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METHOD AND APPARATUS FOR PURGING LIQUID AND LIQUID
VAPOR FROM THE INSIDE OF AN ELONGATED TUBE

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2 Sheets-Sheet 1

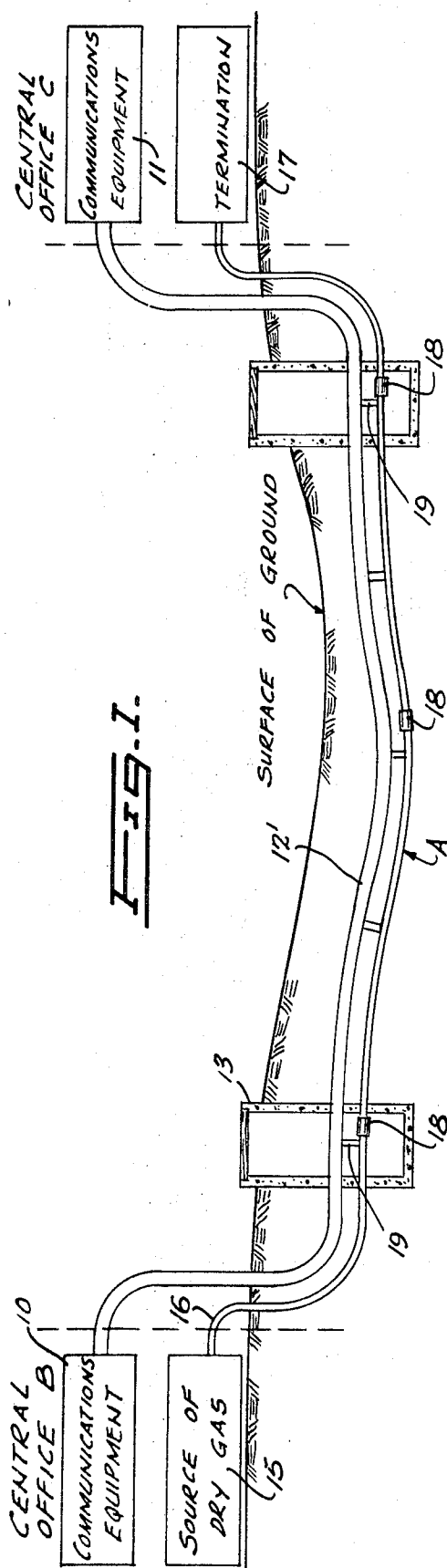


Fig. 1.

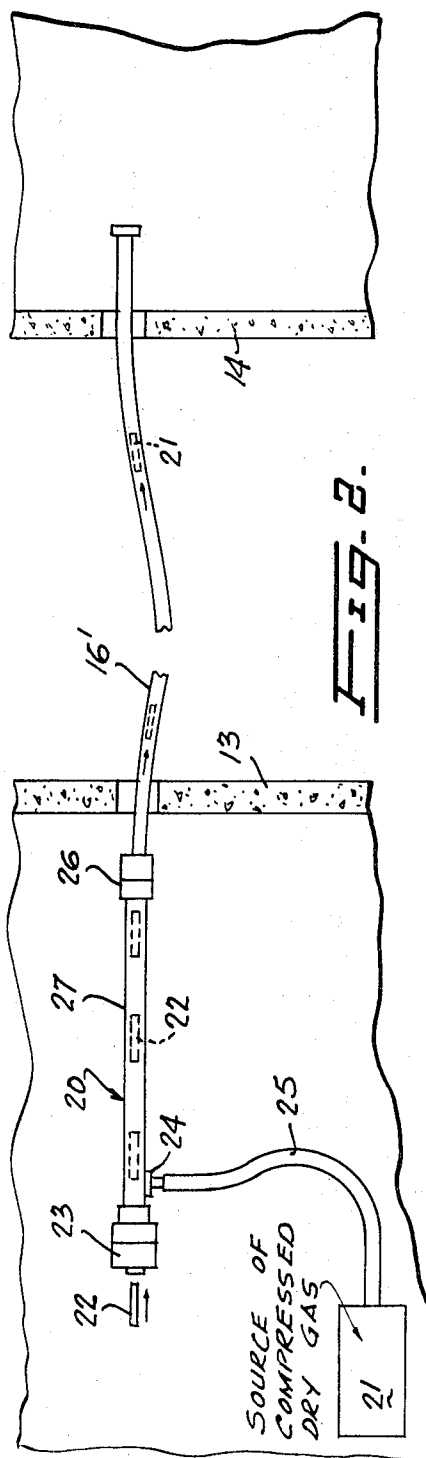


Fig. 2.

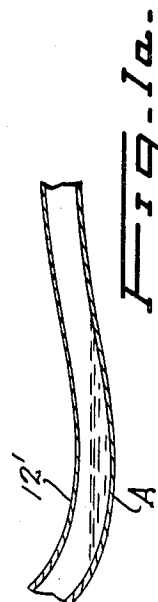


Fig. 1a.

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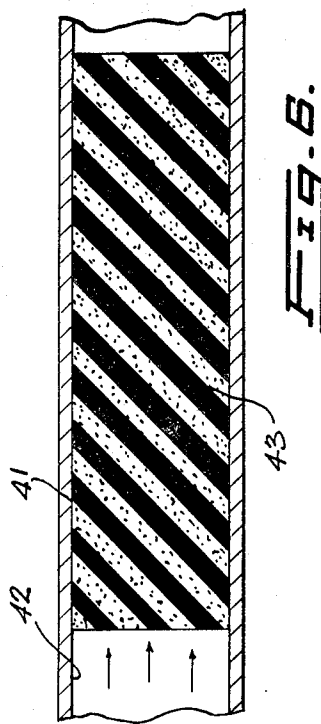
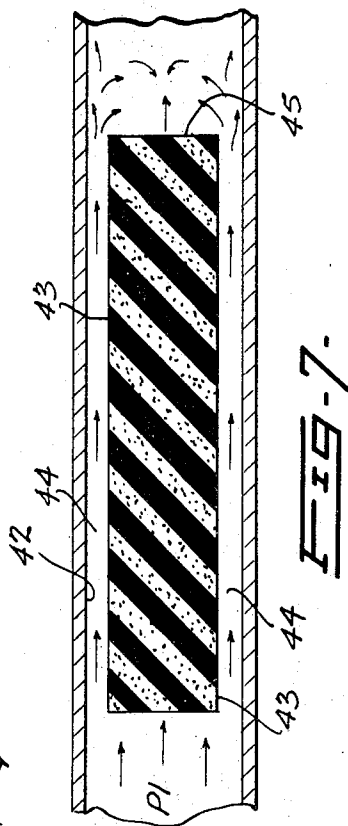
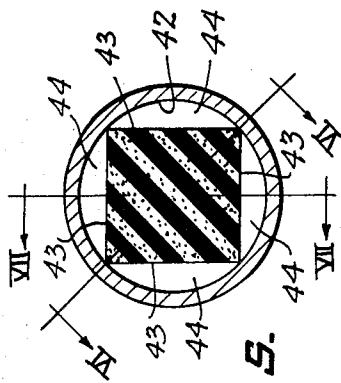
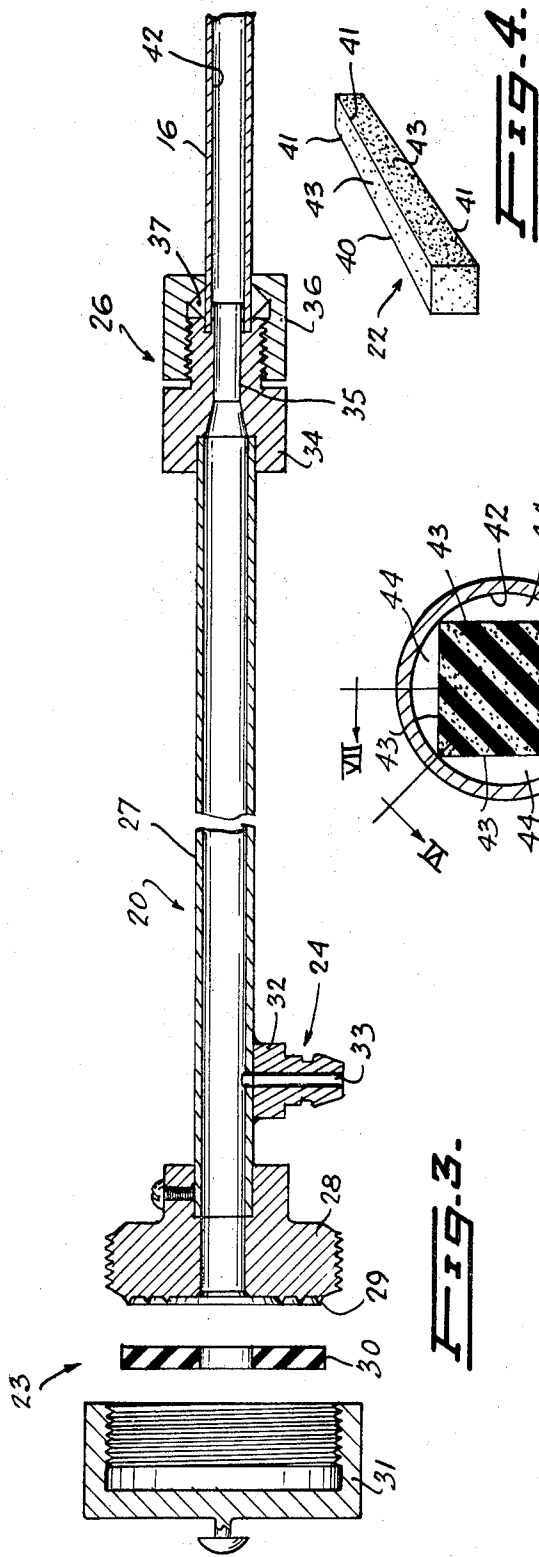
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2 Sheets-Sheet 2



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METHOD AND APPARATUS FOR PURGING LIQUID AND LIQUID VAPOR FROM THE IN- SIDE OF AN ELONGATED TUBE

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7 Claims

ABSTRACT OF THE DISCLOSURE

A source of dry pressurized gas is applied about a rear end surface of an elongated projectile in a confined space to propel the projectile into the interior of a tube to be purged of liquid and liquid vapor, and the supply of gas is maintained under pressure about the rear end surface of the projectile to drive it toward a remote open end of the tube.

The projectile is composed of elastic, liquid-impermeable material; is bar-shaped; and is rectangular or square in cross-section throughout substantially its total length, the diagonal of which is from about 10% to about 30% greater than the inside diameter of the tube.

A gun for propelling the projectile through the tube has a cylindrical barrel, a first closable inlet extending axially of the barrel at one end thereof for inserting one or more projectiles, a second inlet extending radially of the barrel for connecting the source of pressurized gas about the rear end surface of the projectile in the barrel, and an outlet for connecting the other end of the barrel to the interior of the tube. The outlet of the gun has a partially tapered constricted portion to ensure that projectiles are propelled into the interior of the tube at intervals.

This invention relates to a method and apparatus for purging liquid and liquid vapor, e.g. water, from the inside of an elongated tube. The invention is particularly suitable for purging tubes that are used to feed dry gas to communications cables, for keeping these cables free of moisture.

It is common to protect communications cables from water and water vapor by enclosing the cables and by continuously pumping dry gas into their enclosures. This method also maintains the cables under positive pressure. Leaks in the cable enclosure can then be detected by measuring the pressure drop along selected lengths of the cable.

These cables are usually pressurized through spaced access points connected to plastic supply tubes which are placed alongside the cables either below, on or above the ground. The distance between access points can vary from several feet up to about 5000 feet. The supply tubes are composed of several sections with connectors joining the sections together.

When the tubes are laid underground or in a ditch, due to the contours of the ground there tend to be low-lying portions of the tubes where water droplets can accumulate, and higher portions where there will be no water. Water and water vapor can find their way into these tubes in several ways: (1) if a connector leaks; (2) if a connector has been left open such as in a manhole, and the manhole becomes flooded with water; (3) if the tubes are installed underground well in advance of their actual use without being sealed or pressurized; or (4) if water vapor in the tubes condenses under varying temperature conditions.

The principal object of this invention is to purge water and water vapor from such tubes, it being understood that the invention is applicable to other liquids.

Prior to applicants' invention, it was common to attack this problem by continuously pumping dry air through the tubes until the water was removed and an acceptable relative humidity was reached. This process sometimes took days, and even weeks, depending upon the amount of water in the tubes. One tube, for example, was pumped for three weeks, after which the relative humidity inside the tube was still 80%. A relative humidity of 7% is considered to be acceptable in the communications cable field. It will be understood that such a process is inefficient, time consuming and costly, particularly since large amounts of compressed air must be used.

This prior art process was also less than completely successful regardless of how long the dry air was pumped through the tube. It has been observed in laboratory experiments that dry air forced down a tube, rather than purging the tube of pockets of water in low-lying portions of the tube, merely bubbled through these pockets of water. Having bubbled through water and encountered water vapor, the air was no longer dry by the time it had passed through the tube. This effect compounded the problem by introducing water droplets in higher-lying portions of the tube that had been relatively dry before.

In attempting to solve this problem, applicants considered the feasibility of propelling a projectile along the interior of the supply tube from one end to the other. Such a consideration had to take into account the possibility of minor constrictions in the tubes; the potential problem that the projectiles might tend to jam in the tube; and the problem of overheating and disintegration of the projectiles due to friction and tumbling.

Applicants have provided a method and apparatus which overcome the above disadvantages of the prior art and which permit the more efficient purging of liquid and liquid vapor from tubes in a less expensive and time consuming manner. Applicants have discovered that substantially all the liquid and liquid vapor can be removed by propelling a projectile through the tube under the force of a continuous source of pressurized dry gas; and by providing means to slow down the projectile to reduce the above-noted problems of friction; while at the same time allowing a portion of the pressurized gas to travel past the projectile.

According to the apparatus of applicants' invention there is provided a projectile comprising an elongated body of elastic, liquid-impermeable material, and means for applying a source of dry pressurized gas about a rear end surface of the projectile in a confined space to propel the projectile into the interior of the tube and for maintaining the supply of such gas under pressure about the rear surface to drive the projectile towards a remote open end of the tube. The body of the projectile has first surface means (e.g. edges of a bar of square or rectangular cross-section) for continuously slidably engaging the inner wall surface of the tube. The body also has second surface means (e.g. faces between the edges) which when the projectile is in the tube, define passageways extending from the rear surface of the projectile to the leading end thereof between the inner wall surface of the tube and the second surface means. These passageways enable a sufficient portion of the gas to escape past the projectile to diminish the speed of the projectile while locally increasing the speed of gas in the passageways to exert a scrubbing action on the wall surface and turbulent flow adjacent the leading end of the projectile, thus causing liquid and vapor to travel toward the open end. By use of this apparatus, substantially all the liquid and liquid vapor

can be purged from the tube as the projectile passes from one end to the other.

By using elastic material for the projectile, it can readily pass through minor constrictions in the tubes. Such constrictions can result from a part of a connector for joining together two sections of a tube, which is so placed inside the tube as to reduce its inner diameter. Also, portions of the tube can become oval in cross-section when subjected to an extreme weight such as a large rock, or by the introduction of sharp bends in the tube.

By making the projectiles elongated, problems of disintegration and jamming due to tumbling have been avoided. In addition, the slidable engagement of the first surface means serves to reduce by friction the velocity of the projectile. Since this surface means forms only line contacts with the inner wall of the tube, which lines represent only a relatively small proportion of the total surface area of the projectile, the amount of heat generated due to friction is low, and in practice has been found to be low enough to prevent excessive heating of the projectile.

In the preferred form of the projectile, the elongated body is bar-shaped and rectangular or square in cross-section throughout substantially its total length, the diagonal of the cross-section being from about 10% to about 30% greater than the inside diameter of the tube and preferably about 20% greater.

According to another feature of applicants' invention, a gun for propelling the projectile through the supply tube is provided, comprising inlet means for inserting the projectile into the gun and for connecting a continuous source of pressurized gas to the space behind the projectile about a rear end surface thereof; outlet means from which the projectile is to be propelled into the interior of the supply tube; and a barrel for connecting the inlet means to the outlet means.

In applicants' preferred embodiment, the inlet means includes a first closable inlet for inserting the projectile and a second inlet for connection to the continuous source of pressurized gas. The barrel can be used to store one or more projectiles, once inserted, prior to being fired. When a number of projectiles is to be stored in the barrel and then fired, a constriction is provided at the outlet means to stop each projectile momentarily at the constriction so that the projectiles are propelled into the interior of the supply tube at intervals.

An embodiment of applicants' invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a schematic representation of an environment in which the invention can be used;

FIG. 1a shows a greatly enlarged section of FIG. 1 illustrating the accumulation of water in low-lying portions of the tube;

FIG. 2 is a schematic arrangement of applicants' apparatus in use;

FIG. 3 is a partly exploded, detailed view of a novel gun, according to applicants' invention;

FIG. 4 is a perspective view of a projectile, according to applicants' invention;

FIG. 5 is a sectional end view of a tube containing a projectile therein;

FIG. 6 is a sectional view taken along lines VI—VI of FIG. 5; and

FIG. 7 is a sectional view taken along lines VII—VII of FIG. 5.

Referring to FIG. 1, two Central Offices B and C are shown containing communications equipment 10 and 11, respectively, with a communications cable 12 interconnecting the equipment at the Offices. Portion 12' of the cable 12 extends underground and passes through manholes 13 and 14.

A source of dry gas 15, such as air, located in Central Office B is shown connected to a supply tube 16 which is laid beside the cable 12 for most of its length ends in Central Office C at a termination 17. The tube 16 is

formed in sections which are joined together by connectors 18. Compressed dry gas is fed to the enclosure of the cable 12 from the tube 16 via access connections 19. As can be seen from FIG. 1, the cable 12 and the tube 16 follow the general contour of the ground. If a connection 18 leaks or is left open in one of the manholes 13, 14, and the manhole becomes flooded with water, water will accumulate in the low-lying regions of the tube 16, such as the region A, as demonstrated in FIG. 1a.

Referring to FIG. 2, applicants' apparatus is shown for purging water and water vapor from the section 16' of the tube 16 between manholes 13 and 14. Firstly the connectors 18 are removed at each manhole. A gun 20 is provided to serve as means for applying a source of dry pressurized gas 21 about a rear end surface of a projectile in a confined space to propel the projectile into the interior of the tube section 16', and for subsequently maintaining the supply of gas under pressure to the rear of the projectile to drive it toward a remote open end of the tube section 16' in manhole 14.

The gun 20 comprises inlet means shown as a first closable inlet 23 for inserting the projectiles 22 and a second inlet 24 for connecting the source 21 to the gun 20 via a pipe 25. The gun further consists of an outlet means, shown as outlet 26, connected to the tube section 16' and a barrel 27 for storing the projectiles 22 and for connecting the inlets 23, 24 to the outlet 26. The remote end of the tube section 16' is left open in manhole 14.

Prior to propelling any projectiles through the tube section 16', it is tested for any serious blockages or leaks by forcing dry gas through the tube. The outlet 26 of the gun 20 is connected to the end of the tube section 16', the inlet 23 of the gun 20 is sealed to the barrel 27, and the source of dry gas 21 is applied to the inlet 24 via pipe 25. Compressed dry gas is forced through the tube section 16' at a pressure of 60–80 lbs./sq. in. The source 21 can be typically a 220 cu. ft. nitrogen cylinder having a pressure regulator, or some other source of dry gas such as air. If a serious blockage or leak is discovered, the tube section 16' must be repaired before proceeding with the purging process.

The source 21 is then disconnected from the inlet 24 and the inlet 23 is opened. Three projectiles 22 are inserted into the barrel 27 through inlet 23, which is then closed, and the source 21 is reconnected to the inlet 24. The dry gas under a pressure of 60–80 lb./sq. in. propels the projectiles down the barrel 27 and into the interior of the tube section 16'. The maintenance of the source 21 drives the projectiles toward the remote open end of the tube section 16'. By this process, substantially all the water is removed and the relative humidity reduced to an acceptable level.

This operation requires approximately one minute per 100 ft. of tube and consumes approximately 10 cu. ft. of nitrogen or other dry gas per 100 ft. of tube.

When two or more projectiles are in the tube at the same time, a cushion of gas is built up between a leading and a trailing projectile. This cushion provides enough pressure to the rear end surface of the leading projectile to propel it through the tube. A pressure as low as 20 lb./sq. in. is sufficient to propel the projectiles through the tube under ideal conditions i.e. in the absence of constrictions, but the higher pressures are recommended to ensure that the projectiles are propelled right through the tube.

To maintain the oxygen content in the manhole 14 at a safe level for humans, if nitrogen is being used, the tube section 16' should be extended to a location outside the manhole, allowing free discharge of the nitrogen, or a manhole ventilator-heater should be used. Tests have shown that one 224 cu. ft. nitrogen cylinder is sufficient for a tube section of approximately 100 feet in length. A two man crew with two-way communication is recommended for this operation.

In a laboratory experiment, applicants propelled 10

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projectiles through 1300 ft. of tube into which approximately 2 quarts of water had been introduced. This experiment achieved a relatively humidity reading of 4.3%. After 16 projectiles had been propelled through the tube, a relative humidity reading of 0.4% was reached. According to the practice of one telephone operating company using this invention, a reading of 7% relative humidity or less is considered acceptable.

Reference is now made to FIG. 3 for an understanding of the detailed construction of the gun 20. The barrel 27 is formed of seamless brass tubing and, for ease of loading, has an inside diameter slightly larger than that of the plastic tube 16. For example, for a $\frac{3}{8}$ " inside diameter tube 16, it is recommended to use a barrel having a $\frac{1}{2}$ " diameter. The length of the barrel 27 is not critical, beyond the need for it to be long enough to store the number of projectiles 22 to be propelled in one firing of the gun.

The inlet 23 comprises a breach 28 secured to one end of the barrel 27 and having rings 29 for sealing against a neoprene washer 30. A knurled cap 31 is placed over the breach 28 and the washer 30 to complete the assembly.

The inlet 24 comprises a coupling 32 brazed to the outer surface of the barrel 27 defining an opening 33 for communication between the pipe 25 and the barrel 27.

The outlet 26 of the gun comprises a connector 34 brazed to the other end of the barrel 27. The inside surface of the connector 34 tapers at an angle of about 30° from the end of the barrel 27 to form a partially tapered, constricted portion 35. The tube 16 is connected to the constricted portion 35 of the connector 34 by means of a cap 36 and a washer 37. It can be seen that the diameter of the constricted portion 35 is less than the inside diameter of the tube 16. In practice, this diameter is the same as the inside diameter of a connector 18, i.e. 0.312 in. in the case of a 0.375 in. inside diameter tube. The provision of the constricted portion 35 ensures that the projectiles will be spaced apart as they are propelled down the tube 16, and also that anything which will pass out of the portion 35 will also pass through a connector 18 of the tube 16.

The operation of the apparatus when the projectiles 22 are in the barrel 27 requires a special explanation. Under the force of the source of dry gas 21, the leading projectile is propelled down the barrel 27 until it reaches the start of the taper of the constricted portion 35. The projectile 22 thus slows down while it is being forced through the constricted portion 35 into the interior of the tube section 16' where it regains some velocity and is driven toward its remote open end. Meanwhile, the second projectile reaches the constricted portion 35 where it slows down, thus creating a space between the first two projectiles in the tube section 16'. The trailing projectile similarly is spaced from the second projectile. Thus the three projectiles travel through the tube section 16' in spaced-apart relation as long as a constant gas pressure is applied at the inlet 24.

Variations can be made to the structure of the gun 20. For example, a trigger can be installed for controlling the flow of compressed dry gas through the inlet 24. It is important that the compressed dry gas be applied radially of the barrel 27 of the gun 20. It has been found in practice that if compressed gas is applied axially of the barrel, the projectiles tend to jam (bunch up at the constricted portion 35) and the gun 20 does not fire. By applying the gas radially, a spiral action is imparted to its flow and this action permits the gun to fire. In effect, it allows the air to flow completely about the rear end surface of the projectile rather than being applied directly behind it.

Reference will now be made to FIGS. 4 to 7 for an understanding of the construction of the projectiles 22, and of what applicants believe to be the mode of operation of their invention.

Each projectile 22 comprises an elongated body 40 composed of elastic, liquid-impermeable material, such

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as closed cell sponge rubber. One successful material used is Ontario Rubber Standards G231N Neoprene Closed Cell Sponge. The essential properties of the material are its impermeability to liquid and its elasticity or resilience to permit it to move past constrictions in the tube.

The body 40 is provided with first surface means shown as edge surfaces 41 for continuously slidably engaging the inner wall surface 42 of the tube 16 when the projectile 22 is propelled therethrough (see FIGS. 5 and 6). This sliding engagement of the surfaces 41 serves to reduce by friction the velocity of the projectile 22. Since these edge surfaces 41 form only line contacts with the inner wall 42 of the tube 16 and such edge surfaces represent only a relatively small proportion of the total surface area of the projectile 22, the amount of heat generated due to friction is low, and in practice has been found to be low enough to prevent disintegration of the projectile 22.

Each projectile 22 is provided with second surface means shown as side surfaces 43, which when the projectile is in the tube, define passageways 44 extending from the rear surface of the projectile 22 to the leading end thereof between the inner wall surface 42 of the tube and the surfaces 43.

As best shown in FIG. 7, these passageways 44 enable a sufficient portion of the gas to escape past the projectile 22 to diminish the projectile's speed. At the same time, the speed of the gas is increased in the passageways, because of the reduced cross-sectional area through which it flows. This faster flowing gas in the passageways exerts a scrubbing action on the wall surface 42. As a consequence of the faster flowing gas, a pressure differential is created across the projectile 22 i.e. pressure P1 is greater than pressure P2. A turbulent flow of gas adjacent the leading edge 45 of the projectile is also produced.

Each projectile 22 should preferably be at least rectangular in cross-section i.e. it should have at least four sides. Other cross-sections with fewer sides, such as a triangle, will work, but with less favourable results. A projectile with a triangular cross-section will travel more slowly, because the passageways 44 will be larger allowing more gas to by-pass the projectile. Also, the projectile will be less stable in its travel through the tube 16, and it would be more costly to produce a triangular shape.

The projectile can have more than four sides. However, it should be understood that the more sides the projectile has, the closer it comes to resembling a perfect cylinder. This will tend (1) to increase the speed of the projectile due to reduction in the volume of gas escaping past the projectile sides, and (2) to reintroduce the problem of heat generation and consequent damage or disintegration of the projectile due to increased friction resulting both from the greater speed and the increase in surface area in contact between the projectile and tube.

Applicants have found that the most effective rectangular cross-section for the projectile 22 is a square having a diagonal about 20% greater than the inside diameter of the tube 16. However, it has been found that this diagonal dimension can vary within a range of about 10% to 30% greater than the inside diameter of the tube 16. A square cross-section is ideal, because there are then four equal passageways 44 between the surfaces 43 of the projectile and the wall 42 of the tube 16 which provides for best stability.

As a practical matter, applicants have found that closed cell foam rubber is readily available in $\frac{3}{8}$ " sheets. Projectiles $\frac{5}{16}$ " wide were cut from the sheet to form the projectiles. Since the diagonal dimension of these rectangularly shaped projectiles should ideally be about 20% greater than the nominal inside diameter of the tube, such projectiles are suitable for use in standard tubing having an inside diameter of 0.375 inch.

The length of the projectile 22 is not critical. Theoretically there is no maximum length, it being important only that the projectile can be propelled through the tube 16

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from one end to the other. The minimum length of the projectile 21 is governed by a requirement to prevent tumbling. In practice, it has been found that the length of the projectile 22 should preferably be a minimum of twice the length of its diagonal dimension. For a projectile having a rectangular cross-section of $\frac{3}{8}$ in. x $\frac{5}{16}$ in. tests have shown that a length of about 3 in. was the most effective. This represents a length of about eight times the diagonal dimension.

How the projectile 22 succeeds in purging water and water vapor from the tube 16 is not fully understood. Although applicants do not wish to be held to the accuracy of their theory of operation of the apparatus, the following represents to the best of their knowledge what is believed to happen as the projectile travels along the tube. Since the problem of drying the wet inside surface of a long tube appears to consist essentially of lifting off a layer of water from the inner wall of the tube, it is believed that a "jet-stream" of fast moving gas in the passageways scrubs the inner wall of the tube to remove a layer of water in a dynamic cleaning action. When this gas reaches the leading end of the projectile, the gas and the projectile push existing gas and water in the tube along the tube in front of the projectile.

However, tests with a cylindrical projectile having an outside diameter slightly smaller than the inside diameter of the tube, including an anchor attached to the projectile by a cord to reduce its velocity, showed that this projectile did not effectively dry the tube. It is therefore concluded that simple "jet-stream" action does not appear to be the only mechanism at work in applicants' invention.

Applicants believe that the most likely mode of operation is a combination of the "jet-stream" effect referred to and the action of the turbulent gas stream around the leading edge 45 of the blunt projectile 22 (see FIG. 7). It is thought that violent eddy currents around the sharp leading corners of the projectile 22 cause destruction of the boundary layer resulting in water droplets clinging to the tube surface being broken down into a fine mist, this mist being subsequently carried away by the gas stream ahead of the projectile.

We claim:

1. A method of purging liquid and vapor of said liquid from the interior of an elongated tube of substantially circular cross-section comprising the steps of:

(a) locating a projectile at one end of the interior of the tube, the projectile comprising an elongated body of elastic, liquid-impermeable material, said body having a solid polygonal cross-section, all edges of the polygon defining an imaginary circle having a diameter from about 10 percent to about 30 percent

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greater than the inside diameter of the tube and being in continuous sliding contact with the inner wall surface of the tube, all sides of the polygon being spaced from the inner wall surface of the tube to define passageways extending from the rear end surface of the projectile to the leading end thereof between the inner wall surface of the tube and the sides of the polygon;

(b) and maintaining a supply of dry pressurized gas about the rear end surface of the projectile to drive it toward a remote open end of the tube, to cause a portion of the gas to escape along the passageways at a locally increased speed to scrub the inner wall surface of the tube, and to set up a turbulent flow at the leading end of the projectile to cause liquid and vapor to travel toward said open end of the tube.

2. A method as defined in claim 1 wherein the body is composed of closed cell sponge rubber.

3. A method as defined in claim 1 wherein the tube is plastic, the liquid is water and the gas is air.

4. A method as defined in claim 1 wherein the body of the projectile is bar-shaped and rectangular in cross-section.

5. A method as defined in claim 1 wherein the body of the projectile is bar-shaped and square in cross-section.

6. A method as defined in claim 5 wherein the diameter of said circle is about 20 percent greater than the inside diameter of the tube.

7. A method as defined in claim 5 wherein the length of the body is at least twice as great as the diameter of said circle.

References Cited

UNITED STATES PATENTS

1,547,440	7/1925	Penn	15—104.06
1,673,890	6/1928	Smith	15—104.06
1,808,870	6/1931	Strasburg	15—3.5
2,058,825	10/1936	Rallet et al.	166—18
2,915,422	12/1959	Stone	134—8
3,067,721	12/1962	Collins	15—104.06X
3,073,688	1/1963	McCune	134—8UX
3,135,322	6/1964	Neugebauer	134—8UX
3,148,689	9/1964	Bean et al.	137—1
3,204,274	9/1965	Knapp	15—104.06
3,276,061	10/1966	Ver Nooy	15—104.06

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U.S. Cl. X.R.

15—104.06; 134—22