July 31, 1956 C. F. CARTER 2,756,906

FILLING MACHINE

Original Filed April 1, 1952 5 Sheets-Sheet 1

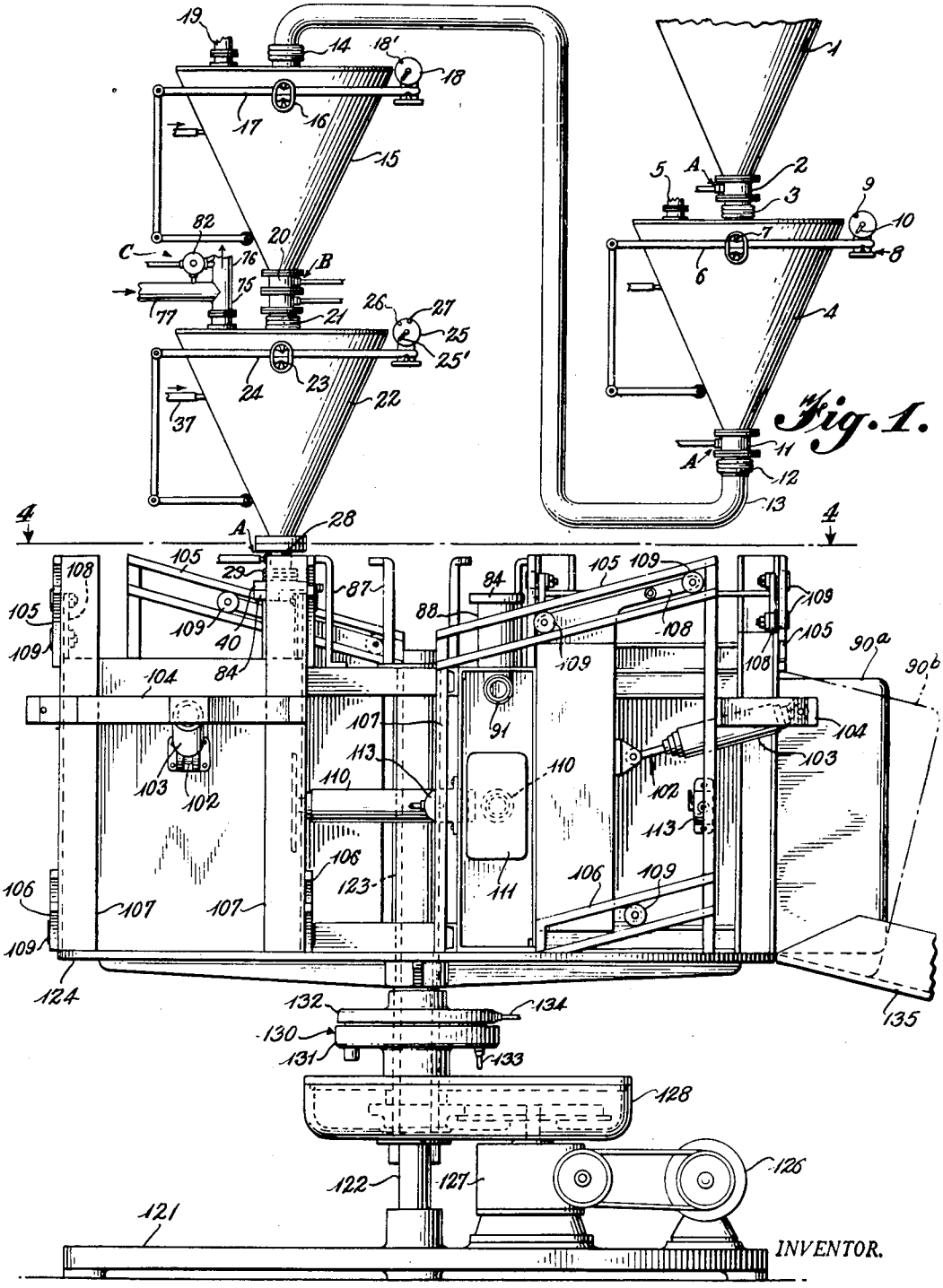


Fig. 1.

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FILLING MACHINE

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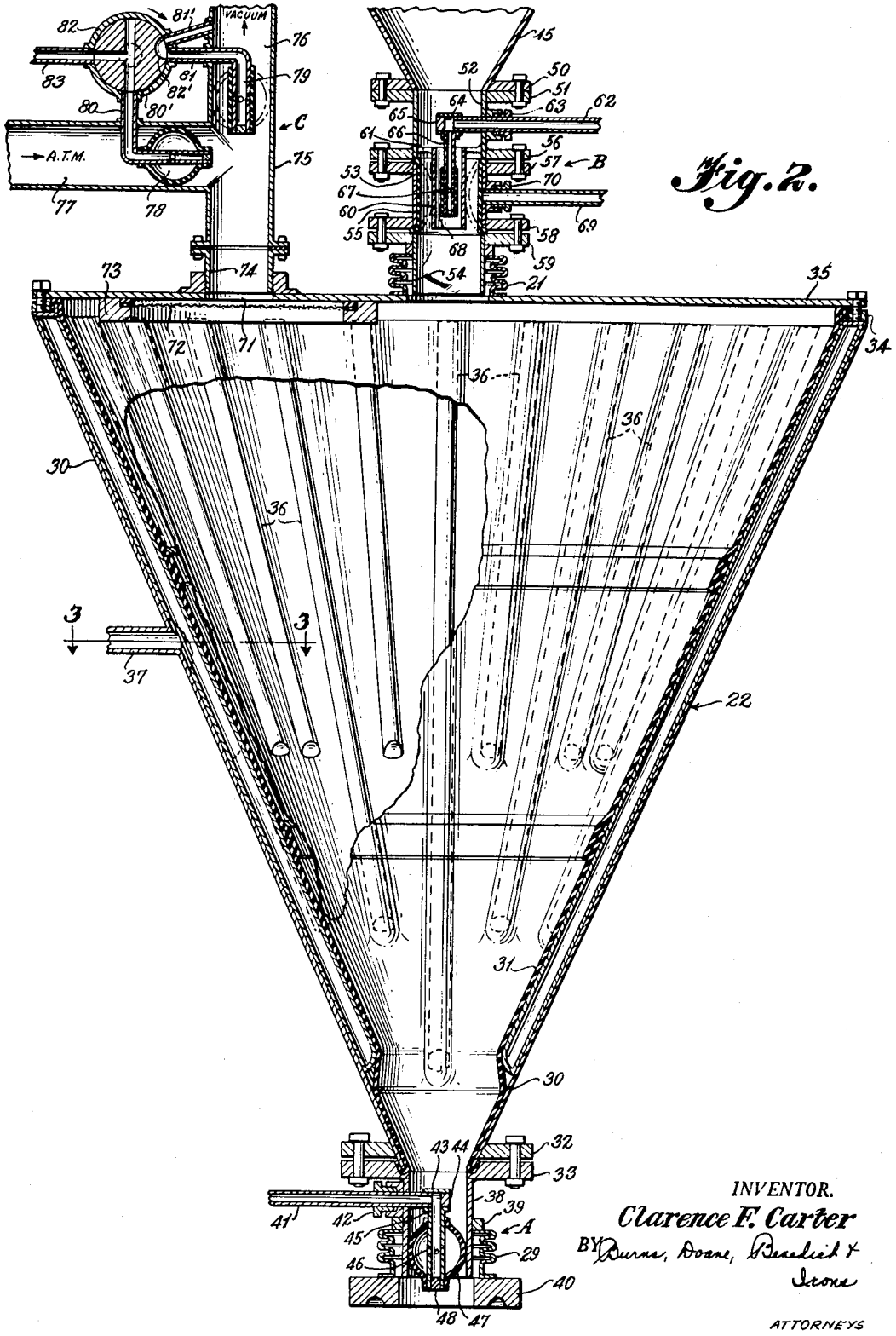


Fig. 2.

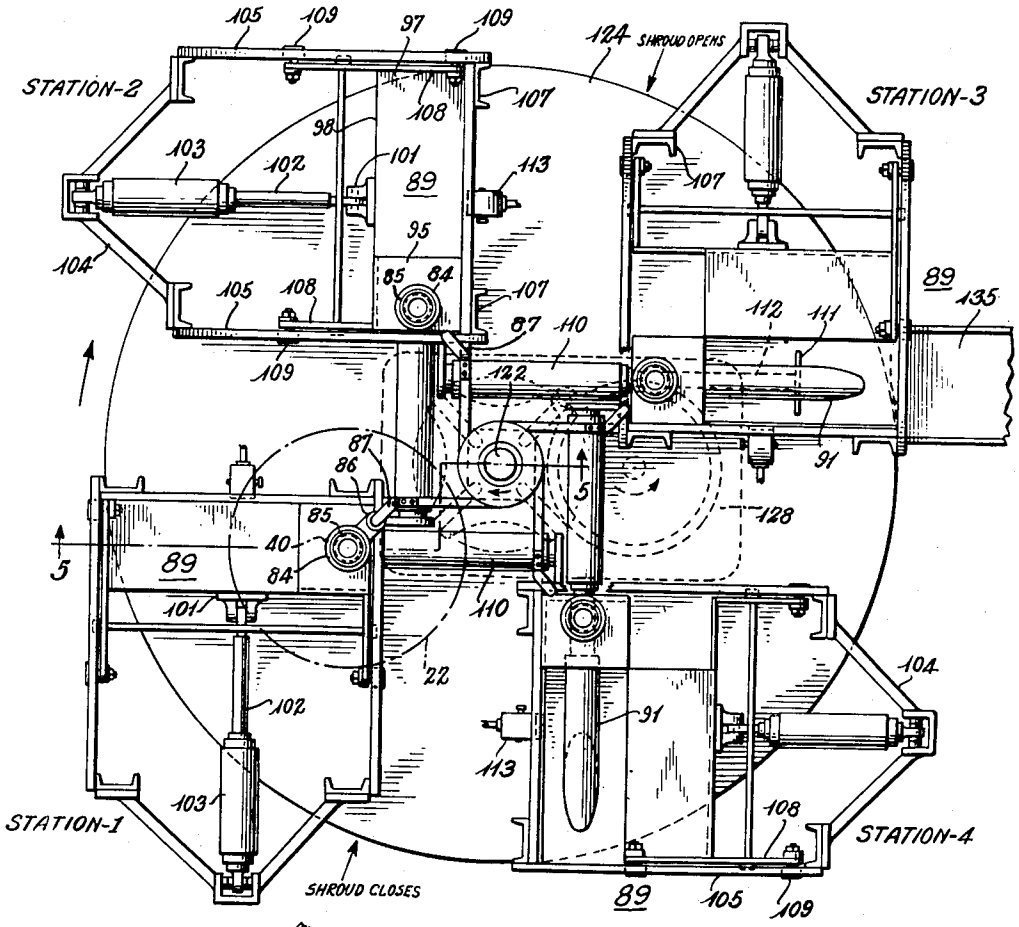
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FILLING MACHINE

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Fig. 4.



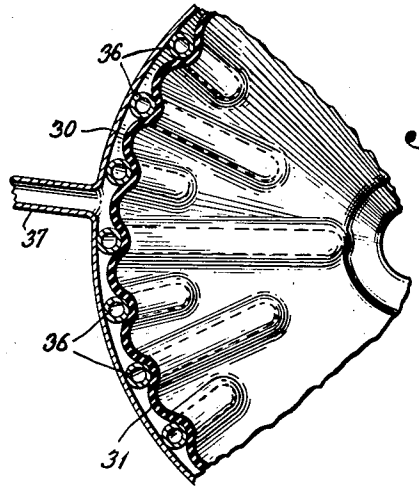


Fig. 3.

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FILLING MACHINE

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Fig. 5.

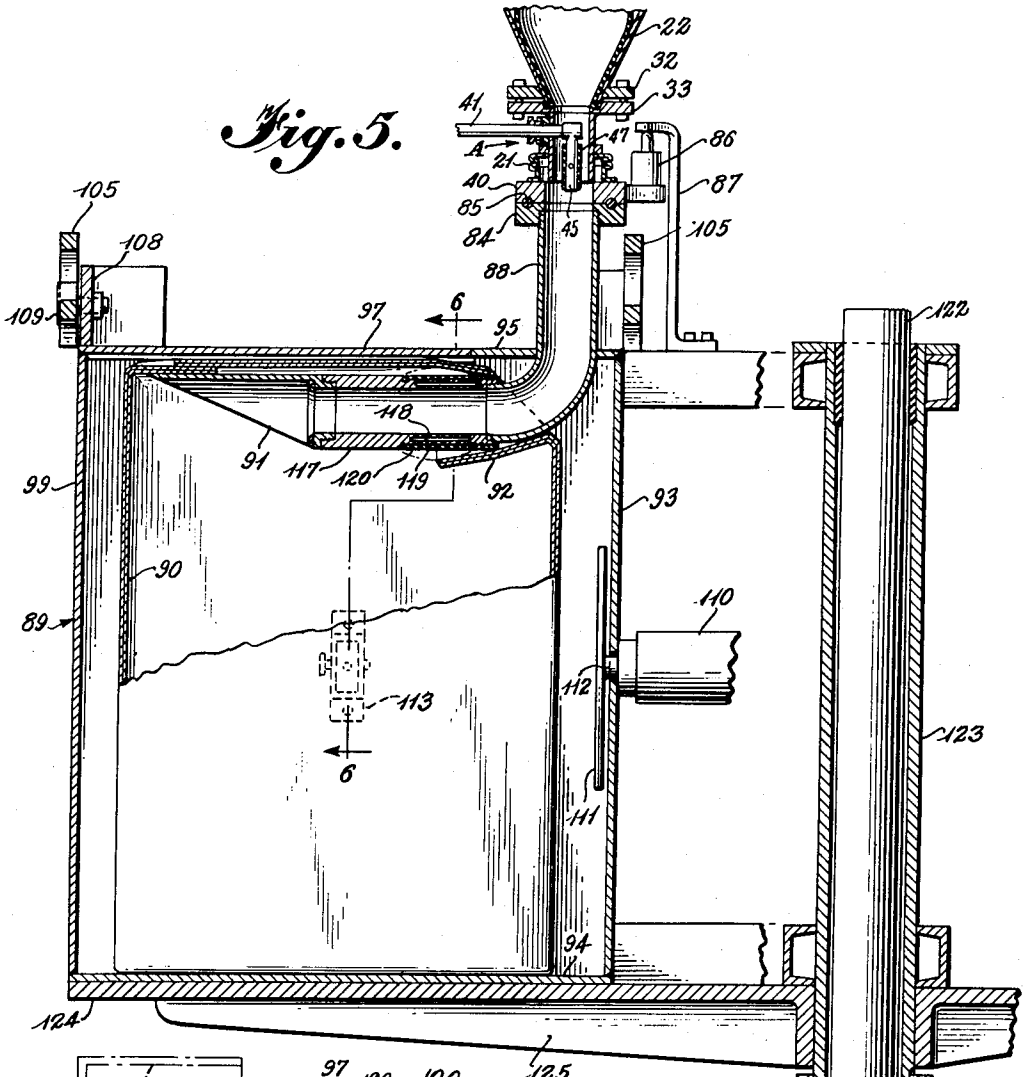
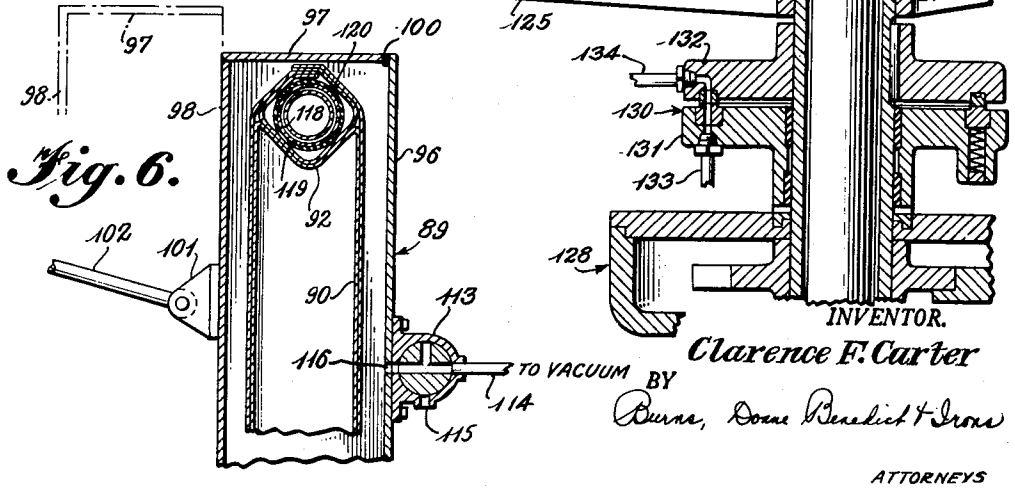


Fig. 6.



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Fig. 7.

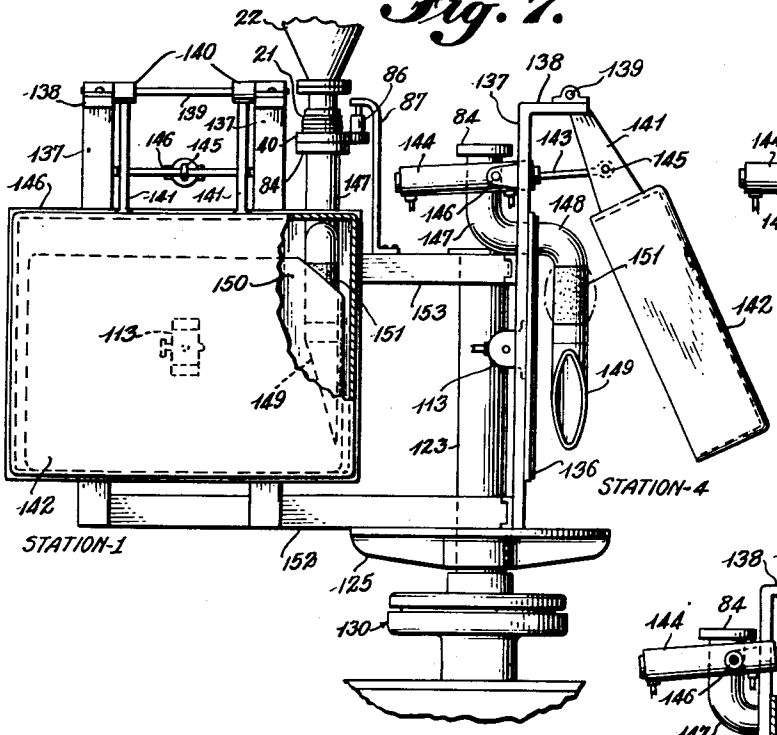


Fig. 9.

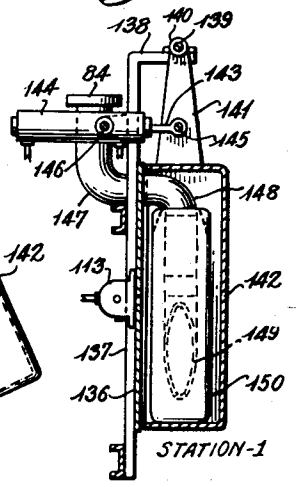
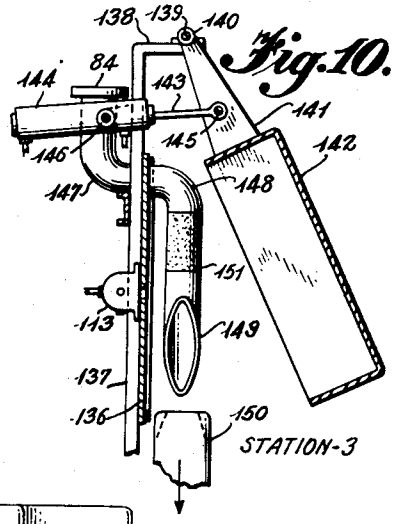


Fig. 10.



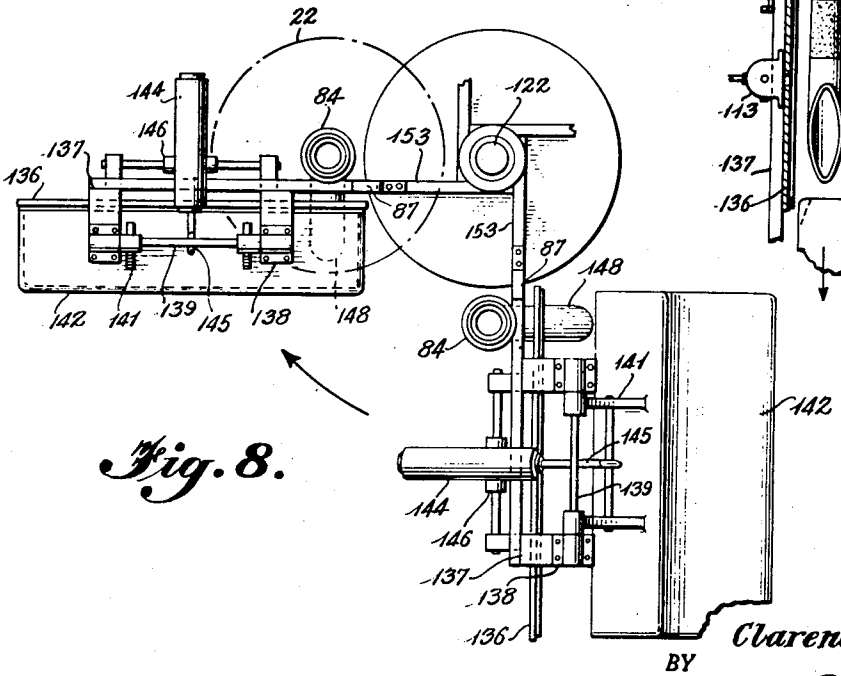


Fig. 8.

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United States Patent Office

2,756,906

Patented July 31, 1956

2,756,906

FILLING MACHINE

Clarence F. Carter, Danville, Ill.

Original application April 1, 1952, Serial No. 279,889, now Patent No. 2,687,271, dated August 24, 1954. Divided and this application January 16, 1953, Serial No. 339,320

4 Claims. (Cl. 222—203)

This invention relates to an automatic machine for weighing fine powders and vacuum filling of containers, and to the method thereof.

It is an object to automatically weigh powders with substantial accuracy, and to deliver them by vacuum methods to bags, boxes, cartons and the like, particularly containers holding 10–100 pounds of powder.

It is a further object to de-aerate the powders before delivery to the containers, so as to eliminate objectionable outage therein after the contents have settled.

Figure 1 is an elevation of a machine designed to accomplish these purposes.

Figure 2 is a sectional elevation of a hopper and valving mechanism shown diagrammatically in Figure 1.

Figure 3 is a plan view in section along the lines 3—3 of Figure 2.

Figure 4 is a plan view of the machine along lines 4—4 of Figure 1.

Figure 5 is an elevation in partial section of one of the shroud elements of the machine, with a bag in filling position.

Figure 6 is an end view in section along lines 6—6 of Figure 5.

Figure 7 is an elevation in partial section of a modification using a different type shroud and filling spout which may be used in place of those shown in Figure 1, one being in filling position and another with the shroud open and in position for receiving an empty bag.

Figure 8 is a plan view of Figure 7.

Figure 9 is an end view in section of a closed shroud with the bag filled.

Figure 10 is an end view in section showing the shroud open and the filled bag being dropped.

Referring to the figures, the automatic weighing feature will be described first, particularly in relation to Figures 1, 2 and 3. 1 is a large storage hopper of any conventional design. At the bottom of the hopper is a valve 2, connected by way of flexible coupling 3, to a first gross-weight hopper 4. Valve 2 is of the type generally designated A in Figure 2. A line 5, in the top of the hopper, leads to a source of vacuum and to atmospheric relief, through an arrangement generally designated as C in Figure 2. The hopper is suspended on a balance arm 6, by means of the knife edge 7. The lever actuates a conventional weighing scale 8. On the scale dial is a contact point 9, which may be contacted by the indicator hand 10 to close an electrical circuit not shown, thereby operating a solenoid valve and causing valve 2 to close, as hereinafter more fully explained. The contact 9 may be made adjustable by known means to correspond to any desired weight of material. At the bottom of hopper 4 is a second valve 11 of the type shown at A. A second flexible connection 12 joins the outlet of the valve with duct 13, which leads to a flexible connection 14 opening into weighing hopper 15. This hopper also is mounted by knife edge 16, on arm 17. This actuates a scale 18 similar to scale 8, equipped with a contact point 18', which actuates through appropriate electrical connections a solenoid valve which operates to cause valve 11 to close. The vacuum-relief line 19 is of the construction shown at C. At the outlet of the hopper is a valve 20, of the type designated B on Figure 2. A flexible connection 21 leads to final weighing hopper 22. This is mounted on the knife edge 23 and arm 24. A scale 25 is actuated by arm 24, has two contact points, one at 26 and one at 27, which may be contacted by pointer 25' to actuate solenoid valves controlling valve 20. Mounted on the bottom of the hopper is a valve 28, of the type designated A. A flexible connection 29 joins the hopper to a line discharging into a container as hereinafter described in greater detail.

Figure 2 is an elevation in section of hopper 22, showing details of the construction of valves A, B and C, as well as details of the internal hopper structure. Hoppers 4 and 15 are of similar construction. The hopper comprises an outer wall 30 of any suitable material such as sheet metal. The hopper is lined with a flexible material such as rubber, either synthetic or natural, the liner being designated 31. At the lower end, the liner is turned back over the end of the sheet metal hopper wall, and is held in place by flange 32 attached to the hopper and flange 33 attached to valve A. A channel 34 extends around the top of the hopper, and the liner 31 is turned back over the inside edge thereof and is held in place by the hopper lid 35 when it is clamped or bolted in place. Lying between the liner 31 and the outer wall 30 is a plurality of rubber tubes 36. These are sealed at their lower ends, and are held in position at the upper end by being turned back over the channel and held in place by the hopper top 35. These tubes are spaced apart as shown, the distance generally being of the order of 0.5–1 inch. Since the amount of surface at the upper end of the tapered hopper is greater than at the lower end, some of the tubes are necessarily shorter than others. An air-vacuum line 37 leads into the space between wall 30 and liner 31. This is connected to the atmosphere and to a source of vacuum not shown, through a three-way valve not shown, whereby the space between the wall 30 and the liner 31 may be alternately evacuated and relieved to the air. Since the tubes 36 are sealed and contain air, the flexible liner 31 will assume the position shown in Figure 3 when the space is evacuated, but upon relief of the air, the liner will return to its normal position. By rapidly alternating between vacuum and relief during the time the hopper is being filled and emptied, the liner is caused to vibrate and thus dislodge the powder that may be in the hopper, causing it to flow freely and quickly out of the hopper without substantial holdup. This action also assists in de-aerating the powder within the hopper.

The valve designated A is attached to hopper 22 by means of flanges 32 and 33. The body of the valve 38 is generally cylindrical. A flexible connection 29 is mounted by means of flange 39 to the exterior of the valve. The flexible connection is attached to flange 40. An air-vacuum line 41 extends through a compression fitting 42 to a T, 43, which is plugged at 44. Extending downwardly from the T is a tube 45, perforated at 46. Around the tube and covering the perforations is a rubber sleeve 47. Tube 45 is plugged at 48. The sleeve 47 is attached at each of its ends to tube 45, and when air pressure is applied through line 41, assumes the position shown in the dotted lines, thus completely closing the passage through the valve. Line 41 leads to a three-way valve which connects to a source of air pressure and to a vacuum supply. When vacuum is applied to line 41, tube 47 assumes the position shown in the drawing. It is important that vacuum be applied, since otherwise the sleeve 47 may not resume its normal position but may

wrinkle. Upon application of the vacuum, a substantially unobstructed annular passage is formed.

Hopper 15 is connected to the valve generally designated B, by means of flanges 50 and 51. This valve has three sections 52, 53 and 54, which are generally cylindrical. A rubber liner 55 is held terminally in section 53 by being pinched between flanges 56 and 57, 58 and 59. This rubber liner may be beaded at the ends.

Inside the cylindrical body is a smaller tube 60, which is supported by means of spider 61 or other suitable means. A relatively large, annular passageway is formed between tube 61 and liner 55. An air-vacuum line 62 extends through an appropriate compression fitting 63 to T 64, which is plugged at 65. Extending downwardly therefrom is a small tube 66, which is perforated at 67. This tube is plugged at the lower end. A rubber sleeve 68 is attached, as was described in connection with valve A, to tube 66. The liner 55 is inflated by applying air pressure to air-vacuum line 69, which extends through the wall of the section 53, through compression fitting 70. Upon being inflated, the liner 55 assumes the position shown by the dotted line. In a similar manner, by applying air to line 62, the liner 68 may be inflated to close the passageway between tube 60 and the liner 68.

Cover plate 35 is provided with an opening 71, which is covered by a screen 72 mounted by any convenient means, such as bracket 73. Corresponding with the opening 71 is an outlet tube 74, which may be attached to the T 75, one arm 76 of which leads to a source of vacuum, and the other arm 77 leads to the atmosphere. Mounted within lines 76 and 77 are two valves 78 and 79, of the type described in greater detail in connection with valve A. From these lead the lines 80 and 81, connecting with a three-way valve or cock 82. This valve connects by way of line 83 to a source of compressed air. Through shell of cock 82 is an opening 80', and a line 81' leading to line 76. A groove 82' affords communication between lines 81 and 81' when the cock is in the position shown, to deflate valve 79. When the cock is turned 90° counterclockwise, valve 78 is relieved through line 80, groove 82' and opening 80'.

Refer to Figure 5. Flange 40 is designed to coincide with flange 84 in sealing relationship. Flange 40 is forced against flange 84 and sealing rubber 85 by applying air pressure to air cylinder 86, the piston of which strikes bracket 87, forcing the two flanges into sealing relationship. This is done after hopper 22 has been filled and the contents are to be drawn into the container.

Leading from flange 84 is the filling tube or head 88. This extends through the top of a split shroud 89, which, when closed completely, surrounds a container such as bag 90. The bag shown is of the multi-walled type, which is sealed or sewed before filling and which is filled through a small opening left in one corner for introduction of the filling spout 91. This opening is closed after the filling operation is complete, by a flap 92, which automatically covers the opening when the contents of the bag rest against it. Such bags are of familiar design and form no part of this invention. The shroud 89 is made up in two sections, and may be of the type shown in Figures 1, 4, 5 and 6, or may be of the type shown in Figures 7 to 10. These sections, when closed, form a vacuum-tight receptacle surrounding the bag, as shown in Figures 5 and 6. One section of the split shroud is stationary, and is made up of wall 93, bottom 94, top section 95, and wall 96. The other, movable section is made up of top section 97 and walls 98 and 99. At all points of contact between the movable and the stationary sections is a resilient washer or sealing member such as shown at 100, to insure a gas-tight seal. On the movable section is mounted a bracket 101, to which is pivotally attached the piston 102 of an air cylinder whereby the movable section can be moved away from and upwardly from the stationary section to the position shown in the dotted lines in Figure 6 and in plan view in the representations of the two open shrouds on the righthand side of Figure 4. In plan view, the closed shrouds are illustrated by the two shrouds on the lefthand side of Figure 4. Since the split shrouds and the mechanism for opening and closing them are identical, the same reference numerals are employed. The air cylinder 103 is pivotally mounted on a frame 104, which is attached to the main frame of the machine. A pair of upper guide tracks 105, 105, and a corresponding pair of lower guide tracks 106, 106 (best seen in Figure 1), are mounted on frame 104 and are attached to a frame 107, 107, on which the stationary member of the split shroud is rigidly mounted. These guide tracks slope upwardly and away from the stationary member of the split shroud.

Mounted on the movable member of the shroud is a bracket 108, supporting rollers 109, which follow the guides 105 and 106 when the movable portion of the shroud is retracted by the air cylinder 103 and its piston 102. The air cylinders are of conventional design and need not be explained in detail. The manner of opening the shroud by swinging the movable portion outwardly and upwardly, permits ready placement of the bag on the filling nozzle 91 and removal of the filled bag from the shroud. The bag is removed from the shroud by operation of an air cylinder 110, which is mounted on wall 93 of the stationary member of the shroud and which has a platen 111 attached to piston 112 of the air cylinder. When the shroud is open, as shown in the upper righthand corner of Figure 4, the platen 111 thrust the bag outwardly and off of the floor 94 of the stationary member of the shroud. An empty bag is then placed in position as shown in Figure 5, by slipping the opening at the valve end over the nozzle 91.

Mounted on wall 96 of the stationary member is a three-way valve 113, which leads to a source of vacuum attached to line 114 when the valve is in the position shown and when the shroud is closed for filling. The three-way valve has a port 115 open to the atmosphere. Communication to the interior of the shroud is made through port 116.

The filling spout 91 may be equipped with a sealing device to prevent passage of powder from the interior of the bag into the shroud during the filling operation. In this case a section of extra heavy pipe 117 is provided. A portion of the pipe is cut away at 118, and over this is placed a grid or screen 119. A rubber sleeve 120 is placed over and supported by the grid. The sleeve is preferably a section of thin-walled rubber tubing, which is attached at either end to the pipe, and which fits substantially flush with the outside of the pipe section 117. This leaves an annular space around a part of the length of the pipe 117, which serves as an air pocket. When the interior of the shroud is evacuated during the filling operation, the thin-walled tubing 120 is caused to expand into the position shown by the dotted lines, due to expansion of the air within this annular space. The expanded tube 120 thus presses against the end of the bag and the closure flap 92 sufficiently to prevent dust from escaping from between the filling spout and the bag into the shroud. Since the rubber tube 120 is substantially flush with the outside of pipe 117, it offers no impediment to the bag being placed over the spout.

The apparatus can be operated as a single-head unit, or a plurality of the shroud elements can be mounted on a rotatable dial, as shown in Figures 1 and 4, for a more rapid filling operation. In this case, the unit is mounted on a stationary base 121, supporting a vertical pipe 122, over which is a rotatable pipe 123 to which is rigidly attached a rotatable dial or platform 124, supported by a web 125. The supporting frames 107 for the stationary portion of the split shrouds are rigidly attached to dial 124. The dial is rotated by any suitable means, such as motor 126, speed reducer 127, and Geneva movement 128. These are all well known mechanical devices and need not be described in detail. Mounted above the

Geneva movement is a conventional rotary air valve, generally indicated at **130**. This supplies air to the air cylinders which open and close the shrouds and eject the filled bags, and is designed to time their operation at the appropriate stations. The rotary valve and timing means are not per se a part of the invention, since any suitable means may be used. The lower member **131** is stationary, and the upper member **132** revolves with the member **123**. Air inlets **133**, and air outlets **134**, are provided. Air passes through grooves (not shown) in the face of member **131**. These coincide with the ports **134**, so that air is supplied at the required time, and for the interval necessary, to operate the air cylinders for opening of the shroud and ejection of the bag at the proper stations.

The weighing hoppers are supported by any suitable structure not shown, above the rotating elements. As shown in Figure 4, station I is the filling station. As the device is rotated between stations II and III, the air cylinder **103** is actuated by air received from rotary valve **130** through line **134** to cause the shroud to open, so that by the time it reaches station III, it is completely open and the bag is ready for discharge. At this point, air cylinder **110** is actuated to push the bag out of the shroud into chute **135**, from whence it travels to the disposal point. The shroud unit at station IV is open, and at this point a bag is slipped over the filling spout. It will be noted that the rotation of the unit is intermittent, so that during the period of time necessary to fill the unit in station I, there is plenty of time for the filled bag to be ejected at station III and for another bag to be placed over the filling spout at station IV. After the bag is filled at station I, and as the element to which the bag has been added at station IV moves forward into station I, the split shroud is closed by the air cylinder, and by the time the element reaches station I, it is ready to be filled. In Figure 1, at **90***a* and **90***b*, a filled bag is shown as it is ejected from the open shroud.

The operation

As illustrated in Figure 1, three weighing hoppers and a storage hopper are provided. Two of the weighing hoppers are for obtaining rough weights, and likewise serve the purpose of de-aerating the powder. The third hopper **22** is a final-weight hopper.

A powder such as carbon black, zinc oxide, or any other finely divided bulk material, is placed in storage hopper **1**. Hopper **4** is evacuated through line **5**. Powder is drawn through valve **2**, which is open. Since hopper **4** is suspended by means of the knife edge **7** and the lever **6**, and is conducted by flexible coupling to the storage hopper **1** and the line **13**, the arm **6** is free to act upon scale **8**, the indicating pointer **10** of which is set at 0 before the filling operation begins. As the hopper fills with powder, the arm **10** rotates and eventually contacts point **9**, which closes an electrical circuit actuating a solenoid valve, causing valve **2** to close as hereinbefore described. By the use of relays and a timing device, all well known, valve **2** can be kept closed until hopper **4** is ready to receive another charge of powder. Scale **8** is set so that the amount of material weighed into hopper **4** is in excess of that which is ultimately to be delivered to the container. This excess amount may vary from a few ounces to several pounds. The material having been delivered to hopper **4**, hopper **16**, which is empty at this point, is evacuated, line **5** is closed to vacuum and is relieved to atmospheric pressure; valve **11** is opened and the contents of hopper **4** move into hopper **15**. The scale **18**, actuated in a similar manner to scale **8**, causes valve **11** to close when the pointer strikes contact **18'**. Again the charge transferred to hopper **15** is slightly in excess of that to be ultimately delivered to the container, although in general it may be more nearly the desired amount than is that delivered to hopper **4**. Hopper **15** is now released to atmospheric pressure by operation of the valve on line **19**, and hopper **22** is evacuated. Valve **20** is opened, this operating in the following manner to deliver an accurate, predetermined weight of powder to hopper **22**.

The valves in Figure 2 are shown in position for drawing powder from hopper **15** into hopper **22**. Valve **79** is open, valve **78** is closed, valve B is open, and valve A is closed. Hopper **22** is being evacuated, which causes powder to flow from hopper **15** into hopper **22** through the two annular spaces shown in valve B. Hopper **22** is suspended as shown in Figure 1. When the weight of material in hopper **22** is sufficient such that scale indicator **25'** strikes contact point **26**, the solenoid valve controlling line **69** is actuated, thereby applying air pressure to liner **55** and causing it to inflate and close the outer large annular space around tube **60**. This shuts off the major flow of powder. The point of contact is selected so that the weight of powder introduced into hopper **22** is slightly less than that ultimately desired. This may be a matter of an ounce or several ounces, depending upon the size of the valve and the amount of powder to be weighed. Powder continues to be drawn through the inner annular space around tube **66**, and the scale indicator **25** continues on as the weight of powder in hopper **22** increases until it contacts point **27**, at which point another solenoid valve is actuated to apply air pressure to line **62** and inflate rubber sleeve **68**, thus closing the valve and shutting off any further flow of powder from hopper **15**. Hopper **22** now contains the exact amount of powder desired, and it is ready for transfer to the ultimate container. The solenoid valves referred to may be of type such as V–5 of Skinner Chuck Company, Norwalk, Connecticut.

Valve **20** is then closed, and hopper **22** is released to atmospheric pressure. By this time one of the shrouds, containing an empty bag and ready for filling, moves into position at station I. Flanges **40** and **84** are clamped together as shown in Figure 5. The interior of the shroud is evacuated by pulling a vacuum through line **114**, and three-way valve **113** being in the position shown in Figure 6. Until the shroud is substantially evacuated, valve **28** is kept closed. As it is evacuated, the thin rubber tube **120** expands to seal the opening in the corner of the bag. When the desired vacuum has been reached (and this is ordinarily within the range of about 15 to 20 inches of mercury), valve **28** is opened, and the entire contents of hopper **22** are pulled into the bag. The sudden release of the contents into the bag causes the material to pack. As previously pointed out, each of the hoppers is constructed as shown in Figure 2, so that the vibrating effect of the inner liner prevents hangup of powder inside the hopper, so that this, together with the difference in pressure on the powder in the hopper and within the bag, causes the complete delivery of an accurately weighed amount of material to the container.

At this point valve **113** is rotated 90° counterclockwise to relieve the vacuum within the shroud, the air cylinder **86** is released, and the seal between flanges **40** and **84** is broken. Since the flexible coupling **21** is stretched when the flanges are clamped together, the contraction upon release allows flange **40** to swing clear of flange **84**. In the rotary machine above described, the hopper **22** is again filled with an accurately weighed amount of powder while the dial is being rotated one quarter turn to bring the next unit into filling position. The normal position of flange **40** must be slightly above flange **85**, to permit the shroud unit to move into filling position, and when it reaches this position, the air cylinder **86** may be actuated by any well known means to cause flange **40** to seal against flange **84** and gasket **85**.

As previously mentioned, the operation of this filling apparatus causes a de-aeration of the powder. Many fine powders such as carbon black and the like, are light and fluffy due to the fact that air is entrapped between the particles. Such a condition is necessary to the free flow of the powder, but if this fluffy powder is placed directly

in a container, the container must be of sufficient volume to hold the desired weight of aerated powder, which means that when the powder settles, the container will show considerable outage. This is undesirable.

In the present apparatus, each of the hoppers 4, 15 and 22 are constructed as shown in Figure 2. The operation of this device has been explained above. The walls alternately present the corrugated pattern shown in Figure 3 and then assume a substantially smooth inner surface when the vacuum is released. This exerts a lateral squeezing or kneading action on the powder as it lies in the hopper. This aids in releasing entrained air in the powder. Since, as the hopper is being filled, it is under vacuum, the combined effect of the vacuum and the kneading action is to hasten the removal of air from the powder, and to cause it to become more and more compact. When the hopper is discharged, either to the next hopper in line, or to the container, the body of the powder is drawn downwardly and into the constriction at the valve, so as to further tend to squeeze out the air entrapped in the powder. Thus, as the powder progresses from one hopper to the next, the ultimate effect is to continuously knead the powder and to force the air out of it, and as a consequence, it becomes more and more compact; that is, the apparent density is reduced. By the time it reaches the container, the largest portion of entrapped air has been removed, and as a consequence, a smaller container could be used than if the air-filled powder were directly introduced into the container. The movement of the withdrawn air is counter to the movement of the powder, so that it is continuously agitated, and this assures rapid and uniform flow without compacting the powder to such an extent that it will bridge, or collect on the walls.

In Figures 7 to 10 is illustrated another and preferred form of shroud. This shroud comprises a plate **136**, rigidly mounted on the supports **152**, **153** which may be used in place of dial **124**. A support **137** is provided for this purpose. Support **137** is provided with an arm **138**. Plate **136** serves as one side of the shroud. Mounted on the arm **138** is a rod **139**, which passes through the bearings **140** attached to levers **141**, which in turn are attached to the movable member of the shroud **142** which forms the remaining side thereof. The piston **143** of an air cylinder **144** is pivotally connected at **145** to cross bar **146**, which extends between the member **141**. The air cylinder is mounted on a bracket **146'**, which is attached to supports **137**. A three-way valve **113** is attached to the stationary member **136**, as previously described in connection with Figure 6. A filling spout is attached to the flange **84** as a vertical section **147**, forming an S at **148** and passing through one corner of the stationary member **136** and thence downwardly to a spout **149**. A bag **150**, which is sewed as previously described, and having a sealing flap at the top corner, is slipped over the vertical spout **149**. In this case the bag lies on its side, resting on the bottom of the member **142**, as may be seen by examination of the righthand portion of Figure 7, and Figure 9. The spout **149** may be provided with a sealing means **151**, such as that illustrated in connection with Figure 5. When the bag is filled, it assumes the position shown in Figure 9. When the shroud element reaches station III, the movable element **142** of the split shroud is thrust outwardly by actuating air cylinder **144**, and the bag drops downwardly as shown in Figure 10 onto a chute or conveyor belt, to be removed to storage.

As illustrated, two elements of a four-shroud unit are shown in Figures 7 and 8. It is possible to construct the apparatus with only three units, and hence three stations, namely, a filling station, a dumping station, and a bag-placement station. As previously mentioned, this can also be constructed as a single-station machine. The multiple-station machines provide for greater filling capacity than can be realized with a single-unit machine. The various operations are synchronized by suitable timing devices, so that it is automatic. Generally the bags are placed in position by hand. The containers can be positioned for filling by automatic means, which will vary depending upon the type and construction of the container, appropriate modifications being made for this purpose. The machine can also be designed to operate with a larger number of units and having more than one filling station.

The invention is not limited to the exact embodiments illustrated.

This application is a division of my co-pending application Serial No. 279,889, filed April 1, 1952, and now United States Patent No. 2,687,271.

I claim as my invention:

1. A hopper having an opening at the top and a discharge outlet at the bottom, comprising a rigid tapered outer shell, a continuous elastic inner liner attached to the hopper in gastight relationship at the top and the discharge outlets, a plurality of tubular elements between the liner and the shell to space the liner from the shell, said elements being fixed to the shell adjacent the top at substantially regular intervals around the periphery thereof, and extending downwardly along the shell wall toward the outlet of the hopper, a top for the top opening of the hopper, means in the hopper top for introducing powder into the hopper, and means for cyclically evacuating and relieving the vacuum in the space between the liner and the shell.

2. The apparatus of claim 1 wherein the tubular elements are rubber tubes sealed at each end.

3. The apparatus of claim 1 wherein some tubular elements extend to points adjacent the discharge outlet, and some elements extend to points intermediate the length of the hopper.

4. A hopper comprising a rigid conical outer shell having an open top and a bottom outlet, a continuous elastic inner liner attached to the shell in gastight relationship at the top and discharge end, a plurality of elongated spacing elements between the liner and the shell, said elements being fixed to the shell at substantially regular intervals around the periphery thereof and extending downwardly along the shell wall from the top toward the outlet of the hopper, a top for closing said hopper, means for evacuating the hopper, means for introducing powder into the hopper through said top when evacuated, means for releasing the vacuum on the hopper, vacuum means for removing powder from the hopper through the bottom outlet, and means for cyclically evacuating and relieving the vacuum in the space between the liner and the shell.

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