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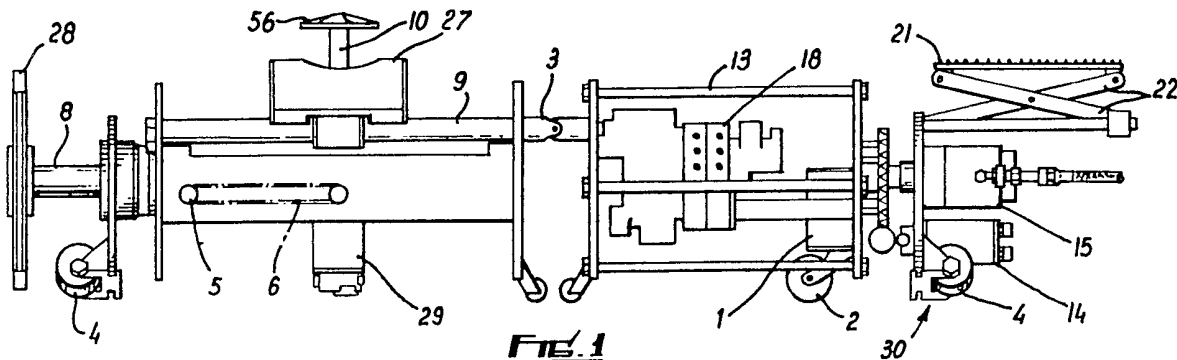
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(54) Apparatus for and method of repairing ducts

(57) Duct repairing apparatus comprises a carriage adapted to enter a duct, a drill (56) disposed on a latitudinally movable support (7), first means (28) adapted to detect the longitudinal location of a cavity in the wall of the duct, second means (28) adapted to detect the latitudinal location with respect to the carriage of said cavity, and means (13) for aligning the drill with the cavity. The invention also provides a method of repairing sewers.



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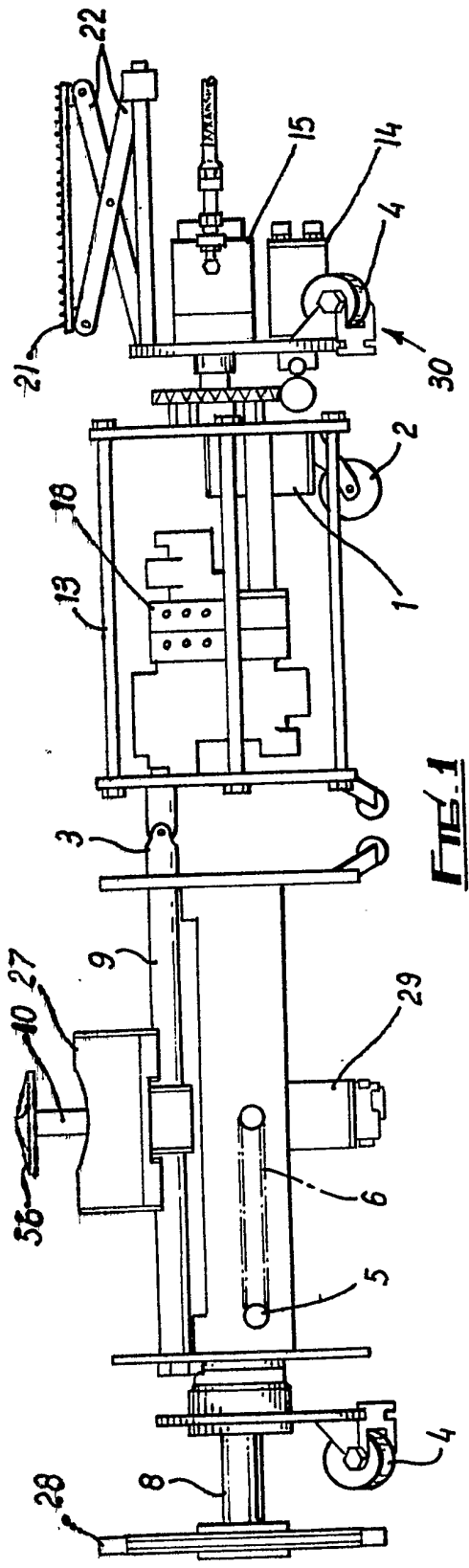


FIG. 1

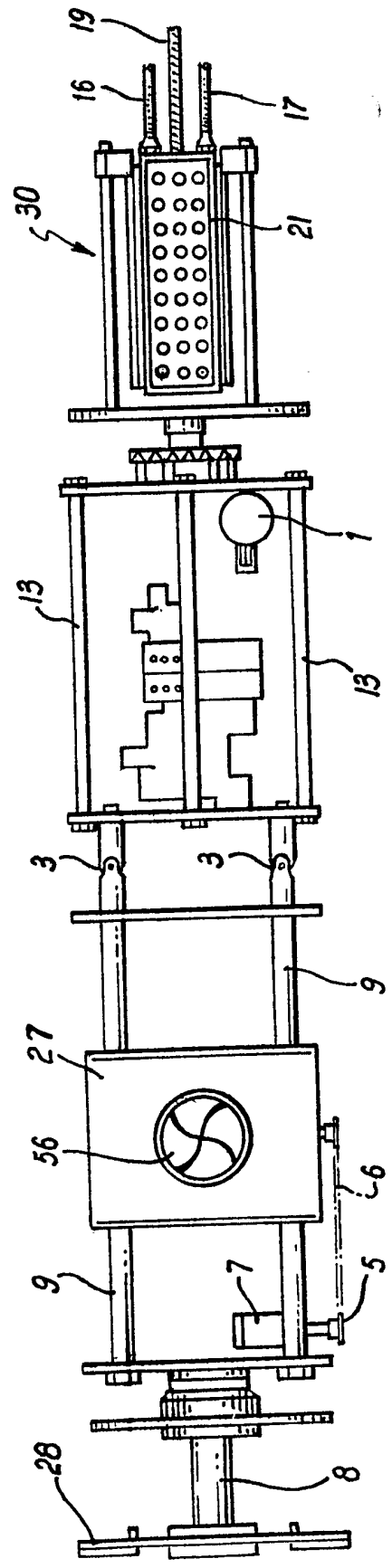
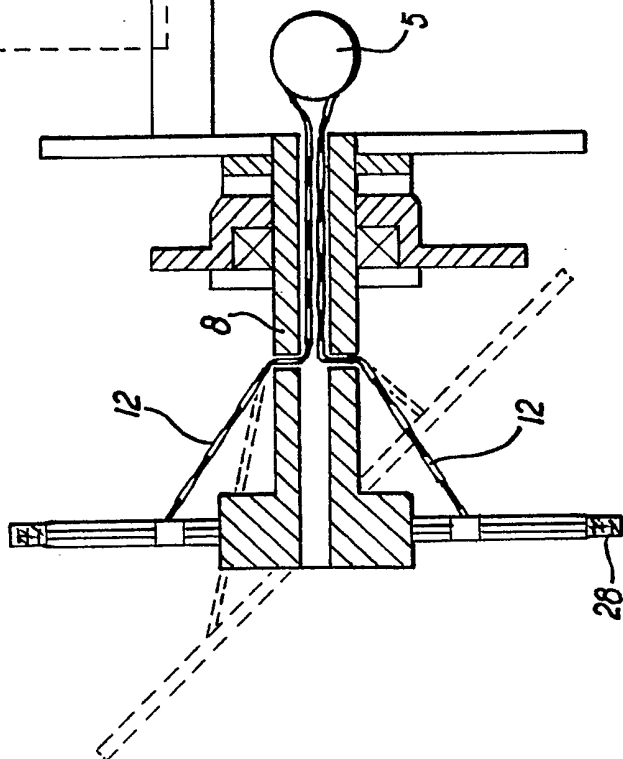
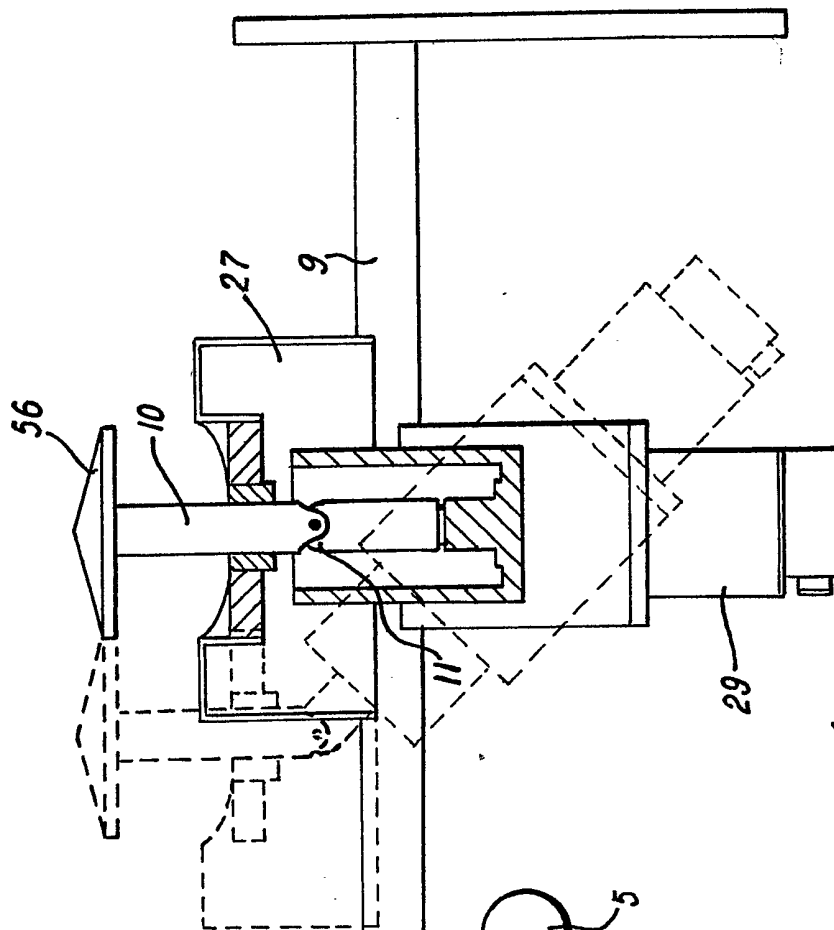
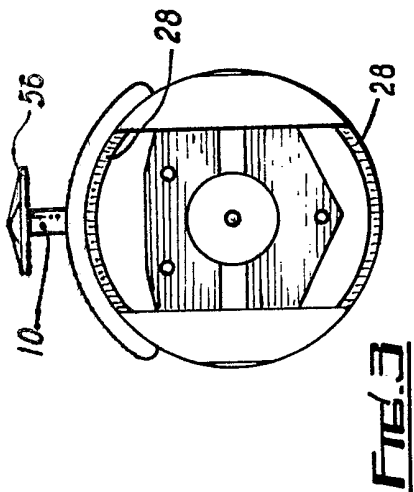


FIG. 2

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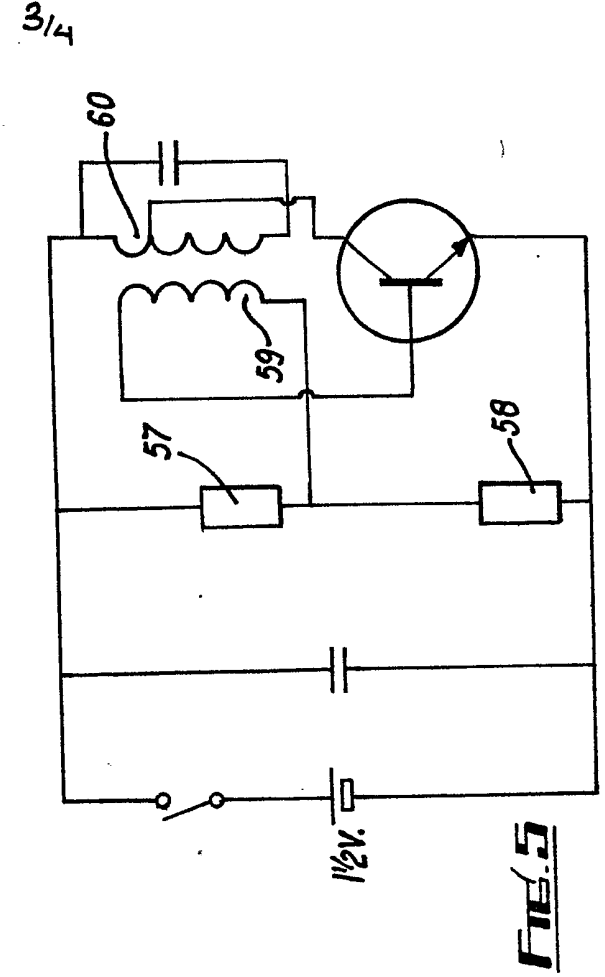
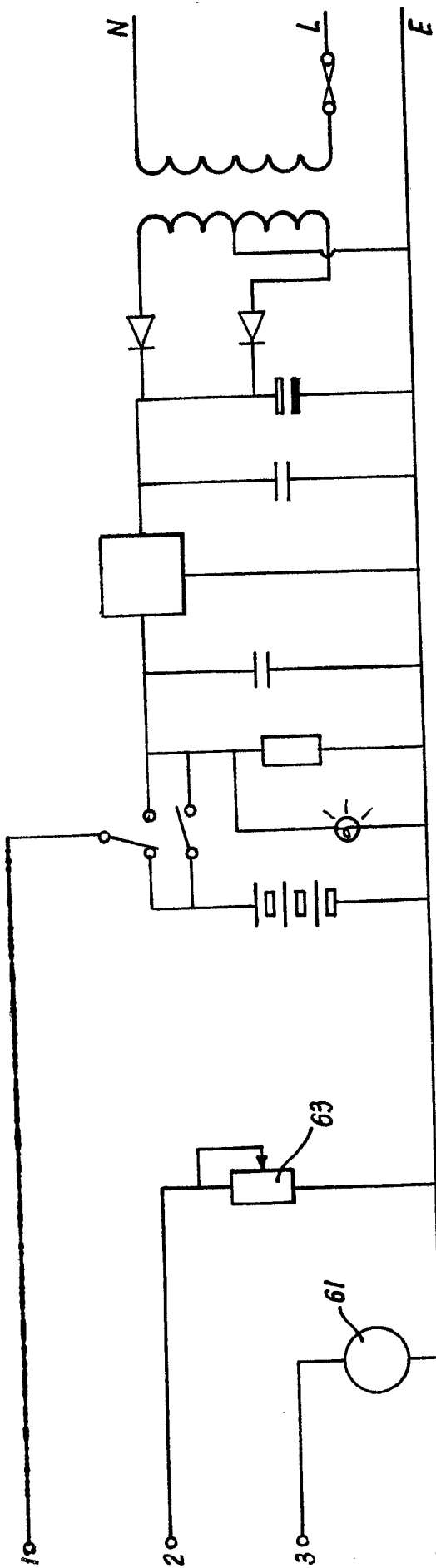
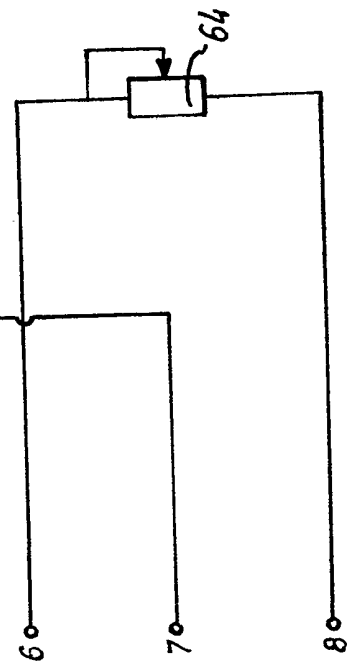


FIG. 7

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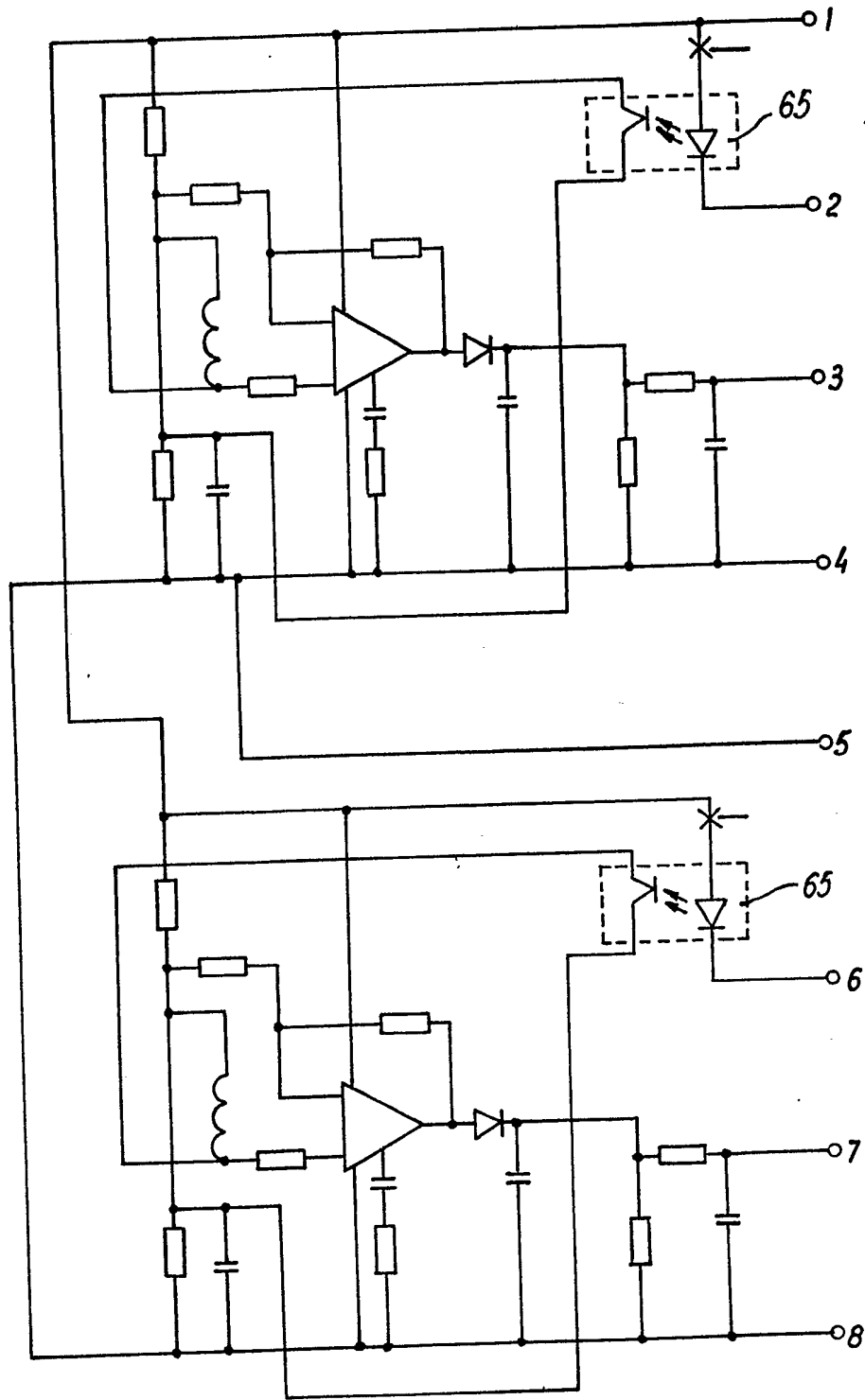


FIG. 6

SPECIFICATION

Apparatus for and a method of repairing ducts

5 The present invention relates to apparatus for and a method of repairing ducts having branch ducts, communicating with them particularly, but not exclusively, sewers for the discharge of effluent.

10 Main sewers used in the United Kingdom and elsewhere are often brick built, of considerable age and are subject to heavy internal corrosion and external pressure. As a result incipient main sewer collapse is widespread and there have been many examples of actual collapse. Apart from the danger to health and the resulting interruption to the sewer system, main sewers are often located beneath main thoroughfares and sever traffic disruption may result. The weight of traffic may promote collapse in such circumstances the cost of the disruption is added to the actual cost of carrying out the repair.

25 It is known to provide a method of repairing a duct having one or more branch ducts communicating with it including the steps of inserting a liner into the duct so that it is disposed substantially coaxial with the duct, feeding a cutting device having an extendable cutting head down the or each branch duct and, with the device stationary, extending and operating the cutting head to cut an aperture in the liner between the duct and the or each branch duct, subsequently pumping a settable material between the liner and the internal wall of the duct and allowing it to set to form a reinforcing layer extending around the internal surface of the duct.

40 Such a method suffers from the disadvantage that it is often impossible to insert a bulky cutter head down a branch duct, due to for example sharp bends in the duct, blockages or collapse of the walls of the duct.

45 According to a first aspect of the present invention duct repairing apparatus comprises a carriage adapted to enter a duct, a tool disposed on a movable support, first means adapted to detect the longitudinal location with respect to the carriage of a cavity in a wall of the duct, and second means adapted to detect the latitudinal location with respect to the carriage of said cavity.

55 The cavity may be a side duct, branch duct or fault in the duct wall. A preferred apparatus also comprises means adapted to align the tool with said cavity in the wall of the duct. The support may be moveable latitudinally or radially outwardly of the apparatus.

60 The means for detecting a cavity may comprise one or more detectors of electromagnetic radiation, magnetism or sound waves. The apparatus may additionally comprise a source of electromagnetic radiation, magnetism or sound waves adapted to be inserted into a

branch duct into proximity with the detector. Such a source may comprise a radio transmitter, a source of high energy radiation or a magnet.

70 Alternatively or in addition a source of electromagnetic or other radiation may be provided upon the carriage, and may comprise a radar transmitter, a source of visible or near-visible radiation or a sonar-type device. In this case the detectors are responsive to signals reflected from the walls of the duct.

75 A preferred embodiment of the first aspect of this invention comprises a radio transmitter adapted to be located centrally in a side duct or branch duct and a directional radio receiver located upon the carriage.

80 The transmitter may be secured to an inflatable member such as a cylindrical bag, arranged so that inflation of the member positions the transmitter centrally within the cavity i.e. axially with respect to a side duct. The transmitter and inflatable member may be sufficiently small to be insertable into partially collapsed or convoluted side ducts.

85 Preferably the receiver includes a first element such as a coil arranged to detect a signal emanating from a source disposed laterally of the element or at a direction laterally of a particular longitudinal location of the carriage. The aforesaid location of the carriage is preferably that at which the drill is located. The receiver preferably also includes a second element, such as an additional coil, arranged to detect the latitudinal direction of the signal when the latter has been located at the aforesaid longitudinal location.

90 The tool may comprise a drill, sprayer or other apparatus. A sprayer may find application in the repair of the lining of gas mains, being arranged to spray epoxy resin or a similar coating material upon the inner surface of the gas main.

105 Apparatus including a drill find particular application in the repair of sewer ducts which are too small for entry by a person, being employed to cut a liner inserted into the duct to facilitate communication with side or branch ducts.

110 The carriage may be wheeled to facilitate passage through the duct. Alternatively skids or tracks may be provided. The locations of the wheels may be adjustable to accommodate different sizes of passages.

115 The tool is preferably located on a support which is rotatable about a longitudinal direction with respect to the apparatus and more preferably generally axially with respect to the duct. Side ducts may enter the main duct at a non-perpendicular angle to the axis of the main duct. The support for the tool is preferably adapted to be inclined at such angles by being arranged to tilt about a transverse axis of the apparatus.

120 The receiver may be disposed on the support so that the tool is coplanar with the first

longitudinal direction and is coaxial with the second latitudinal direction. Alternatively the receiver and support may be spaced apart and arranged to move in concert, means being provided for moving the tool into a location in which the receiver has been aligned with the cavity.

Apparatus in accordance with the invention preferably comprises one or more clamps adapted to secure the carriage within a duct as the drill is actuated.

Apparatus in accordance with this invention preferably also comprises a power supply such as a hydraulic fluid line, connected to an external source such as a compressor.

The drill may comprise any convenient means for cutting the liner including one or more blades or a thermal cutting means such as a heated wire.

According to a second aspect of the invention a method of repairing a duct comprises the steps of; inserting a generally cylindrical liner into the duct, passing a duct repairing apparatus as herein described into the liner, detecting the longitudinal location of a side duct, detecting the latitudinal location of the side duct, drilling a hole in the liner in alignment with the side duct, withdrawing the apparatus from the duct, sealing the hole with an inflatable member, grouting the cavity between the duct and liner and removing the inflatable member.

The apparatus may be passed through a duct consecutively drilling holes in the liner to open each of a plurality of side ducts.

The method may include the step of aligning the drill with the side duct. The angle of entry of the side duct of a sewer into the main duct may be generally determined by inspection with closed circuit television apparatus or from a plan of the sewer system.

The inflatable member may be inserted down the side duct to a location where it partially enters the duct so that, upon inflation the holes in the liner and entrance to the side duct are both sealed. The material used for grouting the duct is thereby prevented from obstructing the side duct.

Alternatively, the inflatable member may be inserted into the side duct from within the liner, for example by means of a device located upon the carriage of the apparatus.

The method and apparatus may be used for repair of any duct including sewers, pipes in chemical plants, gas mains and the like.

The invention is further described by way of example with reference to Figures 1 to 7 of the accompanying drawings, of which:

Figure 1 is an elevation showing apparatus in accordance with the invention;

Figure 2 is a plan view of Figure 1;

Figure 3 is an end elevation of Figure 1;

Figure 4 is a partial cross section of the apparatus;

Figure 5 is a circuit diagram of the transmit-

ter;

Figure 6 is a circuit diagram of the subterranean part of the receiver;

Figure 7 is a circuit diagram of the surface part of the receiver.

Figures 1 to 4 show a duct repairing apparatus adapted to be used in a cylindrical duct. The carriage of the apparatus is supported by four wheels 4 which are arranged to extend radially towards the wall of the duct. A hydraulic motor 1 is arranged to drive a wheel 2 to move the apparatus along the duct. The chassis is articulated by means of universal joints 3 to facilitate insertion of the apparatus into a duct, for example through a man-entry chamber. A hydraulic motor 29 is connected to a drill bit 56. The cutting face of the bit 56 is shallow so that the extent by which it has to be moved to cut a hole is minimised. Receiver coils 28 are adapted to detect a signal from a transmitter located in a side duct when the latter is in the plane of the coil. The coil is also adapted to rotate upon the shaft 8 to detect the latitudinal or angular location of the transmitter. A hydraulic motor 7, connected by a sprocket 5 and chain drive 6 to the motor 29, facilitates tilting of the latter to align the bit with side ducts which enter the main duct at an angle of less than 90°. The drill bit 56 is located upon a block 7 which is mounted for sliding motion upon bars 9. The shaft 10 of the bit 56 is slidable within a bearing in the block 7 and is connected to the motor 29 by means of a universal coupling 11 so that the bit 56 is maintained in use in a perpendicular attitude although it may be driven at an angle towards the wall of a duct. This arrangement confers the advantage that the bit always cuts evenly into the wall of the duct but minimises the radial size of the apparatus.

The sprocket 5 is also connected by a chain drive 12 (Fig.4) to the receiver coil 28 so that the coil tilts in concert with the drill. The motor 7 may be located at any convenient location within the apparatus. Four hydraulic rams 13 have a stroke equal to the distance between the coil 28 and drill bit 56. Extension of the rams while the clamp 21 engages the wall of a duct causes the drill bit 56 to be moved to the precise location to drill into a side duct located by the coil 28. The clamp 21 is mounted by a pantograph arrangement 22 upon a carriage 30. A hydraulic motor 14 and rotary coupling 15 allow the coil, drill and supporting chassis to be rotated axially when the clamp engages a duct wall. Power is supplied to the motors by means of hydraulic feed and return pipes 16, 17 acting through valves 18. An electric cable 19 supplies control signals to the valves.

In use of the apparatus a tubular line of polyethylene or other plastics material is inserted into the duct and the apparatus placed within the liner.

Radio transmitters are inserted down each side duct and are arranged at the opening of the latter adjacent the main duct. Each radio transmitter may be carried by an inflatable bag, inflation of which causes the transmitter to be located axially in the side duct. The apparatus is then caused to pass along the duct until the coil detects a signal from a source at any position in the plane of the coil in a longitudinal plane perpendicular to the main duct or at an angle thereto if the coil is tilted. The carriage is stopped when the signal received by the first coil reaches a maximum. The clamp 21 is actuated to secure the apparatus in position. The drill and receiver assembly is then rotated until the signal received by a directional element of the second coil reaches a maximum. The rams 13 are then actuated to move the drill into alignment with the transmitter in the side duct. The transmitter is then withdrawn and the drill actuated to cut a hole in the plastics liner. The apparatus is then withdrawn from the liner and the side duct and liner are sealed with an inflatable member in the conventional manner. The cavity between the wall of the duct and the liner may be grouted and the inflatable member removed.

Figures 5 to 7 illustrate the circuitry. The transmitter shown in Figure 5 is arranged to suit a signal at 100kHz. The resistors 57, 58 have resistances of 2 k Ω and 9.1 k Ω respectively. The coil 59 has 16 turns and the coil 60 has 510 turns, the tap being made at the 500th turn.

Figure 6 shows the circuit diagram for the peak detector circuit of the subterranean receiver. This circuit provides an output of sufficient strength to actuate the circuit shown in Figure 7 which is located in use above the surface of the ground. Meters 61 and 62 display the position of the receiver coils while the potentiometers 63 and 64 permit the sensitivity of the apparatus to be adjusted.

The receiver shown in Figure 6 includes opto-couplers 65 which provide a low impedance path for D C voltage from above ground. This improves the response time of the apparatus particularly when long (e.g. 25m) connecting cables are used. The use of alternating current circuitry reduces the susceptibility of the apparatus to external interference when compared to nucleonic or magnetic detector arrangements.

In an alternative embodiment of the invention the coil may be located around the drill bit or close to the latter so that separate alignment of the drill is not necessary after alignment of the coil and transmitter.

CLAIMS

1. Duct repairing apparatus comprising a carriage adapted to enter a duct, a tool disposed on a movable support, first means adapted to detect the longitudinal location

with respect to the carriage of a cavity in a wall of the duct and second means adapted to detect latitudinal location with respect to the carriage of said cavity.

2. Apparatus as claimed in claim 1, further comprising means adapted to align the tool with the said cavity.

3. Apparatus as claimed in claim 1 or 2, wherein the means for detecting a cavity comprises one or more detectors of electromagnetic radiation, magnetism or sound waves.

4. Apparatus as claimed in claim 3, wherein said means for detecting a cavity comprises a directional radio receiver.

5. Apparatus as claimed in claim 4, further comprising a radio transmitter adapted to be inserted into said cavity.

6. Apparatus as claimed in claim 5, wherein the transmitter is secured to an inflatable member arranged so that inflation of the member positions the transmitter centrally within the cavity.

7. Apparatus as claimed in any of claims 4 to 6, wherein the receiver includes a first element arranged to detect a signal emanating from a source disposed either laterally of the element or laterally of a particular location of the carriage.

8. Apparatus as claimed in claim 7, wherein the receiver includes a second element arranged to detect the latitudinal location of said signal.

9. Apparatus as claimed in any preceding claim, wherein the tool comprises a drill.

10. Apparatus as claimed in any of claims 1 to 8, wherein the tool comprises a sprayer.

11. Apparatus as claimed in any preceding claim, wherein the tool is located upon a support which is rotatable about a longitudinal axis with respect to the apparatus.

12. Apparatus as claimed in claim 11, wherein the support is arranged to tilt about a transverse axis of the apparatus.

13. Duct repairing apparatus substantially as hereinbefore described with reference to Figures 1 to 7 of the accompanying drawings.

14. A method of repairing a duct comprising the steps of: inserting a generally cylindrical liner into the duct, passing a duct repairing apparatus as claimed in any of claims 9 to 13 into the liner, detecting the longitudinal location of a side duct, detecting the latitudinal location of the side duct, drilling a hole in the liner in alignment with the side duct, withdrawing the apparatus from the duct, sealing the hole with an inflatable member, grouting the cavity between the duct and liner and removing the inflatable member.

15. A method as claimed in claim 14, including the step of aligning the drill with the side duct.

16. A method as claimed in claim 14 including the steps of inserting the inflatable member down the side duct and inflating the

member so that the side duct and hole in the liner are both sealed.

17. A method of repairing ducts substantially as hereinbefore described with reference to Figures 1 to 7 of the accompanying drawings.

18. A method of repairing sewers in accordance with any of claims 14 to 17.

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