(57) Abstract: The present invention relates to video inspection apparatus (100) for inspecting a pipeline (5). The apparatus (10) comprises a reel on which a cable is wound; a support (101) on which the reel is rotatably mounted; a camera (103) connected at one end of the cable; an electric battery mounted on the support (101) and connected to the camera via a wire running through the cable; and a liquid crystal display screen (104) mounted on the support (101) and connected to the camera via a wire running through the cable. The cable can be manually unwound from the reel and fed down the inspected pipeline in order to advance the camera along the inspected pipeline with an image of the interior of the pipeline relayed to and displayed on the screen (104). The reel, the cable, the camera, the support (101), the electric battery and the screen (104) together form a self-contained unit which can be carried by a single human operator to an inspection site and used there without connection to any ancillary apparatus.
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VIDEO INSPECTION APPARATUS

The present invention relates to video inspection apparatus and in particular to video inspection apparatus for use in inspecting the interior of pipework.

It is known to mount a camera at the end of a stiff but flexible cable and then to manually insert the camera in a pipe and push the camera down the pipe using the stiff flexible cable to push the camera along the pipe. The cable must be stiff enough to allow the camera to be pushed along the pipe, yet flexible enough to allow the camera to negotiate bends. Typically the cable has been dispensed from a reel rotatably mounted on a stand or frame.

Passing through the cable are wires providing an electrical supply to the camera at the end of the cable and also feeding back the video signals obtained by the camera. Typically lighting is provided along with the camera so that the interior of the pipe can be illuminated during inspection. The power supply for the lighting also passes along the cable.

To date inspection apparatus such as described above has been used in inspection of large scale pipes such as sewers. Usually it is transported to site by a van and power for the apparatus is provided by batteries of the transporting vehicle, or by a portable generator or from a mains electricity supply. A cable supplying power will be run e.g. from the vehicle and will engage in a socket provided on the inspection apparatus, which will itself be manually portable to be located near an entry point for the
sewer pipe to be inspected. A video screen showing the image recorded by the camera has in the past been mounted on the stand supporting the cable reel, but at other times the video display has been located inside the transporting vehicle and cable run from the cable reel to the video screen apparatus inside the vehicle. The video screens used in the prior art were screens of cathode ray tubes which made the apparatus cumbersome and not truly portable and dictated against use of battery (rather than mains) power because of their power requirements.

The present invention provides video inspection apparatus for inspecting a pipeline comprising:

- a cable windable in a reel;
- drum means on which the reel is windable, the drum means being rotatably mounted on a support;
- camera means connected at one end of the cable;
- an electric battery mounted on the support and connected to the camera means via a wire running through the cable; and
- flat screen display means mounted on the support and connected to the camera means via a wire running through the cable; wherein

the cable can be manually unwound from the reel thereof and fed down the inspected pipeline in order to advance the camera means along the inspected pipeline with an image of the interior of the pipeline relayed to and displayed by the flat screen display means; and

the drum means, the cable, the camera means, the support, the electric battery and the flat screen display means together form a self-contained unit which can be carried by a single human operator to an inspection site and used there without connection to any ancillary apparatus.
The present invention provides an independent unit which is transportable by a single human operator and which in itself comprises all the elements necessary for an inspection of a pipe. It is envisaged that the apparatus being more portable can be used for a whole variety of new jobs, such as the inspection of piping in the interior of a house. Whereas the prior art inspection systems were designed for inspection of fairly large scale pipes usually accessible from manholes in a pavement or a road, the present invention provides apparatus which could be used by any plumber to inspect pipework in a multitude of situations.

The present invention provides in a second aspect video inspection apparatus for inspecting a pipeline comprising:

a first cable windable in a first reel;
a second cable windable in a second reel;
a drum means on which the first and second reels are windable, the drum means being rotatably mounted on a support;

first camera means connected at one end of the first cable;

second camera means connected at one end of the second cable;

an electric battery mounted in the support and connectable with the first and second camera means via wires running through the first and second cables; and

flat screen display means mounted on the support and connectable with the first and second camera means via wires running through the first and second cables; wherein

the first and second cables can each be manually unwound respectively from the first and second reels thereof in order to advance the first or the second camera means along the inspected pipeline;
the first and second cables are connectable to the flat screen display means so that images recorded by the first or second camera means can be relayed to the flat screen display means for display thereby; the first and second cables are connectable to the electric battery so that electrical power can be relayed to the first and second camera means; and the drum means, the first and second cables, the first and second camera means, the support, the electric battery and the flat screen display means together form a self-contained unit which can be carried by a single human operator to an inspection site and used there without connection to any ancillary apparatus.

Preferred embodiments of inspection apparatus according to the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a first side elevation of a first embodiment of video inspection apparatus according to the invention;

Figure 2 is a second side elevation of the embodiment of video inspection apparatus shown in Figure 1;

Figure 3 is a cross-section through the embodiment shown in Figures 1 and 2, taken along the line A-A' of Figure 2 in the direction of the arrow;

Figure 4 is a view of the front of the flat screen display unit of the first embodiment of video inspection apparatus, the display unit having been shown in side view in Figures 1 and 2 and in rear view in Figure 3; and
Figure 5 is a perspective view of a second embodiment of video inspection apparatus according to the invention.

Turning to Figure 1 there can be seen in the figure video inspection apparatus 10 comprising a flat screen display unit 11 mounted on a frame 12 which carries a rotatable reel 13 mounted to rotate about a spindle extending from the frame 12. In the Figure there can also be seen a battery pack 14 and two different cameras 15 and 16. The camera 15 has a diameter of 50mm and the camera 16 has a diameter of 25mm. In Figure 2 at the left hand side there can be seen the front of the two cameras 15 and 16. At the front of the camera 15 there is a lens 18 for a camera typically comprising a CMOS sensor and this is surrounded by a plurality of LEDs 19 which provide light to illuminate the interior of a pipe being inspected by the camera. In a similar way the camera 16 has a lens 20 and the camera is surrounded by a plurality of LEDs 21, which again provide illumination in the interior of the pipe being inspected.

The camera 15 has a head 22 which comprises the CMOS sensor and its supporting electronics and also the illuminating LEDs. Immediately behind the head 22 there is a section 23 comprising a coiled spring surrounding the wires which provide the head 22 with power and which relay video signals from the head 22. The coiled spring 23 allows the head 22 to move around corners in the pipework. The coiled spring 23 extends between the head 22 and a socket section 24 which allows connection of the camera apparatus and associated lighting to a cable 25.

In a similar way the camera apparatus 16 comprises a head 26 which houses a CMOS sensor,
illuminating LEDs and their supporting electronics. This head is connected to a socket section 27 by a coiled spring 28 which allows the camera head 26 to flex and move around corners within the pipework. The socket 27 connects the camera to a cable 29.

Turning now to Figure 3 it can be seen that the cable 25 is wound in a reel on the drum 13 which is pivotally mounted on a hub 30 of the supporting frame 12. The drum 13 is rotatable about the hub 30.

The cable 29 is wound in a reel also on the drum 13. The reel of cable 25 and the reel of cable 29 are both concentric, having coincident axes along the axis of the hub 30. The reel of cable 25 is wound to have a diameter greater than the diameter of the wound reel of cable 29.

In Figures 2 and 3 can be seen that the cable 25 terminates at the end opposite to the end connected to the camera at a plug 40 which is attached to a socket 41 mounted on the hub 42 of the rotatable drum 13. In a similar way the cable 25 has an end 43 which has a plug 44 engageable with a socket 45 mounted on the hub 42 of the cable drum 13. On the hub 42 there can be seen in Figure 2 two switches 46 and 47. These switches allow the operator to select between the two cameras 15 and 16. Operation of switch 46 allows selection of camera 16 and operation of switch 47 allows selection of camera 15. The switches 46 and 47 switch the cameras 15 and 16 on and off by controlling the power supply to the camera. The switches 46 and 47 could be replaced by a single three-way switch.

Cables (not shown) will extend through the stand 12 to connect the sockets 45 and 41 with the flat screen display apparatus 11, best seen in Figure 4.
In this figure there can be seen that the video display apparatus comprises an LCD screen 50 and some controls 51, 52, 53 and 54 which allow control of the display, e.g. brightness, contrast, colour and positioning of the image on the screen. The video display apparatus 11 can be pivoted about the top of the stand 12 and then fixed in place by using the clamp 55.

The flat screen apparatus 11 will typically comprise a Liquid Crystal Display (LCD) screen. The LCD screen may be a twisted nematics (TN) LCD screen, a super twisted nematics (STN) LCD screen, a dual scan twisted nematics (DSTN) LCD screen, a stabilised ferroelectric liquid crystal (FLC) display screen or a surface stabilised ferroelectric liquid crystal (SSFLC) display screen. The screen could be backlit or reflective. The screen could be a passive matrix LCD screen or an active matrix or thin film transistor (TFT) LCD screen. Alternatively, the flat screen could be a field emission display (FED) screen, or surface conduction emission display (SED) screen or a vacuum fluorescent display (VFD) screen. All such screens consume low power and thus facilitate a practical realisation of portable pipeline inspection apparatus.

The video inspection apparatus 10 is completely self-contained in that it contains batteries needed to power the cameras 15 and 16 and the flat screen display apparatus 11. The image obtained by either camera 15 or camera 16 is displayed by the flat screen display unit 11 which is part of the apparatus. The operator can select for use either a small diameter camera 16 or a larger diameter camera 15. It is envisaged that the batteries used by the apparatus will be rechargeable. Typically once charged the
battery power pack would provide 3 to 4 hours of power supply and it is envisaged that this would be sufficient to last through a day of use by an operative, with the pack then being recharged overnight. Additionally or alternatively the apparatus could be supplied with several battery packs easily interchangeable.

It is preferred that the drum 13 is associated with a self retracting mechanism. When the cable 25 or cable 29 is pulled out from the reel then a ratchet mechanism operates so that the cable remains at its drawn out length. Once the operator has finished inspection then he will release the ratchet mechanism in a known manner and the drum 13 will rotate under the action of potential energy stored in a spring and will wind the cable 25 or 29 back onto the drum. Alternatively the cables 25 and 29 could be manually unwound from, and then manually wound back on to the reels.

The overall apparatus will be of a size and weight suitable for carrying by a single operator to a point of inspection.

Each cable 25, 29 is preferably a cable comprising a fibreglass core over which a plastic jacket is extruded, the fibreglass rod providing the necessary rigidity and the jacket providing protection for the rod and preventing the rod from snapping.

To use the apparatus described above an operator will transport the apparatus to an inspection site. The operator will then select whether it is appropriate to use the small scale camera 16 or the larger scale camera 15. Once a selection has been made then the operator will pull the relevant cable 25
or 29 from the rotatable drum and feed the camera 15 or 16 along pipework to be inspected, pushing the camera 15 or 16 along manually using the relatively stiff cable 25 or 29. The operator will use the switches 46 and 47 to supply power to the chosen camera and the associated lighting apparatus. The image of the inspected pipe will then appear on the screen 50 and the operator will be able to view the interior of the pipe being inspected. It is possible that the flat screen display apparatus 11 could incorporate some way of recording the video sequence captured by the camera, for subsequent replay.

Whilst above the drum 13 is shown mounted with an axis of rotation horizontal, it is possible that the apparatus could be constructed in such a way that the drum 13 rotates about a vertical axis. It is also possible that the flat screen display apparatus 11 rather than being mounted at the top of the stand 12 is mounted on the hub of the stand.

Whilst above the apparatus 10 has been described with two cameras 15 and 16 of different diameters, in an alternative arrangement the cameras would be identical, but attached to cables which have different characteristics. One cable could be short and stiff to allow access around tight bends. The other cable could be longer and less stiff to allow inspection of long lengths of straight pipe or pipes with gentle corners. Of course, both the cameras could be different to each other and the cables different to each other.

Figure 5 shows a second embodiment of video inspection apparatus 100. This embodiment is a hand-held unit comprising a single reel of cable (not shown) encased in a moulded plastic housing 101 which
has a carrying handle 102. A camera 103 can be seen, the camera being connected at the end of the cable and being manually retractable from housing 101 so that the camera 103 can be pushed along pipework to be inspected by feeding the stiff cable along the pipework. A flat screen 104 can be seen which is integrated in the housing 101. The cover 105 secures in place a removable battery pack (not shown) which again is integral with the unit and powers the unit.

The unit may, for instance, be supplied with two battery packs, each rechargeable, having each 3 to 4 hours operational life. The battery packs can be exchanged when needed. The camera 103 will be a camera as described before in the first embodiment with LEDs provided surrounding the camera and providing illumination in the interior of the inspected pipework. The casing 101 provides the support on/in which the other elements are mounted. The reel will be mounted to be rotatable in the casing about a generally horizontal axis when the casing 101 is rested on a level surface.
CLAIMS

1. Video inspection apparatus for inspecting a pipeline comprising:
   a cable windable in a reel;
   drum means on which the reel is windable, the drum means being rotatably mounted on a support;
   camera means connected at one end of the cable;
   an electric battery mounted on the support and connected to the camera means via a wire running through the cable; and
   flat screen display means mounted on the support and connected to the camera means via a wire running through the cable; wherein
   the cable can be manually unwound from the reel thereof and fed down the inspected pipeline in order to advance the camera means along the inspected pipeline with an image of the interior of the pipeline relayed to and displayed by the flat screen display means; and
   the drum means, the cable, the camera means, the support, the electric battery and the flat screen display means together form a self-contained unit which can be carried by a single human operator to an inspection site and used there without connection to any ancillary apparatus.

2. Video inspection apparatus as claimed in claim 1 wherein the flat screen display means comprises a liquid crystal display screen.

3. Video inspection apparatus as claimed in claim 1 or claim 2 comprising a carrying handle.

4. Video inspection apparatus as claimed in any one of claims 1 to 3 wherein the reel is encased in
moulded plastic housing.

5. Video inspection apparatus as claimed in any one of claims 1 to 4 wherein the electric battery is detachably mounted in the apparatus.

6. Video inspection apparatus as claimed in any one of the preceding claims wherein the electronic battery is a rechargeable battery and the apparatus has connecting means to allow the rechargeable battery to be connected to an external power supply to be recharged.

7. Video inspection apparatus as claimed in any one of the preceding claims wherein the apparatus has a cable retracting mechanism comprising a ratchet means and a spring means whereby whilst the cable is manually drawn from the reel thereof then potential energy is stored in the spring means which potential energy is subsequently used by the spring means to wind the cable back into the reel thereof, the ratchet means acting to prevent retraction of unwound cable until the ratchet means is released by the operator.

8. Video inspection apparatus as claimed in any one of the preceding claims wherein the cable comprises a fibreglass core over which a plastic jacket is extruded.

9. Video inspection apparatus is claimed in any of the preceding claims wherein the camera means comprises: a CMOS sensor encased in a first housing; a connector encased in a second housing for connecting the camera means to the cable; and a helical spring joining the first and second housings.

10. Video inspection apparatus as claimed in any of
the preceding claims wherein the camera means comprises illumination means for illuminating the interior of the inspected pipeline, the illumination means being supplied with power by a wire running through the cable connecting the illumination means to the electric battery.

11. Video inspection apparatus as claimed in any of the preceding claims wherein the drum means is mounted to be rotatable about a spindle of the support which in use of the apparatus extends generally horizontally.

12. A method of inspecting an interior of a pipeline using video apparatus as claimed in any of the preceding claims, the method comprising the steps of:

   a human operator manually transporting the video inspection apparatus to an inspection site;
   the human operator inserting the camera means into the pipeline to be inspected and then unwinding from the reel thereof the cable attached to the camera means to push the camera means along the pipeline; and
   the human operator viewing on the video display means an image of the interior of the inspected pipeline as recorded by the camera means whilst the camera means is advanced down the pipeline.

13. Video inspection apparatus for inspecting a pipeline comprising:

   a first cable windable in a first reel; 
a second cable windable in a second reel; 
a drum means on which the first and second reels are windable, the drum means being rotatably mounted on a support;

   first camera means connected at one end of the first cable;
   second camera means connected at one end of the
second cable;
an electric battery mounted in the support and
connectable with the first and second camera means via
wires running through the first and second cables; and
flat screen display means mounted on the support
and connectable with the first and second camera means
via wires running through the first and second cables;
wherein
the first and second cables can each be manually
unwound respectively from the first and second reels
thereof in order to advance the first or the second
camera means along the inspected pipeline;
the first and second cables are connectable to
the flat screen display means so that images recorded
by the first or second camera means can be relayed to
the flat screen display means for display thereby;
the first and second cables are connectable to
the electric battery so that electrical power can be
relayed to the first and second camera means; and
the drum means, the first and second cables, the
first and second camera means, the support, the
electric battery and the flat screen display means
together form a self-contained unit which can be
carried by a single human operator to an inspection
site and used there without connection to any
ancillary apparatus.

14. Video inspection apparatus as claimed in claim 13
wherein the flat screen display means comprises a
liquid crystal display screen.

15. Video inspection apparatus as claimed in claim 13
or claim 14 comprising a carrying handle.

16. Video inspection apparatus as claimed in any of
claims 13 to 15 wherein the first camera means is of a
first size and is suitable for use in pipelines of a
first range of cross-sectional areas and the second camera means is of a second smaller size and is suitable for use in pipelines of a second range of smaller cross-sectional areas.

17. Video inspection apparatus as claimed in any of claims 13 to 16 wherein the first and second camera means are each generally cylindrical in overall shape and configuration and the first camera means has an external diameter larger than the external diameter of the second camera means.

18. Video inspection apparatus as claimed in any one of claims 13 to 17 wherein the cable attached to one of the camera means is of a first stiffness and the cable attached to the other camera means is of a second greater stiffness.

19. Video inspection apparatus as claimed in any one of claims 13 to 18 wherein the cable attached to one of the camera means is of a first length and the cable attached to the other camera means is of a second longer length.

20. Video inspection apparatus as claimed in claim 15 wherein the flat screen display means has a single screen and switching means enables an operator to selectively connect the flat screen display means either to the first camera means to display on the screen images recorded by the first camera means or to the second camera means to display on the screen images recorded by the second camera means.

21. Video inspection apparatus as claimed in any one of claims 13 to 20 wherein switching means is provided to enable the operator to selectively connect the electric battery to either the first camera means or
the second camera means and thereby select which camera means is operational.

22. Video inspection apparatus as claimed in any one of claims 13 to 21 wherein the electric battery is detachably mounted on the support.

23. Video inspection apparatus as claimed in any one of claims 13 to 22 wherein the electric battery is a rechargeable battery and the apparatus has connecting means to allow the rechargeable battery to be connected to an external power supply to be recharged.

24. Video inspection apparatus as claimed in any of claims 13 to 22 wherein each cable has associated therewith a cable retraction mechanism comprising a ratchet means and a spring means and when each cable is manually drawn from the relevant reel thereof then potential energy is stored in the spring means, which potential energy is subsequently used by the spring means to wind the cable back into the reel thereof, the ratchet means acting to prevent retraction of each cable until the ratchet means is released by the operator.

25. Video inspection apparatus as claimed in any one of claims 13 to 24 wherein each cable comprises a fibreglass core over which a plastic jacket is extruded.

26. Video inspection apparatus as claimed in any one of the claims 13 to 25 wherein each camera means comprises: a CMOS sensor encased in a first housing; a connector for connecting the camera means to the cable; and a helical spring joining the first and second housings.
27. Video inspection apparatus as claimed in any one of the claims 13 to 26 wherein each camera means comprises illumination means for illuminating the interior of the inspected pipeline.

28. Video inspection apparatus as claimed in any of the claims 13 to 27 wherein the first and second reels are co-axially mounted on the drum means to be rotatable about a spindle of the support, the first reel being larger in diameter than the second reel and the first reel being mounted surrounding the second reel.

29. Video inspection apparatus as claimed in claim 28 wherein the spindle in use extends generally horizontally.

30. A method of inspecting an interior of a pipeline using video inspection apparatus as claimed in any one of claims 13 to 29, the method of comprising the steps of:

- a human operator manually transporting the inspection apparatus to an inspection site;
- the human operator selecting between the first and second camera means;
- the human operator inserting the selected camera means into the pipeline to be inspected and then unwinding the cable attached to the selected camera means from the relevant reel and using the unwound cable to push the selected camera means along the pipeline; and
- the human operator viewing on the flat screen display means an image of the interior of the inspected pipeline as recorded by the selected camera means whilst which the selected camera means is advanced down the pipeline.