlying discs 130, 129. It will be noted that the plate 133 has a diameter larger than that of the discs 130, 129 but smaller than that of the bottle-supporting plate 128 whereby each alined series of bottles, semi-circular recesses and funnels have a common axis. Inasmuch as the entire structure rotates as a unit it will be clear that such vertical alinement of the bottles and funnels remains fixed throughout the circular path of movement of the bottles from the in-feed to the out-feed stations.

Having in mind the bottle-rotating and funnel arrange-

ment shown in Figure 29, attention is again directed to Figures 7 and 8. It should be clear that if the inclined chute **35** is removed from Figures 7 and 8 and if the rotary assembly of Figure 29 be disposed under the trough for unitary rotation with the measuring disc **65** (with the funnels alined with the holes **66**) the powder dispensed from the chambers **66** will drop directly into the alined funnel for direction into the associated bottle. This is precisely the action which takes place in my bottle-filling machine except that I provide a simple arrangement whereby the capacity of the individual measuring chambers can be adjusted to any desired volume within a practical range.

Reference is now made to Figure 33 which essentially is a horizontal section taken along the line G—G of Figure 29. The rotary, measuring-chamber wheel comprises two concentric discs **160** and **190**, see also Figure 29, secured to the shaft **158** for rotation as a unit with the rotary structure already described. The lower disc **160** rests upon the bottom of the vibratory trough **117** and includes rectangular, radial recesses **191** alined with the funnels **134**. Within each such recess is a rectangular bar **192** such bars having a thickness equal to that of the disc **160** and radial lengths substantially less than the corresponding length of the recesses, whereupon each bar is slidable, radially, within the associated recess. The precise positioning of each bar within its recess is established by means of the associated screws **193** which pass through the relatively narrow, radial slots **195** formed in the upper, smaller-diameter disc **190** and into suitably-threaded holes in the bars. By loosening such screws the bars **192** can be moved radially outwardly or inwardly of the recesses within the limits afforded by the slots **195** to thereby decrease or increase, respectively, the volumetric capacity of the individual measuring chambers Y, said chambers being constituted by that portion of the recess **191** between the periphery of the disc **160** and the forward end of the rectangular bar **192**. Throughout a predetermined angle of rotation of the disc **160** certain of the measuring chambers will run through, as it were, the powder **27** at the front end of the vibrating trough and will immediately be filled. Upon further rotation of the disc such filled chambers will be completely closed, the periphery of the disc being closed by the side plate **197** which has a thickness substantially equal to that of the disc, and the upper surface of the disc being covered by a plate **198**, shown in Figure 34 which is a top view of the apparatus shown in Figure 29. As shown in Figure 34, the plate **198** has a circular opening through which the upper disc **190** extends upwardly. It will be noted that the right hand portion of the plate **198** is arcuate conforming to the circumference of the lower disc **160**, more clearly shown in Figure 29, so that it will be apparent that the plate **198** completely covers the tops of all measuring chambers except those passing through the powder **27** accumulated at the front end of the vibratory trough and against the vertical wall **199** of the plate **198**. Reverting back to Figure 33, it will be noted that the side plate **197** extends to a point beyond the center line of the in-feed belt **101** at which point the trough bottom also terminates. Hence, as the filled measuring chambers pass beyond this point the powder is free to fall from such measuring chamber into the alined funnel and into the alined bottle, the latter being firmly secured in position on the rotating structure prior to the point at which the chamber empties into the funnel. By the time the bottle is rotated to the point identified by the funnel **134F** all the powder will have been transferred from the measuring chamber into the bottle and such filled bottle is in condition and position to be moved by succeeding bottles onto the out-feed belt **103**. By reason of the structural arrangement of the apparatus, best viewed in an overall sense by reference to Figure 29, the measuring chamber disc **160** is vibrated with the trough thereby assuring a positive filling and emptying of the chambers regardless of the characteristics of the particular powder, and at a constant density for any given setting of the vibration.

From the above description of Figures 33 and 34 the showing of the upper part of Figure 29 will now be clear. The powder **27** is shown piled up against the vertical wall **199**. One filled measuring chamber Y is shown in the left hand side of the rotatable disc **160** whereas an empty such chamber is shown on the right hand side and over the alined funnel drawn in cross-section. Clearly shown are the rectangular bars **192** secured in desired position by the associated screws **193** passing through the elongated, radial slots in the upper disc **190**.

I have now described the rotary structure which moves the bottles in alinement with individual funnels for accepting the discharge of measured quantities of powder from the measuring chambers, the unitary unrestricted vibrational arrangement of the trough and the measuring chambers, and the feature for adjusting the volumetric capacity of the chambers. I shall now describe an arrangement whereby such bottle-filling machine can quickly and conveniently be adjusted to operate with bottles of another size.

Reference is now made to Figure 35 which, generally, is similar to Figure 31 but drawn to a smaller scale. The rotary disc **200**, in Figure 35, corresponds, in function, to the disc **130** shown in Figure 31. The illustrated peripheral, semi-circular recesses **201**, in the disc **200** are made to correspond to the diameter of the maximum size bottles **102**. The disc **200** has an integral upwardly-extending collar **202** terminating in an arm **203** that is pivotally connected to an arm **204**. Disposed immediately below the disc **200** is a similar disc **200'**, not visible in Figure 35, and which is provided with recesses corresponding exactly to the recesses **201**. Such lower disc includes an upwardly-extending collar **202'** terminating in an arm **203'** that is pivotally connected to an arm **204'**. Both discs **200** and **201'** are connected for simultaneous rotation as a unitary part of the rotatable structure and when the discs are in exact alinement, the single, so-formed, peripheral recesses accept the large size bottles **202** as they are pushed in succession onto the supporting plate **128**.

The ends of the arms **204** and **204'** are provided with suitable eyelets which overlap to accept the fastening screw **206** which passes through a radial slot **207** in the upper disc **200** and a relative oblique slot in the lower disc. A nut threaded on the end of the screw **206**, below the lower surface of the lower disc, serves to lock the pivoted-arm assembly in fixed position. Upon loosening such nut the arms **204, 204'** may be moved as a unit along the path defined by the slot **207**. When such common point of the arms **204, 204'** is moved closer to the center of the discs the interconnected arms **203, 203'** impart a rotary movement to each disc, with the collars **202, 202'** serving as mutual bearings. The upper disc **200** rotates in a counter-clockwise direction whereas the lower disc rotates in a clockwise direction. Such relative displacement of the two discs is shown in Figure 35 from which it is apparent that the effective size of the peripheral recesses has been reduced thereby adapting the disc (or better, discs) for operation with the smaller-diameter bottles **102'**. In the industry, bottle sizes are standardized and referred to by numbers. Hence, the upper disc may be provided with a correspondingly-numbered scale **210** whereby the proper size of the recesses can be set by alining an index, associated with the screw **206**, with the appropriate scale marking.

It is desirable, although not essential, that the guide rails associated with the in-feed and out-feed belts be adjusted when the machine is set for operation with bottles having a diameter substantially different from those of the previous run. Toward this end the in-feed rails

212, Figure 36, may be mounted so that they are biased toward the center of the in-feed belt by suitable springs, the nuts 212' serving to limit the inward movement of the guard rails to prevent undue pressure upon the bottles. Alternatively, the rails may be supported on adjustable mountings as, for example, the mounting 213 supporting one of the out-feed guard rails 214.

In the bottle-filling machine it is desirable to incorporate a safety arrangement whereby the machine will cease operating in the event empty bottles are not fed to the bottle-filling station. One such arrangement is illustrated in Figure 27 which is a fragmentary view looking down on the succession of bottles 102 moving in the indicated direction on the in-feed belt toward the bottle-supporting disc. A pivoted arm 220 has a somewhat resilient finger 221 that is adapted for sliding contact with the bottles. The arm is mechanically biased in a clockwise direction by a suitable spring 222 and carries an electrical contact 223 positioned to engage a stationary contact 224 when the arm is in the illustrated position. These contacts act as an on-off switch interposed in the electrical circuit between the source of power and the machine motor and vibrators. Thus, when the bottles are removed from the in-feed belt, the spring 222 will rotate the arm to separate the contacts 223, 224.

Figure 28 is a circuit diagram of the machine. Here I show, diagrammatically, the in-feed belt 101 driven by a motor 230, the out-feed belt 103 driven by a motor 231, the motor 120 which rotates the rotary structure including the measuring disc 160, the vibratory trough 117 vibrated by the electro-magnetic vibrator 115 and the hopper 22 vibrated by the electro-magnetic vibrator 30. The machine can be connected to a source of power, such as a 120 volt, 60 cycle power line, by means of the plug connector 232 and through the protective fuses 233. Closure of the manually-operated main switch 234 energizes the belt-driving motors 230 and 231 the circuit being traceable as follows; the switch 234, leads 235 and 236 to one side of each motor, and the return leads 237, 238 back to the other side of the power line. The in-feed belt 101 carries empty bottles to the filling station and the out-feed belt 103 removes the filled bottles to another station. Associated with the in-feed belt 101 is a normally-open safety switch 240, the operation of such switch having been described hereinabove with reference to Figure 27. The bottles moving along the in-feed belt close the switch 240 thereby energizing the electro-magnetic vibrators and the motor 120 as is readily apparent from a study of the diagram. Since power is supplied to the vibrators and the motor 120 only through the switch 240 the opening of such switch, as will be the case when empty bottles are not supplied to the filling station by the in-feed belt, results in a shutting-down of the vibratory measuring and dispensing functions of the machine. However, the in-feed and out-feed belts continue in operation as long as the main switch 234 remains in the closed position.

From the above description of various embodiments of my invention it will be apparent that my machine includes many outstanding features and advantages.

1. The machine is of simple, straight forward design and construction yet of rugged character thereby promoting a long operating life with a minimum of maintenance.

2. The machine can be quickly and conveniently dismantled and reassembled so that the parts coming into contact with the powder may be cleaned.

3. The machine is capable of operating at accuracies within a fraction of a percent in any operating range from ounces per hour to tons per hour.

4. The precisely-measured quantities of powder dispensed by the machine, when reduced to a dry basis, are not adversely affected by the changes in the moisture content of the powder.

5. The machine will operate equally well with dry, free-flowing granular powders and sticky amorphous powders.

6. The quantities of powder dispensed are not effected by variations in the depth of the powder contained within the hopper.

7. Automatic means are provided for the feedback of excess, or overflow, powder from the measuring-dispensing station to the other end of the trough.

While the illustrated embodiments of my powder-feeder and bottle-filling machine are designed particularly for dispensing relatively small quantities of powder it will be understood that the same principles are applicable to large machines as, for example, for use in filling containers with fertilizer. Those skilled in this art will be able to make necessary or desired changes and variations in the illustrated components and their relative, operative assembly to meet specific requirements without thereby departing from the spirit and scope of my invention. In particular, I wish to point out that the degree of inclination of the vibratory trough is not a critical factor. In fact, while I prefer to incorporate such inclined surface in the practical form of my machine the entire trough may actually be horizontal. Also, while describing herein electromagnetic means of vibration, other purely mechanical means may be employed with equal effect.

Having now given a detailed description of the construction and operation of my invention what I desire to protect by Letters Patent of the United States is set forth in the following claims.

I claim:

1. Apparatus for dispensing measured quantities of a material comprising a storage hopper for the material and having a discharge opening; a vibratory trough receiving material discharged from the hopper; means vibrating the trough in a manner to vibratorily move the material along the trough; a member having a plurality of measuring chambers disposed at one end of the trough; means moving the said member to cause said chambers to move in succession from a chamber-discharge position external of the trough to a chamber-filling position within the trough; and means continuously vibrating the measuring chambers as they move from one to the other of said positions.

2. A powder-feeder comprising a storage hopper for powder, a vibratory trough having one end disposed under the discharge opening of the hopper, means to vibrate the trough in a manner to vibratorily move the powder discharged from the hopper to the other end of the trough, means effectively closing off the other end of the trough said means including a plurality of measuring chambers, and means to move the measuring chambers in succession from a point within the trough to a point external of the trough.

3. The invention as recited in claim 2, wherein the measuring chambers are constituted by openings in a rotatable disc that is in face contact with a portion of the trough bottom, and including means to rotate the disc at a predetermined speed.

4. The invention as recited in claim 3, wherein the measuring chamber openings are formed in the peripheral surface of the disc.

5. The invention as recited in claim 3, wherein the measuring chamber openings are formed by circumferentially-spaced holes extending through the disc.

6. The invention as recited in claim 2, wherein the trough includes a lower portion disposed under the hopper discharge opening, an upper portion at the other end, and an intermediate, inclined portion extending from the said lower portion to the upper portion.

7. Apparatus for dispensing measured quantities of powder at a predetermined rate comprising a storage hopper for powder and having a discharge opening; a substantially-rectangular trough having closed ends, one end portion of the trough being disposed under the hopper with the trough bottom spaced from the hopper dis-

charge opening; a rotatable disc having a plurality of measuring chambers, said disc extending partially into the trough and into face contact with the trough bottom; means to vibrate the trough in a manner to move the powder discharged from the hopper toward the disc; and means rotating the disc at a predetermined speed.

8. Apparatus for dispensing measured quantities of powder at a predetermined rate comprising a storage hopper for powder and having a discharge opening at the bottom; a substantially-rectangular trough having closed ends, one end portion of the trough bottom being spaced below the hopper discharge opening; means to vibrate the trough in a manner to move the powder discharged from the hopper to the other end of the trough; a shaft extending through the trough bottom at the other end of the trough; a disc secured to said shaft, a portion of said disc being in face contact with the trough bottom and a portion of the disc extending outwardly of the trough; means forming a plurality of circumferentially-spaced measuring chambers in said disc, said chambers being open at all times to the trough bottom; and means rotating the said shaft at a predetermined speed, the recited arrangement being such that the measuring chambers are filled with powder as they rotate within the trough and such powder is discharged from the measuring chambers as they rotate to a point external of the trough.

9. The invention as recited in claim 8, wherein the means rotating the said shaft is connected to the shaft by a flexible coupling.

10. The invention as recited in claim 8, wherein the means forming the measuring chambers are a plurality of radial recesses formed in the periphery of the disc.

11. The invention as recited in claim 8, wherein the means forming the measuring chambers are a plurality of holes extending through the disc.

12. The invention as recited in claim 8, wherein the trough bottom includes an intermediate, inclined portion.

13. The invention as recited in claim 8, wherein the means to vibrate the hopper is an electro-magnetic vibrator supporting the hopper from a base, and the means rotating said shaft is secured to the said base.

14. Apparatus for dispensing measured quantities of powder at a predetermined rate comprising a platform; an electro-magnetic vibrator supported on said platform by vibration-absorbing means; a substantially horizontally-disposed trough supported by the said electro-magnetic vibrator, said trough having closed ends; a rotatable disc extending partially into the trough at one end, said disc being in face contact with the trough bottom and including a plurality of circumferentially-spaced measuring chambers each such chamber being open to the trough bottom; a motor carried by the platform; means including a flexible coupling mechanically coupling the motor to said disc; and a storage hopper for powder supported on said platform, said hopper having a discharge opening disposed over the other end of the trough and spaced from the trough bottom.

15. The invention as recited in claim 14 and including a second electro-magnetic vibrator secured to the hopper; and including adjustable means to space the hopper discharge opening a predetermined distance from the trough bottom.

16. The invention as recited in claim 14, wherein the trough includes an upwardly-inclined bottom portion terminating in a substantially horizontal portion under the said disc, and wherein the portion of the disc extending outwardly of the trough is less than one half of the disc.

17. The invention as recited in claim 16, wherein the thickness of the disc is less than the height of the trough side walls and including a vertical partition member extending across opposite side walls of the trough and across a segment of the disc.

18. The invention as recited in claim 16, wherein the measuring chambers are formed by circumferentially-spaced, longitudinal holes passing through the disc.

19. Apparatus for dispensing measured quantities of powder at a predetermined rate comprising a storage hopper for powder and having a discharge opening; a substantially-rectangular trough having closed ends, one end portion of the trough being disposed under the hopper with the trough bottom spaced from the hopper discharge opening; means vibrating the trough substantially along its main axis; a pair of rotatable discs each having a plurality of circumferentially-spaced holes extending therethrough, said disc being in overlapping mutual face contact and at least half but not all of each disc extending into the trough; means rotating the discs about displaced axes at equal speeds; the recited arrangement being such that the holes in the two discs are displaced laterally in a plane passing through the disc axes when such holes are exterior of the trough one hole in each disc will be in vertical alinement within the trough when the axes of such holes lie in the said plane.

20. Apparatus for dispensing measured quantities of powder at a predetermined rate comprising a storage hopper for powder; a trough positioned to receive at one end powder discharged through the hopper opening; means to vibrate the trough to move the powder to the other end of the trough; a rotatable disc disposed within the trough said disc having two series of circumferentially-spaced holes extending therethrough, each series of holes lying on a different radius; means rotating the disc at a predetermined speed; means directing the flow of the powder over each series of holes in mutually exclusive relationship; and means effective at predetermined points in the rotary movement of the holes to dispense the powder from the two series of holes to different points.

21. Apparatus for dispensing measured quantities of powder at a predetermined rate comprising a vertically-disposed hopper having a discharge opening; a first vibratory trough positioned to receive at the rear end the powder discharged from the hopper; a first electro-magnetic vibrator adapted when energized to move the powder to the front end of the trough; a rotatable disc extending partially into the first trough at the front end, said disc being provided with a plurality of circumferentially-spaced measuring chambers; a second vibratory trough disposed along side of the first trough; a second electro-magnetic vibrator adapted when energized to move powder from the front end of the second trough to the rear end; means directing the flow of powder from the front end of the first trough to the front end of the second trough; means directing the flow of powder from the rear end of the second trough to the rear end of the first trough; and means rotating the disc at a predetermined speed.

22. The invention as recited in claim 21, wherein each trough includes an inclined central portion and such central trough portions are reversely disposed with respect to each other.

23. Apparatus for dispensing a measured quantity of powder into a bottle comprising a storage hopper for the powder, a vibratory trough receiving powder discharged from the hopper, means vibrating the trough to vibratorily move the powder along the trough, a normally-open measuring chamber, means moving the measuring chamber to a first position within the trough and to a second position external of the trough, means effective when the chamber is in the first position to fill the chamber with the powder under vibratory movement within the trough, means effective to close the chamber as it is moved from the first to the second position, and means effective when the chamber is in the second position to discharge the powder into a bottle.

24. Apparatus for automatically filling bottles with measured quantities of a powder comprising a storage hopper for the powder; a vibratory trough disposed to receive powder discharged from the hopper; a rotatable member provided with a plurality of circumferentially-spaced measuring chambers, a portion of said member

being disposed within the trough and another portion being disposed external of the trough; power means to rotate the said member whereupon the measuring chambers move in succession into and out of the trough; means vibrating the trough to move the powder discharged from the hopper into the measuring chambers as they move inside the trough; a supporting plate rotatable with the said shaft; means moving a succession of empty bottles on the supporting plate; means automatically alining the bottles on the supporting plate into individual bottle-filling registry with the measuring chambers; means automatically discharging powder from the measuring chambers into the alined bottles; and means effective upon rotation of the supporting plate to move the filled bottles off said supporting plate.

25. The invention as recited in claim 24, including means vibrating the said rotatable member.

26. The invention as recited in claim 24, wherein the rotatable member is a disc in face contact with the trough bottom and the said measuring chambers are constituted by radial recesses formed in the disc periphery.

27. The invention as recited in claim 26, and including adjustable means to set the radial depth of the recesses to a predetermined value.

28. The invention ae recited in claim 24, wherein the central portion of the trough bottom is inclined upwardly toward the said rotatable member.

29. The invention as recited in claim 24, wherein the means automatically alining the bottles on the supporting plate into bottle-filling registry with the measuring chambers comprises a pair of spaced discs disposed over the supporting plate and rotatable therewith, said spaced discs being provided with alined arcuate recesses formed in the disc periphery, and the means moving the empty bottles onto the supporting plate moves such bottles into edge contact with the said spaced discs.

30. The invention as recited in claim 24 including a plurality of funnels individually alined with the measuring chambers said funnels being disposed between the measuring chambers and the bottles and rotatable with the said rotatable member.

31. The invention as recited in claim 24, wherein the means effective upon rotation of the supporting plate to remove the filled bottles off the supporting plate comprises a guard rail having an end extending into the path of movement of the filled bottles as the latter are moved in a circular path by the supporting plate.

32. The invention as recited in claim 24 including a vertical wall disposed over that portion of the rotatable member disposed within the trough and the rate of vibratory movement of the powder from the hopper to the measuring chambers exceeds the rate of powder discharged from the trough by the measuring chambers.

33. Apparatus for automatically filling bottles with measured quantities of a powder comprising a storage hopper for the powder and including a discharge opening; a vibratory trough disposed to receive powder discharged from the hopper; means imparting vibrations to the trough to move the powder discharged from the hopper to the front end of the trough; a rotatable disc in face contact with the trough bottom at the front end of the trough, said disc being provided with a plurality of normally-open, circumferentially-spaced openings constituting measuring chambers and said disc being so disposed with respect to the trough that some of said chambers will be inside the trough while others will be external of the trough; a vertical shaft secured to the disc; a universal coupling connecting said shaft to a drive shaft; a set of vertically-extending posts secured to the drive shaft said posts being spaced on either side of the said coupling; a bottle-supporting plate secured to the post and including a central clearance hole for said coupling; a pair of spaced drive plates secured to the posts and disposed over the said first plate, said drive plates including central clearance holes for the said coupling and alined, peripheral recesses adapted to accommodate the bottles; a funnel-carrying plate secured to the said vertical shaft, said plate being disposed below the trough and said plate carrying a plurality of vertically-disposed funnels each alined with one of the measuring chambers; and an alined pair of peripheral recesses in the said spaced drive plates, an in-feed conveyor belt moving a succession of empty bottles onto the supporting plate and into radial contact with the alined peripheral recesses in the spaced drive plates whereby such bottles will be rotated by the supporting plate in vertical alinement with the funnels and measuring chambers; means including the trough vibrations to accumulate the powder at the front end of the trough to a depth exceeding the thickness of said rotatable disc and completely covering at least one of the measuring chambers; means effective upon rotation of the rotatable disc to close the measuring chambers filled with powder; means effective upon rotation of the chambers externally of the trough to discharge the powder from the measuring chambers through the alined funnels and into the alined bottles; and a relatively-fixed guard rail extending into the arcuate path of travel of the so-filled bottles to direct the bottles from the supporting plate to an out-feed conveyor belt.

34. The invention as recited in claim 33, wherein the said vertical shaft rotates in a bearing affixed to the trough whereby the said trough and rotatable disc are vibrated as a unit, and including adjustable members slidably-positionable within the measuring chambers to adjust the effective chamber volume to a predetermined value.

35. The invention as recited in claim 33, wherein each of the said spaced drive plates comprises a pair of superposed co-acting discs having corresponding peripheral recesses and wherein each such pair of co-acting discs are rotatably relative to each other to displace the corresponding recesses a predetermined number of angular degrees.

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