

Oct. 1, 1957

W. S. BOHLMAN ET AL
VIBRATORY PACKING MACHINE

2,807,975

Filed April 1, 1953

3 Sheets-Sheet 1

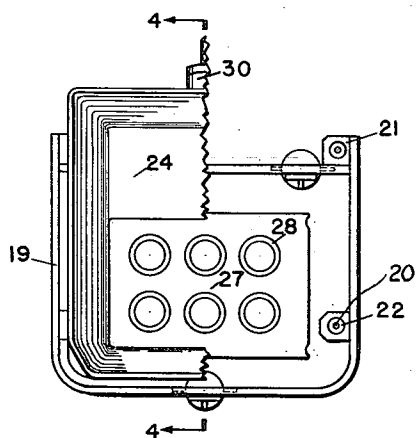


FIG. 1

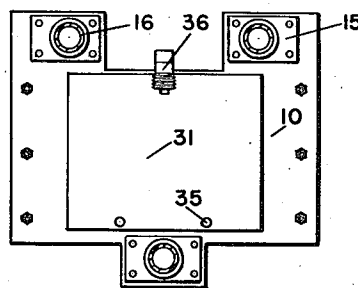


FIG. 3

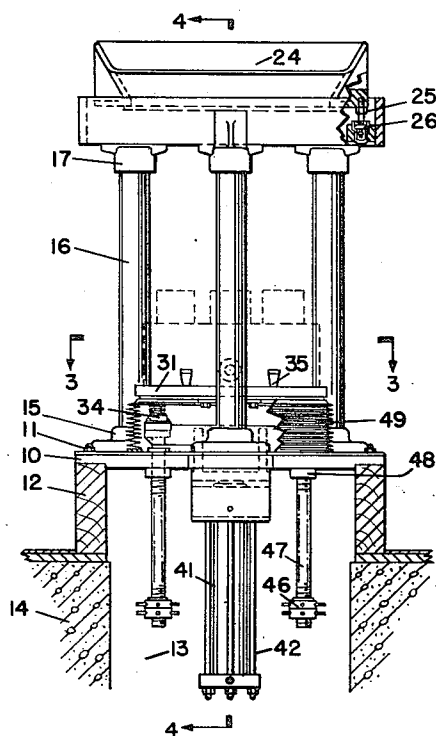


FIG. 2

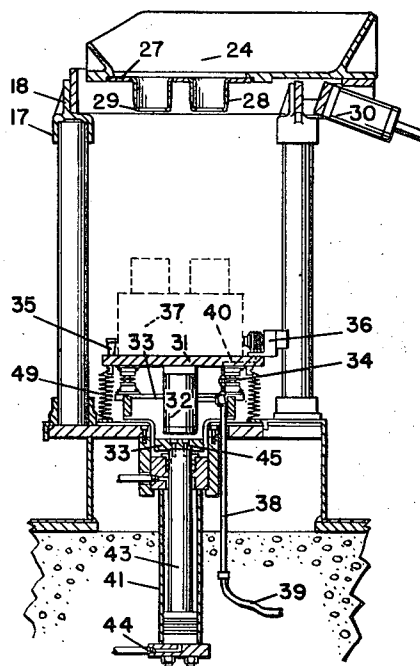


FIG. 4

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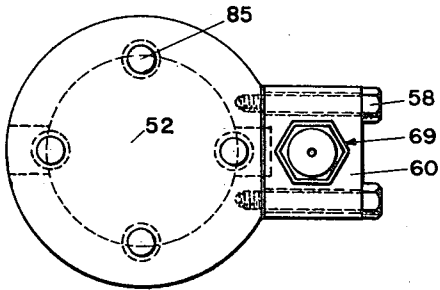


FIG. 5

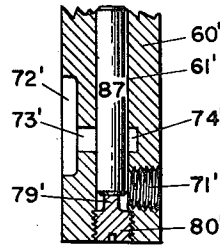


FIG. 7

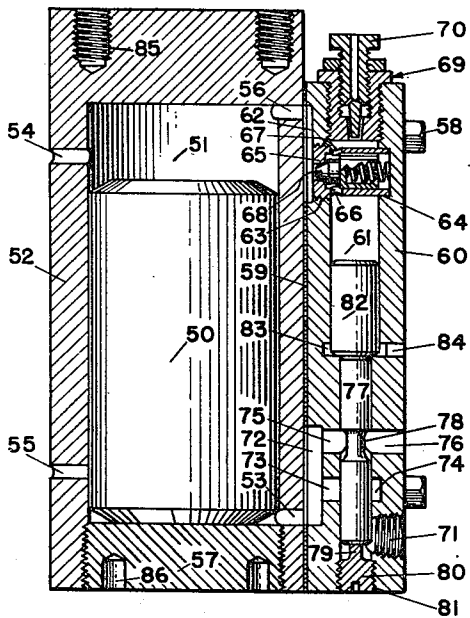


FIG. 6

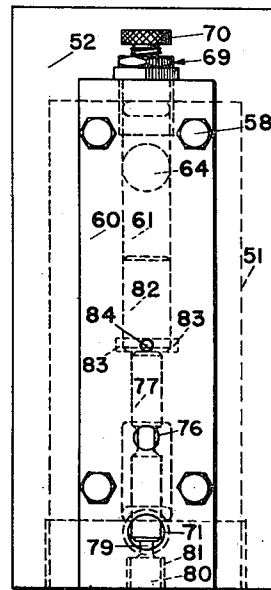


FIG. 8

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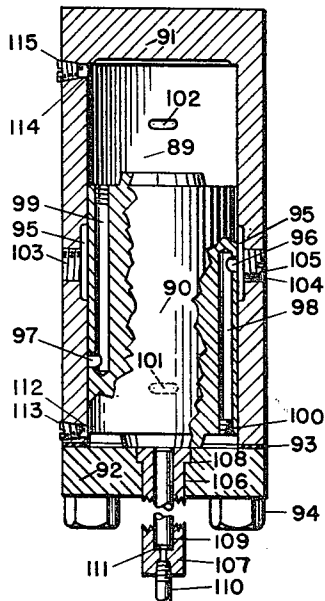


FIG. 9

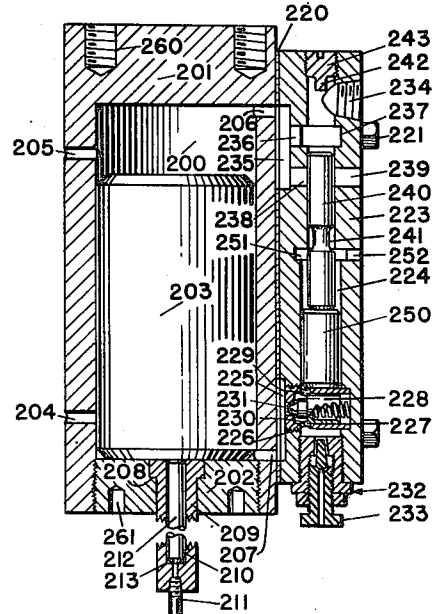


FIG. 10

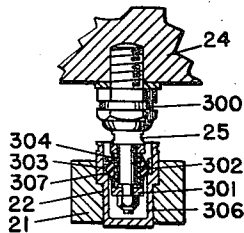


FIG. 11

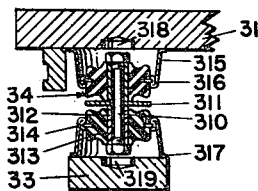


FIG. 12

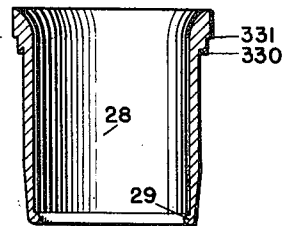


FIG. 13

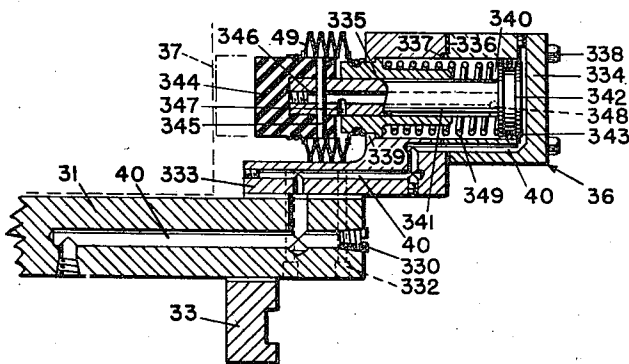


FIG. 14

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VIBRATORY PACKING MACHINE

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Application April 1, 1953, Serial No. 346,115

13 Claims. (Cl. 86—20)

This invention relates to a vibratory packing machine and more particularly to a vibratory packing machine especially adapted to the packing of large size explosive cartridges.

Packing by vibration is, in most cases, a very desirable and easy method of packaging loose, pulverulent materials. As long as it is only necessary to fill the container or to settle a predetermined weight of a particular material in a container, it has been found that vibration can usually be employed quite readily. Problems, of course, arise in the determination of the particular type of vibrator or the particular frequency of vibration which will give optimum performance and power economy with a given material. For example, it has been found with known vibratory packing equipment that a high-speed vibration does not lend itself to the packing of light, fluffy, materials such as soap chips or aluminum leafing powder. With heavier materials it has been found that with known equipment, high vibration frequency and greater force of each oscillation are necessary. The solution of these problems has been found in the designing of specific electric or fluid-actuated vibrators for particular applications at considerable expense. As a result, the actual use of vibratory packing has been relatively limited despite its overall attractiveness.

A problem of even greater magnitude has been encountered in attempting to pack an entire container to a uniform density. In the packing of most materials, a substantially uniform density is not important as long as a certain weight of the material is packed in a prescribed space. In such applications as the packing of explosive cartridges, however, it is very often essential that the entire cartridge be packed as near as possible to a uniform density. Further, it is equally important and desirable to pack successive cartridges to substantially the same density in order to obtain the same brisance and detonation velocity in successive cartridges of the same type. In the past, various types of vibratory packing machines employing various sources of vibration have been tried but to the present time no successful vibratory packer for explosive cartridges has ever been developed.

The first attempts to pack explosive cartridges by vibration were directed to the use of eccentric wheels and cam mechanisms which imparted a jolting motion to the shuttle holding the cartridge. It was also attempted to employ fluid-operated jolters similar to those used in founding machines in packing sand around molds. Both of these types were completely unsuccessful. The speed of vibration of each was relatively slow with the result that the bottom portion of the cartridge was of greatest density with a progressive diminution in density toward the top. Furthermore, neither type of device was satisfactory in packing explosives from the safety standpoint.

There are now available many types of high speed vibrators, but none of these have proved successful in explosive packers. Electric vibrators cannot be safely used because of the undesirability of having an electrical

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device in close proximity with explosive materials. Currently available fluid-actuated vibrators are characterized by vibration frequencies which are either too high or too low and are further unsatisfactory in that they do not combine a satisfactory power delivery with a satisfactory frequency. While their frequency can be varied by varying the pressure of the actuating medium, the changed speed of vibration is accompanied by a corresponding change in the power of the vibration.

As a result, the manufacturers of explosives are universally packing large size explosive cartridges by hand and are employing the well known Hall-type or Kimber-type packing machine for smaller cartridges. Packing with the Hall-type or Kimber-type machine is achieved by forcing explosive into the shells by means of reciprocable tamping rods. While leaving much to be desired in speed and uniformity of packing, these packers do an acceptable job with the smaller explosive cartridge. Consequently, most of the improvements in explosive packers have centered around this type of machine. However, the Hall-type machine has not been found feasible for cartridges of above two inches in diameter. A few Kimber-type machines have been rebuilt to pack cartridges up to five inches in diameter but have not been used to any great extent.

Now in accordance with the present invention, large size explosive cartridges may be quickly packed to a high and uniform density by vibration. Furthermore, in accordance with an additional embodiment of the vibratory packing machine of the invention, the power of the vibration and the vibration frequency may be independently and positively controlled to achieve the optimum packing efficiency for any given material at the lowest possible power expenditure.

Generally described, the present invention comprises a platen having rigidly attached thereto a pneumatic vibrator having a unidirectional power stroke upwardly and substantially parallel to the vertical axis of the platen, support means for the platen, and resilient mountings connecting the platen to its support means. According to various embodiments of the invention, the unit of a platen vibrator, resilient mountings and platen support means is, by suitable supporting members, mounted in combination with means for introducing the materials to be packed into the containers and means for raising and lowering the platen assembly with relationship thereto. According to an additional embodiment of the invention, means are provided for rigidly positioning the cartridges on the platen during the packing operation. According to still further embodiments of the invention, various pneumatic vibrators having a unidirectional power stroke are employed in conjunction with the platen and/or the means for introducing the material into the containers.

In order to be operable as the shuttle vibrator in the vibratory packer of the invention, the vibrator must have a unidirectional power stroke. Preferably, the vibrators used in the invention will also be equipped with frequency control valves which will enable the operator to employ a vibration of the necessary force and frequency to give optimum packing efficiency. The preferred vibrator has in combination a casing forming a cylinder, a reciprocable piston disposed in the cylinder, exhaust ports located in the casing adjacent the opposite ends of the cylinder, an air inlet for pressurized air leading to one end of the cylinder, an air exit passage for air compressed by the piston leading from the opposite end of the cylinder, and a valve assembly; said valve assembly having in combination a first passageway therethrough which is in communication at one end with the air inlet in the vibrator casing and at the other end with a source of pressurized air; a second passageway therethrough, one end of which

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is in communication with the air exit passage in the vibrator casing and the other end of which leads to the atmosphere, said second passageway having a check valve at the end thereof which registers with the air exit passage and a metering means for air at the end thereof leading to the atmosphere; and slidable means disposed within the valve assembly which is movable in one direction to close the first passageway under the force exerted by the compressed air admitted to the second passageway through the check valve and which is movable in the opposite direction to open the first passageway under the force exerted by the pressurized air when sufficient of the compressed air is released to the atmosphere through the metering means.

If a vibrator is employed which does not have a frequency control valve assembly, the vibrator preferred has in combination a casing forming a cylinder, a reciprocable piston mounted in the cylinder, an annulus formed in the cylinder wall substantially equidistant from the ends thereof, a passage extending longitudinally into the piston at a point which registers with the annulus in the cylinder wall when the piston is in the down position and which remains in communication with said annulus during a substantial portion of the piston's upward power stroke, a duct leading from said passage and opening into the cylinder from the bottom of the piston, and exhaust ports located in the casing adjacent the opposite ends of the cylinder, the distance between the exhaust ports being substantially equal to the length of the piston.

Also included in the present invention is a process or system for packing pulverulent materials to a high and uniform density which comprises introducing the pulverulent material into a container, intermittently imparting a plurality of vertical upwardly applied impulses to the container and allowing the container to fall freely after each upwardly applied impulse. In one specific embodiment of this process, the upward movement of the container continues until the inertia supplied by the upward impulse is dissipated. Then the container is allowed to fall freely until the next upward impulse is applied. This type of motion is obtained with the apparatus of the invention when the containers are not secured to the platen. In a further embodiment of this process, the upward motion of the container is gradually arrested and the free fall of the container is gradually decelerated prior to application of the next upward impulse. This type of motion is obtained with the apparatus of the invention when the containers are secured to the platen. In either type of vibratory movement, there is no force other than gravity applied during the downward travel of the container with the result that packing accomplished by the upward force applied is not undone by a reversely applied force.

Having generally described the present invention, further and more specific illustration is given with reference to the accompanying drawings wherein reference symbols refer to like parts wherever they occur. In the drawings, Fig. 1 is an elevational plan view of a vibratory packing machine in accordance with an embodiment of the invention. Fig. 2 is a side, part elevational, part sectional view of the device of Fig. 1. Fig. 3 is a plan view of the device of Figs. 1 and 2 taken along line 3—3 of Fig. 2. Fig. 4 is a part elevational, part sectional view of the device of Figs. 1, 2, and 3 taken along line 4—4 of Fig. 1 or Fig. 2. Fig. 5 is a plan view of an embodiment of the preferred platen vibrator. Fig. 6 is a part elevational, part sectional view of the vibrator of Fig. 5. Fig. 7 is a part elevational, part sectional view of an alternate portion of a vibrator valve assembly which may be substituted for the corresponding portion of the valve assembly of the vibrator shown in Fig. 6. Fig. 8 is an elevational end view of the vibrator of Fig. 6. Fig. 9 is a part elevational, part sectional view of a vibrator which may be used for either the feed hopper or platen vibrator. Fig. 10 is a part elevational, part sectional

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view of an alternate hopper vibrator. Fig. 11 is a sectional view of one of the resilient hopper mountings shown in Figs. 2 and 4. Fig. 12 is a sectional view of one of the resilient platen mountings shown in Figs. 2 and 4. Fig. 13 is a sectional view of a feed hopper nipple shown in Fig. 4. Fig. 14 is a part sectional, part elevational view of the shuttle box positioning means shown in Fig. 4.

Referring now to the drawings, and more particularly to Figs. 1—4, a vibratory packing machine is shown in which a steel base plate 10 is secured by bolts 11 to a hardwood base 12 over a pit 13 lined with concrete 14. Secured to the base plate 10 on cast brass bases 15 are three stanchions 16 formed from heavy brass pipe. Cast brass caps 17 with vertically extending projections 18 are secured to the upper ends of the stanchions 16. Secured to the vertical projections 18 of the stanchion caps 17 is an aluminum hopper supporting frame 19. Attached to the hopper supporting frame 19 by brass cap screws 20 are hopper mounting plates 21 containing stepped bores 22. Fitted into the bores 22 are bronze casings 306 shown in detail in Fig. 11. A feed hopper 24 is connected to the feed hopper supporting frame 19 by studs 25 and tube-form resilient mountings 26, which supporting assembly will be specifically described with reference to Fig. 11.

Disposed in the bottom of the feed hopper 24 is a bronze nipple plate 27 having nipples 28 extending downward therefrom. Each of the nipples 28 has a constriction 29 formed immediately adjacent to its egress orifice as shown specifically in Fig. 13. A pneumatic vibrator 30 is secured to the hopper support frame 19 at an angle of about 20° below the horizontal. The vibrator 30 has a unidirectional power stroke in the direction away from the hopper 24 and will be subsequently described in detail.

Disposed below the hopper assembly and over the base plate 10 is a rectangular aluminum platen 31 having rigidly attached thereto and suspended therefrom a pneumatic vibrator 32, various embodiments of which will be specifically described hereinafter with reference to Figs. 5—9. The platen is secured to a platen support frame 33 by means of resilient mountings 34 which will be subsequently described with reference to Fig. 12. Disposed in one side of the platen 31 are rubber-capped positioning studs 35. Secured to the opposite side of the platen 31 is a fluid-actuated gripping piston assembly 36 which will be subsequently described with reference to Fig. 14. Disposed on the platen 31 between the positioning studs 35 and gripping piston assembly 36 is a shuttle box 37. The shuttle box 37 may loosely hold the container to be loaded so as to allow free vertical movement or may hold the containers rigidly and thus transmit the movement of the platen 31 directly to the containers. An air delivery pipe 38, which is connected to a power line (not shown) by a rubber hose 39, supplies air to both the vibrator 32 and also to the gripping piston assembly 36 by means of a passage 40 in the platen as shown in Fig. 14.

A cylinder 41, maintained in position by guy rods 42, is disposed below the platen assembly and extends downward into the pit 13. Within the cylinder 41 is mounted an elongated piston 43 which is actuated by a fluid medium admitted to the bottom of the cylinder through an inlet 44. The upper end of the piston 43 is connected to the platen support frame 33 by means of bolts 45. The distance to which the platen 31 can be raised by the piston 43 is determined by the setting of the lock nuts 46 on guide rods 47. The guide rods 47 pass through bushings 48 disposed in orifices in the base plate 10 and are connected to the platen support frame 33 midway between the resilient mountings 34. A bellows 49 is secured to the top of base plate 10 and the bottom of the plate 31 and prevents the material being packed or

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foreign matter from gaining access to the area enclosed therein.

In Figs. 5, 6, and 8 is shown an embodiment of the preferred pneumatic vibrator having a unidirectional power stroke for use on the platen as shown in Fig. 4. In this preferred pneumatic vibrator a reciprocable piston 50 is positioned in cylinder 51 formed by a casing 52. An air inlet 53 to the cylinder is located in one end of the casing 52 and exhaust ports 54 and 55 are positioned in the casing 52 at points equidistant from the ends of the cylinder. The distance between exhausts ports 54 and 55 is such that during reciprocation one end of the piston begins to cover one port as the other end of the piston begins to uncover the other port. An additional air exit passage 56 from the cylinder 51 is situated in the casing 52 at the end opposite the air inlet port 53. A threaded plug 57 seals the bottom of the vibrator casing 52 and is of a size which enables insertion and withdrawal of the piston 50.

Affixed to the side of the vibrator casing 52 by bolts 58 and sealing gasket 59 is a valve assembly having a casing 60 which forms a chamber 61 having two portions of different diameter. A recess 62 is located in the valve casing 60 and is in communication with the air exit passage 56 in the vibrator casing 52. A thread 63 is formed in valve casing 60 and extends into the chamber 61. A recess 64 is formed in the wall of casing 60 opposite the thread 63. A threaded spring-actuated check plug 65 threadedly engages the thread 63 with the base of the plug being retained in the recess 64. Check plug 65 has ports 66 and 67 located respectively in the upper and lower walls thereof. A valve 68 in check plug 65 allows the passage of compressed air through ports 66 and 67 into the chamber 61 from the recess 62 but prohibits a reverse flow. Above the check plug 65 the casing 60 is threaded to receive a threaded, adjustable exhaust valve 69. The valve 69 is adjusted by screw 70 and whenever the valve 69 is partially or fully open, chamber 61 is in communication with the atmosphere through the ports 66 and 67 in the check plug 65 and through the valve 69.

An air inlet 71 is located in the valve casing 60 near the closed end of the portion of chamber 61 having the smaller diameter. A passage 72, formed by a recess in the valve casing 60, is in communication with inlet port 53 in the vibrator casing 52. In communication with recess 72 is a passage 73 which opens into chamber 61 above the air inlet 71. Recess 74 in the casing 20 is a continuation of passage 73 across chamber 61 and into the casing 60. Also in communication with the recess 72 is a passage 75 which opens into the chamber 61 at a point above passage 73. Passage 76 is a continuation of passage 75 across chamber 61 and through casing 60 to the atmosphere.

A reciprocable piston 77 is disposed in slidable, substantially air-tight relationship in the portion of the valve chamber 61 having the smaller diameter. An annular groove 78 is cut in the piston 77 at a point which causes the groove 78 to register with passages 75 and 76 when, as shown, the piston is fully within the portion of the chamber having the smaller diameter. The distance to which the piston 77 may extend into this portion of the chamber is governed by the projection 79 of the threaded plug 80 disposed in the threaded opening 81 of the valve casing 60 at the base of the chamber 61.

A piston 82 is disposed in slidable, substantially air-tight relationship below check plug 65 in the portion of the chamber having the greater diameter. The length of the piston 82 is such that when it is forced upward by the piston 77, the lower end of the piston 77 is able to clear the upper edge of passage 73 and recess 74, thus bringing air inlet 71 and passage 72 into communication. An annulus 83 is formed in the wall of chamber 61 at the point where the piston 82 meets the piston 77 when the

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piston 77 is resting on the projection 79 of the plug 80. An orifice 84 is provided in the valve casing 60 which leads from the annulus 83 to the atmosphere, thus allowing air to enter the large portion of the chamber 61 under the piston 82 when said piston is forced upward by the piston 77. When the piston 82 returns to the position shown in Fig. 6, the air admitted on the up-stroke exhausts to the atmosphere.

Threaded sockets 85 are provided in the top of the vibrator casing 52 for securing the vibrator to the platen. Sockets 86 are provided in the plug 57 to receive a spanner for securing the plug 57 in place.

Referring particularly to Fig. 7, a portion of a valve assembly is shown which may be substituted for the corresponding portion of the valve assembly shown in Fig. 6. A chamber 61' is formed in a casing 60' and is closed at its lower portion by a threaded plug 80' having a projection 79'. An air inlet 71' is disposed in the casing 60' and opens into the chamber 61' at a point substantially opposite the projection 79' of the threaded plug 80'. A recess 72' is formed in the casing 60'. A passage 73' leads from the recess 72' and opens into the chamber 61' at a point above the air inlet 71'. The passage 73' is extended across the chamber 61' and extends a short distance into the opposite cylinder wall to form a recess 74'. A reciprocable cylindrical piston 87 is disposed in slidable, substantially air-tight relationship within the chamber 61'. It is at once apparent that the structure shown in Fig. 7 differs from the corresponding portion of the valve assembly shown in Fig. 6 only in that the exhaust passages 75 and 76 and annular groove 78 in the piston 77 of Fig. 6 have been omitted. The substitution of the portion of the valve assembly of Fig. 7 for the corresponding portion of the valve assembly of Fig. 6 results only in a slightly shorter power stroke of piston 50 since less air is able to escape from the cylinder 51 during the exhaust stroke of the piston 50. The structure shown in Fig. 6 is preferred although the increased air cushion below the piston inherent in the structure of Fig. 7 gives quieter operation.

The vibrator illustrated in Figs. 5, 6, and 8 operates as follows: Pressurized air is admitted through air inlet 71 of the valve assembly. Pistons 77 and 82 are forced upward by the pressure of the incoming air and the pressurized air flows through passage 73, passage 72, and air inlet 53 to cylinder 51 at the base of the vibrator piston 50. Vibrator piston 50 is forced upward and once the piston has closed exhaust port 54, the remaining air in the top of the cylinder 51 is compressed and forced through air exit passage 56, recess 62 and the check plug 65 into the chamber 61 above the piston 82. Due to the fact that the area of the end of the piston 82 is greater than the area of the end of piston 77, the air compressed in the valve assembly above piston 82 is able to force pistons 82 and 77 downward, whereupon the lower end of the piston 77 shuts off the flow of incoming air through air inlet 71. Depending upon the setting of the needle valve 69, a certain period of time is required for sufficient of the pressure above the piston 82 to be bled to the atmosphere. Once sufficient of the pressure above the piston 82 has been released, the pressure of the incoming air through air inlet 71 is able to force the piston 77 upward once more and allow the pressurized air to flow to the vibrator cylinder 51 at the base of the vibrator piston 50. While the piston 82 is depressed, however, the vibrator piston 50 falls due to the force of gravity and the expansion of the air cushion at the top of the cylinder 51. When the vibrator piston 50 falls, the air below the piston is exhausted through exhaust port 55 and backward through air inlet 53 to passage 72 from which it is bled to the atmosphere through passage 75, the annular groove 78 in the piston 77, and passage 76. Once the exhaust port has been covered by the falling vibrator piston 50, the passage provided through the valve assembly is the only

means of exhaust from the lower part of the vibrator cylinder 51.

It is at once apparent that the frequency of the vibrator described can be altered at will merely by adjusting needle valve 69 to vary the rate at which the air is released to the atmosphere from above piston 82. This variation in vibration frequency is achieved without any diminution whatsoever in the force of the individual power stroke of the vibrator piston 50. Consequently, it is possible to vary both the force of the individual power stroke and the vibration frequency to suit the demands of the particular material being packed with the vibratory packing machine of this invention.

In Fig. 9 is shown a part sectional, part elevational view of a pneumatic vibrator having a unidirectional power stroke which may be easily converted for use as a platen vibrator or as the hopper vibrator in the vibratory packing machine in accordance with the invention. A reciprocable piston 90 is disposed in a cylinder 89 formed by a casing 91. The lower portion of the casing 91 is formed by a cylinder head 92 which is held in air-tight relationship to the remainder of the casing 91 by a gasket 93 and studs 94. An annulus 95 is formed in the wall of the cylinder at a point equidistant from the ends thereof. Passages 96 and 97 are formed in the outer periphery of piston 90 at points which register with the center of annulus 95 when the piston 90 is alternately at the end of either its exhaust or power stroke. A duct 98 leads from the passage 96 through the piston 90 to the bottom of piston 90. A duct 99 leads from the passage 97 through the piston 90 to the top of the piston 90. Duct 98 is plugged with a threaded plug 100. Exhaust ports 101 and 102 are disposed in the wall of the cylinder at a point equidistant from the ends of the cylinder. The distance between the exhaust ports 101 and 102 is such that during reciprocation one end of the piston begins to cover one exhaust port just as the opposite end of the piston begins to uncover the other exhaust port. A threaded air inlet port 103 is disposed in one side of the casing 91 and leads into the annulus 95. A threaded air inlet port 104 is disposed in the opposite side of the casing 91 and also leads into the annulus 95. A threaded plug 105 is disposed in the air inlet port 104. A stepped aperture 106 is formed in the cylinder head 92 and disposed therein is a length of pipe 107 having a flange which registers with the shoulder 108 of the aperture 106. A reciprocable piston 109 is mounted in the bore of the pipe 107 in slidable, substantially air-tight relationship. The lower portion of the bore of the pipe 107 is threaded to receive an air hose 110 from a compressed air line or a sealing plug (not shown). The bore of the pipe 107 is constricted and forms a shoulder 111 which limits the downward movement of the piston 109 to its own length.

Passages 112 and 114, sealed by threaded plugs 113 and 115, respectively, are provided for the attachment of the vibration frequency control valve assembly similar to that shown in Fig. 6. To adapt the control valve assembly shown in Fig. 6 to the vibrator of Fig. 9, it is only necessary to extend the recess 72 upwardly in the direction of recess 62 for a distance sufficient to bring recess 72 into communication with air inlet 103 when recess 62 is in communication with either of passages 112 and 114, respectively. Suitable threaded holes must be formed in casing 91 to accommodate bolts 58. When fitted with the control valve assembly, the frequency of the vibrator of Fig. 9 may be positively controlled while maintaining a stroke of uniform power.

As shown the vibrator of Fig. 9 is adapted for use as the hopper vibrator and operates as follows: Compressed air is admitted through hose 110 to the bore of the pipe 107 below the piston 109 at a pressure necessary to raise the piston 109 and thus force the piston 90 upward. The rising piston 90 causes the air to exhaust through the exhaust port 102. Once the piston 90 has closed the

exhaust port 102, the air in the end of the cylinder is compressed to form a cushion which prevents piston 90 from striking the top of the cylinder. When the piston 90 has been raised to the up position, compressed air is admitted through air inlet 103 which flows through the annulus 95, passage 97, and the duct 99 to the cylinder above the piston 90. The piston 90 is forced downward to the bottom of the cylinder. As the passage 97 in the piston 90 passes the lower edge of the annulus 95, the air to the top of the cylinder 89 is shut off and as the upper edge of the piston 90 uncovers the exhaust port 102, the air above the piston begins to exhaust to the atmosphere. Meanwhile as the piston 90 is forced downward, the air below the piston is exhausted through exhaust port 101, and the piston 109 is forced downward into the pipe 107 by the base of the piston 90. The piston 109 in the bore of pipe 107 is prevented from entering pipe 107 beyond its own length by the shoulder 111. A cushion of air is also formed on the lower part of the piston which prevents the piston from striking the cylinder head 92. Due to the cushions of air formed at the ends of the cylinder during the exhaust stroke and the power stroke of the piston 90, the vibrator illustrated is characterized by a relative quietness in operation.

To adapt the vibrator as shown in Fig. 9 for use as the shuttle vibrator in the vibratory packing machine of the invention, the air hose 110 is detached from the pipe 107 and replaced by a suitable sealing plug. The plug 105 is removed from the air inlet 104 and is placed in air inlet 103. The hose from the air line is then connected to air inlet 104. The plug 100 is removed from the duct 98 and placed in the duct 99. When compressed air is now admitted through air inlet 104, the operation of the vibrator is identical to that shown in Fig. 9 except that the power stroke of the piston 90 is up instead of down. Since the piston will fall by gravity when the flow of pressurized air to the base of the piston is shut off, no means for returning the piston to its original position is necessary. Consequently, when the vibrator is used as the shuttle vibrator, the pipe 107 may be removed from cylinder head 92 and replaced by a suitable plug.

In Fig. 10 is shown an alternate embodiment of a vibrator which may be used as the hopper vibrator in the vibratory packing machine of the invention. A cylinder 200 is formed by a casing 201 and a cylinder head 202 threadedly engaged in one end thereof. A reciprocable piston 203 is mounted in the cylinder 200. Exhaust ports 204 and 205 are located in the cylinder wall equidistant from the ends of the cylinder and are separated by a distance such that one end of the piston 203 begins to uncover one of the exhaust ports as its opposite end begins to cover the other. An air inlet port 206 in the casing opens into one end of the cylinder while an air exit passage 207 leads from the opposite end of the cylinder. A stepped orifice 208 is formed in the cylinder head 202, and disposed therein is a flanged pipe 209 having a centrally disposed stepped bore 210. The lower end of the pipe 209 is threaded to receive an air hose 211 leading to an air line (not shown). A reciprocable piston 212 is mounted in the bore 210 of the pipe 209. The travel of the piston 212 into the bore 210 of the pipe is limited to its own length by the shoulder 213 formed by the constriction of the stepped bore 210.

Affixed to the side of the vibrator casing 201 by a gasket 220 and studs 221 is a valve assembly having a casing 223 which forms a chamber 224 having sections of different diameters. A recess 225 is located in the valve casing 223 and is in communication with the air exit passage 207 in the vibrator casing 201. A thread 226 is formed in the valve casing 223 and extends into the chamber 224. A recess 227 is formed in the wall of the casing 201 opposite the thread 226. A threaded spring-actuated check plug 228 threadedly engages the

thread 226 with the base of the plug being retained in the recess 227. The check plug 228 has ports 229 and 230 located respectively in the upper and lower walls thereof. A valve 231 in the check plug 228 allows the passage of compressed air through ports 229 and 230 into the chamber 224 from the recess 225 but prohibits a reverse flow. The casing 201 is threaded at its lower end to receive a threaded adjustable exhaust valve 232. The valve 232 is adjusted by screw 233 and whenever the valve 232 is partially or fully opened, the chamber 224 is in communication with the atmosphere through ports 229 and 230 in the check plug 228 and through the valve 232.

An air inlet 234 is located in the valve casing 223 near the closed end of the portion of the chamber 224 having the smaller diameter. A passage 235 is formed by a recess in the valve casing 223. In communication with the recess 235 is a passage 236 which opens into the chamber 224 below the air inlet 234. Recess 237 in the casing 201 is a continuation of passage 236. Also in communication with the recess 235 is passage 238 which opens into the chamber 224 at a point below the passage 236. Passage 239 is a continuation of passage 238 across the chamber 224 and through casing 223 to the atmosphere.

A reciprocable piston 240 is disposed in slidable, substantially air-tight relationship in the portion of the valve chamber 224 having the smaller diameter. An annular groove 241 is cut in the piston 240 at a point which causes the groove to register with the passages 238 and 239 when the piston 240 is fully within the portion of the chamber having the smaller diameter. The distance to which the piston 240 may extend upwardly into this portion of the chamber is governed by the projection 242 of the threaded plug 243 disposed in the valve casing 223 in the top of the chamber 224.

A piston 250 is disposed above the check plug 228 in slidable, substantially air-tight relationship in the portion of the chamber 224 having the greater diameter. The length of the piston 250 is such that when it is forced downward by the piston 240, the upper end of the piston 240 is able to clear the lower edges of the passage 236 and recess 237, thus bringing air inlet 234 and passage 235 into communication. An annulus 251 is formed in the wall of the cylinder 224 at the point where the piston 250 meets the piston 240 when both are at the limit of their upward movement and when the piston 240 is in contact with the projection 242. A passage 252 is provided in the valve casing 223 which leads from the annulus 251 to the atmosphere, thus allowing air to enter the large portion of the chamber 224 above the piston 250 when said piston is forced downward by the piston 240. When the piston 250 is again forced to the up position, the air admitted on the down stroke exhausts to the atmosphere.

Threaded sockets 260 are provided in the top of the vibrator casing 201 for securing the vibrator to the hopper. Sockets 261 are provided in the cylinder head 202 to receive a spanner for securing the cylinder head in place.

It will be seen that the operation of the vibrator shown in Fig. 10 is similar to that of the vibrator shown in Figs. 5-8, the only differences being that the valve assembly has been inverted to give a power stroke in the down direction, and means have been provided at the bottom of the cylinder for returning the vibrator piston to the up position in preparation for each power stroke. As in the case of the vibrator shown in Figs. 5-8, the vibration frequency may be positively controlled by adjusting the needle valve 232 and thus regulating the period necessary for the air line pressure to overcome the pressure below the piston 250.

In Fig. 11 is shown one of the resilient mounting assemblies employed to connect the feed hopper 24 to

the bracket 21 of the feed hopper support frame 19. An elongated threaded stud 25 is equipped with an enlarged stop nut 300 approximately midway from the ends thereof and a small stop nut 301 on the lower extremity thereof. A tube-form resilient mounting 302 is disposed between stop nut 300 and stop nut 301 and comprises concentrically disposed steel tubes 303 and 304 having a resilient rubber mass 305 bonded therebetween in shear. The outer tube 303 is shorter than the inner tube 304 and is disposed equidistant from the ends of the inner concentrically disposed tube 304. A stepped bore 22 is formed in the hopper mounting plate 21 and is lined with a bronze casing 306 machined to fit the stepped bore 22 in the hopper mounting plate 21. The inner diameter of the casing is also stepped to form an annular shoulder 307. The lower end of the outer tube 303 of tube-form resilient mounting 26 is disposed upon the shoulder 307. The portion of the elongated stud extending above the stop nut 300 is disposed in a recess formed in the body of the hopper 24. Four similar mountings are disposed as shown in Fig. 1.

In Fig. 12 is shown in detail one of the resilient mounting assemblies employed to connect the platen 31 to the platen support frame 33. This particular assembly comprises two plate-form resilient mountings 34 mounted in a series on a brass cap screw 310 and separated by a brass washer 311. Each of the plate-form mountings shown consists of a steel sleeve 312 having bonded about its periphery in shear a mass of rubber 313. An annular plate 314 is disposed in the outer edge of the mass of rubber 313 and protrudes therefrom. The plate 314 is secured in the annular orifice of a cup-shaped support member 315 by a crimp 316. The cup-shaped support member has an annular flange 317. The annular flange 317 of the upper mountings is secured to the underside of the platen 31 while the annular flange of the lower mounting is secured to the upper surface of the platen support frame 33. A recess 318 is provided in the underside of the platen 31 and a recess 319 is provided in the upper side of the platen support frame 33 to allow the ends of the brass cup screw 310 to reciprocate without touching the platen or the platen support frame.

In Fig. 13 a feed nipple 28 is shown which comprises a bronze tube having an annular projection 330 and an annular flange 331 near the upper end thereof to secure the nipple in the nipple plate 27. An annular constriction 29 is formed around the inner periphery of the egress orifice of the nipple 28. The size of the individual nipple and the number of nipples employed depend upon the size and number of the explosive cartridges or other containers being filled. Once the containers become filled, the material being introduced can no longer pass into the containers and cores are formed in the feed nipples. When the vibration of the hopper and shuttle is stopped and the nipples are disengaged from the mouths of the containers, the constriction 29 causes the nipples to retain the cores. When the nipples are then lowered into empty containers, the cores are removed when vibration is resumed. While it is preferred to form a constriction in a cylindrical bore as shown, similar results can be obtained by employing a nipple with a tapered bore. Coring can only be uniformly obtained with straight bores when the material being packed is characterized by extremely poor flowing qualities.

Referring particularly to Fig. 14, a sectional view of a portion of the platen assembly is shown to illustrate the operation of the shuttle box gripping piston assembly 36 which holds the shuttle box in position on the platen during the packing operation. The gripping piston assembly 36 shown in Figs. 3 and 4 has a casing formed by a base member 33, a cylinder head 334 and a piston guide member 335. The base member 333 and the cylinder head 334 are maintained in tight sealing relationship by means of gaskets 336 and 337 and studs 338.

The piston guide member 335 is held in forced fit by the flange 339 of the base member 333. The casing so formed defines a cylinder 340. A piston 341 having an enlarged head 342 is concentrically maintained in the cylinder 340 by the piston guide member 335. The enlarged piston head 342 is grooved to receive a packing ring 343. The small opposite end of the piston 341 extends from the guide member 335. A rubber cap 344 is secured to the end of the piston 341 extending beyond the piston guide member 335 by a pin 345.

One end of a bellows 49 is secured to the piston guide member 335 and the other end of the bellows 49 is secured to the rubber cap 344. The piston 341 has a bore 346 extending from the end protruding from the piston guide member 335 to the enlarged piston head 342. The bore 346 is in communication with the inside of the bellows 49 through a passage 347. The bore 346 is also in communication with the cylinder 340 through a passage 348. The enlarged piston head 342 of the piston 341 is normally held in the position shown by the coil spring 349. Air from the power line is delivered to the cylinder 340 on the opposite side of the enlarged piston head 342 through a passage 40 which passes through the platen 31, the base member 333 and the cylinder head 334.

When air is supplied through passage 40 to the end of the cylinder 340, pressure is exerted on the enlarged piston head 342 causing the piston 341 to move through the piston guide member 335 until the rubber cap 344 engages the shuttle box 37 and secures it in position against the positioning studs 35 on the opposite side of the platen 31. The spring 349 is compressed by the movement of the piston and when the air pressure on the piston head 342 is removed, the piston 341 is returned to the position shown by the action of the spring 349, and the shuttle box 37 is released.

The packing of large size explosive cartridges on the vibratory packing machine of the invention will now be described with reference to the drawings and particularly to Fig. 4. A shuttle box 37 containing the desired number of explosive cartridges of the desired size is placed upon the platen 31 and positioned securely against the stop studs 35. A nipple plate 27 containing the desired number of nipples of the size desired to correspond with the number and size of cartridges of the shuttle box 37 is attached to the feed hopper. Fluid medium is then admitted to cylinder 41 at the base of the piston 43 and the platen is raised on its support by the piston 43 until the nipples 28 enter the top of the empty shells to the desired distance. The explosive material to be packed is then introduced into the hopper 24. Pressurized air is admitted to the platen vibrator 32, the shuttle box gripping piston assembly 36, and the hopper vibrator 30. The explosive material is then continuously introduced into the right side of the hopper as shown in Fig. 4 and is conveyed to the left as a result of the vibratory movement of the hopper being downward and to the right. The explosive material therefore flows through the nipples and into the shells below. The particular type of vibration induced in the platen 31 by the pneumatic vibrator 32 causes the explosive to be packed in the shells to a high and uniform density. When the shells are filled to the desired density and degree, and a core has formed in the nipples, the supply of air to the hopper vibrator 30, the platen vibrator 32 and the gripping piston assembly 36 is shut off. The pressure of the fluid medium beneath the piston 44 in cylinder 42 is released, and the platen 31 is allowed to settle to its down position. Due to the annular constriction 29 at their egress orifice, the cores are maintained within the nipples. The shuttle box of filled shells 38 is removed for crimping and sealing, is replaced by a box of empty shells and the operation is repeated. When vibration of the hopper is resumed, the cores are dislodged into the empty containers. If desired, the cartridges can be

loosely filled with explosive prior to initiating vibration in the platen. As previously indicated, the shells themselves may be loosely contained in the shuttle box or may be rigidly secured in the box so that the movement of the box is transmitted directly to the shells.

While it is not intended that the following theory of operation of the vibratory packing machine in accordance with this invention should in any way restrict the actual scope of the invention, it is believed its success in packing explosive materials to their necessarily high and uniform density is due to a number of cooperating features. The unidirectional power stroke of the platen vibrator in an upward direction forces the material to be packed into the bottom of the container. If the upward power stroke were followed by a downward power stroke which acted on the shell, the container would be driven away from the packed material and much of the work done by the upward stroke would be undone. However, in accordance with the invention, whether the containers are loosely or rigidly held in the shuttle box, no downward force is applied and only packing force is ever applied to the container. When the containers are rigidly secured in the shuttle box, the free fall of the piston, cushioned at the bottom of its fall by an air cushion in the bottom of the cylinder together with the cushioning provided by the resilient mountings, allows successive packing strokes without any appreciable intermediate loosening. The resiliency of the platen mountings also causes a relatively gradual deceleration of the upward movement of the platen, of the shuttle box, of the cartridge, and of the explosive and consequently, does not undo any substantial portion of the packing accomplished by the upward thrust of each power stroke. Furthermore, since the fall of the vibrator piston is cushioned by the air beneath the piston and since the fall of the platen following the power stroke is also cushioned by the resiliency of the mountings, no substantial jarring takes place which would tend to loosen the material in the cartridge. When the preferred controllable speed vibrator is employed as the platen vibrator, the optimum vibration frequency can be obtained for each material to be packed.

In order to obtain an explosive cartridge having a high and uniform density, it has further been found that a pneumatic vibrator having a unidirectional power stroke in the upward direction must be rigidly attached to the platen. If the vibrator is not so attached, satisfactory packing is only obtained directly over the point where the vibrator strikes the platen. Consequently, the packing efficiency diminishes toward the edge of the platen.

It is realized that many modifications of the vibratory packing machine which are within the scope of the invention will become apparent to those skilled in the art of vibratory packing and to those skilled in the art of manufacturing pneumatic vibrators. The specific design and overall structure of all the parts of the particular machine described and illustrated are obviously not essential to its success. For example, means for elevating the platen other than the fluid-actuated cylinder disclosed could be substituted which might prove equally desirable. The support stanchions and support frames could obviously be arranged in a manner different from that specifically illustrated, and any suitable materials of construction could be substituted for those employed in the structures illustrated.

While the specific design of resilient mountings illustrated is rubber bonded in shear to metal, and is preferred and has been found to give best results, other types of resilient mountings are operable as long as they permit or cause the platen to have the critical movement above described. Such means would include some types of hydraulic cylinders or dash pots and systems of counter-weighted levers. Coil springs have generally been found to be unsatisfactory since a relatively more rapid change in strength takes place which brings about a substantial change in the movement of the platen over a period of

time. Furthermore, coil springs are most undesirable in the packing of explosives from the safety standpoint, since coil springs are known to snap. The breaking of a coil spring is often accompanied by sparks which might possibly cause an explosion despite the fact that the platen, its support frame and the resilient mounting are preferably surrounded by a protective bellows as shown in the drawings. The specific type of mounting illustrated is greatly preferred since it is very easy to install or to replace, gives exceptionally long wear, and has been found to impart the most effective motion to the platen.

It is preferred that the exhaust ports of the vibrators of the invention be spaced evenly from the ends of the vibrator cylinders and that these ports be separated by a distance substantially equal to the length of the piston. With this arrangement the best results are achieved both from the standpoint of smoothness of operation and economy of air. However, this preferential arrangement is not essential to the operation of the vibrator. As long as the port being uncovered by the piston during the power stroke is located far enough from the end of the cylinder to enable the piston to gain sufficient velocity, the momentum of the piston will insure completion of the stroke even though the port is open during the last portion of the stroke. When the piston is returned to its starting point, either by gravity or other means, the port should be located close enough to the end of the cylinder to allow most of the air to exhaust and thus give a substantially full stroke. The auxiliary exhaust means shown in the drawings is helpful in this regard.

The exhaust port being covered by the piston during the power stroke should be placed close enough to the opposite end of the cylinder to allow the piston to make a substantially full stroke but should be located far enough from the end of the cylinder that enough air is trapped and compressed in the end of the cylinder to fully depress the valve piston or other slidable means in the valve assembly. All of these factors must be coordinated to give optimum results in each particular design and size of vibrator in accordance with the invention.

It is preferred that two separate but coacting pistons be employed in the valve assembly as illustrated in the drawings. A single piston having two different diameters is operable, but is not preferred because the single piston is more difficult to lap to the substantially air-tight fit necessary to satisfactory operation of the valve assembly.

In view of the fact that many modifications of the invention are possible, it is to be understood that the invention is to be limited only by the scope of the appended claims.

This application is a continuation-in-part of my copending application Serial No. 134,530, filed December 22, 1949, now abandoned.

What we claim and desire to protect by Letters Patent is:

1. In a vibratory packer especially adapted to the packing of large size explosive cartridges, the combination which comprises a platen having rigidly attached thereto and vertically suspended therefrom a pneumatic vibrator having a unidirectional power stroke upwardly and substantially parallel to the vertical axis of the platen, support means for the platen and resilient mountings connecting the platen to its support means, said pneumatic vibrator having in combination a casing forming a cylinder, a reciprocable piston disposed in the cylinder, exhaust ports located in the casing adjacent the opposite ends of the cylinder, an air inlet for pressurized air leading to one end of the cylinder, an air exit passage for air compressed by the piston leading from the opposite end of the cylinder, and a valve assembly; said valve assembly having in combination a first passageway therethrough which is in communication at one end with the air inlet in the vibrator casing and at the other end with a source of pressurized air; a second passageway therethrough,

one end of which is in communication with the air exit passage in the vibrator casing and the other end of which leads to the atmosphere, said second passageway having a check valve at the end thereof which registers with the air exit passage and a metering means for air at the end thereof leading to the atmosphere; and slidable means disposed within the valve assembly which is movable in one direction to close the first passageway under the force exerted by the compressed air admitted to the second passageway through the check valve and which is movable in the opposite direction to open the first passageway under the force exerted by the pressurized air when sufficient of the compressed air is released to the atmosphere through the metering means.

2. In a vibratory packer especially adapted to the packing of large size explosive cartridges, the combination which comprises a frame, a hopper equipped with feeding means for introducing explosive material into the container, said hopper being connected to the frame by resilient mountings, means for vibrating the hopper, a platen disposed below the hopper having rigidly attached thereto and vertically suspended therefrom a pneumatic vibrator having a unidirectional power stroke upwardly and substantially parallel to the vertical axis of the platen, support means for the platen, and resilient mountings connecting the platen to its support means; said pneumatic vibrator having in combination a casing forming a cylinder, a reciprocable piston disposed in the cylinder, exhaust ports located in the casing adjacent the opposite ends of the cylinder, an air inlet for pressurized air leading to one end of the cylinder, an air exit passage for air compressed by the piston leading from the opposite end of the cylinder, and a valve assembly; said valve assembly having in combination a first passageway therethrough which is in communication at one end with the air inlet in the vibrator casing and at the other end with a source of pressurized air; a second passageway therethrough, one end of which is in communication with the air exit passage in the vibrator casing and the other end of which leads to the atmosphere, said second passageway having a check valve at the end thereof which registers with the air exit passage and a metering means for air at the end thereof leading to the atmosphere; and slidable means disposed within the valve assembly which is movable in one direction to close the first passageway under the force exerted by the compressed air admitted to the second passageway through the check valve and which is movable in the opposite direction to open the first passageway under the force exerted by the pressurized air when sufficient of the compressed air is released to the atmosphere through the metering means.

3. In a vibratory packer especially adapted to the packing of large size explosive cartridges, the combination which comprises a frame, a hopper equipped with feeding means for introducing explosive material into the container, said hopper being connected to the frame by resilient mountings, means for vibrating the hopper which consists of a pneumatic vibrator having a unidirectional power stroke, said vibrator being mounted on the hopper at an angle which causes one component of force from the power stroke to be directed along the horizontal axis of the hopper opposite the desired direction of flow of the material to be packed and another component of force to be directed downward along the vertical axis of the hopper, said vibrator being equipped with means to return the vibrator piston to its original position against gravity prior to each power stroke, a platen disposed below the hopper having rigidly attached thereto and vertically suspended therefrom a pneumatic vibrator having a unidirectional power stroke upwardly and substantially parallel to the vertical axis of the platen, support means for the platen, and resilient mountings connecting the platen to its support means; at least one of said hopper vibrator and said platen vibrator having in combination a

casing forming a cylinder, a reciprocable piston disposed in the cylinder, exhaust ports located in the casing adjacent the opposite ends of the cylinder, an air inlet for pressurized air leading to one end of the cylinder, an air exit passage for air compressed by the piston leading from the opposite end of the cylinder, and a valve assembly; said valve assembly having in combination a first passageway therethrough which is in communication at one end with the air inlet in the vibrator casing and at the other end with a source of pressurized air; a second passageway therethrough, one end of which is in communication with the air exit passage in the vibrator casing and the other end of which leads to the atmosphere, said second passageway having a check valve at the end thereof which registers with the air exit passage and a metering means for air at the end thereof leading to the atmosphere; and slidable means disposed within the valve assembly which is movable in one direction to close the first passageway under the force exerted by the compressed air admitted to the second passageway through the check valve and which is movable in the opposite direction to open the first passageway under the force exerted by the pressurized air when sufficient of the compressed air is released to the atmosphere through the metering means.

4. In a vibratory packer for packing explosive cartridges, the combination which comprises a platen; means including a movable mass connected to said platen for applying an upward impact to the platen and means for applying power to said mass in one direction only; support means for said platen and resilient mountings connecting said platen to its support means; a hopper above said platen for supporting a pulverulent explosive material for delivery to a cartridge; and said platen being adapted to support an elongated cartridge to receive flow of explosive material from said hopper.

5. A packer in accordance with claim 4 wherein said means for applying said impact to said platen and for applying said power to said mass is a pneumatic vibrator assembly rigidly attached to said platen and adapted to apply said impact in a direction substantially parallel to the vertical axis of said platen.

6. A packer in accordance with claim 5 wherein said hopper is adapted to deliver explosive material to a plurality of cartridges and contains a separate nipple extending from its bottom side for engaging each said cartridge to deliver said explosive material thereto; each said nipple having a lesser diameter at its egress orifice than at its ingress orifice.

7. A packer in accordance with claim 5, including at least one cartridge disposed on said platen; a pulverulent explosive material in said hopper; and each said cartridge being adapted to receive flow of explosive material from a bottom side of said hopper.

8. A packer in accordance with claim 5 wherein said pneumatic vibrator is substantially vertically suspended from said platen.

9. A packer in accordance with claim 5 wherein said pneumatic vibrator comprises in combination a casing forming a cylinder, a reciprocable piston mounted in the cylinder, an annulus formed in the cylinder wall substantially equidistant from the ends thereof, a passage extending longitudinally into the piston at a point which registers with the annulus in the cylinder wall when the piston is in the down position and remains in communication

with said annulus during a substantial portion of the piston's upward power stroke, a duct leading from said passage and opening into the cylinder from the bottom of the piston, and exhaust ports located in the casing adjacent the opposite ends of the cylinder, the distance between the exhaust ports being substantially equal to the length of the piston.

10. A packer in accordance with claim 5 wherein said pneumatic vibrator comprises in combination a casing forming a cylinder, a reciprocable piston mounted in the cylinder, an annulus formed in the cylinder wall substantially equidistant from the ends thereof, a passage extending longitudinally into the piston at a point which registers with the annulus in the cylinder wall when the piston is in the down position and remains in communication with said annulus during a substantial portion of the piston's upward power stroke, a duct leading from said passage and opening into the cylinder from the bottom of the piston, and exhaust ports located in the casing adjacent the opposite ends of the cylinder, the distance between the exhaust ports being substantially equal to the length of the piston.

11. A packer in accordance with claim 5 including a frame; said hopper being connected to the frame by resilient mountings; and means for vibrating said hopper.

12. A packer in accordance with claim 11 wherein said pneumatic vibrator comprises in combination a casing forming a cylinder, a reciprocable piston mounted in the cylinder, an annulus formed in the cylinder wall substantially equidistant from the ends thereof, a passage extending longitudinally into the piston at a point which registers with the annulus in the cylinder wall when the piston is in the down position and which remains in communication with said annulus during a substantial portion of the piston's upward power stroke, a duct leading from said passage and opening into the cylinder from the bottom of the piston, and exhaust ports located in the casing adjacent the opposite ends of the cylinder, the distance between the exhaust ports being substantially equal to the length of the piston.

13. A packer in accordance with claim 11 wherein said means for vibrating the hopper comprises a pneumatic vibrator mounted on the hopper at an angle which causes one component of force from the power stroke to be directed along the horizontal axis of the hopper opposite the desired direction of flow of the material to be packed and another component of force to be directed downward along the vertical axis of the hopper, said vibrator being equipped with means to return the vibrator piston to its original position against gravity prior to each power stroke, and a platen disposed below the hopper.

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