Aug. 25, 1970 P. VON ARX 3,525,111

APPARATUS FOR TREATING THE INNER WALL SURFACE OF
A GENERALLY CYLINDRICAL DUCT

Filed June 25, 1968 9 Sheets-Sheet 1

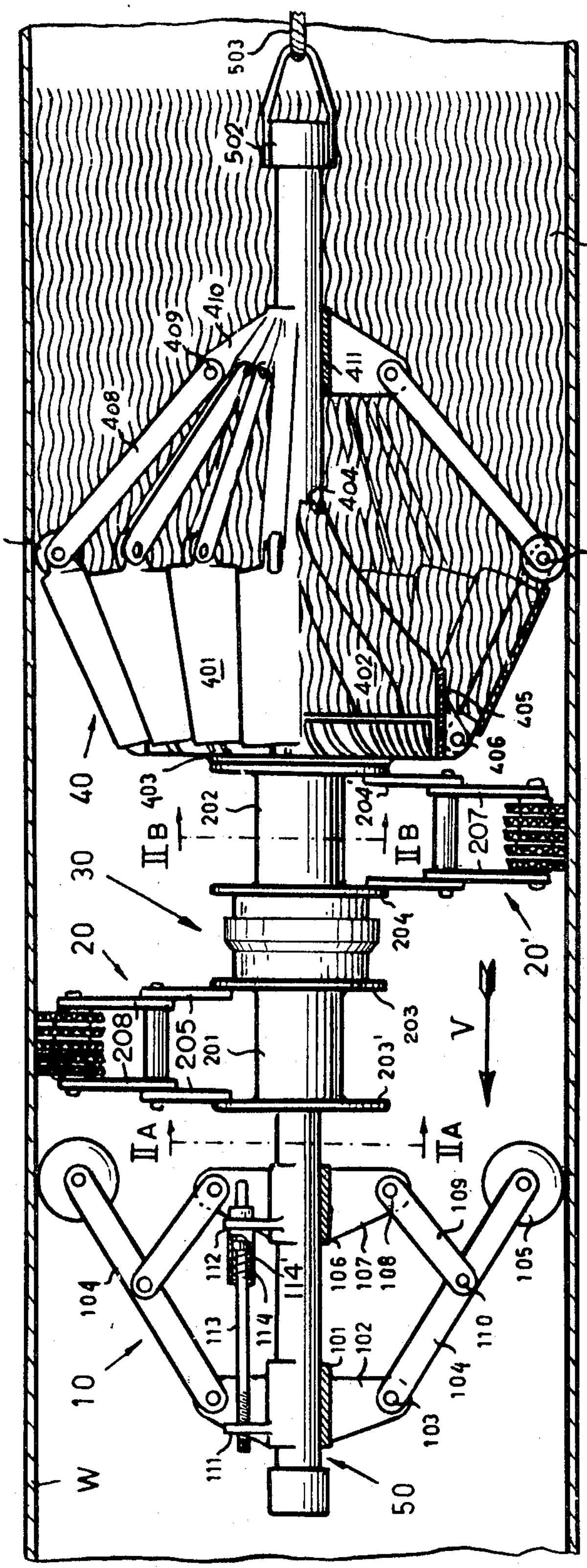

Fig. 1

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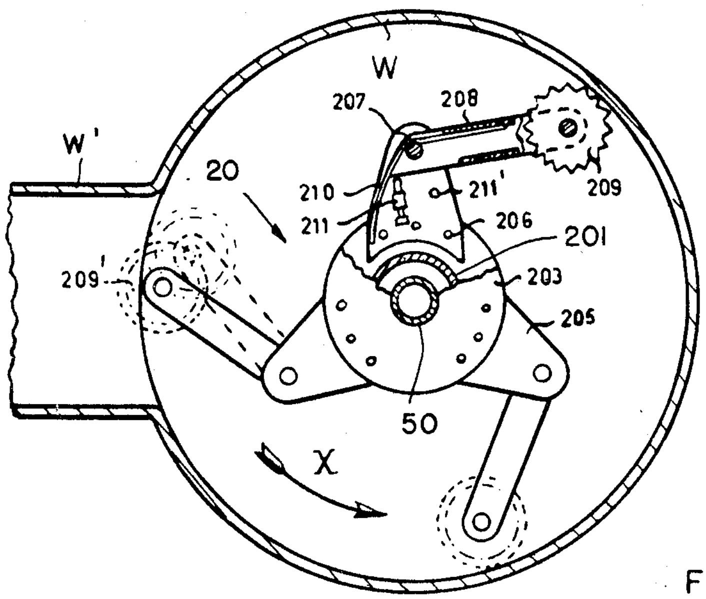

Fig. 2A

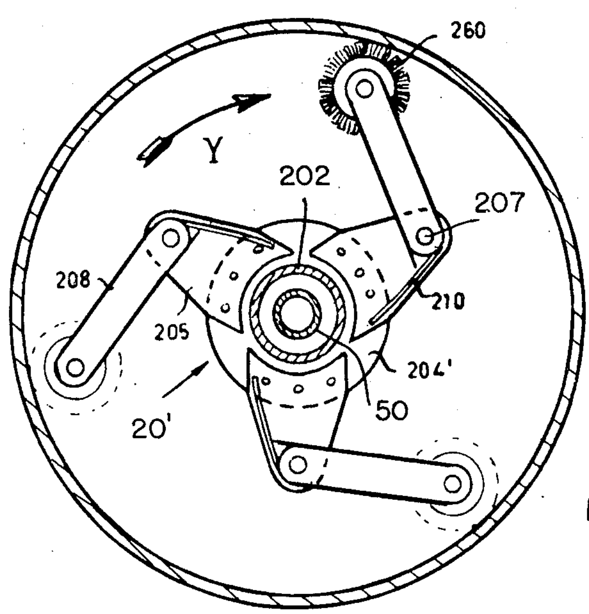

Fig. 2B

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APPARATUS FOR TREATING THE INNER WALL SURFACE OF A GENERALLY CYLINDRICAL DUCT

Filed June 25, 1968 9 Sheets-Sheet 3

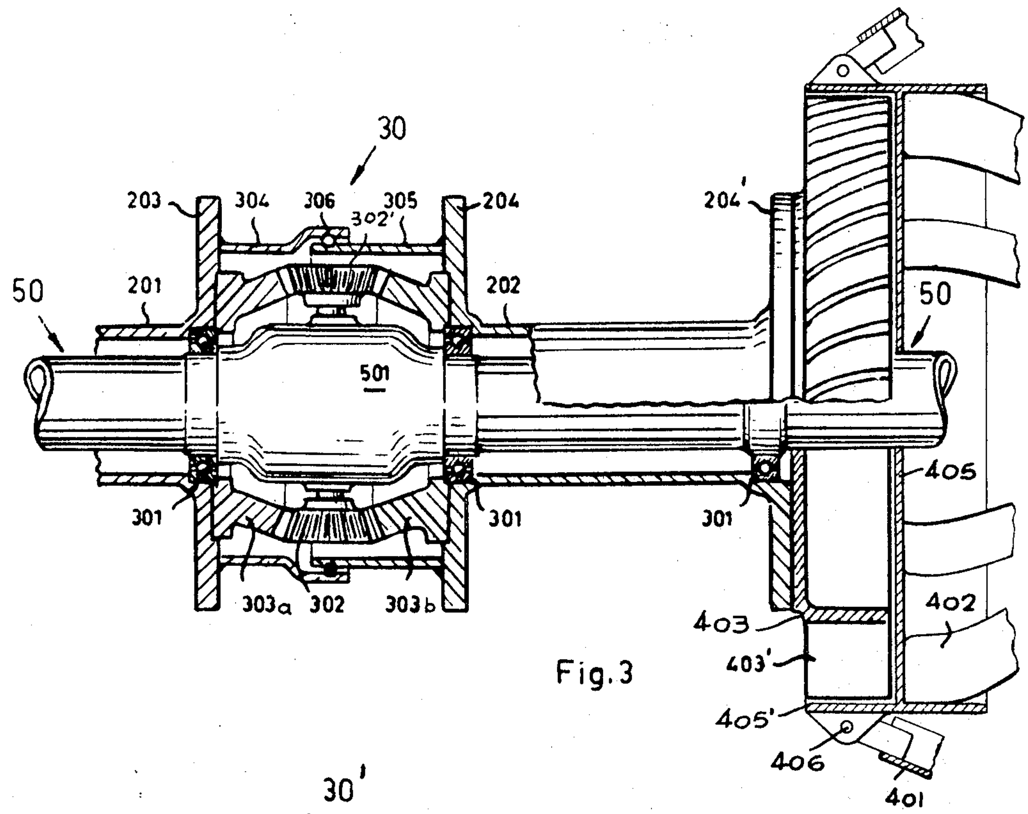

Fig.3

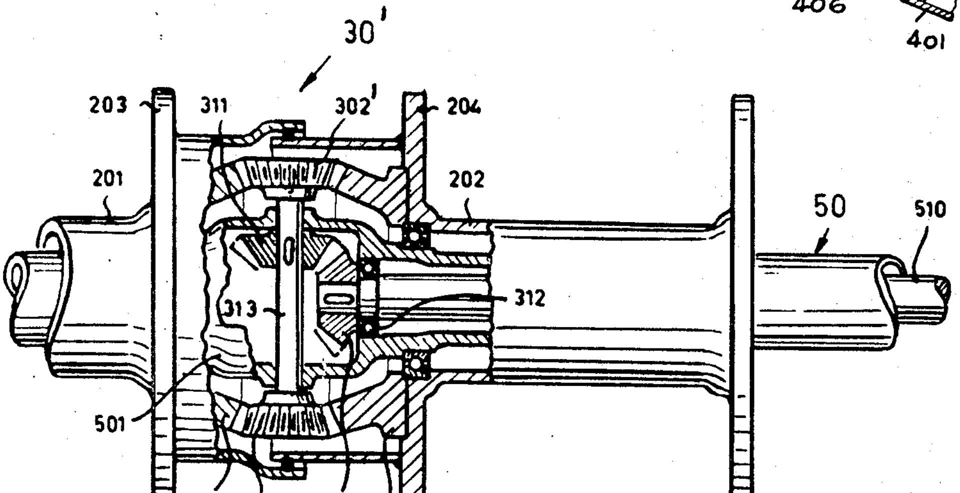

Fig.4

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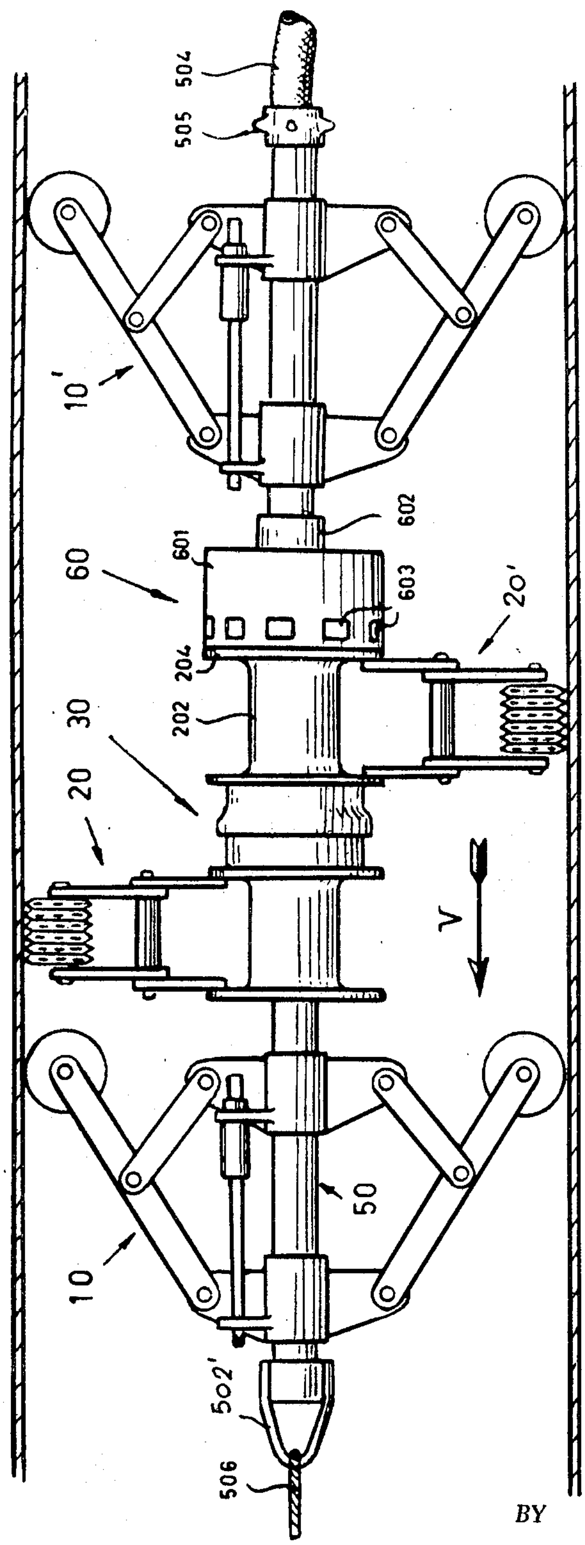

Fig. 5

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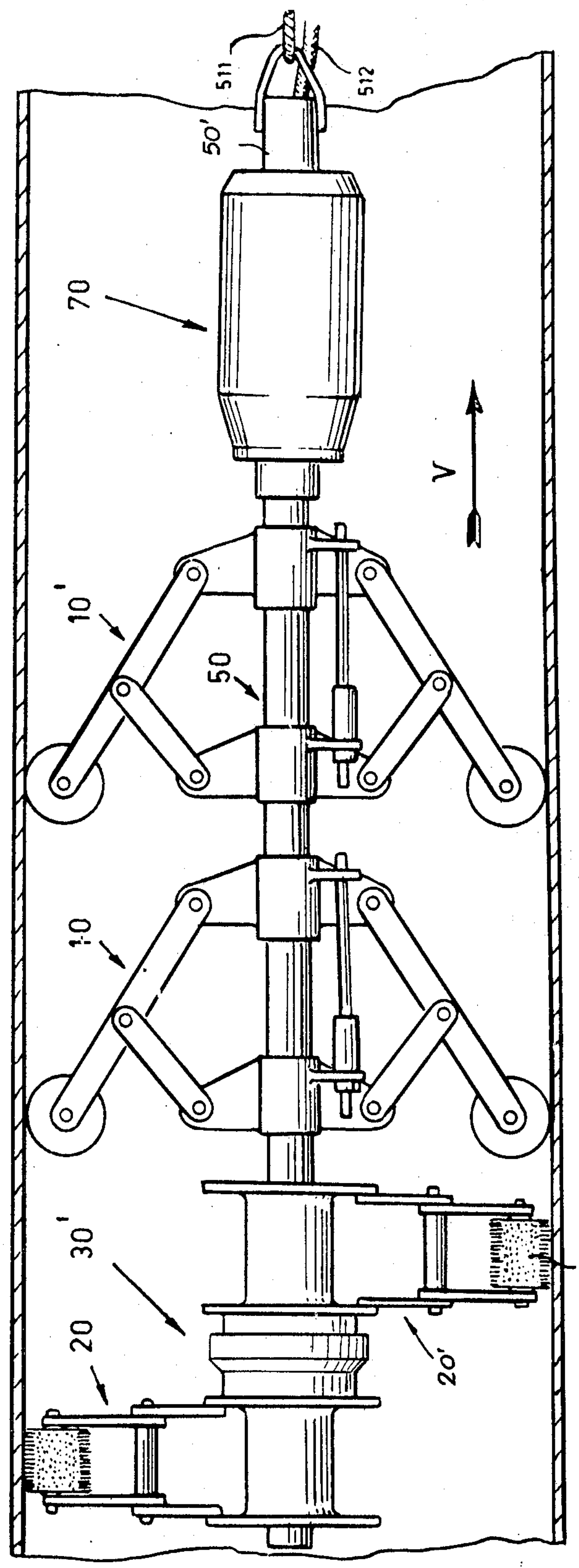

Fig. 6

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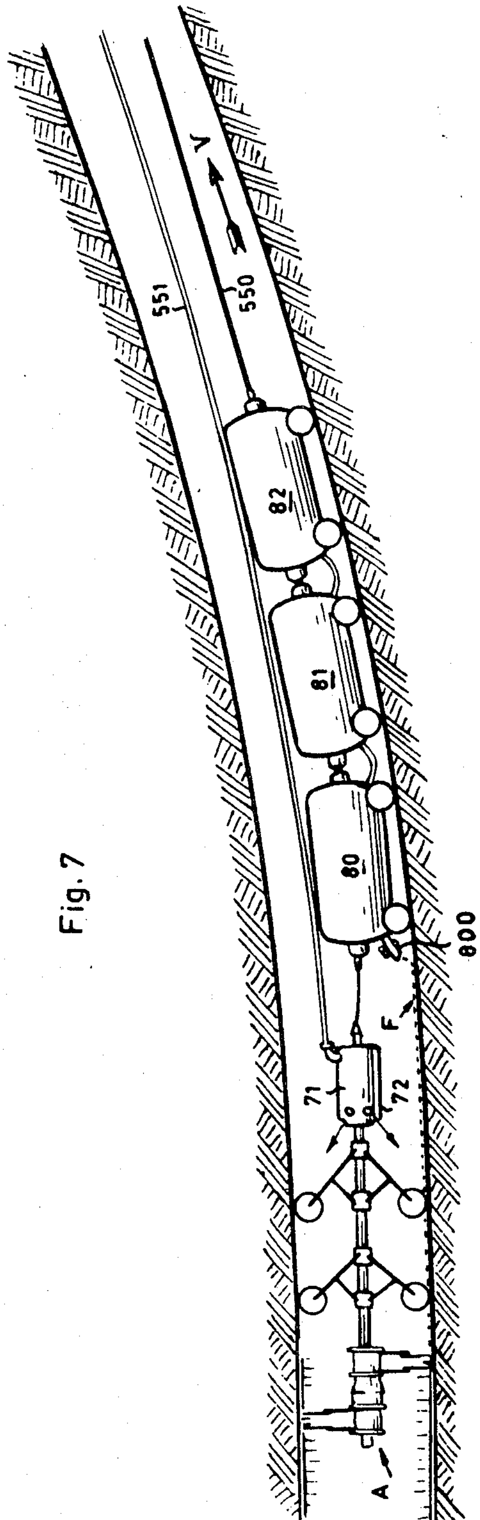

Fig. 7

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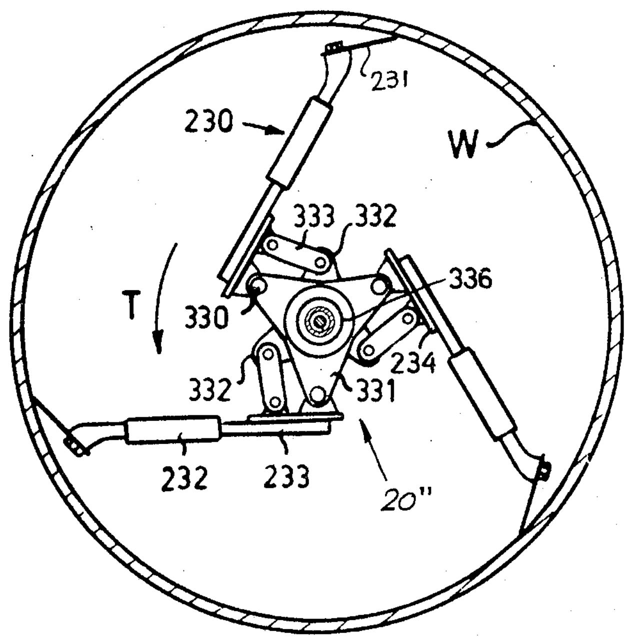

Fig. 8 A

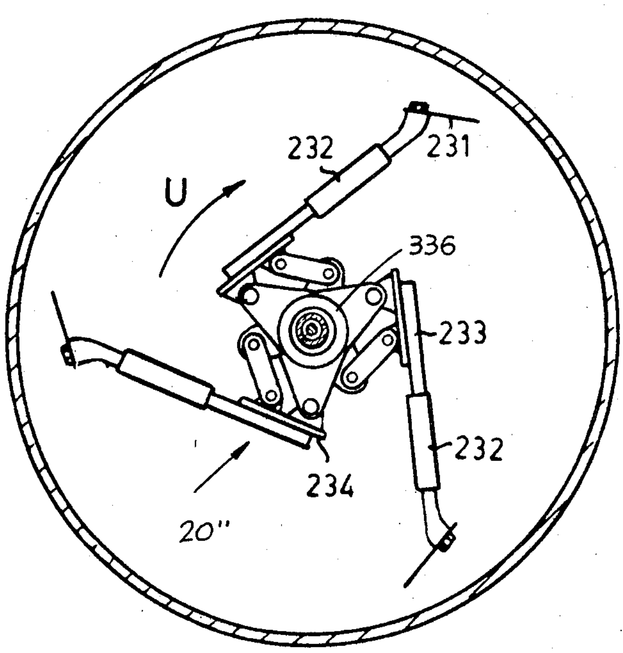

Fig. 8 B

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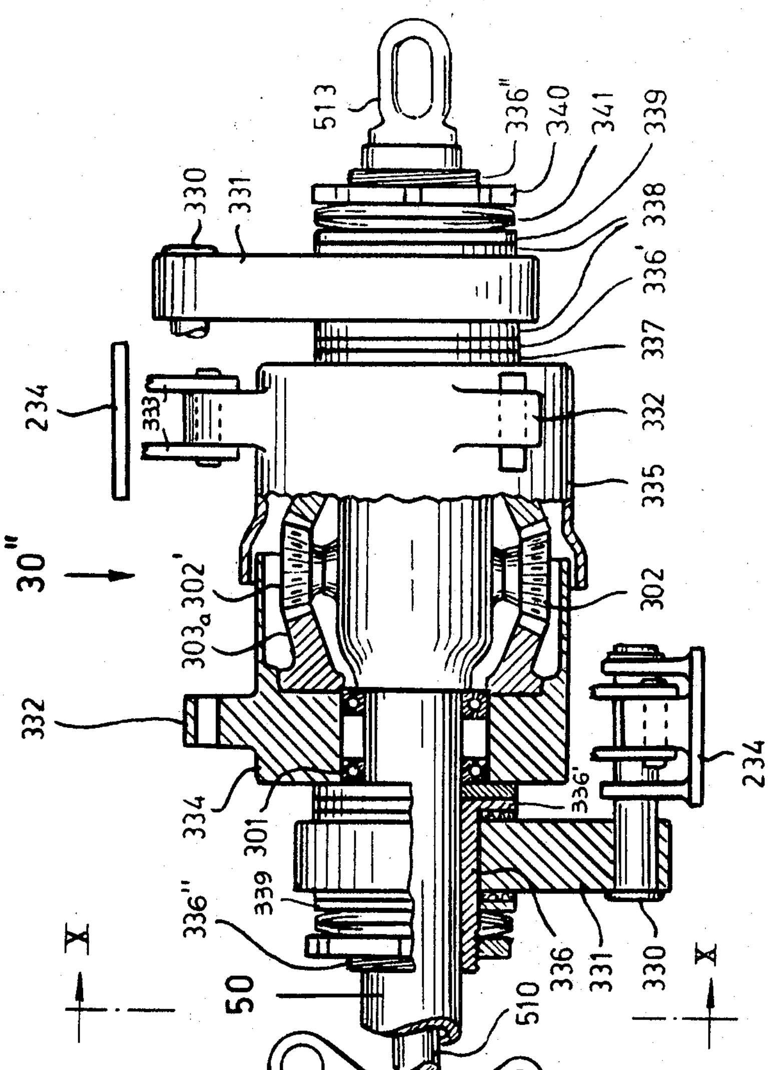

Fig. 9

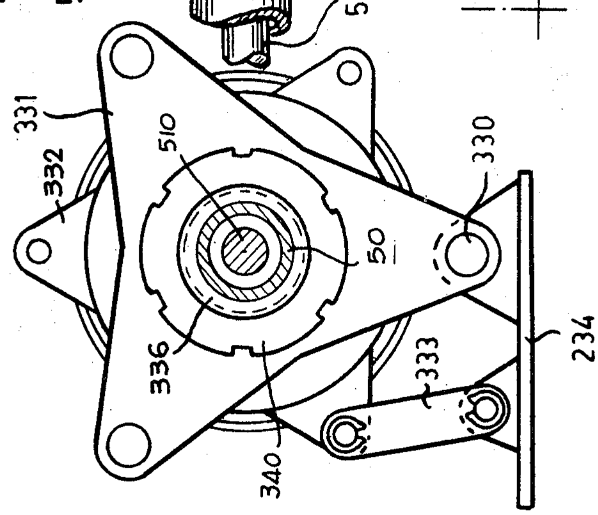

Fig. 10

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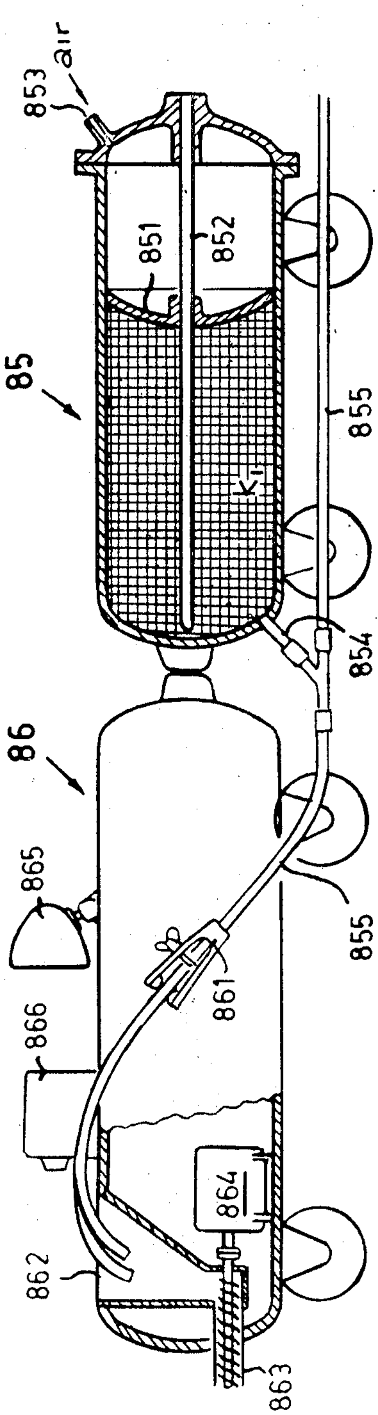

Fig.11

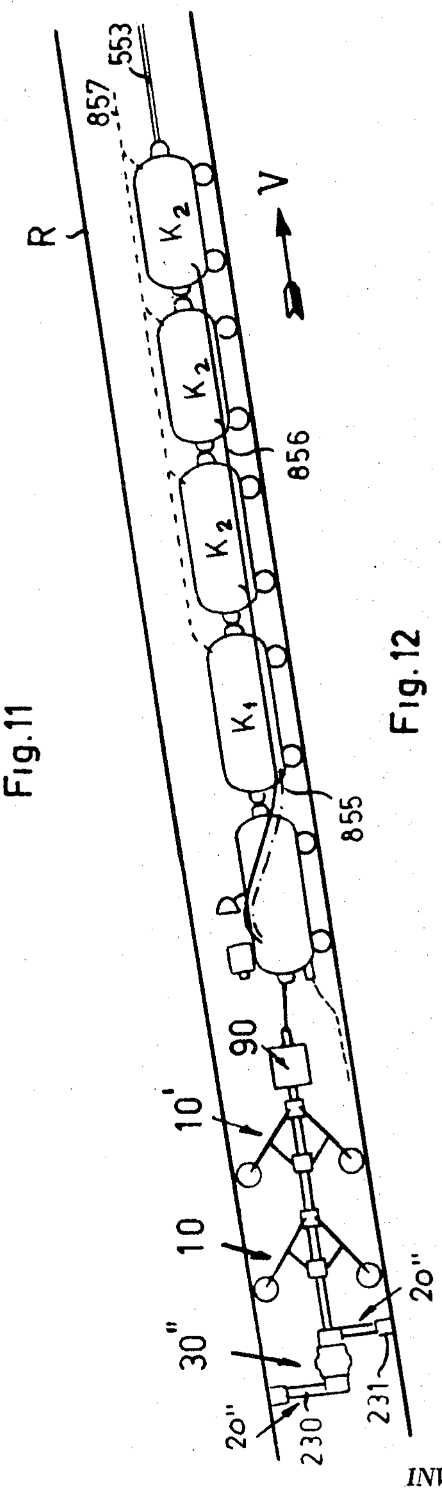

Fig.12

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3,525,111
APPARATUS FOR TREATING THE INNER WALL SURFACE OF A GENERALLY CYLINDRICAL DUCT

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Claims priority, application Switzerland, June 28, 1967, 9,375/67; May 14, 1968, 7,430/68
Int. Cl. B08b 9/04
U.S. Cl. 15—104.06 14 Claims

ABSTRACT OF THE DISCLOSURE

A wheeled support, designed to make at least three-point contact with the inner wall of a duct to be scraped or coated, is connected via an axially extending rod with two relatively rotatable hubs each carrying a radial array of tools which sweep the wall surface as the support advances through the duct. A reversing gear train is interposed between the two hubs whereby rotation of one hub about the shaft axis, under the control of a turbine or some other power plant coupled thereto, causes the arrays to rotate in opposite directions; reversal of the driving motion may be used to withdraw the tools from contact with the duct wall.

The present invention relates to an apparatus for treating (e.g. scraping or coating) the inner wall surface of a generally cylindrical duct, such as a sewer or a water main.

In the treatment of such duct surfaces it is known to introduce a rotatable tool carrier into the duct and to advance this carrier along the duct axis at a rate so related to the speed of rotation of the tool carrier that the several tools thereof effectively scrape, polish, coat or otherwise treat every part of the inner wall surface. Difficulties arise, however, in the presence of internal discontinuities, such as rivet heads, over which the tools must pass; while a resilient mounting of the tools readily enables them to yield inwardly, their return into contact with the wall surface in the wake of the obstacle is generally somewhat delayed (especially in the case of rapidly rotating carriers) so that an untreated zone or "shadow" remains in the vicinity of any such rivet head or the like. These untreated zones are, however, objectionable since, in the case of a coating, they facilitate the onset of corrosion and since they may allow the accumulation of contaminants.

It is, therefore, an important object of this invention to provide an apparatus for the treatment of such duct surfaces which avoids the drawback just described.

Another object of this invention is to provide means for securely guiding such a rotatable tool carrier along the duct axis even where the shape of the duct departs from linearity; this is particularly important in the case of abrasive or chip-removing tools (such as milling heads) which might otherwise tend to bite into the duct wall at a branching point or a curve.

According to an important feature of my invention, I provide a common well-engaging support for a pair of tool-carrying hubs which are mounted for coaxial rotation on an elongate member extending axially from the support, these hubs being linked by a reversing transmission which causes them to rotate in opposite directions whenever power is supplied to them. One of the hubs may be connected directly to a turbine, electric motor or other appropriate drive means; alternatively, the drive means may act upon both hubs through the intermediary of the reversing transmission, e.g. a differential gearing.

In operation, therefore, the sets of tools on the two

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carriers approach an internal obstacle from opposite directions so that the "shadow" left by one set of tools is promptly effaced by the other set.

In an advantageous embodiment, applicable particularly to paint spreaders and similar coating devices, the source of motive power for the tool carriers is reversible and each carrier is designed to swing an array of tool-supporting arms radially outwardly when rotating in one sense and to withdraw these arms inwardly when rotating in the opposite sense, thus allowing the apparatus to be retracted through the duct (e.g. preparatorily to the application of a second coat) without harmful contact between the tools and the coat already applied.

According to another important feature of my invention, the well-engaging support comprises a pair of relatively axially displaceable bosses which, in the nature of an umbrella frame, are interlinked by arms that swing radially outwardly upon a movement of the two bosses toward each other. The outer end of each arm carries a guide roller which yieldably bears upon the inner duct surface under the urging of a spring or other biasing means tending to reduce the spacing of the two bosses. This arrangement ensures that the elongate member carrying the rotatable hubs remains always well centered within the duct even if the diameter of the latter should change within certain limits; it also maintains proper guidance if, e.g. at the junction point with a lateral branch, one of the guide rollers should momentarily lose contact with the duct wall.

The guiding effect is further improved if the umbrella-like array of guide rollers is duplicated at axially spaced locations. Instead of merely providing two identical supporting units for this purpose, I may mount the second set of rollers on a similar umbrella-frame construction associated with a turbine serving as the source of motive power for the tool carriers, the turbine being driven by a flow of water or other fluid passing through the duct itself. In any case, it is highly desirable that at least one set of guide rollers be disposed downstream of the tool carriers as seen in the direction of advance, thereby relieving the revolving tools of the task of feeling their way through the duct.

In general, the choice of a suitable prime mover for the driving of a tool carrier will depend upon the environment in which the equipment is to be used. For the scraping of sewers and water mains, for example, the aforedescribed type of turbine will frequently be suitable; yet in the performance of painting or lubricating jobs involving the spreading of a viscous fluid, a driving liquid such as water can obviously not be used and reliance must be placed on electric motors or the like. Internal-combustion engines are evidently out of the question when the apparatus is designed to handle a flammable liquid.

My invention will be described in greater detail with reference to the accompanying drawing in which:

FIG. 1 is a side-elevational view (parts broken away) of an apparatus according to the invention used for the cleaning of a high-pressure water main;

FIGS. 2A and 2B are cross-sectional views taken on the lines IIA—IIA and IIB—IIB, respectively, of FIG. 1;

FIG. 3 is a cross-sectional view of a reversing transmission forming part of the system of FIG. 1;

FIG. 4 is a view similar to FIG. 3, illustrating a modification;

FIGS. 5 and 6 are views similar to FIG. 1, illustrating other embodiments;

FIG. 7 is an overall sectional view of a duct in the process of treatment by a coating applicator of the type shown in FIG. 6;

FIGS. 8A and 8B are cross-sectional views generally similar to FIG. 2A or FIG. 2B, showing a modified tool carrier in two different positions;

FIG. 9 is a view similar to FIG. 4, showing a modification of the transmission thereof in combination with a pair of tool carriers of the type illustrated in FIGS. 8A and 8B.

FIG. 10 is an end view taken on the line X—X of FIG. 9;

FIG. 11 is a side-elevational view, partly in section, of a pair of tank cars to be used in combination with the equipment illustrated in preceding figures; and

FIG. 12 is a diagrammatic view generally similar to FIG. 7 showing a duct in the process of being painted by an assembly incorporating the units of FIGS. 9–11.

Reference will first be made to the system shown in FIGS. 1, 2A, 2B and 3 which comprises an apparatus for the internal cleaning of water pipe W. The principal elements of the apparatus are, from left to right in FIG. 1, a guiding and support unit **10**, a first tool carrier **20**, a reversing transmission **30**, a second tool carrier **20'** and a driving unit **40**. The several units are mounted on a rod **50** extending axially within the duct W.

Unit **10** comprises a pair of axially spaced bosses **101**, **106**, boss **101** being rigid with tube **50** while boss **106** is axially slidable thereon. Boss **101** has a set of fins **102** extending in different radial directions, e.g. three or four such fins spaced 120° or 90° apart. A corresponding number of arms **104** are articulated at **103** to the respective fins **102** and are further connected via associated links **109** with corresponding fins **107** of boss **106**, the links **109** being articulated to the fins **107** at **108** and to the arms **104** at **110**. The free outer end of each arm **104** has a guide roller **105** journaled thereon for contact with the inner wall surface of duct W. This contact is yieldably maintained by a biasing device including a pair of lugs **111**, **112** on bosses **101** and **106**, respectively, an axially extending spindle **113** threadedly received in lug **111** and a spring housing **114** secured to lug **112**. A coil spring **114'** in housing **114** tends to draw the boss **106** toward the boss **101**, thereby swinging the arms **104** outwardly in the manner of an umbrella frame; rotation of spindle **113** allows the maximum separation of the two bosses to be adjusted in order to accommodate ducts of different average diameters.

Units **20** and **20'**, illustrated in greater detail in FIGS. 2A and 2B, are mirror-symmetrically identical and comprise each a bobbin-shaped hub **201** or **202** with flanges **203**, **203'** or **204**, **204'** to which a peripheral array of radial brackets **205** and freely swinging arms **208** are attached. The hubs **201** and **202** are journaled on tube **50** by means of ball bearings **301** (FIG. 3). The brackets **205** are secured to the respective flanges by screws **206** and are traversed by pivot pins **207** on which the arms **208** are fulcrumed. These arms, which have the shape of flattened sleeves, are biased for outward swinging (counterclockwise in FIG. 2A, clockwise in FIG. 2B) by leaf springs **210** which pass around the pins **207** into the arms and have their outer ends soldered or otherwise anchored to the respective mounting brackets **205**. The outward swing is limited by an adjustable stop **211** in the form of a screw threaded into a nut on a corresponding mounting bracket, another stop in the form of a pin **211'** defining the inner limit of the swing.

Each pair of parallel arms **208** on a common pin **207** carry, at their free ends, a set of rotary tools such as milling or scraping heads **209** which are held between these arms with a certain friction so that their peripheral speed is lower than that of the array as a whole. These tools could also be equipped with bristles or pins, as illustrated at **260** in FIG. 2B. With suitable adjustment of the stop **211**, the presence of a branch W' (FIG. 2A) will cause only a limited excursion of the rotary tool, as indicated at **209'**, so that normal contact with the inner surface of the main duct is soon restored. Arrows X (FIG. 2A) and Y (FIG. 2B) indicate the sense of rotation of each array **20**, **20'**.

Transmission **30**, FIG. 3, is mounted on an enlarged portion **501** of the tubular rod **50** and comprises a differential gear train with two diametrically opposite sun gears **302**, **302'** which are independently rotatable and mesh with respective planet gears **303*a***, **303*b*** welded onto the adjoining flanges **203**, **204** of hubs **201** and **202**. Overlapping extensions **304**, **305** of these hubs engage each other through ball bearings **306** and form a housing around the sun and planet gears.

The driving unit **40** shown in FIG. 1, and partly illustrated in FIG. 3, comprises a turbine wheel **403** which is freely rotatable on rod **50** but is rigid with the adjoining flange **204'** of hub **202**. Wheel **403** with its blades **403'** is surrounded with small clearance by a flange **405'** of a wheel **405** rigid with rod **50**, the wheel **405** carrying a set of stationary guide vanes **402** which are fastened at their trailing ends to a sleeve **404** threadedly or otherwise engaging the rod **50** in a relatively fixed position. A spider **411** is axially slidable on sleeve **404** and has radial ribs **410** linked at **409** to a set of arms **408** which at **407'** form junctions with a set of deflecting plates **401**, the latter being pivoted at **406** to the flanged wheel **405**. The pivot pins **407'** carry rollers **407** which, like the guide rollers **105** of unit **10**, bear upon the inner wall surface of duct W.

When a body of water rushes through the duct W in the direction of arrow V, it is deflected by plates **401** toward the blades **403'** of turbine rotor **403** to turn this rotor and the hub **202** of tool carrier **20'** about the axis of the duct in the direction Y (FIG. 2B); tool carrier **20** then rotates in the opposite direction X (FIG. 2A). The water pressure also urges the wheels **407** outwardly against the duct wall and at the same time propels the entire assembly in the direction of arrow V, i.e. to the left in FIGS. 1 and 3. This propulsion may be controlled by a restraining force exerted upon a cable **503** which is hooked onto an eye **502** at the trailing end of rod **50**. Furthermore, the water sweeps away fragments of lime, rust and other matter scraped off the inner duct surface.

Whereas in FIG. 1 the assembly is guided at its front by the wheels **105** of unit **10** and at its rear by the wheels **407** of turbine **40**. I have illustrated in FIG. 5 an arrangement in which this turbine has been replaced by another guide unit **10'** identical with unit **10**. This arrangement is particularly applicable where the available water pressure would be insufficient to operate the umbrella-type drive unit **40** of the preceding embodiment. In FIG. 5, motive power is supplied by a modified water turbine **60** having a shell **601** with peripheral apertures **603** secured to flange **204** of carrier hub **202**; apertures **603** form a set of rotor vanes co-operating with similar vanes (not shown) in a tubular stator **602** which is unitary with tube **50** and receives a steady stream of water or other fluid under pressure via a hose **504** clamped at **505** onto the open trailing end of the tube **50**. In this case, separate propulsion means must be provided to advance the assembly through the duct; for this purpose FIG. 5 shows a cable **506** tied to an eye **502'** at the leading end of the rod and connected at its opposite extremity to a winch or the like, not shown.

In FIG. 6, which represents an apparatus for the application of a protective coating, the two guide units **10**, **10'** have been shown interposed between the tool carriers **20**, **20'** and an electric drive motor **70** therefor, this motor being equipped with reduction gearing not further illustrated. In this instance, both guiding units **10**, **10'** lie ahead of the applicators **20** and **20'**, i.e. downstream in the direction of advance V, in order not to disturb the coating of fresh paint deposited on the inner wall surface of the duct. The rotary tools, **261** of these carriers may be brushes or rollers adapted to spread the paint evenly onto the surface; the delivery of the paint to these applicators will be decribed hereinafter with reference to FIG. 7.

Motor **70** is energized via an electric cable **512** entering the duct, together with a towing cable **511**, from the downstream side. The hollow rod **50** terminates at the motor housing, the cable **511** being anchored to a stub **50'** at the opposite end of this housing. A shaft **510** (FIG. 4), driven by the motor, is journaled within rod **50** with the aid of ball bearings **312** and terminates in the enlarged part **501** thereof where it is keyed to a bevel gear **310** in mesh with another bevel gear **311**, the latter being keyed to a transverse pin **313** which is rigid with the sun gear **302** of a modified differential **30'** and has the opposite sun gear **302** loosely mounted thereon. Thus, rotation of motor shaft **510** again turns the two tool carriers **20** and **20'** in opposite directions as illustrated in FIGS. 2A and 2B.

In FIG. 7 I have shown an assembly A similar to that of FIG. 5, except that the electric motor **70** has been replaced by an air motor **71** having discharge apertures **72** for air delivered under pressure through a hose **551**. This figure also shows three tank cars **80, 81, 82** serving as containers for respective components of the protective coating to be applied; vehicle **80** also acts as a mixing vessel and may include a source of propellant for discharging the mixture F at a controlled rate through a valve-operated outlet **800** onto the floor of the duct ahead of the assembly A. Traction is imparted to the entire train via a cable **550**: as the train moves uphill, the flow of the mixture to the applicators is accelerated.

If a reversible power source (such as motor **70** in FIG. 6) is available to drive the tool carriers, a reversal of the input torque may be utilized to withdraw the rotary tools from contact with the inner duct surface, e.g. for the purpose of moving the applicators back by a certain distance for recoating a previously coated section of the duct. An arrangement enabling such withdrawal has been illustrated in FIGS. 8A, 8B, 9 and 10 which show the aforedescribed drive shaft **510** and tubular mounting rod **50** together with a differential gearing **30''** generally similar to transmission **30'** of FIG. 4.

FIGS. 8A and 8B show one of the two mirror-symmetrical tool carriers **20''** associated with transmission **30''**, these tool carriers comprising a central hub **331** of generally triangular shape which is journaled on a sleeve **336** press-fitted onto the rod **50**. Hub **331** is rotatable on that sleeve against the frictional resistance of a pair of brake linings **338** respectively carried on a flange **336'** of sleeve **336** and on a washer **339** pressed against the hub **311** by a pair of Belleville springs **341**; the pressure of these springs can be adjusted by a nut **340** engaging the threaded end **336''** of the sleeve. Cover plates **337** help retain the ball bearings **301** by which the two halves **334**, **335** of the differential housing are journaled on rod **50**. Each of these two halves has a peripheral array of three lugs **332** to which links **333** are articulated. These links, in turn, are pivotally connected with respective platforms **234** which are also fulcrumed at **330** to corresponding points of the three-cornered hub **331**. The platforms **234** carry shanks **233** of respective tool holders **232** to which trowel-like tools **231** are fastened. The assembly **330–333** and associated elements have been shown on a larger scale in FIG. 10.

An eye **513** rigid with rod **50** again allows the exertion of traction upon the apparatus to propel it through a duct W.

When the shaft **510** rotates in the direction T (counterclockwise) as indicated in FIG. 8A, the lugs **332** tend to overtake the frictionally retarded fulcral **330** in a manner causing the arms **232** to swing outwardly, thereby applying the trowels **231** to the inner wall surface of duct W. When rotation is reversed, as indicated at U in FIG. 8B, the arms are inwardly retracted to lift the trowels off the wall. With an inclined duct, as illustrated at R in FIG. 12, the apparatus may be simply allowed to roll back upon such retraction preparatorily to a recoating; otherwise, special means (e.g. a second cable at the opposite end of the train) would have to be provided for such reversal of motion.

FIG. 11 shows details of a pair of tank cars **85, 86** serving as storage and mixing vessels for the constituents of a multicomponent coat. The vessel **85** has a piston **851** guided on a rod **852** and displaceable to the left under pressure of air admitted through an inlet **853**; this piston bears upon a first component K_1 which is ejected through a valve-controlled outlet **854** into a hose **855**, the conduit system being duplicated on the opposite side of the train. Hose **855** is provided with a clamp **861** serving for a controlled throttling of its throughput. As illustrated in FIG. 12, other tank cars containing components K_2, K_3, K_4 are similarly connected to the same hose **855**. A mixing chamber **862** in vessel **886** receives the several components from both conduit systems and is equipped with a feed screw **863**, driven by an electric motor **864**, for discharging the mixture at a controlled rate onto the floor of the duct. A tube **857** supplies air under pressure to all tank cars in parallel and extends alongside a traction cable **553**. A reversible drive motor **90**, whose power cable has not been illustrated, turns the rotatable tool carriers **20''** on opposite sides of transmission **30''** FIG. 11 also illustrates a floodlight **865** and a television camera **866** mounted on car **86** to enable remote observation of the coating operation.

Elements shown in different embodiments may be substituted or combined, within the limits of compatibility, or modified in ways apparent to persons skilled in the art without departing from the spirit and scope of my invention as defined in the appended claims.

I claim:

1. An apparatus for treating the inner wall surface of a generally cylindrical duct, comprising:
- a support axially displaceable inside a duct to be treated and provided with guide means engageable with the inner periphery of said duct;
- an elongate member extending axially from said support;
- propulsion means for axially advancing said support and said member through said duct;
- a first hub mounted on said member for rotation about the axis of said duct;
- a second hub mounted on said member for rotation about said axis in axially spaced relationship with said first hub;
- drive means for rotating said first hub about said axis;
- reversing transmission means linking said first hub with said second hub for rotating the latter in a direction opposite the sense of rotation of said first hub, said transmission means including a differential gearing on a part of said member lying between said hubs;
- and tool means on each of said hubs engageable with the inner wall surface of said duct.

2. An apparatus as defined in claim **1** wherein said hubs are provided with overlapping extensions forming a housing around said differential gearing.

3. An apparatus as defined in claim **1** wherein said member is a tube and said differential gearing includes a pin transverse to said axis journaled in said part, a sun gear rigid with said pin, a pair of planet gears in mesh with said sun gear and respectively connected with said hubs, a shaft extending axially within said tube and coupled with said drive means, and gear means in said part drivingly coupling said shaft with said pin.

4. An apparatus as defined in claim **3** wherein said drive means comprises a motor supported on said tube and operatively connected with said shaft.

5. An apparatus as defined in claim **1** wherein said drive means comprises a prime mover on said member, said prime mover being directly coupled with said first hub.

6. An apparatus as defined in claim **5** wherein said prime mover comprises a turbine.

7. An apparatus as defined in claim **6** wherein said member is a tube, said turbine having an apertured shell forming vanes positioned for impingement by a motive fluid transmitted to the interior of said shell through said tube.

8. An apparatus as defined in claim 6 wherein said turbine comprises a rotor on said member rigid with said first hub and provided with a peripheral array of blades, a spider axially slidable on said member, a peripheral array of linkages connecting said rotor with said spider, and a set of guide rollers on said linkages engageable with the inner wall surface of said duct, said linkages including a set of deflecting plates surrounding said blades and disposed for impingement by a fluid stream in said duct to direct the fluid toward said blades while urging said rollers outwardly against said wall surface.

9. An apparatus as defined in claim 1 wherein said support comprises a first boss rigid with said member, a second boss axially slidable on said member, a peripheral array of arms linked with said bosses for outward swinging upon a displacement of said second boss toward said first boss, and biasing means for urging said bosses toward each other, said guide means including a roller on an outer end of each of said arms.

10. An apparatus as defined in claim 9, further comprising adjustable stop means for limiting the outward swing of said arms.

11. An apparatus as defined in claim 9 wherein said support is disposed downstream of said hubs.

12. An apparatus as defined in claim 1 wherein said support is duplicated at axially spaced locations along said member, at least one of said locations being downstream of said hubs.

13. An apparatus for treating the inner wall surface of a generally cylindrical duct, comprising:

- a support axially displaceable inside a duct to be treated and provided with guide means engageable with the inner periphery of said duct;
- an elongate member extending axially from said support;
- propulsion means for axially advancing said support and said member through said duct;

- a first hub mounted on said member for rotation about the axis of said duct;
- a second hub mounted on said member for rotation about said axis in axially spaced relationship with said first hub;
- reversible drive means for rotating said first hub about said axis;
- reversing transmission means linking said first hub with said second hub for rotating the latter in a direction opposite the sense of rotation of said first hub;
- tool means on each of said hubs engageable with the inner wall surface of said duct, said tool means including a peripheral array of arms fulcrumed on each of said hubs and swingable in a transverse plane, said transmission means including couplings linking said arms with said drive meas independently of said hubs for rotary entrainment in either direction; and
- frictional means for retarding the rotation of said hubs whereby said arms swing outwardly upon rotary entrainment in one direction and inwardly upon rotary entrainment in the opposite direction.

14. An apparatus as defined in claim 13 wherein said transmission means comprises a differential gearing having a sun gear coupled with said drive means and having a pair of planet gears in mesh with said sun gear, said couplings including articulated connections between said arms and said planet gears.

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U.S. Cl. X.R.

15—104.14; 118—105