

[54] **APPARATUS FOR COATING THE INNER WALL SURFACE OF A DUCT**
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 [22] Filed: **May 21, 1973**
 [21] Appl. No.: **362,014**

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[30] **Foreign Application Priority Data**
 May 24, 1972 Switzerland 7785/72

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[52] **U.S. Cl.** **118/105**; 15/104.09; 117/95;
 118/7; 118/112; 118/408; 118/DIG. 10
 [51] **Int. Cl.** **B05c 7/06**; B05c 11/02
 [58] **Field of Search** 117/95; 118/408, 105, 254,
 118/DIG. 10; 15/104.05, 104.06 R, 104.09

[57] **ABSTRACT**
 An apparatus for the application of a coating on the inner wall surface of a duct comprising a forward and rearward piston, axially displaceable and defining a space therebetween for a coating mass, and further including a rotating polishing device upstream of both pistons, and a guide cable attached to the polishing device and passing through both pistons.

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6 Claims, 12 Drawing Figures

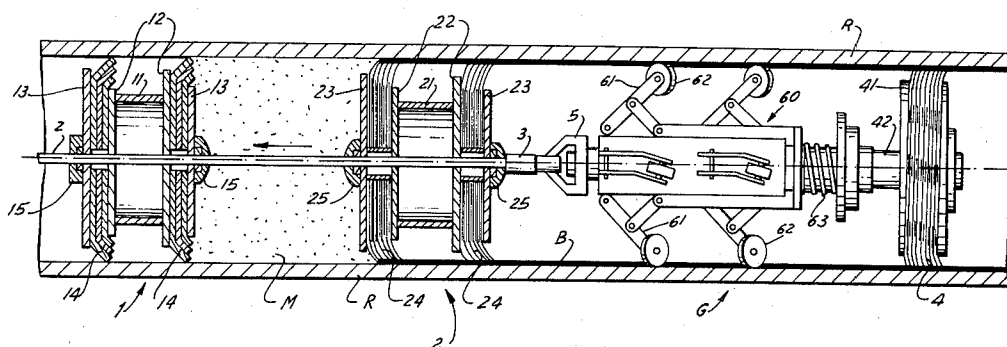


FIG. 1

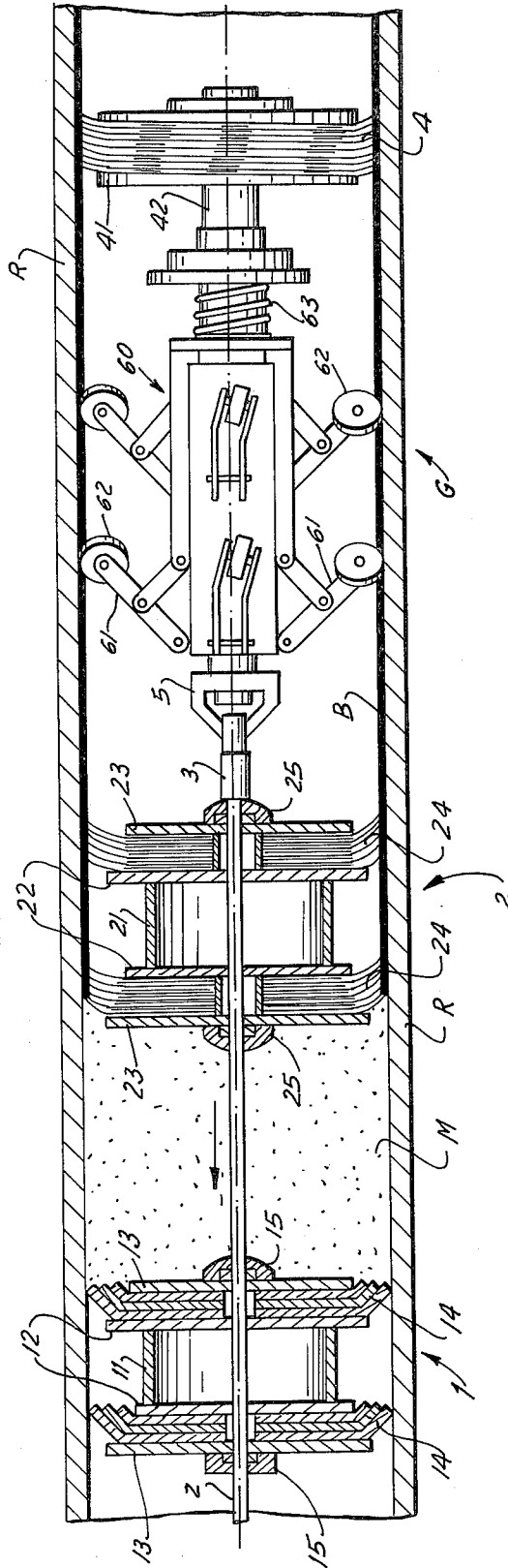


FIG. 2

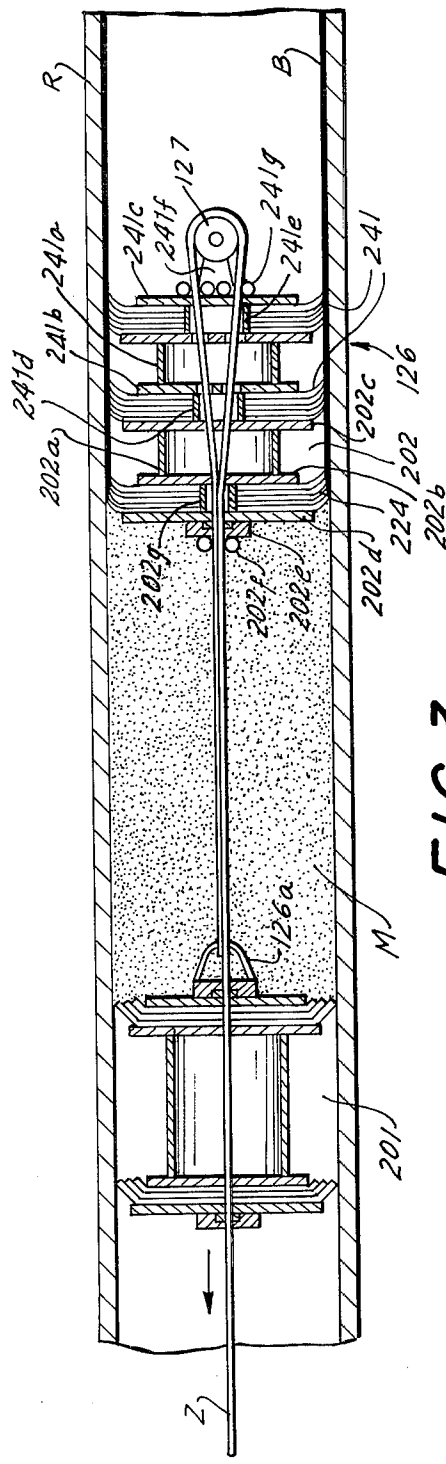
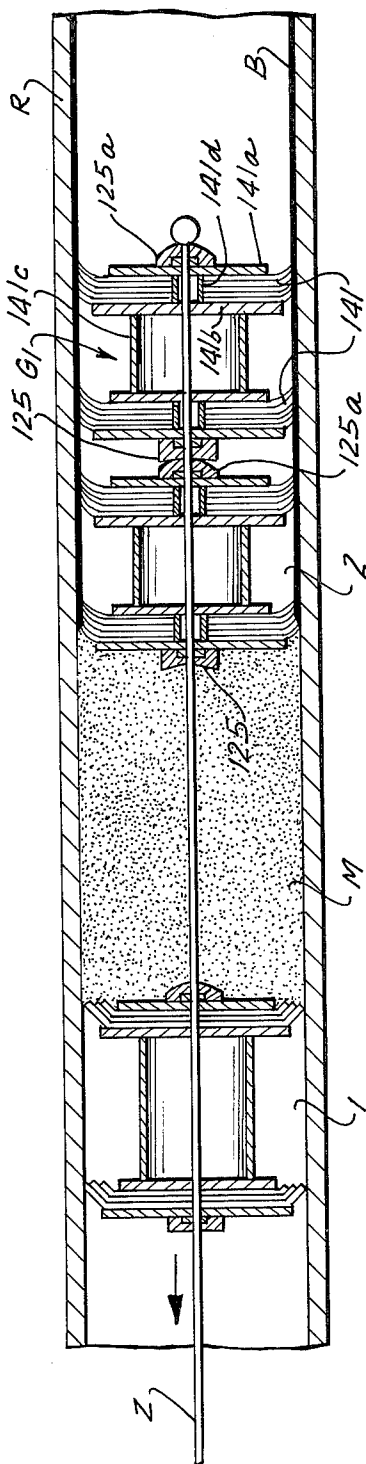


FIG. 3

FIG. 4

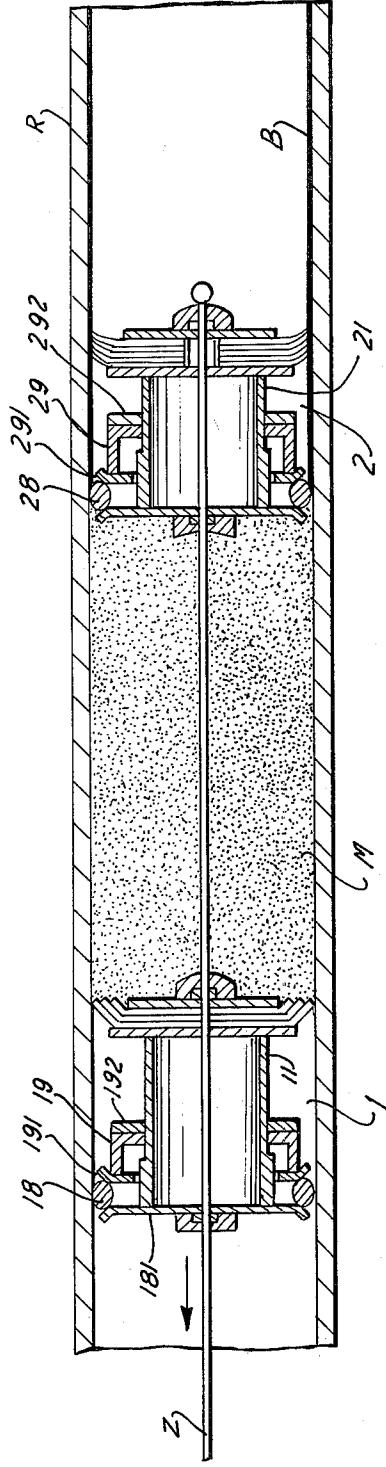
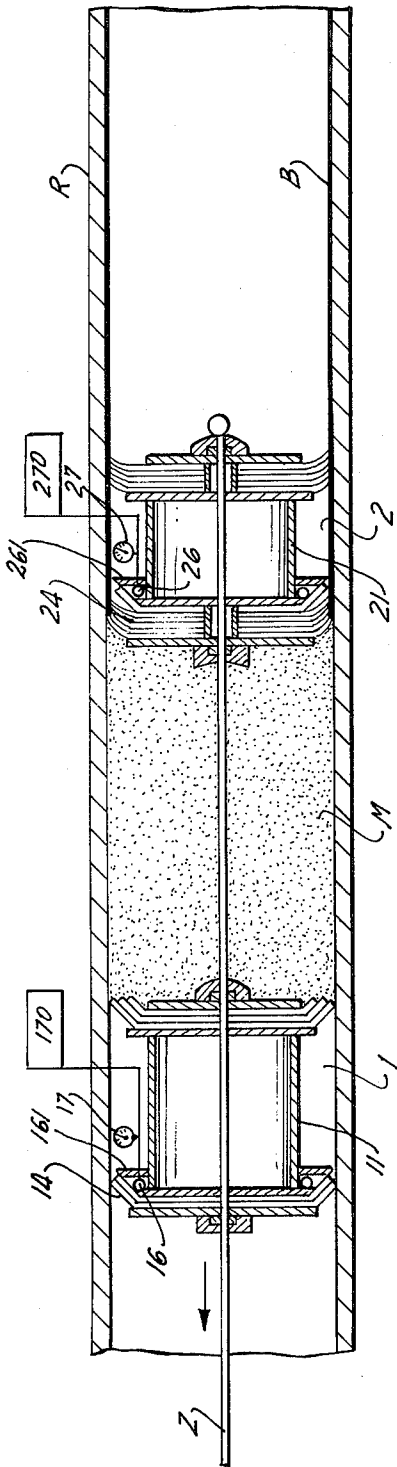


FIG. 5

FIG. 6

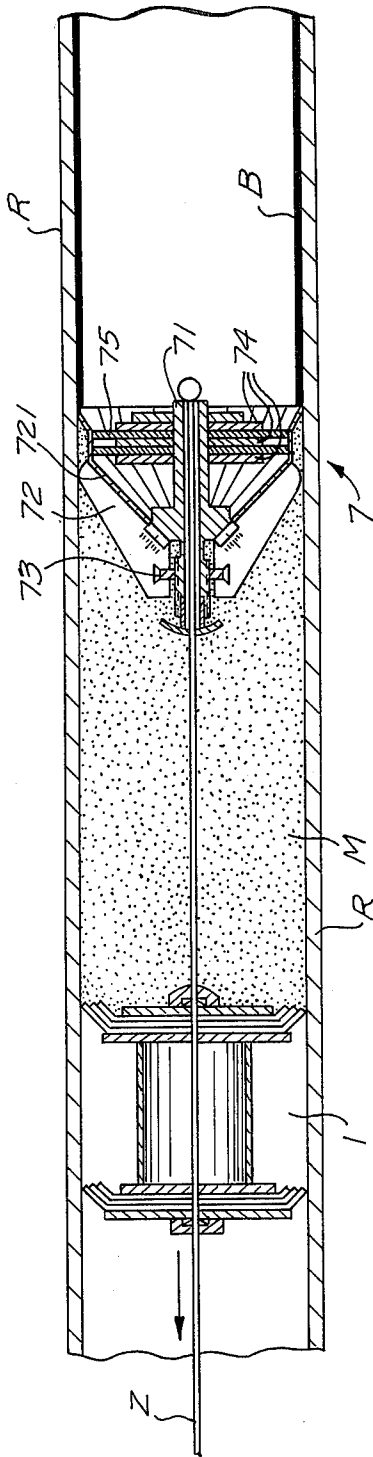


FIG. 7

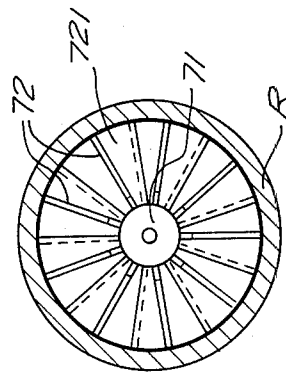


FIG. 8

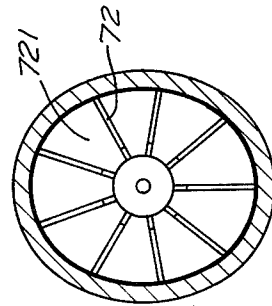


FIG. 9

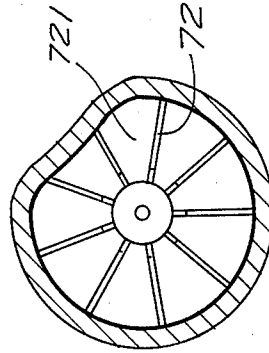


FIG. 10

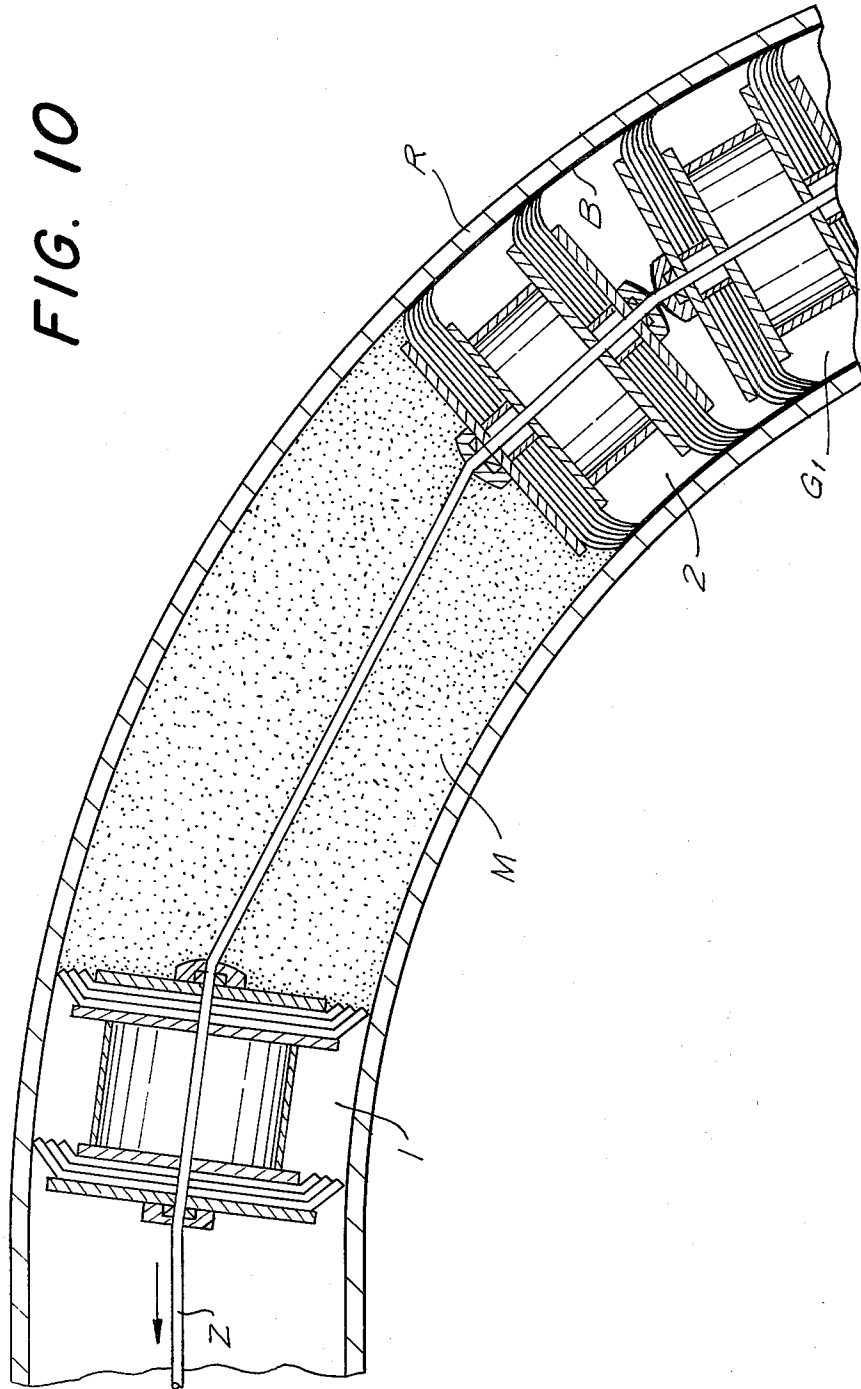


FIG. II

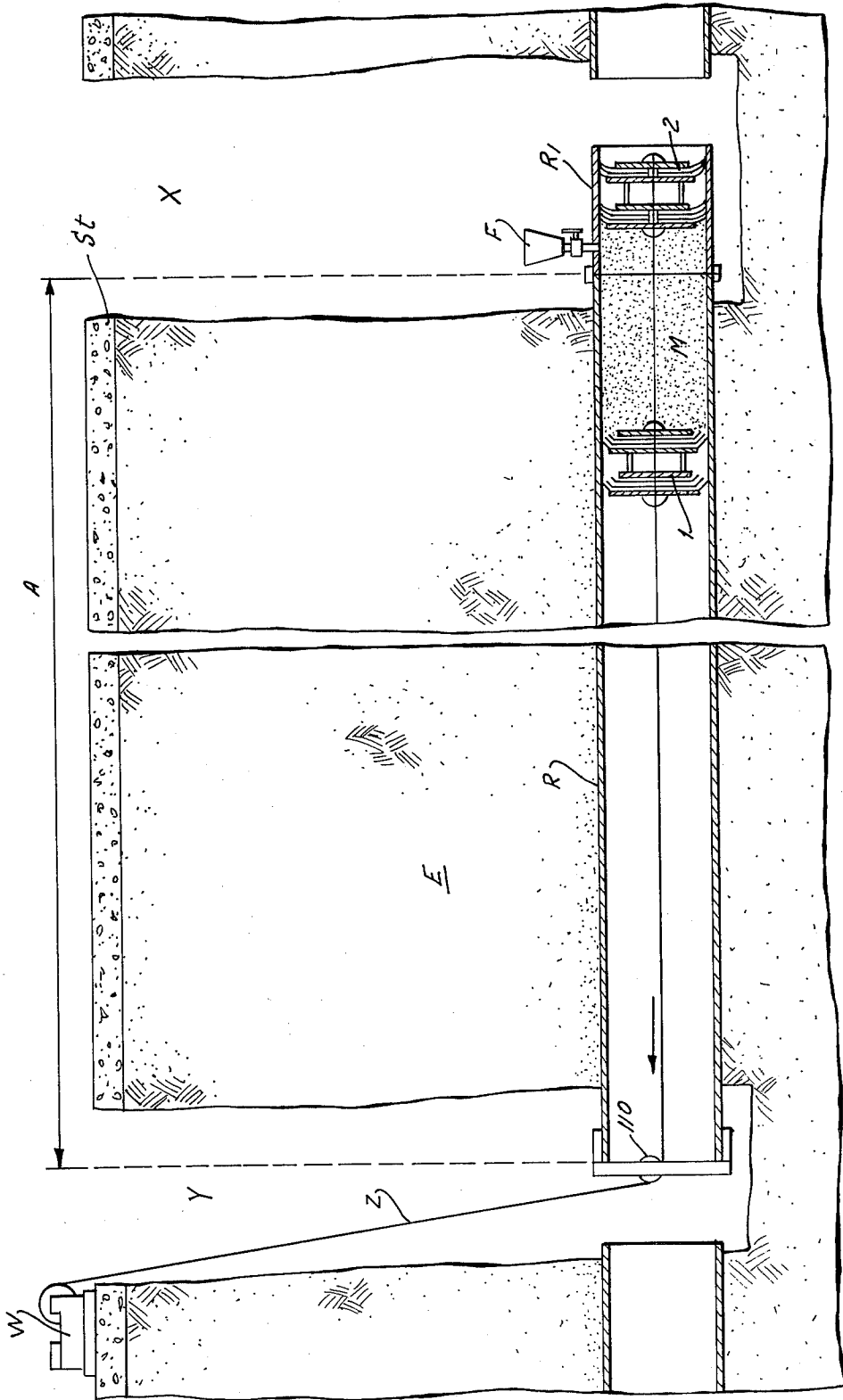
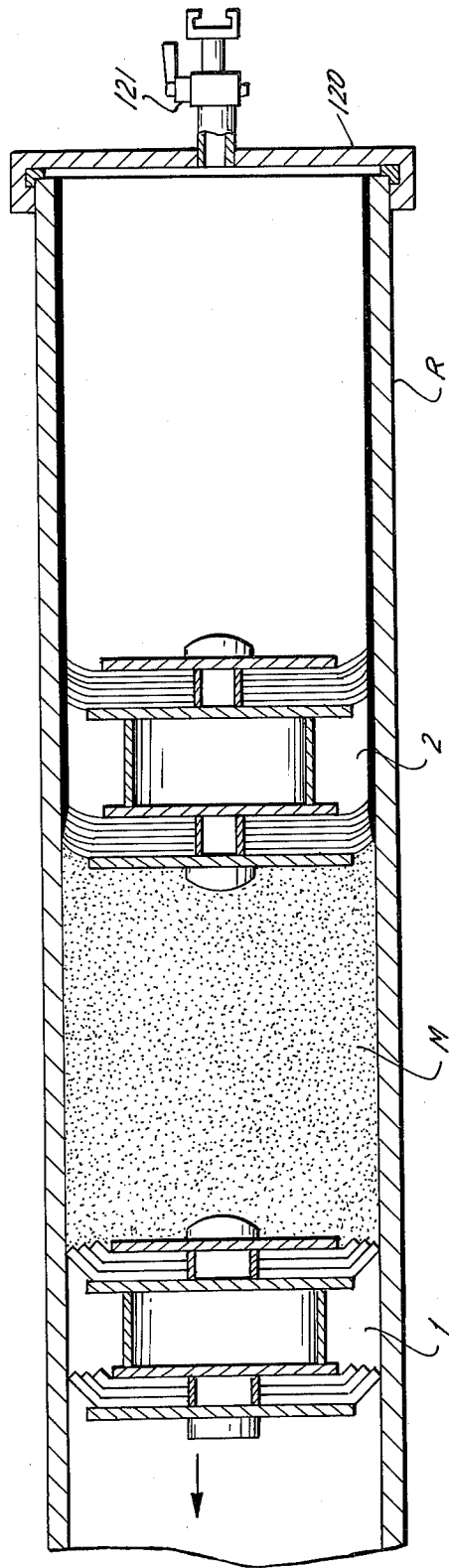


FIG. 12



APPARATUS FOR COATING THE INNER WALL SURFACE OF A DUCT

FIELD OF THE INVENTION

The present invention relates to an apparatus for and a method of coating the inner wall surface of a duct, particularly a duct already in place.

BACKGROUND OF THE INVENTION

It is frequently desired to provide sealing and corrosion-resistant coatings along the inner wall of a duct, pipe or conduit, e.g., as a rust removal or preventive measure in water mains. The duct can also be a gas main. Such a duct must be cleaned out and joints and areas penetrated by corrosion be sealed off before a coating of the inner wall surface thereof can be undertaken. Likewise, the inner wall surfaces of pipelines, the ducts of sewage systems, and high-pressure conduits of power plants can be coated, after thorough cleaning and removal of rust, to protect the same against corrosion and decay. Suitable materials for coating masses to be used on the inner wall surfaces of ducts are paint formulations as well as synthetic resin materials which may contain fillers such as glass fibers.

It is known in the art to coat the inner wall surface of ducts with such materials. However, comparatively complicated apparatus and techniques are used and seldom can the inner surfaces of ducts having comparatively large diameters, say at least 400 mm, be coated with conventional systems.

OBJECTS OF THE INVENTION

It is, therefore, an important object of my invention to provide a method of and an apparatus for the application of a coating on the inner wall surface of a duct which avoids the above-described drawbacks, is simple and easy to operate and can be used in ducts having large as well as small diameters.

Another object of my invention is to provide a method of and an apparatus with which a coating of uniform and easily controllable thickness can be applied.

Another object of the invention is to provide a method of and an apparatus for the internal coating of a duct, tube, conduit, pipe or other channel of closed cross section having cross-sectional irregularities, and ducts having bends.

Still another object of the invention is to provide an improved method and apparatus whereby a coating can be applied to the inner wall surface of a duct laid in the ground.

SUMMARY OF THE INVENTION

These objects and others which will become apparent hereinafter are attainable in accordance with my invention with a system for coating the inner wall surface of a duct whereby a pair of pistons are forced through a duct with the rearward piston being driven and the forward piston frictionally retarded so that a coating mass between the pistons is extruded under pressure around the trailing piston onto the duct surface. More particularly the coating or sealing mass of a viscous flammable material is disposed between axially spaced pistons which are introduced into the duct and have peripheries which form seals confronting the inner duct surface so as to trap the mass between the pistons.

The apparatus thus comprises a forward and a rearward piston having first and second sealing means, respectively, and means for advancing the rearward piston through the duct. The two pistons and the inner wall surface therebetween jointly define a space for a coating mass. The first sealing means of the forward piston is so constructed and arranged as to provide increased sealing when the pressure exerted on the coating mass and consequently on the first sealing means increases, and the second sealing means of the rearward piston is so constructed and arranged as to increasingly yield when the pressure exerted on the coating mass and consequently on the second sealing means increases.

Thus, the coating mass is permitted to issue or escape (extrude) between the second sealing means and the inner wall surface of the duct, when the pressure on the coating mass increases.

According to a particularly advantageous feature of this invention, the advancing means can be a guide cable. It is attached to the rearward piston with a fastening device and caused to pass or be drawn through a hole in the forward piston. Sealing means are provided for the hole in the forward piston and the guide cable to prevent the escape of coating mass to the area of the duct which is downstream of the piston assembly. When the guide cable is pulled, the pistons and the coating mass contained therebetween are advanced through the duct, i.e., the trailing piston is drawn forwardly and exerts an axial pressure upon the flowable but viscous mass ahead of it. The hydraulic force exerted by the fluid mass advances the leading piston and, at the same time, biases its seal (first sealing means) outwardly against the wall of the duct to prevent escape of the mass around the leading piston. The resulting frictional retardation of the leading piston, in turn, permits buildup of the pressure in the fluid mass and causes deflection of the seal of the trailing piston (second sealing means) to cause extrusion of the flowable mass therearound. The pressure is thus a function of the rate at which the assembly is drawn through the duct.

According to a further feature of my invention, the apparatus can comprise a polishing device positioned in the duct upstream of the piston assembly to smooth the coating. A guide cable is attached to the polishing device and passes or is drawn through holes in the rearward as well as the forward piston. Respective sealing means for the two pistons and the guide cable, respectively, are provided to prevent undesired escape of the coating mass to areas of the duct outside the piston assembly. When the guide cable is pulled, the polishing device pushes the rearward piston, which action pressurizes the coating mass so that the entire piston assembly can be advanced in the forward direction through the duct.

According to a particularly advantageous feature of my invention, the above-described polishing device can be provided with guide means for inducing rotary motion to the polishing device in the duct while the guide cable is pulled and the piston assembly thereby is pushed in the forward direction through the duct. Connecting means between the guide means of the polishing device and of the guide cable is provided for permitting such rotary motion of the polishing device without imparting a substantial twisting to the guide cable.

According to a further feature of my invention, the means for advancing the pistons and the coating mass can include means for providing pressurized air in the duct area which is upstream of the two pistons. In other words the trailing piston may be urged through the duct by an airpressure differential across the assembly of the pistons.

According to a further feature of my invention, the first and second sealing means for the forward and the rearward piston, respectively, can be sealing rings, held or supported and pressed between outer and inner rigid discs, to effect increased sealing and friction between the two pistons and the duct surface, respectively.

The sealing rings can be solid or hollow rings. In the case of a hollow ring, means for controlling the pressure in the hollow ring is provided for varying the contact pressure between the hollow ring and a solid ring and then also the contact pressure between the solid ring and the inner wall surface of the duct.

According to a particularly advantageous feature of my invention, the second sealing means can be formed as a set of self-adjusting springy polishing or coating-doctoring members. They follow the cross-sectional irregularities of the duct when the coating apparatus is advanced through the duct.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIGS. 1-6 are longitudinal sections of portions of ducts and partially longitudinal sections of coating apparatuses according to the invention accommodated therein;

FIGS. 7-9 are transverse sections which show how the sealing means of the second piston in FIG. 6 operates in a duct with a deformed cross-section;

FIG. 10 is a longitudinal section which shows how a coating apparatus according to FIG. 2 is adapted in a duct with a bend;

FIG. 11 is a vertical section which shows how a coating apparatus according to the present invention can be used in a duct laid below a street; and

FIG. 12 is an axial section which shows how a coating apparatus according to the present invention can be driven with pressurized air.

SPECIFIC DESCRIPTION

Reference will first be made to FIG. 1, which shows a coating apparatus consisting of two pistons 1 and 2 and a polishing device G in a duct R to be formed with a coating B. A guide cable Z drawn through central holes in pistons 1 and 2 is attached to a driver 3 rotatably connected to polishing device G by means of swivel coupling 5.

Piston 1 comprises a short intermediate tube portion 11 and two disk-shaped inner flanges 12 rigidly fastened thereto. Two outer flanges 13 and sealing means 15 hold and press two sets of first sealing rings 14 made of tough rubber against inner flanges 12, respectively. The sealing effectivity of rings 14 increases when they are pressed harder by outer disks 13 and when the pressure exerted by coating mass M enclosed between pistons 1 and 2 increases.

The first sealing means 14 comprises three horizontally stacked rubber disks with at least the leading disk

having a diameter in excess of that of the duct and the flange 12 or disk 13 immediately behind each stack of rubber disks. At least when the first or leading piston 1 is inserted into the duct, therefore, the outer periphery of the seal stacks is deflected rearwardly so as to be conically rearwardly divergent. The coating mass acting upon the rearwardly inclined lip of the rearmost stack of sealing disks biases the lip against the inner wall of the duct.

Trailing piston 2 is similar in construction to piston 1 and consists of short tube portion 21 with two axially spaced inner flanges 22, two sets of second sealing rings or cuffs 24, made of a material softer than the first sealing rings 14, outer flanges or disks 23, and sealing and fastening means 25 preventing leakage around the cables.

Polishing or smoothing device G comprises a central portion 60 and a brush holder 41 rotatably mounted and axially offset from a central portion on a common bar 42 and connected thereto by spring means 63. Central portion 60 is provided with two sets of swingable arms 61 and wheels mounted on the outer extremities of arms 61 and touching the inner wall surface of duct R. Wheels 62 are aligned in a direction which is slightly inclined in relation to the axis of duct R. Brush holder 41 holds polishing brushes 4.

The brush holder comprises a pair of disks whose confronting faces are inclined to the axis of the device so that the brush 4 likewise assumes an inclination to the axis as has been shown in FIG. 1.

In operation, pistons 1 and 2 and coating mass M enclosed therebetween and polishing device G are jointly advanced through duct R by pulling guide cable Z from a location ahead of the pistons. Polishing device G is pulled thereby and in its turn pushes piston 2, coating mass M and piston 1. The pressure on the coating mass M increases, the second sealing means 24 of piston 2 yield and coating material M is extruded between the seal 24 and the inner wall surface of duct R to produce a layer B is formed on the inner wall surface of duct R. However, the following requirements must be met to obtain a continuous and uniform coating B:

1. There must be a considerable friction between first sealing rings 14 of piston 1 and the inner wall surface of duct R, providing a braking action when piston 1 is pushed through duct R. Then the necessary pressure will be exerted on coating mass M and on the seal 24 of piston 2 so that the latter will yield and coating mass M can issue around seal 24 as mentioned previously.

2. The second seal 24 must have such characteristics and be so held that the coating mass M does not escape when guide cable Z is not pulled and substantially no external pressure is exerted on coating mass M. However, when guide cable Z is pulled to the extent that the coating apparatus advances in duct R, second sealing rings 24 must be so constructed that they yield and a ring-shaped body of coating mass M is extruded between sealing rings 24 and the inner wall surface of duct R and a coating of this shape is formed on the inner wall surface of duct R. The direction of orientation of sealing rings 24 and also sealing rings 14 in the areas where they come in contact with or approach the inner wall surface is of course of importance. The increased pressure of coating mass M tends to lessen the contact pressure between sealing means 24 and the inner wall surface of the duct because sealing rings 24 are bent in an upstream direction and away from the

coating mass M, whereas the contact pressure between sealing rings 14 and the inner wall surface of the duct tends to increase when the pressure of coating mass M increases because sealing rings 14 also are bent in an upstream direction but towards coating mass M and not away from it.

3. The contact pressures between sealing rings 14 and 24 and the innerwall surface of duct R, respectively, must be mutually balanced so that the desired coating thickness can be obtained.

4. The amount of coating mass M fed between pistons 1 and 2 must be calculated taking into consideration the desired thickness of the coating B, the inner diameter of duct R, and the length of duct to be coated.

Polishing and smoothing device G is rotated in duct R when the coating apparatus is advanced therein due to the above-mentioned inclined direction of wheels 62. Spring 63 is tensioned due to the braking action of polishing brushes 4. Arms 61 are pivotally connected to an extension brush holder 41, and arms 61 and wheels 62 are urged outwardly against the inner wall surface of duct R when the distance between the central body 60 and brush holder 41 increases as a consequence of increasing speed of the advancing coating apparatus in duct R and increasing friction between brushes 4 and the inner wall surface. This, and the fact that the wheels lie at angles to the axis, i.e., along helical arcs, ensures reliable rotation and improved smoothing by polishing device G as the coating apparatus advances and the speed thereof varies. The flanges or disks 23 are held away from flanges 22 by spacer tubes through which the cable Z passes.

The polishing device G₁ in FIG. 2 is nonrotating. It is similar in construction to piston 2 as indicated in the figure. However, piston 2 is provided with tightly held sealing rings whereas polishing device G₁ is provided with polishing brushes 141 which can be loosely held sealing rings.

In FIG. 2 the system makes use of a nonrotating polishing or wiping assembly G₁ which abuts directly upon and therefore pushes the trailing piston 102. The smoothing assembly G₁ may be identical in all respects to the trailing piston 2 and hence the latter may be provided on its leading disk with a sealing sleeve 125 having a forwardly concave surface conforming to a spherical section. Its trailing sleeve may be provided with a spherically convex portion 125a so that, when the spherically convex portion of an upstream assembly abuts the spherically concave portion of a downstream assembly or vice versa, a swivel joint will be formed at the surfaces allowing the application of the driving force from the upstream assembly while permitting the train of pistons to negotiate bends in the duct. Of course, as shown in FIG. 10, both abutting sleeves may be convex with comparable effect since the surfaces roll upon one another.

FIG. 3 illustrates a particularly advantageous feature of my invention wherein the end of guide cable Z is pulled around cable pulley 127 mounted on piston 126 on its upstream side, urged back through holes in piston 202 and is connected to an eye 126a mounted on piston 201 on its upstream side. The result of this guide cable arrangement is that the pressure on coating mass M is doubled when the guide cable Z is pulled and the coating apparatus starts advancing in duct R. Piston 126 is provided with forwardly positioned tightly held sealing

rings 224 and two rearwardly positioned polishing means 241, e.g., two sets of polishing brushes.

In the embodiment of FIG. 3, the piston assembly 126, carrying the pulley 127 comprises the second or trailing piston 202 having the function described for the piston 2 and a smoothing device 241 which is rigidly fixed to the piston 202.

In other words, the piston assembly 126 comprises a pair of rigid drums 202a and 241a each provided with a small-diameter flange 202b, 241b in the forward direction, and a large diameter flange 202c, 241c at the trailing end of the drum. Ahead of the small-diameter flange 202b of the piston portion 202, there is provided a large diameter disk 202d carrying a seal 202e surrounding the two passes of the cable Z which extend through the piston and formed with rollers diagrammatically shown at 202f to reduce frictional interengagement of the oppositely moving cable passes and the piston. A spacer tube 202g is disposed between the flange 202b to limit the compression upon the sealing lamella 224.

A larger diameter spacer tube 241d is provided between the leading flange 241b and the trailing flange 202c to limit the compression applied to the first set of polishing lamella 241 forming the nonrotating brush and constituted in the form of elastomeric disks of low stiffness which are readily deflected rearwardly and wipe the coating B.

A similar spacer tube 241e is disposed between the trailing flange 241c and a small-diameter disk 241f carrying the pulley 127. Rollers 24g upon the disk 241f reduce friction between the cable and the piston assembly. It will be apparent that not only is there a mechanical advantage of two by the use of the described cable arrangement, to thereby increase the pressure upon the coating mass M, but also a relative displacement of the two pistons 201, 202 toward one another as the entire assembly is drawn through the duct in the direction of the arrow.

FIG. 4 shows means for controlling the contact pressure between the sealing means 14 and 24 on pistons 1 and 2, respectively, and the inner wall surface of duct R. An air-filled ring-shaped tube 16 is accommodated between sealing means 14 and a ring-shaped flange 161 on tube portion 11. Tube 16 is connected to pressure controlling means 170 over a monometer 17. When a higher friction between sealing means 14 and the inner wall surface of duct R is desirable the pressure in tube 16 is increased by actuating pressure controlling means 170.

An air-filled ring-shaped tube 26 is accommodated between sealing means 24 and a ring-shaped flange 261 on tube portion 21. Tube 26 is connected to pressure controlling means 270 over a monometer 27. When a different friction between sealing means 24 and the inner wall surface of duct R is desirable, the pressure in tube 26 is increased by actuating pressure controlling means 270.

FIG. 5 shows a solid rubber ring 18 as sealing means. It is pressed by ring-shaped flange 181 and ring-shaped pressure ring 191 mounted on tube portion 11. Ring 191 increasingly presses sealing ring 18 when nut 19 is screwed in a forward direction and lock nut 192 locks nut 19 in a desirable position, i.e., when the contact pressure between sealing means 18 and the inner wall surface is the desired one. Piston 2 is provided with the same kind of sealing means 28, and corresponding

pressure ring 291, nut 29 and lock nut 292, the three latter elements being mounted on tube portion 21. When the pressure on ring 28 is increased, the thickness of coating B will decrease.

FIGS. 6 and 7 show a rearward piston 7 of quite different construction. It is advantageous when highly viscous and pasty coating masses M are to be applied to the inner wall of duct R. Radially and also axially extending guide plates 72 are mounted on an axially extending hub 71 and swingably held thereon by setting ring 73. They are provided with fins 721, substantially normal to guide plates 72. Fins 721 overlap each other to confine coating mass M. They are pressed against the duct wall by two rubber plates 75 held in place and pressed by three support plates 74. Rubber plates 75 and support plates 74 are also mounted on hub 71. Rubber plates 75 individually urge fins 72 against the duct wall.

FIGS. 8 and 9 show two ducts having deformed cross-sections. Guide plates 72 swing inwardly, towards the axis of the duct, where the duct wall is bent inwardly and outwardly where the duct wall is bent outwardly because rubber plates 75 urge fins 721, fastened to guide plates 72, against the duct wall. Thus, coating mass M is contained by an umbrella-like conical wall, its shape being adapted after the duct wall against which it is pressed. Guide plates 72 do not have dots for sake of clarity.

FIG. 10 shows the coating apparatus of FIG. 2 in operation in a bent portion of a duct. Pistons 1 and 2 and polishing device G₁ adapt themselves very nicely to the curved duct wall when they are advanced through the duct.

FIG. 11 shows a duct R laid in ground E under a street St. The length A of the duct is for instance 700 m. Two pits X and Y have been excavated to expose the duct. Portions of duct R in pits X and Y can be sawed off to allow access to the interior thereof. An auxiliary duct portion R₁ has been adapted to duct R to facilitate the feeding of coating mass M between pistons 1 and 2. The necessary amount of coating mass M is calculated and an excess thereof is introduced, by means of filling device F, to secure an uninterrupted coating of the inner wall surface of the duct. Filling device F is mounted on auxiliary duct portion R₁. Care must be taken not to introduce air in the coating mass when it is fed into the space between pistons 1 and 2. Guide cable Z is reeled in on cable winch over guide pulley 110 adapted on the duct end in pit Y, pistons 1 and 2 and the coating mass M enclosed therebetween advance through duct R, and a coating is formed from coating mass M issuing between the sealing means of rearward piston 2 and the inner wall surface of duct R.

FIG. 12 illustrates the use of an advancing means for the coating apparatus which is quite different from guide cable Z, namely a pressurized-air system. Cover 120 secures the necessary air-tight condition in the upstream portion of duct R and pressurized air is introduced through cock 121. The speed of the advancing coating apparatus through the duct can be controlled by the amount of pressurized air introduced through cock 121.

I claim:

1. An apparatus for the application of a coating on the inner wall surface of a duct, comprising:

a forward and a rearward piston axially displaceable and spaced apart inside said duct and jointly with a portion of said inner wall surface forming therebetween a space for a coating mass, said forward piston having first sealing means along said inner wall surface for providing increased sealing when the pressure exerted on said coating mass increases, and said rearward piston having second sealing means along said inner wall surface which increasingly yields with increasing pressure of said coating mass and permits the issuance of said coating mass between said second sealing means and said inner wall surface;

a polishing device upstream of both said pistons; a guide cable attached to said polishing device and passing through both said pistons; respective means for sealing each piston against said guide cable, respectively, said polishing device pushing both said pistons and said coating mass enclosed therebetween through said duct when said guide cable is pulled;

guide means for said polishing device for inducing rotary motion thereto in said duct while said polishing device pushes said pistons through said duct; connecting means between said polishing device and said guide cable for permitting said rotary motion without substantial twisting of said guide cable, and a swivel joint between said polishing device and said rearward piston permitting relative pivotal movement thereof while transmitting axial force from said polishing device to said rearward piston.

2. The apparatus defined in claim 1 wherein said first and second sealing means are sealing rings.

3. The apparatus defined in claim 2, wherein said sealing rings are solid rings, further comprising respective means for holding said solid rings and pressing the latter to effect increased sealing and friction between said two pistons, respectively, and said inner wall surface.

4. The apparatus defined in claim 2, further comprising two ring-shaped flanges on said pistons, respectively; two hollow rings restrained between said sealing rings and said ring-shaped flanges, respectively; and two means for controlling the pressure in said hollow rings, respectively, said hollow rings urging said sealing rings, respectively, to increasingly press against the inner wall surface of said duct, when said pressure controlling means are actuated and the pressures in said ring-shaped hollow rings are increased.

5. The apparatus defined in claim 1 wherein said second sealing means includes a set of self-adjusting springy polishing members which follow the cross-sectional irregularities of said duct while in operation.

6. The apparatus defined in claim 1, further comprising means for adjusting the contact pressure between said first sealing means and said inner wall surface, thereby determining the friction between said first sealing means and said inner wall surface and consequently the pressure exerted on said coating means when said pistons and said coating mass jointly are advanced.

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