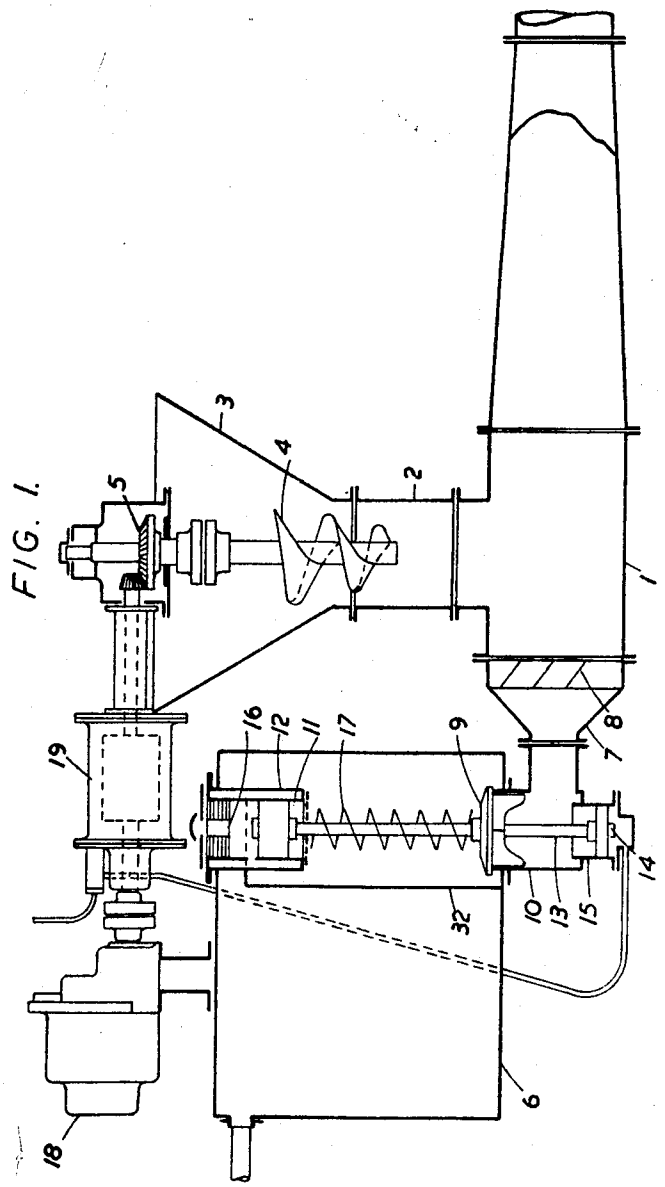
July 24, 1956 E. RICH 2,756,111

STOWING OF WASTE IN MINES

Filed Nov. 1, 1952 4 Sheets-Sheet 1

FIG. 1.



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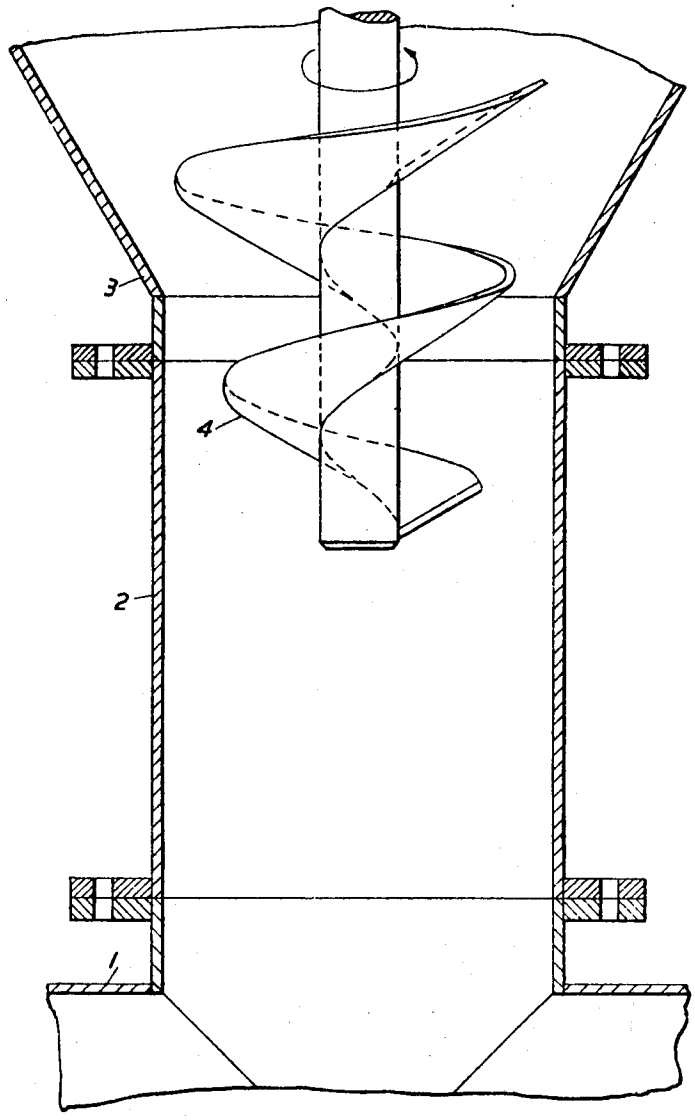
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STOWING OF WASTE IN MINES

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FIG. 2.



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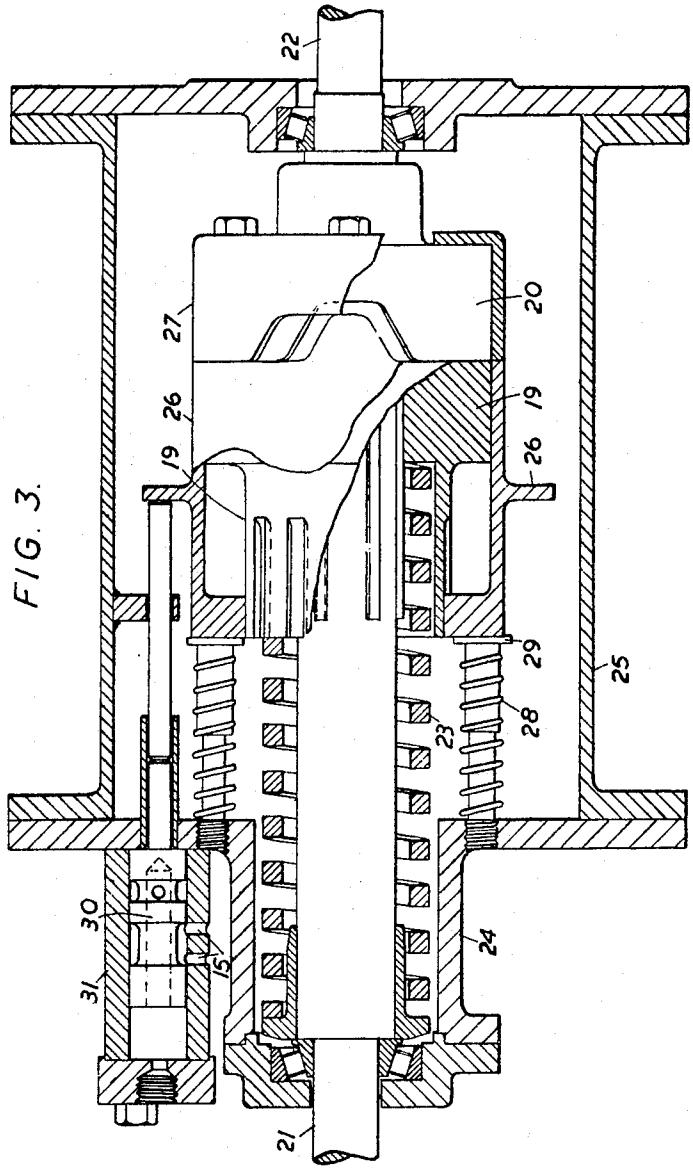


FIG. 3.

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STOWING OF WASTE IN MINES

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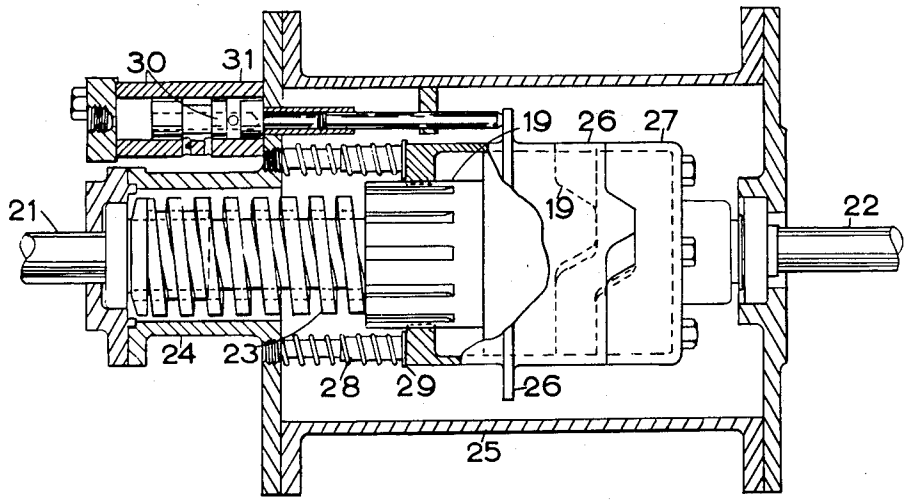


FIG. 4.

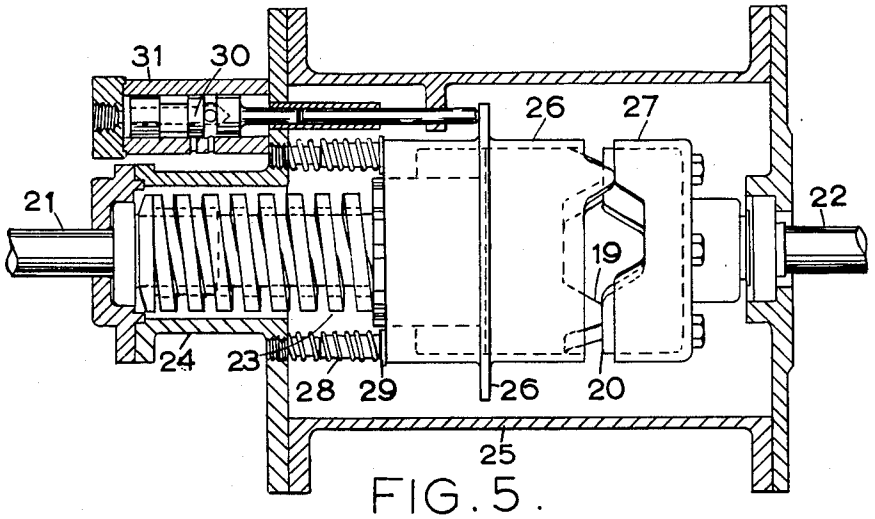


FIG. 5.

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2,756,111

STOWING OF WASTE IN MINES

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Application November 1, 1952, Serial No. 318,164

Claims priority, application Great Britain November 7, 1951

6 Claims. (Cl. 302—26)

The subject of the present invention is an improvement over the continuous pneumatic process of stowing waste in mines, and consists in a process and apparatus for projecting the stowing material into place by the rapid expansion of successive charges of compressed air. As a result, substantial economies in compressed air requirements compared with the continuous process are effected, and the stowed material may be more densely packed.

It is known in the continuous process that when the waste for stowing purposes is continuously transported through pipes by compressed air, relatively large volumes of air are required in order to maintain a certain minimum velocity, which is necessary in the piping to carry the larger and heavier particles. It has thus been ascertained that when handling the type and size of material commonly used for stowing in mines, the minimum free air volume required is about 1500 cubic feet per minute, which must be compressed to about 80 lbs. per square inch gauge pressure. Furthermore it has been found that unless the quantity of material to be transported and the distance of transportation are large, very inefficient use of the compressed air results. For good practice the volume of air required should not exceed about 100 cubic feet of free air used per cubic foot of material stowed, but few installations seem capable of maintaining such a performance figure for any length of time. The relatively large amount of compressed air required per unit of material stowed arises from the impossibility in the continuous process of increasing the solids/air ratio above a certain practical limit, over which there is a danger of the piping becoming choked. If, however, the material and compressed air are introduced intermittently, it has been found that the solid may be so compacted in the piping as to produce a close fitting seal which behaves as a piston when the compressed air is admitted. By this means full use can be made of the energy of the compressed air to drive the slug of material through the piping. The present invention, therefore, allows a charge of material to be fed and compacted in the piping in advance of the admission of the charge of compressed air, which in the meantime is stored in a suitable receiver. When a suitable amount of material has been so compacted, the compressed air is released very rapidly and drives the material through the piping.

The quantity of compressed air which is consumed per unit of stowing material projected will depend on the length of piping which is connected to the apparatus and through which the material is to be transported; the shorter the piping the less the air required, and vice versa. It is possible with a moderate length of piping to use as little as 20 cubic feet of free air per cubic foot of material stowed. While the lengthening of the discharge piping naturally leads to an increase in the volume of air used per unit volume stowed, it is possible to transport material through as much as 200 feet of piping without exceeding the figure of 100 cubic feet of free air per cubic foot of material stowed which is the best figure achieved in practice in the continuous system.

By suitable proportioning of the volume of material charged, the volume of compressed air released and the diameter and length of the piping employed, the material may be discharged with a considerably higher velocity than is usually achieved in the continuous system. This results in a denser pack of the stowed material and leads to an improved support of the under-ground workings. Furthermore, the apparatus particularly lends itself to the admixture of water with the stowing material to produce a mix which can "set" in place which is usually very desirable.

I will now describe in detail one form of apparatus in which the invention can be carried out.

In the accompanying drawings, Fig. 1 is a view partly in vertical section showing a general arrangement.

Figure 2 is a vertical section showing on a larger scale a specially shaped screw feeder.

Figure 3 is a vertical section showing a form of mechanism through which a motor drives the screw feeder.

Figures 4 and 5 are sections showing the drive mechanism of Figure 3 in greater detail.

As shown in Fig. 1, this form consists essentially of a breech pipe **1**, surmounted by a short length of piping **2** carrying at its other extremity a feeding hopper **3**. A specially shaped screw feeder **4** works partly in the hopper **3** and tube **2**, being driven by bevel gearing **5**. Material to be stowed is introduced into hopper **3** and is then compacted in the breech **1** under the action of the screw feeder **4**, which also prevents the material from being blown out when the compressed air is released. Compressed air for this purpose is stored in a receiver **6** which is connected to breech **1** via a bell-shaped connection **7**. This carries deflecting louvers **8** whose function is firstly to prevent stowing material from finding its way back into the receiver and accessories contained therein, and secondly, to direct the air blast downwards in the breech **1** to ensure complete removal of the material. The receiver **6** retains its charge of compressed air by closure under pressure of the main valve **9** resting on its seat **10**, but the pressure on this valve is partly balanced by pressure in the opposite direction acting on balancing piston **11** working in its cylinder **12** connected to the atmosphere. The valve **9** is therefore kept closed by the air pressure acting on the difference in areas between that of the seat **10** and of the balancing piston **11**. Coaxial with the main valve **9**, balancing piston **11** and extended spindle **13** connecting them, is fitted the actuating piston **14** and its cylinder **15**. This piston at an opportune moment in the cycle receives compressed air and opens main valve **9**, thereby releasing almost instantaneously the entire content of the receiver **6** which discharges into breech **1**. A very rapid opening of the valve **9**, which is an essential factor in the operation of the apparatus, is brought about by reason of the fact that as soon as this valve is just lifted off its seat **10** the pressure difference between its upper and lower sides is reduced. The slight reduction that therefore follows in the total forces trying to return valve **9** back onto the seat **10** means that this force becomes less than that trying to force the balancing piston **11** outwards. The latter piston therefore takes command and results in a very rapid and complete lift of the main valve **9** off its seat, being assisted all the time in this work by the pressure still acting on the underside of piston **14**. The opening is so rapid that means have to be provided to absorb the kinetic energy of the main valve assembly at the end of its stroke, this being done by providing a rubber buffer **16** and allowing air to be trapped in the upper zone of cylinder **12** to form a cushion. By automatic means, to be described in what follows, as soon as the receiver has been discharged, the air pressure acting under piston **14** is cut off and exhausted, whereupon the main valve

assembly returns back onto seat **10** either by gravity, or more conveniently by means of the spring **17**.

The automatic functioning of the cycle whereby material for stowing is introduced and compacted in the breech pipe **1** and then forced out by the compressed air from the receiver **6** is brought about by the particular shape of the screw feeder **4**. This is driven by the unit **18**, which may be either a geared electric motor assembly or compressed air motor. One form of mechanism, functioning automatically and through which the driving motor is connected to the bevel gearing **5**, will be described in detail under Fig. 3. The underlying principle involved in any such device is the employment of the increasing torque required to turn the screw **4** as the breech becomes compacted, to open a valve supplying compressed air for operating piston **14**. Similarly, when the torque on the screw **4** has been reduced, consequent on the stowing material having been discharged from the apparatus, the reverse action is then employed to operate the control valve, thus discharging the air from under piston **14**. That results in the main valve assembly being allowed to close as already mentioned.

The screw feeder assembly therefore has to fulfill two important functions which are:

1. It must rotate smoothly in the stowing material as this is being fed into the breech, that is, it should not be subject to widely varying torque resistance as the larger size particles in the feed are encountered.

2. It must be able to compact the stowing material in the breech **1** and tube **2** immediately over this so as to prevent a blow back through the feed hopper **3** when the compressed air is released from the receiver.

Alone it is not able to satisfy to the full both conditions, but operated in conjunction with screened material commensurate with the diameter of pipe **2**, and given an adequate length of this pipe, then by its particular shape, widely varying torques are avoided which otherwise would upset the correct timing of the air discharge. The shape of this screw is such that the outer edge of its helix traces the surface of a truncated cone, the base of which is uppermost in the receiving hopper **3**. This ensures that as the screw is rotated through the stowing material, the edge of its helicoidal flight is constantly receding from the material, whereupon the larger particles do not tend to cause abrupt stoppages in its rotation. This action in itself however is insufficient to satisfy condition 2 above. This condition demands a seal of compacted material being effectively formed both around the surface of the helix and within the walls of the "stemming" tube **2**. For its fulfillment, the load receiving face of the helix is constructed to make an angle with its vertical axis of about 60 degrees. The action of rotating such a helix within the confines of the stemming tube is that material is forced both downwards and outwards as the breech **1** becomes filled, thus providing a seal against the discharge of air up through the tube **2** and hopper **3**. The effectiveness of such a seal is influenced by the overall length of that part of the stemming tube **2** lying above the top of the breech and lower end of the screw, and by the maximum torque which is applied to the latter. These factors are dependent on the type and size of material it is desired to stow. The particular features of this feeding arrangement are shown in Fig. 2.

The utilisation of the increasing resistance to torque produced at the shaft of the feed screw **4** to operate the timing cycle for the discharge of air from the receiver, may be carried out in a number of ways. I will describe one form of mechanism which is adapted to any form of drive **18** on Fig. 1, and it is shown in Fig. 3. This mechanism, in employing the resistance to torque principle laid down is essentially mechanical. The same final result could, however, be obtained by other mechanisms operated either electrically or pneumatically, and coupled up to their respective driving units to utilise the increase in power potential at the units which results from the increasing resistance to torque at the screw.

The mechanism shown in Fig. 3 is inserted between the driving motor **18** and the bevel gearing **5**. Its function is to translate the increased resistance to torque offered by the screw feeder into simple lateral motion. This is effected by providing a dog clutch assembly, which consists of two members **19** and **20** the former being free to slide on splines cut in the driving shaft **21** coupled to motor **18**. The latter, **20** is firmly keyed to the driven shaft **22** which operates the bevel gearing. The moving member **19** of the above assembly is kept hard up against the keyed member **20** by means of a strong compression spring **23**. The reaction of this spring is eventually taken up by the front cover **24** of the cylindrical container **25** in which the whole mechanism is enclosed. Lateral motion is produced in the first instance by making the faces of the engaging teeth of the assembly slope at an angle of about 45 degrees to the plane of rotation. Hence, when a resistance to torque is manifested by the member **20**, member **19** tries to disengage by sliding along the splined shaft **21** so compressing the spring **23**. The compression exerted by the spring **23** is adjusted to give the desired limiting torque to the screw **4**, which when exceeded finally throws member **19** out of complete disengagement with member **20**. The value of this torque will of course always be somewhat less than that available from the driving motor.

Furthermore by suitable proportioning of the circumferential length of the male and female serrations on the mating edges of the members **19** and **20** it becomes possible to provide a portion of circular arc or "land" on member **20** over which the male ends of member **19** will ride after disengagement and before they eventually drop back again into the mating position with member **20**.

It will be apparent that the moment for discharge of the receiver contents will have arrived when the dog clutch assembly is fully disengaged; that is when the screw has offered a resistance to further torque superior to that determined by the set compression of the main spring **23**. The utilization of the lateral motion produced by member **19** disengaging from member **20** to operate a control valve for purposes of turning in air to the piston **14** leads, however, to erratic timing. It is desirable to correct for this by causing the operation of the control valve to take place only after the two members of the main dog clutch assembly are fully disengaged; that is when the member **19** is riding over the "land" on member **20**, as is shown in Fig. 4. The achievement of correct valve timing in the cycle is obtained by providing a secondary clutch consisting of a pair of sleeves with mating teeth inclined to the plane of rotation, these sleeves being so positioned relative to members **19** and **20** that they only start to separate after member **19** is fully disengaged from member **20**. The lateral motion to the left produced when this secondary clutch opens is utilised to move the control valve **30**, which opens compressed air to cylinder **15** for the operation of piston **14**. Exhaust from this cylinder takes place as the valve moves back to the right, when both main and secondary clutches close as shaft **21** rotates with shaft **22** fixed. The dropping back into engagement of member **19** on member **20** provides a very useful "kick" which serves to free the screw feeder and thus allows clearing of tube **2**, the compacted material in which then drops down into the empty breech **1**, and a new cycle is started.

The secondary clutch consists of two sleeves **26** and **27**, which are fitted coaxially over the main clutch assembly **19** and **20**. Sleeve **26** is free to slide over the outer surface of member **19**, being guided, positioned and prevented from rotating independently of member **19** by the splines on member **19** with which it engages. It is kept in close contact with sleeve **27** by means of spring loaded buffers **29** over which it rubs, these buffers being fixed to the front cover **24** and urged against sleeve **26** by means of the

light springs 28. Sleeve 27 on the other hand is securely fixed to member 20. In a manner similar to that provided for the mating of members 19 and 20, these sleeves are provided with a pair of engaging teeth or dogs; the length of arc of both male dogs of sleeve 26 and the length of "land" between the corresponding female serrations in sleeve 27, are less however than the corresponding lengths in members 19 and 20. The arc of "land" on sleeve 27 being less than that on member 20 which it overlies, allows a sufficient timing lag for member 19 to have come out of engagement with member 20 before sleeve 26 starts to come out of engagement with sleeve 27. This is shown in Fig. 4, where 19 is just beginning to ride over the "land" of 20, and sleeve 26 is at the point of starting to disengage from sleeve 27. This action becomes possible because member 19 can slide, but not rotate independently, of sleeve 26, and thus allows 26 to remain in contact with sleeve 27 until such time as the leading edges of the dogs of the sleeve meet.

As shaft 21 continues to rotate, with shaft 22 fixed since the screw feeder is held firm by the compacted material in tube 2, the leading edges of the mating teeth of the sleeves 26 and 27 having met, 26 will be forced away to the left of 27. This lateral motion is transmitted directly to the valve 30 which then admits compressed air to cylinder 15, the position occupied by both clutches and the valve at this stage being shown in Fig. 5. Continued rotation of shaft 21 with shaft 22 fixed causes the clutches to drop back into engagement again, i. e. member 19 with member 20 and sleeve 26 with sleeve 27, the valve 30 moving back to the right by reason of the air pressure acting on it. In so doing and again occupying the position shown in Fig. 3 it allows the compressed air admitted to cylinder 15 during its former position to be exhausted to atmosphere.

For convenience in accessibility, valve 30 and its cylinder 31 are bolted to the front cover 24, and line or compressed air is connected to cylinder 31 through its cover, passing down through valve 30 which is hollowed internally and provided with a port for exit of the compressed air in its narrower or right hand waist. On movement of the valve to the left when sleeve 26 separates from sleeve 27, this waist lines up with the pipe connection from cylinder 31 to cylinder 15 as shown in Fig. 1, admitting compressed air to 15. Return of valve 30 to the right under pressure of the air when sleeves 26 and 27 close, brings the left hand waist in valve 30 over the connection to cylinder 15, and air is allowed to exhaust to atmosphere via the port drilled in cylinder 31.

As already stated, the dimensions of the breech 1, stemming tube 2 and receiver 6, as well as the diameter and length of the piping coupled with breech 1 to deliver the stowing material at the desired place, are all dependent on the nature and size of the material to be handled and the distance from the apparatus of the eventual delivery point. The receiver 6 is therefore made large enough to supply the air requirements for the longest length of delivery pipe ever likely to be used. If a length of pipe less than the maximum for which the apparatus may have been designed is used the receiver capacity is desirably adjusted to secure efficient usage of compressed air. For this purpose we may install in the receiver a water tight partition 32 surrounding the main discharge valve assembly 9, 10, and 11. This divides the receiver into two zones still interconnected over the upper edge of the partition, and allows the available space for compressed air to be reduced at will by running water into the outer zone, the inner remaining empty to accommodate the main discharge valve assembly.

I claim:

1. An apparatus for pneumatically stowing material, comprising a breech for receiving a charge of material to be stowed, a hopper for supplying material, a pipe connecting the breech and hopper for conducting material from the hopper into the breech, said breech having a discharge outlet for material, a screw feeder for feeding material from the hopper through the pipe into the breech, driving means having a connection for driving the screw feeder, a container for holding a charge of compressed air, means for conducting compressed air from the container into the breech, a valve for releasing compressed air from the container for flow through the conducting means into the breech, a clutch in the connection between the driving means and the screw feeder, said clutch being disengageable when the breech is full of material to be stowed, and means for opening said valve, whereby the charge of air in the container is delivered to the breech and the charge of material therein is projected through the discharge outlet of the breech.

2. An apparatus as claimed in claim 1, including means responsive to the opening of the clutch for opening the valve.

3. An apparatus as claimed in claim 2, in which the means responsive to the opening of the clutch includes a time-delay means operable for opening the valve after the clutch is fully disengaged.

4. An apparatus for pneumatically stowing material, comprising a breech for receiving a charge of material to be stowed, a hopper for supplying material, a pipe connecting the breech and hopper for conducting material from the hopper into the breech, said breech having a discharge outlet for material, a screw feeder for feeding material from the hopper through the pipe into the breech and having some turns thereof within the hopper, driving means having a connection for driving the screw feeder, a container for holding a charge of compressed air, means for conducting compressed air from the container into the breech, a valve for releasing compressed air from the container for flow into the breech, a driving clutch in the connection between the driving means and the screw feeder having members which disengage when the breech is full of material to be stowed, a second clutch means operatively associated with the driving clutch and having members which separate after the members of the driving clutch are fully disengaged, and means actuated by the opening of the members of the second clutch for opening the air-release valve.

5. An apparatus for pneumatically stowing material in which the material to be stowed is compacted in successive slugs in a loading breech, comprising a loading breech for receiving a charge of material to be stowed, said breech having an inlet for the material to be stowed and a discharge outlet for the successive slugs of material, means for delivering material to be stowed and for successively compacting slugs of material in the breech, a container for holding a charge of compressed air, means for conducting compressed air from the container to the breech on the side thereof opposite the discharge outlet of the breech, a release valve for releasing compressed air from the container for flow into the breech, and means for automatically opening said valve upon the completion of each slug of material in the breech, whereby successive slugs of the material to be stowed are respectively projected through the breech discharge outlet by successive charges of compressed air.

6. An apparatus as claimed in claim 1, in which the thread of the screw feeder progressively decreases in diameter toward the breech, whereby the material acted on by the screw feeder is forced downwardly and outwardly in the pipe as the breech becomes filled.

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