APPARATUS FOR LOADING BOREHOLES

Filed Aug. 26, 1968 2 Sheets-Sheet 1

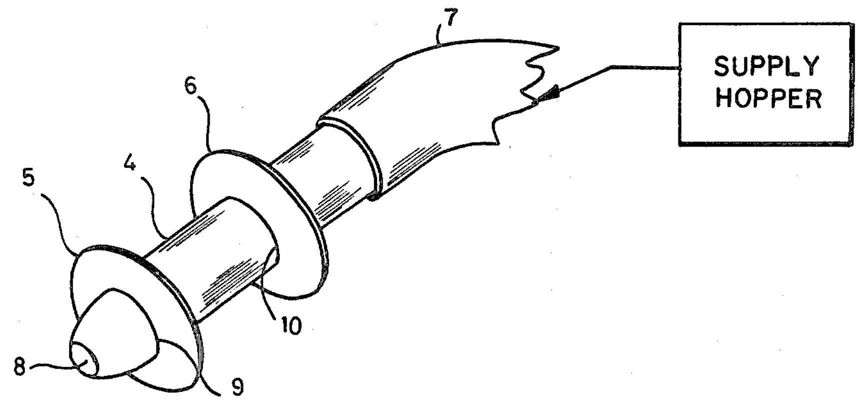

FIGURE 1

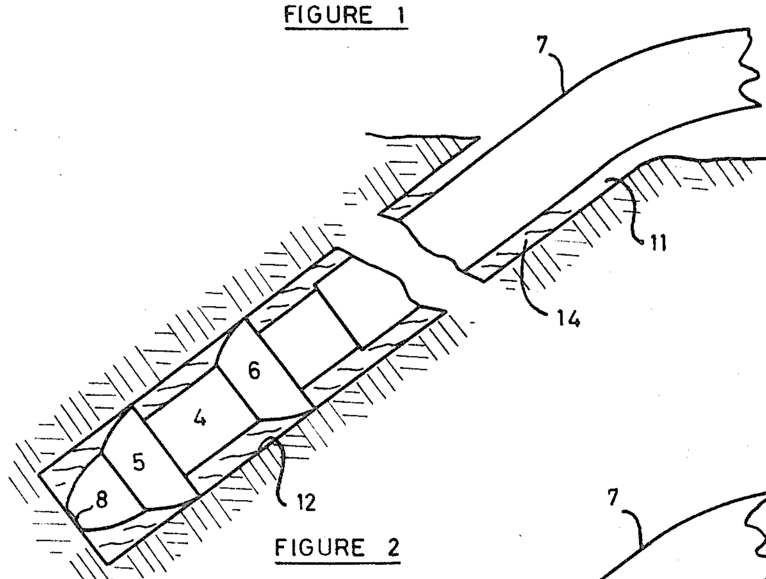

FIGURE 2

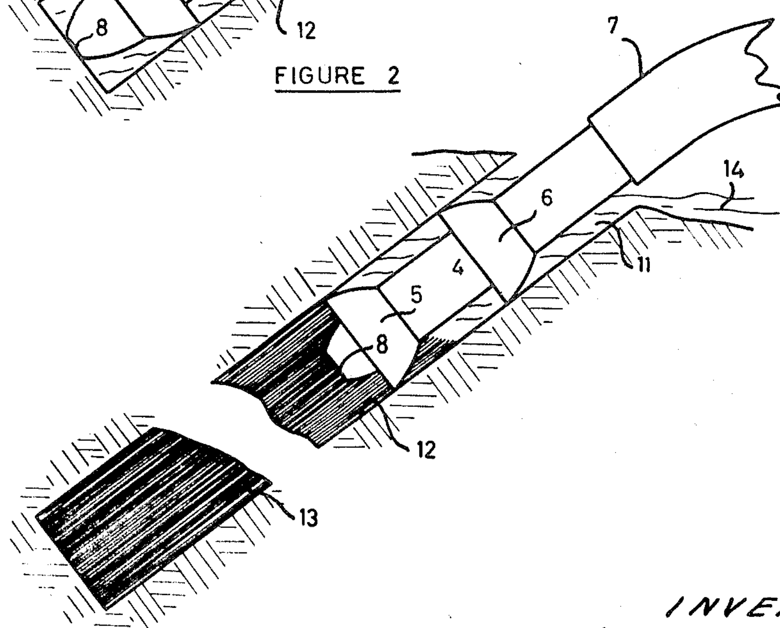

FIGURE 3

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APPARATUS FOR LOADING BOREHOLES

Filed Aug. 26, 1968 2 Sheets-Sheet 2

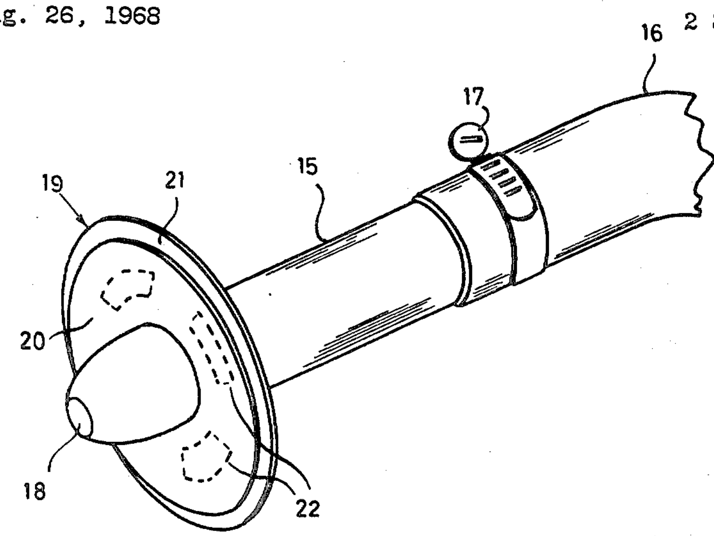

FIGURE 4

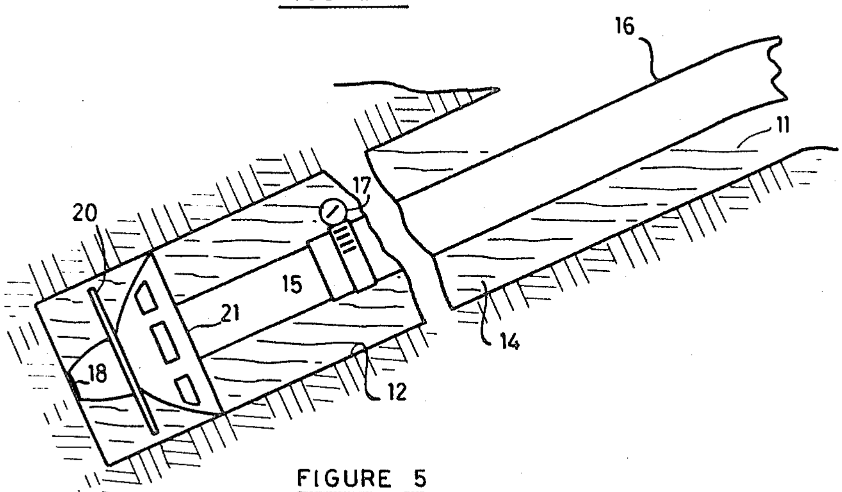

FIGURE 5

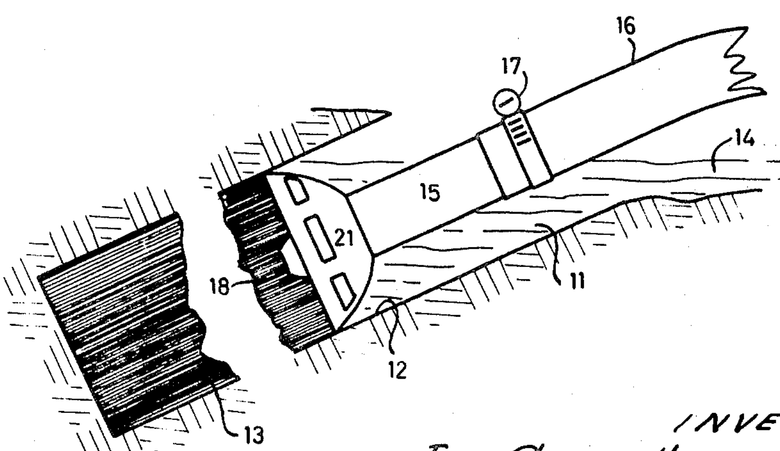

FIGURE 6

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APPARATUS FOR LOADING BOREHOLES

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Int. Cl. E02d *7/24*
U.S. Cl. 61—35 9 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for filling a borehole with a slurried or plastic mass. The apparatus comprises a tubular member having an open bore, at least one flexible annular element mounted on the tubular member and a flexible hose connecting the inlet end of the tubular member to supply means for supplying the slurried or plastic mass.

This invention relates to loading boreholes. More particularly, it relates to loading holes bored in civil engineering and mining operations for the purposes of cement grouting, foundation construction and blasting with explosives.

It is well known practice to fill or load boreholes simply by pouring the less viscous slurries down holes, which are substantially vertical to the ground surface. Materials of a more viscous nature are placed in the holes by being pumped through hoses inserted to varying depths within the holes. The principal difficulty with this loading procedure is the impossibility of seeing the rate at which the hole is being filled, which knowledge would enable the operator to withdraw the hose at a similar rate. If the hose is withdrawn too slowly, it becomes embedded in the material and is likely to leave a columnar gap or cavity on being withdrawn. Conversely, if the hose is withdrawn too rapidly, the material is likely to be dropped from a height above the rising surface of the slurry and entrap pockets of air. In most of these operations, discontinuity in the material filling of the hole is undesired or detrimental for the intended purpose.

The difficulty of loading materials against gravity in boreholes, slanting upwardly from the horizontal, is too well known to require elaboration.

There is yet another problem to be solved when boreholes contain substantial quantities of water. Slurries dropped or pumped into holes under wet conditions may be adversely affected by too great a degree of dilution so that, for instance, the grouting or cement mixture loses its property of strength when set or the explosive mixture cannot be initiated by a detonator or the explosion fails to propagate through the mixture.

It is extremely difficult, if not impossible, to fill holes of small diameter with a highly viscous material and more particularly if the holes contain water.

The chief object of the present invention is to enable operators to fill boreholes more completely with loading materials than appears feasible with known procedures.

A further object is to load wet boreholes in such a manner that the loading materials are not deleteriously affected by the water in the holes. Other objects will become apparent from the following description of the invention.

Accordingly, for filling a borehole with a slurried or plastic mass, this invention provides apparatus comprising a tubular member having an open bore, at least one flexible annular element mounted on the tubular member and a flexible hose connecting the inlet end of the tubular member to supply means for supplying the slurried or plastic mass. The flexible annular element may be a flat

ring or washer or disc of a suitable material such as natural or synthetic rubber or a synthetic plastics material.

In order to hold the ring securely on the tubular member or nozzle of the apparatus, it may be seated in a groove or slot encircling the tubular member transverse to its longitudinal axis. In another modification of the invention, the ring may be clamped on the tubular member by suitable means fitted to the member. Clamping and screwing devices for securing annular fittings around the outer circumference of pipes and tubes are well known and are, therefore, not described and illustrated in this specification. Any such mechanical means suitable for the purpose may be employed. The major portion of the ring stands proud of the surface of the tubular member to provide a circular disc-like structure on the body of the member.

In another embodiment of the invention, two flexible annular elements are mounted on the tubular member. Such an arrangement assists in aligning the apparatus centrally in the hole and, thereafter, maintains it in a position substantially co-axial with the hole during its passage through the hole.

In yet another embodiment of the invention, at least one of the flexible annular elements is paired with a second, co-operating flexible annular element of greater diameter and having performations therein to perform in combination with the element as a non-return valve. The perforations in the second flexible annular element may be orifices or slots through its material surrounding the tubular member.

For a more complete understanding of the invention, embodiments of the apparatus and the method employed will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a view in perspective of the apparatus,

FIG. 2 is a view, partly in section, of a borehole and apparatus at the commencement of a borehole loading operation,

FIG. 3 is a view, partly in section, of a borehole and apparatus at the conclusion of a borehole loading operation,

FIG. 4 is a view in perspective of another embodiment of the invention,

FIG. 5 is a view, partly in section, of a borehole and the apparatus illustrated in FIG. 4 at the commencement of a borehole loading operation, and

FIG. 6 is a view, partly in section, of a borehole and the apparatus illustrated in FIG. 4 at the commencement borehole loading operation.

Referring to the drawings in which similar parts are indicated by like numerals, FIG. 1 shows the complete assembly of tubular member **4**, flexible annular elements **5** and **6** and flexible hose **7**. The tubular member **4** is illustrated as a nozzle with an open bore, the inlet end of which communicates with the bore of the hose **7** and the outlet or discharge end of which is shown at **8**. The hose **7** covering the inlet end of the nozzle **4** may be fastened thereto by a circular clip but, usually, the grip of the hose over the end of the nozzle is sufficiently tight to prevent disengagement during a loading operation. The end of the hose **7** remote from the nozzle **4** is connected to supply means, such as a pump, a pressurized slurry container or a mixer-placer unit provided with a pump (not shown), for supplying the slurry or plastic mass under pressure to the nozzle 4. In these drawings, the flexible annular elements **5** and **6** are flat neoprene rings or discs secured in shallow, circular grooves as at **9** and **10** on the nozzle **4**.

In practice, the apparatus is pushed down a borehole **11** by means of hose **7** until it is felt to have touched the bottom of the hole as illustrated in FIG. 2. If there is water in the hole, it is displaced past the rearwardly flexed neoprene rings. The neoprene rings **5** and **6** are then flexed into the opposite direction by slightly retracting hose **7**. At this stage, the neoprene rings **5** and **6** act as flexible seals between the nozzle **4** and the wall **12** of the borehole **11**. Pumping of the slurry or plastic mass is then started.

As soon as the space—as defined by the wall **12** and the face of the borehole, the neoprene ring **5** and the surface of the nozzle **4** projecting from it—is filled with the mass **13**, the pressure exerted by the discharge from outlet **8** of the continuing flow of mass **13** forces the apparatus to rise in the borehole **11**. If there is water as indicated by reference numeral **14**, lying in the borehole, it may have been urged to flow past the ring **5** by the mass **13** and will then be raised by the piston action of the nozzle as the nozzle is displaced from the bottom of the hole. The neoprene rings act as barriers to separate the mass **13** from the water **14** as well as to ensure that the space forwardly of ring **5** in the borehole **11** is completely filled with the mass **13**.

As the apparatus begins to rise in the borehole, the neoprene rings **5** and **6** are flexed in the direction as shown in FIG. 3. In this trailing position, the efficiency of the seal improves with the increase of pressure differential across the neoprene ring **5**. A portion of the mass **13** may escape into the space between the two rings **5** and **6** due to surface irregularities in the borehole. However, this action will only further serve to ensure that the borehole **11** is completely filled with mass **13** to the exclusion of water **14** and unwanted air gaps.

It will be understood that the assembly of nozzle **4** and neoprene rings **5** and **6** acts as a sealing piston in the borehole **11**, while accommodating variations in the diameter of the borehole, which may be likened to a cylinder. Moreover, the operator does not have to exercise any control over the rate of speed of withdrawal of the apparatus from the borehole. Having inserted the apparatus in the borehole and reversed the flexure of the flexible rings, he may then let it be ejected at a controlled rate, which is governed entirely by the rate at which the borehole **11** is being properly filled by mass **13**.

The conclusion of the borehole loading operation is illustrated in FIG. 3, at which stage the pumping of the mass **13** through hose **7** is stopped. There may be a marker on the hose **7** adjacent the inlet end of the nozzle **4** as a visual warning to the operator to stop pumping or, if desired, pumping may be stopped as soon as the inlet end of the nozzle appears at the mouth of the borehole **11**. The apparatus is then removed from the borehole **11** and inserted into another borehole, when the loading procedure described above is repeated.

It will be seen from the illustration in FIG. 3 that the water **14** has been almost completely expelled from borehole **11** and has overflowed from its mouth. The very minor volume of water shown may be removed entirely, if so desired, by continuing the pumping operation until the mass **13** rises to the mouth of borehole **11**. In any event, much of this water would be removed by the rings **6** and **5** in withdrawing the apparatus from the borehole. If mass **13** is an explosive composition, any water left in the borehole after withdrawal of the apparatus may be removed and/or absorbed by the stemming material, such as rock cuttings or rubble, which may be poured into the hole to cover the explosive composition according to normal blasting practice.

Referring now to FIG. 4, in which is depicted a modification of the assembly shown in FIG. 1, reference numeral **15** indicates a tubular member with an open bore, such as a nozzle. Its inlet end communicates with the bore of flexible hose **16** and that end of the nozzle **15** may be secured within the hose **16** by means of a fastener or circular clip **17**, if considered necessary. The outlet or discharge end of the nozzle **15** is shown at **18**. The free end of the hose **16** is connected to supply means, such as a pump or pressurized supply hopper (not shown), for supplying the slurry or plastic mass under pressure to the

nozzle **15**. In this assembly, there is illustrated one pair of flexible annular elements intended to act in combination as one unit **19**. There may be more than one such unit **19** mounted on nozzle **15** or there may be both the type **5** and **6** and the type **19** of flexible annular elements mounted on the same nozzle.

Element **20** is similar to elements **5** and **6** of FIG. 1 but element **21** is of greater diameter than element **20** and has perforations through its material such as, for instance, slots **22**. Preferably, element **20** may be as shown and is of a size which gives little, if any, contact with the wall of the borehole for which it has been selected as having suitable dimensions.

The method for filling a borehole **11**, when using the assembly of FIG. 4, follows the same steps as are described above with reference to FIGS. 2 and 3. This description will be amplified with reference to FIGS. 5 and 6 to explain more exactly the action of the paired elements **20** and **21**, co-operating to perform as a unit **19** or flexible annular element **19**.

In charging a borehole **11** with a plastic or slurried mass **13** though a tubular member **15** fitted with one or more paired flexible annular elements **20** and **21**, the perforated element **21** is flexed rearwardly as shown in FIG. 5 by frictional contact with the wall **12** of the borehole **11** as the member **15** is pushed down the hole **11**. This action separates the two elements **20** and **21** of the pair **19** and allows water **14**, which may be contained in the hole **11**, to pass the periphery of the leading, or first, non-perforated element **20** of smaller diameter and then escape through the perforations **22** of the second, or trailing, element **21**. In the passage of the apparatus down the hole **11**, the water **14** is thus displaced beyond the apparatus without the latter becoming an obstruction in the way of the water. On reaching the bottom of the hole, element **21** is flexed in the opposite direction as previously described. When the mass **13** is pumped through the apparatus and fills the space between the face of the borehole and the leading element **20** to cause the apparatus to rise in the borehole **11**, the second or perforated element **21** is flexed in the opposite direction to press against the non-perforated element **20**, as shown in FIG. 6. This action closes the perforations **22** and the build up of pressure, created by the mass **13** being pumped into the borehole **11**, forces the element **20** against the element **21** and ensures a firm and positive closure of the perforations **22**. The pair **19** of elements **20** and **21** then act as a single unit in the same manner as element **5** or element **6** in the alternative embodiment of the invention shown in FIG. 1 and described above.

For larger holes filled with water, it may require considerable force to push the nozzle, on which is mounted flexible annular elements of the type illustrated in FIG. 1, down to the bottom of the hole. Where such conditions are encountered, it may be advantageous to use the type of element shown in FIG. 4.

Where the rock face is fissured, it is known to use liners of plastics material to ensure the retention of the explosive medium in the borehole. This procedure presents no difficulties in the use of the apparatus and method of the invention since the plastics liner is readily threaded over the nozzle and hose prior to its insertion in the hole. In fact, the placing of the liner is facilitated by this procedure in comparison with the conventional practice of weighting the bottom of the liner with a weight such as a boulder. Filling of the borehole with the explosive slurry than proceeds as described above.

Several trials of the method and apparatus of the invention were conducted at different locations to test the efficiency of operation. All these trials were successful and are described in the following examples.

EXAMPLE I

Tests were carried out at the semi-technical plant of applicant. A vertical pipe, having a bore of four inches and a length of twenty feet, was filled with water. Using a positive displacement pump, having a two inch outlet, and seventy feet of plastic tubing of two inch bore connected to the apparatus assembly as exemplified by FIG. 1, the pipe was completely loaded with a dummy explosive slurry. It was observed that the water flowed evenly from the pipe as the apparatus filled it with the slurry and that the apparatus rose steadily in the pipe during the loading operation. The temperature of the water flowing from the pipe did not fall, indicating that there had not been any mixing with the particulate urea in the dummy slurry, which would have lowered the temperature of the resulting solution formed and discharged from the pipe. The quantity of slurry estimated to fill the pipe corresponded very nearly with the volume of the pipe.

This test was repeated twice with equally good results.

EXAMPLE II

The test conducted in Example I was repeated three times, using two of the units 19—as illustrated in FIG. 4—as the flexible annular elements mounted on the nozzle in place of the two rings previously used.

The three tests produced excellent results.

EXAMPLE III

The test conducted in Example II was repeated but in the absence of water. The dry pipe was loaded successfully to its full capacity with the dummy explosive slurry, indicating that no air gaps were interrupting the continuity of the slurry column.

EXAMPLE IV

The test conducted in Example II was repeated but in the absence of water. The dry pipe was loaded successfully to its full capacity with the dummy explosive slurry, indicating that no air gaps were interrupting the continuity of the slurry column.

EXAMPLE V

A test was conducted in the quarry of the Mooiplaas Dolomite Quarry at Cordelfos in the Transvaal. Six holes were drilled in loose boulders on the quarry floor measuring one and a half inches in diameter by five feet in depth. Two of these holes were horizontal while four holes sloped upwardly from the horizontal level at various angles between fifteen to twenty degrees. Only one ring, of the type exemplified by FIG. 1, was mounted on the nozzle. Each hole was loaded by the apparatus with six pounds of an explosive slurry composition.

On detonation, the blast was successful.

EXAMPLE VI

A test was conducted in a stope on the property of the Vlakfontein Gold Mining Company near Springs, Transvaal, on the following boreholes, which had been drilled a long time previously and were extremely irregular because of rock movement.

6 crater holes measuring 1½ inches diameter by 36 inches deep. Horizontal.
3 crater holes measuring 1½ inches diameter by 72 inches deep. Horizontal.
15 stope holes measuring 1½ inches diameter by 42 inches deep. Angled downwardly and full of water.

The poor condition of the holes made this test an unfair one and considerable difficulty was experienced in inserting and ejecting the nozzles. Nevertheless, the crater holes and eight of the stope holes were charged with a pumpable, explosive slurry composition through a nozzle on which was mounted one ring of the type exemplified by FIG. 1 and the ensuing blasts were successful.

EXAMPLE VII

A test was conducted in a stope on the property of the Vlakfontein Gold Mining Company on the following

boreholes, which had been drilled just prior to the time of the test.

7 stope holes measuring 1½ inches diameter by 42 inches deep and at angles slightly above and below horizontal.
2 stope holes measuring 1½ inches diameter by 42 inches deep and horizontal.
8 holes in the drive at various angles below the horizontal level and all full of water.

The apparatus worked smoothly with one ring, of the type exemplified by FIG. 1, mounted on the nozzle and all holes were loaded with a pumpable, explosive slurry composition.

The blasts were successful.

EXAMPLE VIII

A test, included in simulated shaft sinking experiments on the property of the Vlakfontein Gold Mining Company, was conducted on eight boreholes measuring one and a half inches by five feet deep. Four of these holes were vertical "cut" holes and four holes, which surrounded the "cut" holes, were "easers." The "cut" holes are blasted first and the subsequent blasting of the "easers" widens the hole created by the first blasting operation.

The working place was flooded to a depth of about six inches under water after completion of the borehole drilling. All eight holes were then loaded with a pumpable, explosive slurry composition through an apparatus assembly as exemplified by FIG. 1.

The loading operation and subsequent blasting of the holes were completely successful.

EXAMPLE IX

A test was conducted on the floor of the quarry of the Mooiplaas Dolomite Quarry during a "pop shooting" or secondary blasting operation. This is an operation, which takes place after the main blasting operation, to break up oversize material too heavy for removal or treatment.

Forty holes, measuring one and a quarter inches in diameter by lengths varying from one to two feet in depth, were drilled into large boulders. The holes were then charged with a pumpable, explosive slurry composition through a nozzle on which was mounted one ring of the type exemplified by FIG. 1.

The loading operation and subsequent shattering of the boulders by blasting the charges in the holes were completely successful.

An advantage of the present invention is that it provides a means for loading boreholes at any inclination to the horizontal.

A further advantage is that the apparatus enables the proper filling of holes of small diameter with viscous masses. The size of the hole will determine the choice of size of nozzle and rings. Furthermore, fairly large variations in borehole diameters may be accommodated by a given set of flexible rings.

I claim:

1. For filling a borehole with a slurried or plastic mass, apparatus comprising a tubular member having an open bore with an inlet for supply of said mass and an outlet therefor at the opposite end thereof, at least one flat flexible annular element mounted on the tubular member of a dimension larger than the borehole and adapted for continuous circumferential contact with said borehole, said element being flexed rearwardly by contact with the borehole as said member is moved into and out of said hole, said element functioning to serve as a barrier to mass discharged into said borehole from said outlet so that said tubular member is moved out of said borehole by the action of said discharged mass against said element as the borehole is filled, and a flexible hose connecting the inlet end of the tubular member to supply means for supplying the slurried or plastic mass.

2. Apparatus as claimed in claim 1 in which the element is a flat ring, washer or centrally holed disc.

3. Apparatus as claimed in claim **1** in which the element is of a natural or synthetic rubber or a synthetic plastics material.

4. Apparatus as claimed in claim **1** in which the element is mounted on the tubular member by being seated in a groove or slot encircling the member transverse to its axis.

5. Apparatus as claimed in claim **1** in which two elements are mounted on the tubular member.

6. Apparatus for filling a borehole with a slurried or plastic mass, said apparatus comprising a tubular member having an open bore, at least one flexible annular element mounted on the tubular member and a flexible hose connecting the inlet end of the tubular member to supply means for supplying the slurried or plastic mass, at least one of the flexible annular elements being paired with a second, co-operating flexible annular element of greater diameter and having perforations therein to perform in combination with the element as a non-return valve.

7. Apparatus as claimed in claim **6** in which the perforations in the second flexible annular element are orifices or slots through its material surrounding the tubular member.

8. Apparatus as claimed in claim **1** in which the supply means is a slurry pump or pressurized supply hopper.

9. For filling a borehole with a slurried or plastic mass, apparatus comprising a tubular member having an open bore, at least one flexible annular element mounted on the tubular member and a flexible hose connected to the inlet end of the tubular member, the free end of the flexible hose being adapted for connection to means for supplying the slurried or plastic mass, at least one of the flexible annular elements being paired with a second, co-operating flexible annular element of greater diameter and having perforations therein to perform in combination with the element as a non-return valve.

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