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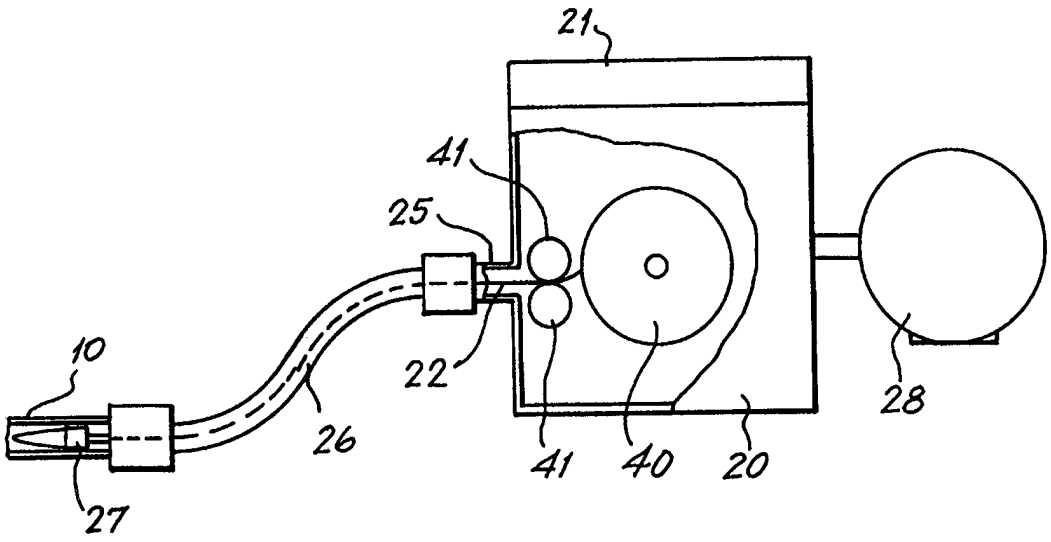

(57) Abstract

There is disclosed pipes, particularly narrow bore pipes such as domestic water supply pipes are rehabilitated by lining with a tube of film material blown through the pipe and expanded into contact with the pipe wall. The tube may be in lay flat form for passing through the pipe.

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LINING PIPES

This invention relates to lining pipes, especially, but by no means essentially, to lining underground small bore pipes such as domestic water and gas supply pipes.

There is an interest in lining such pipes for a number of reasons. In the case of domestic water pipes which are, in many cases, of considerable age and made of lead, there are problems of lead pollution of the domestic drinking water, quite aside from the problem of leakage from broken pipes, which constitutes a substantial fraction of water usage as well as permitting contamination of drinking water. Gas pipes, too, are not necessarily gas tight, obvious dangers arising therefrom not to mention further waste of natural resources.

There has consequently been considerable interest in replacing or rehabilitating existing pipes, particularly lead pipes. However, no single technique appears to have been economically and technically viable for both long and short lengths of pipe. One traditional approach is to remove and replace the pipe with, for example, a high density polyethylene (HDPE) pipe using the cut and cover method. This is expensive and disruptive to traffic. "No-dig" techniques have been developed in which the pipe is pulled out from an excavation with an attached replacement pipe being pulled through from a remote excavation. This is difficult if not impossible where there are bends in the pipe. Often, it is more convenient to resort to laying a new pipe by the side of the old one using "moling" or directional drilling, which, however, requires the use of expensive heavy equipment which can cause a great deal of disruption above ground.

Some trenchless methods are subject to inaccuracies in placement of the pipe and it is difficult to change direction or manoeuvre around obstacles.

In recent years, due to the problems described above and in an attempt to use the existing asset, relining techniques have been developed.

One such technique, designed for lead piping, involves lining the pipe with a specially developed polyethylene terephthalate (PET) liner. This is a multi-step operation involving cleaning the pipe using a rotating cable and brush and blowing through the resulting debris, inserting the liner in the form of a thick walled tube, having a diameter less than the internal diameter of the pipe, heating the pipe using circulating hot water to soften it and increasing the pressure to expand it to fit closely to the pipe and blowing the hot water out with compressed air and cooling the pipe. This is a complicated procedure, but has the advantage that quite long lengths of pipe can be rehabilitated with little disruption.

Pipes are also relined with epoxy resin by a number of techniques. In one method, for pipes of diameter no smaller than 7.6 cm, a spray head is pulled through the pipe. In another, a reservoir of epoxy resin is blown through the pipe by compressed air. Epoxy resin has been applied to gas pipes using a lining pig which is also forced through the pipe by compressed air. A major drawback is the long curing time required - up to sixteen hours - which adds considerably to the down-time.

Another technique is to blow a flexible tubular liner through the pipe. WO 97/04269 describes an eversion technique for doing this. Access need be had, using such a technique, only to the ends of the pipe to be lined.

The present invention provides methods and apparatus for lining pipes that avoid the major disadvantages of most of the prior art techniques, for pipe rehabilitation, and which are simpler and more straightforward to use than more recently devised liming methods.

The invention comprises, in one aspect, a method for lining a pipe having a given internal diameter, comprising the steps of drawing a tube of film material, having clearance from the wall of the pipe, through the pipe whilst passing a flow of fluid through the pipe such as to maintain separation between the tube and the wall of the pipe whereby to lubricate the passage of the tube through the pipe, and expanding the tube against the wall of the pipe.

The tube may be a lay flat tube having gussets whereby its width in lay flat format is less than the internal diameter of the pipe and its opened out diameter is substantially equal to the internal diameter of the pipe.

There is in general no very great difficulty in lining short, wide, straight pipes, in good condition, provided there is easy access at at least one end, preferably both. The problems arise in practice in rehabilitating lead water pipes, say - where access has to be gained by digging, which may not be possible or easy, and where the pipes are narrow bore, e.g. ½ inch (1.27 cm), long, bent, cracked, and even broken. The air-assisted lining technique of the present invention facilitates lining pipes even with these difficulties and are so reliable in operation and trouble-free that they can form the basis of a comprehensive pipe rehabilitation programme.

The tube may be attached to a pig driven through the pipe by driving fluid pressure, the fluid serving also as the lubricant fluid.

The pig may be bullet-shaped having a tapered nose and being open at the rear to form a fluid cavity. The pig may be flexible, and may be fashioned as an envelope of flexible material (such as plastic film material) which is inflated by driving fluid pressure. The pig may have a rigid annular member at the rear forming a fluid inlet. The annular member may form an attachment for the tube.

The pig may, in another embodiment, be fashioned as a moulded hollow cylinder with an open, rear, end and a closed, tapered, leading end. The pig may have an axial rod running from nose to rear and forming an attachment for the tube.

The tube may be drawn through the pipe by an attachment on the tube comprising a loop of strand material (such as nylon monofilament) passed through a punched aperture in the tube, which may be fitted with an eyelet to prevent the strand material cutting through the film material.

The tube may be close-coupled to the pig, as when the pig itself is blown through the pipe by fluid pressure.

The tube may, however, be hauled through the pipe by a hauling line passed completely through the pipe before the tube is introduced into the pipe - the pig may, of course, be used to carry the hauling line through the pipe.

The fluid flow through the pipe will normally, of course, be an air flow, the air being typically derived from a source at 50-100 psi (345 - 690 KPa).

The invention also comprises apparatus for lining a pipe having a given internal diameter comprising

- a tube of film material having clearance from the wall of the pipe
- means for drawing said tube through the pipe
- fluid flow means adapted to pass a flow of fluid through the pipe such as to maintain separation between the tube and the inner wall

of the pipe whereby to lubricate the passage of the tube through the pipe, and

- means to expand the tube against the wall of the pipe.

The invention also comprises a method for securing an end of a tube of film material in a pipe lined by said tube, in which an annular tapered insert is placed at said end of the pipe within the lining tube and forced home into the end of the pipe, the insert having an endwise flange between which and the end of the pipe a quantity of the film material is desirably compressed, though it is usually sufficient to compress the liner against the inner wall of the pipe.

While the annular tapered insert is forced home, the film material of the tube in the end region of the pipe may be held against wrinkling by a temporary insert within and extending into the pipe beyond the tapered insert. The pipe may have a bleed hole in its end region to bleed air trapped between the pipe and the tube when the tube is expanded in the pipe.

This method of securing may be carried out in an extended end of the pipe, as in a plastic extension tube attached as by a standard fitting to the end of the pipe.

This method is useful for securing the lining tube at the end of the pipe from which it emerges in a lining process according to the invention as described above. At the insertion end, the tube may be secured by an annular tapered insert placed at said end of the pipe within the lining tube to wedge the film in the pipe, the insert being carried on an end of a plunger tool which has an axially slidable sleeve on which excess tube material extending out of the pipe may be gripped to be held taut thereon while the plunger tool forces the insert into the end of the pipe.

At one end of the pipe, usually, will be the so-called boundary box forming a junction between the incoming street main-to-premises pipe and the premises own piping. The boundary box usually houses a non-return valve and, in any event, a standard pipe connector, atop a wide bore connection pipe which enters at the side and bends upwardly, being connected, at its side entrance location, to the incoming water pipe.

The boundary box, however, is usually underground at the level of the incoming water pipe and has restricted access. A problem with this is that the wide bore connector pipe connection to the incoming water pipe cannot be accessed without digging, because it is external to the box. The tubular lining cannot, therefore, be terminated at that connection and must be brought up through the connector pipe to terminate at its top connection to the non-return valve or other connections. It is, however, bad practice to leave the lining externally unsupported and indeed to have any air entrapment behind the lining.

The present invention provides a procedure for solving this problem.

The invention comprises a procedure for use in the rehabilitation of water pipes by lining them with a flexible tubular material which is introduced at one end of an open-ended length of the pipe and blown through to the other end of said length, for negotiating a boundary box with restricted access, the boundary box having a cover removable to access valving and a wide bore connector pipe connected at one, horizontal, end to the end of the incoming water narrow bore pipe and bending to an upwardly directed section, the procedure comprising inserting a narrow bore, reducer pipe into the wide bore connector pipe up to the end of the incoming pipe and terminating flush with the top of the connector pipe, and blowing the lining through the reducer pipe and the incoming water pipe.

The reducer pipe is in practice necessary only when connecting to ½ inch (1.27 cm) water pipe - it is not required for ¾ inch pipe (1.91 cm) if the wide bore pipe is, as usual, 20 mm internal diameter.

The reducer pipe, which has an internal diameter suitable for receiving the lining material, approximately the same as the internal diameter of the incoming water pipe, may have its incoming-pipe-contacting end chamfered before insertion.

Since access is problematical, the reducer pipe is desirably cut to length before insertion. This is problematical, however, as the required length is not necessarily known. It can be determined by inserting a measuring member, but observation of the top of the connector pipe is also difficult. This problem is solved, according to an aspect of the invention, by using as a measuring member a graduated length of reducer piping and inserting it through a feed pipe attached to the top of the connector pipe and extending upwardly to a working level. The graduations mark off distance from the leading end of the piping, which is abutted against the end of the incoming pipe for the measurement, and can conveniently be zeroed at the top of the feed pipe when the abutting end of the piping is flush with the lower end of the feed pipe.

When the measuring member is withdrawn the cut-to-length reducer pipe may now be inserted through the feed pipe and pushed by a plunger in the feed pipe until it abuts against the end of the incoming pipe. Its cut end is now flush with the top of the connector pipe.

The plunger may itself be tubular, with a wall thickness sufficient, of course, to engage the reducer pipe, and the lining material may then be introduced through the plunger, to be blown through the reducer pipe and thence through the incoming water pipe, the mains end of which will have been exposed for this purpose.

The blowing operation may be effected by eversion as described in WO 97/04269 or, as in the proposal herein, by attaching or forming a pig at the lead end of the tubular lining material, configured as a layflat tube of appropriate dimensions with lengthwise gusseting to make its width, in layflat condition, less than the internal diameter of the incoming and reducer pipes. Everted lining may already be opened out and in contact with the inner wall of the incoming pipe and the reducer pipe, pig-led pipe will need to be opened out either by air pressure or by water pressure.

In any event, the lining material needs to be secured to the top end of the reducer pipe and if, for this, it needs to be opened out, this can be effected mechanically.

The lining material may be gripped against the end of the reducer pipe flush with the top of the connector pipe by a gripper insert, which can be introduced into a surplus length of lining material left projecting from the reducer pipe. The gripper insert can be a hollow taper wedge which can be fitted on an insert holder on an insertion rod, and pushed through the surplus length thereby, opening up the lining material if still in the form of layflat tube. When the taper wedge encounters the upper end of the reducer pipe, it is pushed in until it firmly secures the lining. The insert holder can now be removed.

According to a further aspect of the invention, the insert holder can have one further function. By providing on the distal end, i.e. the end of the holder inserted into the gripper insert, a spring-out blade, the lining material can be cut off flush with the top of the gripper insert - the blade springs out as soon as it is clear of the gripper insert rod can now simply be rotated to cut all around the tubular lining. The cut-off surplus is withdrawn with the insert holder.

The feed pipe can then be removed, and the non-return valve and/or other fittings reattached and the boundary box closed off again.

The invention also comprises apparatus for use in the rehabilitation of water pipes by lining them with a flexible liner, comprising insertion means for a narrow bore reducer pipe into a wide bore boundary box connector pipe comprising a feed tube attachable to the top of the connector pipe and a plunger adapted to push a length of reducer pipe through the connector pipe to abut the incoming water pipe attached at the other end thereof.

The apparatus may comprise further a measuring member adapted to be inserted through the feed tube to measure the required length of reducer pipe. The measuring member may comprise a graduated length of reducer piping, which may be graduated with a zero at one end of the feed tube when the other end is at the other end of the feed tube and of which the graduations extend outwardly from said zero, so that the graduations indicate, as they level with the said one end of the feed tube, the extent to which the other end of the measuring member extends beyond the other end of the feed tube.

The apparatus may further comprise a gripper insert adapted to be placed in gripping position gripping the lining material against the inner wall of the reducer pipe. The apparatus may further comprise a gripper insert holder adapted to engage a throughway of the gripper insert to hold same and insert it in the gripping position, and then be retracted from the insert leaving the latter in place. Said insert holder may have a blade adapted to be held inside the confines of the gripper insert throughway and blade spring means adapted on withdrawal of the insert holder from the insert to spring the blade out into cutting relation with the lining material.

Methods of and embodiments of apparatus for lining pipes according to the present invention, as well as boundary box arrangements useful therefor in the rehabilitation of water pipes, will now be described with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of a domestic water supply pipe such as might be rehabilitated by a lining method of the invention;

Figure 2 is a diagrammatic illustration of a lining apparatus;

Figure 3 is a side view of one embodiment of pig for use in the method according to the invention; the pig being inflatable, shown inflated;

Figure 4 is a view like Figure 3 of the pig, deflated;

Figure 5 is a view on arrow 5 of Figure 3;

Figure 6 is a lengthwise section through another embodiment of pig according to the invention;

Figure 7 is an end view of a section of gusseted lay flat tube as used in the method;

Figure 8 shows an attachment of the tube of Figure 7 to a pig;

Figure 9 is an end view of the tube of Figure 7 having been inserted in a pipe, and showing the tube being expanded;

Figure 10 is a cross-section through an end-of-pipe arrangement for securing a lining tube in a pipe;

Figure 11 is a cross-section through another end-of-pipe securing arrangement;

Figure 12 is a diagrammatic section through a boundary box;

Figure 13 is a section like Figure 12, showing a first step of a first procedure at the boundary box of Figure 12;

Figure 14 is a section like Figure 12, showing a second step;

Figure 15 is a section like Figure 12, showing a third step;

Figure 16 is a section like Figure 12, showing a fourth step;

Figure 17 is a section like Figure 12, showing a fifth step;

Figure 18 is a section of a detail of Figure 12, to a larger scale, showing a sixth step;

Figure 19 is a section of a detail from Figure 18, to a larger scale, showing a seventh step; and

Figure 20 is an axial view of the end of the insert holder with a sprung blade.

Figure 1 illustrates a domestic water supply pipe 10 extending from a stop-cock 11 at a bounday box, not shown in Figure 1 but referred to in detail below, adjacent an underground street main 12, to a stop-cock 13 within the premises 14. The pipe 10 is typically of lead having a bore of ½ inch (1.27 cm) diameter.

Such pipes 10, even if not worn or damaged (leading to wasteful leakage of water), need to be rehabilitated to avoid lead contamination, proved to be a health hazard.

The drawings illustrate no-dig methods for rehabilitating such pipes which methods have been shown to be reliable and efficient in operation and simple and straightforward to carry out so as to form the basis of a major rehabilitation programme which incidentally is an inexpensive way of plugging leaks without having first to pinpoint the leaks.

Figure 2 illustrates plant for use in the method comprising a pressure vessel 20 with an associated compressor 28, the vessel having a support for a spool 40 of lay flat film tube 22. A length of flexible pressure tubing 26 connects an outlet port 25 to the exposed end of the pipe 10 to be lined, the connections of the tubing 26 to the vessel 20 and pipe 10 being by standard pressure fillings. Access to the vessel 20 is **via** a hatch 21, which can be sealed against the internal pressure of 50-100 psi (345-690 KPa) effected by the compressor 28. Within the vessel 20 is a device that stops the spool 40 overspinning. A clear acrylic tube may project from the vessel 20 to be connected to the tubing 26 to permit visual inspection of the flow state of the tube 22 - if it stops, an operator may increase driving pressure. A tilting mechanism may be provided for the vessel 20. This arrangement is in principle generally similar, though with the refinements mentioned, to the arrangement described in WO 97/04269, which, however, is described there in a form intended for pipe lining by eversion of a tube through the pipe.

According to this present invention, however, the tube is not everted, but is sent through the pipe 10 in lay flat format.

The method, as illustrated, comprises the steps of drawing the tube 22 of film material, via guide rollers 41 from the roll 40, through the pipe 10.

As seen in Figure 7, the lay flat tube 22 is gusseted at 23, 26, whereby its width W in lay flat format is less than the internal diameter D of the pipe 10. While the tube 22 is being drawn through the pipe 10, a flow of fluid - here, air from the pressure vessel 20 - is also passed through the pipe 10 such as to maintain separation between the tube 22 and the wall of the pipe 10 whereby to lubricate the passage of the tube 22 through the pipe 20. A safety tube can also be located at the exit end of the lead pipe 20 during the lining operation. Made of perspex, for example, and having a number of small holes in its wall, it relieves the pressure when the pig reaches it, quickly decelerating the pig, which can be seen clearly through the tube to indicate termination of the blowing operation.

Once through the pipe 10 and secured as hereinafter explained the tube 22 is expanded against the wall of the pipe 10.

Domestic water supply pipes are found in a small number of standard or quasi-standard sizes (by which is meant that although no official standard may have been set, by custom and practice certain sizes are sufficiently prevalent as to appear to be standard). It is a straightforward matter, therefore, to procure a supply of appropriately sized lining tube. The tube 22 when expanded should fit against the wall of the pipe 10, it being better to err slightly on the large side rather than it be too small, although undersized tube 22 may, if of an appropriate material, be widened plastically if heated above a certain temperature as by a hot water or hot air flow under pressure to create a hoop stress in the tube 22.

Pressure internally of the tube 22 is in any event the means by which the tube is expanded from its lay flat format into contact with the walls of the pipe 10,

pressure from the pressure vessel 20 serving for this purpose as reconnection to blow internally of the tube 22 instead of externally over the tube 22 as used for insertion of the tube 22 through the pipe 10.

For drawing the tube 22 through the pipe 10 a pig 27A may be used as illustrated in Figures 3 to 5 or a pig 27B as illustrated in Figure 6.

The pig 27A is bullet-shaped having a tapered nose 28 and being open at the rear 20 to form a fluid cavity 30. The pig is flexible, being made of a plastic film material, fashioned as an envelope which is inflated by driving fluid pressure. It has a rigid annular member 31 at the rear, forming a fluid inlet, which has an open cup end 31 to collect and funnel the fluid flow. Typically, the pig is some 90-100 mm long. It needs to be of such length in order to prevent it from tumbling during its passage through a pipe, but not so long as will lead to snagging through folding. The maximum cross sectional dimension of the pig 27A when inflated is about 12-14 mm, and is thus adapted to negotiate ½ inch (1.27 cm) pipe. For ¾ inch (1.91 cm) pipe, the pig cross-section can be 19.5-22 mm. Naturally, passage through the pipe squeezes the pig down to the internal diameter of the pipe.

Figure 6 shows a moulded plastics material pig 27B with, again, a tapered nose 28 and being open to the rear 29 to form a fluid cavity 30. The cavity walls are thin and flexible, this enabling the device to navigate bends and irregularities in the host pipe 10. An axial rod 33 runs from nose to rear and has a hole 34 for a hauling line.

Figure 8 shows how the tube 22 is attached to the pig 27A, 27B. The tube 22 is punched through near its end and an eyelet 35 inserted and crimped in. A loop of strand material such as monofilament nylon (e.g. fishing line) is attached to the pig 27A, 27B, a looped end pushed through the eyelet 35 and the pig 27A, 27B is then pushed through the loop.

In this configuration, the tube 22 is close-coupled to the pig 27A, 27B and it is the pig, driven by the airflow through the pipe 10, which also serves to lubricate the passage of the tube 22 through the pipe 10, pulls the tube 22 along behind it.

The pig 27A, 27B could, however, be used to pull a hauling line through the pipe 10. When through, the tube 22 could be attached to the hauling line and pulled through, again with the assistance of the lubricating airflow.

The flexibility of the pigs 27A, 27B, and the general designs thereof allow it to negotiate bends - which may in practice be quite sharp - in the pipe 10. The airflow plays a significant role not only in forcing the pigs through the pipe 10 but also in lubricating their passage, whether they are pulling the close-coupled tube 22 or a hauling line which then pulls the tube 22.

After insertion of the tube 22 through the pipe 10, the ends of the tube need to be secured. Figures 10 and 11 show arrangements respectively at the exit and input ends of the pipe 10.

As illustrated in Figure 10, an annual tapered insert 101 is placed at the end of the pipe 10 within the lining tube 22 and forced home into the end of the pipe 10, the insert 101 having an endwise flange 102 between which and the end face of the pipe 10 a quantity of tube 22 material is compressed. In order to hold the tube 22 in the end region of the pipe 10 in position and against wrinkling and being forced back into the tube while the insert is forced home, a temporary insert 103 is used - this insert 103 is provided with a head which is used to force the insert 101 home.

As illustrated, the insert 101 is not in fact placed in the end of the pipe 10 proper, rather in a plastic extension thereof 104 which is attached to the pipe 10 by a standard fitting 105 and which is then attached to the next section of pipe also by a

standard fitting which locks the insert 101 in place. The extension 104 has a bleed hole 106 to allow any air trapped between the tube 22 and the wall of the pipe 20 to escape.

Figure 11 shows the securing arrangement at the insertion end of pipe 10. A length 111 of tube 22 is left projecting out of the pipe 10 and an annular tapered insert 102, without an endwise flange, is inserted within the tube 22 in the end of the pipe 10 by means of a plunger tool 103. The tool has an axially slidable sleeve 104 on which the excess tube material is gripped to be held taut thereon while the plunger tool 103 forces the insert 102 into the end of the tube 10 to wedge the tube 22 firmly in place.

A washer 105 is then placed over the end of the pipe 10, flush with the end of the insert 102, and held in place by a standard fitting.

This latter procedure may, however, be modified as described below when the pipe 10 is accessed via a boundary box.

Boundary boxes come in a number of different configurations but all have a removable cover 113a to access valving 113c, usually a non-return valve, and a connection to piping to the domestic, commercial or industrial premises served by the boundary box, and a wide bore connector pipe 113b connected by a standard fitting 14 to the end 10a of the narrow bore water pipe 10.

Water pipes, as has been remarked, come in standard sizes - in Great Britain 0.5 inch internal diameter (1.27 cm), is for example, commonly encountered. It is desirable when lining pipes with flexible tubular liner, that the liner is a good fit in the pipe, otherwise water pressure can burst the liner, if it is undersize, or it will crease and fold, with risk of occlusion, if it is oversize. The connector pipe 113b of a typical boundary box is larger, usually at 1 inch (25.4 mm), than the incoming water pipe, and

it would be desirable to terminate the lining process at the junction of the incoming water pipe and connector pipe. Access difficulties preclude this with the boundary box *in situ.*

According to the invention, this problem is solved by inserting a narrow bore - the same nominal size as the incoming water pipe 10 - reducer pipe 115 into the connector pipe 113b, up to the end 110a of the incoming pipe 10 and terminating flush with the top 116 of the connector pipe 113b. The lining 22 can then be blown through the reducer pipe 115 and the incoming water pipe 10, the remote end of which, where it joins the street main, also being accessed for this operation.

The problem of inserting the reducer pipe is itself not trivial. The drawings show in sequence various steps in the procedure.

A typical boundary box 113 is shown in Figure 12 as it is encountered at the beginning of the procedure. Figure 13 shows the cover 113a removed, and a non-return valve 113c - with associated box-to-premises connection - removed to access the top 116 of the connector pipe 113b.

Figure 14 shows a feed pipe 117 attached, using the same standard pipe fitting as the non-return valve 113c, to the top 116 of the connector pipe 113b. The top 117a of the feed pipe 117 is connected to a pressure air hose 118 and air blown through to clear away any debris and loose contaminant in the pipes.

Figure 15 shows the introduction of a measuring member 119 into the feed pipe 117. The measuring member is flexible tubing, similar to what will later be used for the reducer pipe and is sufficiently long to be pushed down into contact with the end 10a of the incoming water pipe 10 yet still project out of the feed pipe 117. The measuring member is graduated, zero being at the top of the feed pipe 117 when the other end of the member 119 is flush with the lower end of the feed pipe 117.

When the measuring member is pushed in so far as to contact the end 10a of the pipe 10, the graduation level with the top end 117a of the feed tube 117 is a measure of the required length of reducer pipe.

Such a length is now cut to form the reducer pipe 115, and the leading end 115a chamfered and inserted into the feed pipe 117. A plunger 122 is inserted into the feed pipe 117 to push the cut length of reducer pipe 115 through the connector pipe 113b and into contact with the incoming water pipe 10 (Figure 16). The upper end of the reducer pipe 115 is now flush with the top 116 of the connector pipe 113b. The plunger 122 is hollow and has an upper fitting 123 for attaching a hose 24 from a blower (not shown) to blow the liner 22 through the plunger 122, the reducer pipe 115 and the incoming water pipe 10 (Figure 17).

As mentioned above, the blowing operation can be an eversion technique as described in WO 97/04269 or a technique in which a gusseted layflat tube is drawn through the pipe using a pig - this same boundary box procedure will serve for both types of operation.

Once the liner 22 is all the way through and secured at the street end of the pipe 10, the pressure is released and the hose 24 removed, and the liner 22 cut, leaving a short length above the feed pipe 117. It is now required to secure the liner 22 in the reducer pipe 115. This is done (Figure 18) by inserting a wedge-shaped gripper insert 126. This is first placed on an insert holder 127 on the end of an insertion rod 128 and pushed down the lining tube 22, the cut end of which was left projecting out of the plunger 122. The cut end is, of course, held tight as the insertion rod pushes the gripper insert down the plunger 122, opening up the film (if required) as it moves down the plunger, until it reaches the top of the reducer pipe 115, when, with a little pressure on the insertion rod, it becomes fast in the pipe 115 securely gripping the liner 22

thereagainst. An axially slidable sleeve like sleeve 104 in Figure 11 can be provided on the insertion rod.

Figure 20 is an end-on-view of the end 127a of the insert holder 127. It has a pivoted blade 127b which is loaded by a spring 127c so that its cutting edge projects - broken line - beyond the edge of the holder 127, but can be pivoted so that the entire blade 127b lies within the compass of the holder, solid line, and it is thus so disposed when the gripper insert 126 is fitted on to the insert holder 127 preparatory for the insertion step described above.

Once the insert 126 has been rammed home in the reducer pipe 115, the holder is carefully eased out of the insert. Once the blade 127b is free of the insert 126, it springs out against the liner 22 - still held taut from above - and the insert holder can now be rotated by the insertion rod 128 to cut off the liner just above the gripper insert 126 - see Figure 19.

The insertion rod 128, gripper insert holder 127 and plunger 122 can now be removed from the feed tube 117, and the latter removed from the connector pipe 113b, the valving refitted and boundary box cover 113a replaced.

Depending on the lining technique used, however, it may be necessary to inflate the liner 22 either by air pressure or by water pressure at some stage, and this may involve bleeding out air trapped between the liner and the inner wall of the pipe 104 and the reducer pipe 115.

The tube 22 may be of any suitable plastics material and may comprise multi-layer or multi-component such material. An outer layer thereof may, for example, comprise an adhesive, activatable under heat, in order to adhere to the pipe wall. The

inner surface can be a choice of material adapted to be inert to the fluid flowing through the pipe, which may be of importance in the relining of oil or gas pipes.

CLAIMS

1. A method for lining a pipe having a given internal diameter, comprising the steps of drawing a tube of film material, having clearance from the wall of the pipe, through the pipe whilst passing a flow of fluid through the pipe such as to maintain separation between the tube and the wall of the pipe whereby to lubricate the passage of the tube through the pipe, and expanding the tube against the wall of the pipe.

2. A method according to claim 1, in which the tube is a lay flat tube having gussets whereby its width in lay flat format is less than the internal diameter of the pipe and its opened out diameter is substantially equal to the internal diameter of the pipe.

3. A method according to claim 1 or claim 2, in which the tube is attached to a pig drawn through the pipe by driving fluid pressure.

4. A method according to claim 3, in which the pig is bullet-shaped having a tapered nose and being open at the rear to form a fluid cavity.

5. A method according to claim 4, in which the pig is flexible.

6. A method according to claim 5, in which the pig is fashioned as an envelope of flexible material which is inflated by driving fluid pressure.

7. A method according to claim 6, in which the pig has a rigid annular member at the rear forming a fluid inlet.

8. A method according to claim 7, in which the annual member forms an attachment for the tube.

9. A method according to claim 4, in which the pig is fashioned as a moulded hollow cylinder with an open, rear, end and a closed, tapered leading, end.

10. A method according to claim 9, in which the pig has an axial rod running from nose to rear and forming an attachment for the tube.

11. A method according to any one of claims 1 to 10, in which the tube is drawn through the pipe by an attachment on the tube comprising a loop of strand material passed through a punched aperture in the tube.

12. A method according to claim 11, in which the punched aperture is fitted with an eyelet.

13. A method according to any one of claims 3 to 10, in which the tube is close-coupled to the pig.

14. A method according to any one of claims 1 to 12, in which the tube is hauled through the pipe by a hauling line passed completely through the pipe before the tube is introduced into the pipe.

15. A method according to any one of claims 1 to 15, in which the fluid flow through the pipe is an air flow.

16. A method according to claim 15, in which the air is derived from a source at 50-100 psi (345-690 KPa).

17. A method according to any one of claims 1 to 16, applied to the rehabilitation of lead water pipes.

18. Apparatus for lining a pipe having a given internal diameter comprising

- a tube of film material having clearance from the wall of the pipe
- means for drawing said tube through the pipe
- fluid flow means adapted to pass a flow of fluid through the pipe such as to maintain separation between the tube and the inner wall of the pipe whereby to lubricate the passage of the tube through the pipe, and
- means to expand the tube against the wall of the pipe.

19. Apparatus according to claim 18, in which the tube is a lay flat tube having gussets whereby its width in lay flat format is less than the internal diameter of the pipe and its opened out diameter is substantially equal to the internal diameter of the pipe.

20. Apparatus according to claim 18 or claim 19, in which the pig is bullet-shaped, having a tapered nose and being open at the rear to form a fluid cavity.

21. Apparatus according to claim 20, in which the pig is flexible.

22. Apparatus according to claim 21, in which the pig is fashioned as an envelope of flexible material which is inflated by driving fluid pressure.

23. Apparatus according to claim 22, in which the pig has a rigid annular member at the rear forming a fluid inlet.

24. Apparatus according to claim 23, in which the annual member forms an attachment for the tube.

25. Apparatus according to claim 20, in which the pig is fashioned as a moulded hollow cylinder with an open rear end and a closed, tapered leading end.

26. Apparatus according to claim 25, in which the pig has an axial rod running from nose to rear and forming an attachment for the tube.

27. A method for securing an end of a tube of film material in a pipe lined by said tube, in which an annular tapered insert is placed at said end of the pipe within the lining tube and forced home into the end of the pipe, the insert having an endwise flange between which and the end of the pipe a quantity of the film material is compressed.

28. A method according to claim 27, in which, while the annular tapered insert is forced home, the film material of the tube in the end region of the pipe is held against wrinkling by a temporary insert within and extending into the pipe beyond the tapered insert.

29. A method according to claim 27 or claim 28, in which the pipe has a bleed hold in its end region to bleed air trapped between the pipe and the tube when the tube is expanded.

30. A method according to any one of claims 27 to 29, carried out in an extended end of the pipe.

31. A method for securing an end of a tube of film material in a pipe lined by said tube, in which an annular tapered insert is placed at said end of the pipe within the lining tube to wedge the film into the pipe, the insert being carried on an end of a plunger

tool which has an axially slidable sleeve on which excess tube material extending out of the pipe is gripped to be held taut thereon while the plunger tool forces the insert in to the end of the pipe

32. A procedure for use in the rehabilitation of water pipes by lining them with a flexible tubular material which is introduced at one end of an open-ended length of the pipe and blown through to the other end of said length, for negotiating a boundary box with restricted access, the boundary box having a cover removable to access valving and a wide bore connector pipe connected at one, horizontal, end to the end of the incoming water narrow bore pipe and bending to an upwardly directed section, the procedure comprising inserting a narrow bore, reducer pipe into the wide bore connector pipe up to the end of the incoming pipe and terminating flush with the top of the connector pipe, and blowing the lining through the reducer pipe and the incoming water pipe.

33. A procedure according to claim 32, in which the reducer pipe has its incoming pipe-contacting end chamfered before insertion.

34. A procedure according to claim 33, in which the reducer pipe is cut to length before insertion.

35. A procedure according to claim 34, in which the cut length is determined by first inserting a measuring member.

36. A procedure according to claim 35, in which the measuring member is a graduated length of reducer piping.

37. A procedure according to claim 35 or claim 36, in which the measuring member is inserted through a feed pipe attached to the top of the connector pipe and extending upwardly to a working level.

38. A procedure according to claim 37, in which the cut length of reducer pipe is inserted through the feed pipe and pushed by a plunger in the feed pipe until it abuts against the end of the incoming pipe.

39. A procedure according to claim 38, in which the lining material is introduced through the plunger.

40. A procedure according to any one of claims 32 to 39, in which the lining material is gripped against the end of the reducer pipe flush with the top of the connector pipe by a gripper insert.

41. A procedure according to claim 40, in which the lining material is cut flush with the end of the reducer pipe once gripped thereagainst.

42. A procedure according to claim 41, in which the gripper insert is placed in gripping position by an insert holder which, once the insert is so placed, is withdrawn.

43. A procedure according to claim 42, in which the insert holder releases a blade on withdrawal cutting the lining material.

44. Apparatus for use in the rehabilitation of water pipes by lining them with a flexible liner, comprising insertion means for a narrow bore reducer pipe into a wide bore boundary box connector pipe comprising a feed tube attachable to the top of the connector pipe and a plunger adapted to push a length of reducer pipe through the connector pipe to abut the incoming water pipe attached at the other end thereof.

45. Apparatus according to claim 44, comprising further a measuring member adapted to be inserted through the feed tube to measure the required length of reducer pipe.

46. Apparatus according to claim 45, in which said measuring member comprises a graduated length of reducer piping.

47. Apparatus according to claim 45, in which said length of reducer piping is graduated with a zero at one end of the feed tube when the other end is at the other end of the feed tube and the graduations extend outwardly from said zero, so that the graduations indicate, as they level with the said one end of the feed tube, the extent to which the other end of the measuring member extends beyond the other end of the feed tube.

48. Apparatus according to any one of claims 44 to 47, further comprising a gripper insert adapted to be placed in gripping position gripping the lining material against the inner wall of the reducer pipe.

49. Apparatus according to claim 48, further comprising a gripper insert holder adapted to engage a throughway of the gripper insert to hold same and insert it in the gripping position, and then be retracted from the insert leaving the latter in place.

50. Apparatus according to claim 49, in which said insert holder has a blade adapted to be held inside the confines of the gripper insert throughway and blade spring means adapted on withdrawal of the insert holder from the insert to spring the blade out into cutting relation with the lining material.

51. Apparatus according to any one of claims 44 to 50, further comprising sealable vent means adapted to sealingly vent air through an aperture in a lined pipe connected to the boundary box at the end of said lined pipe remote from the boundary box.

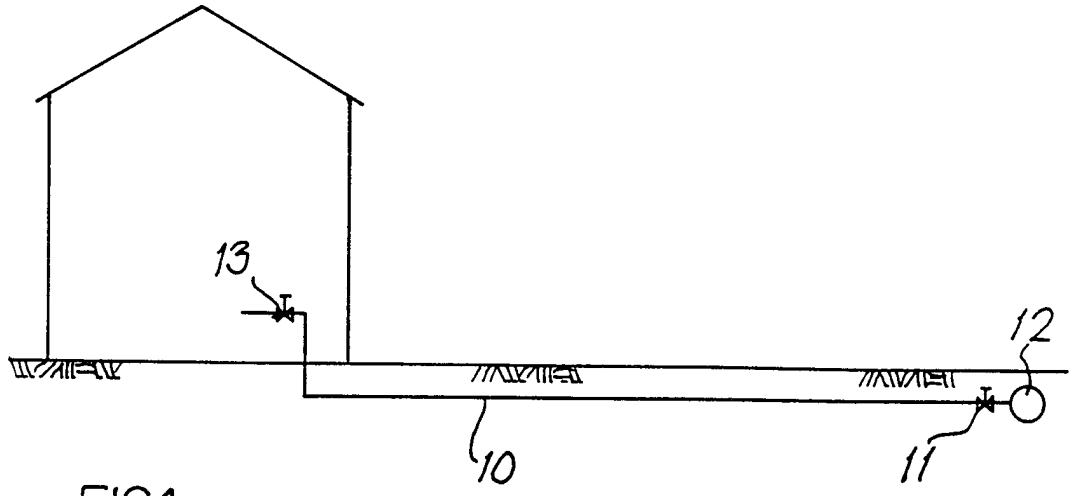

FIG.1

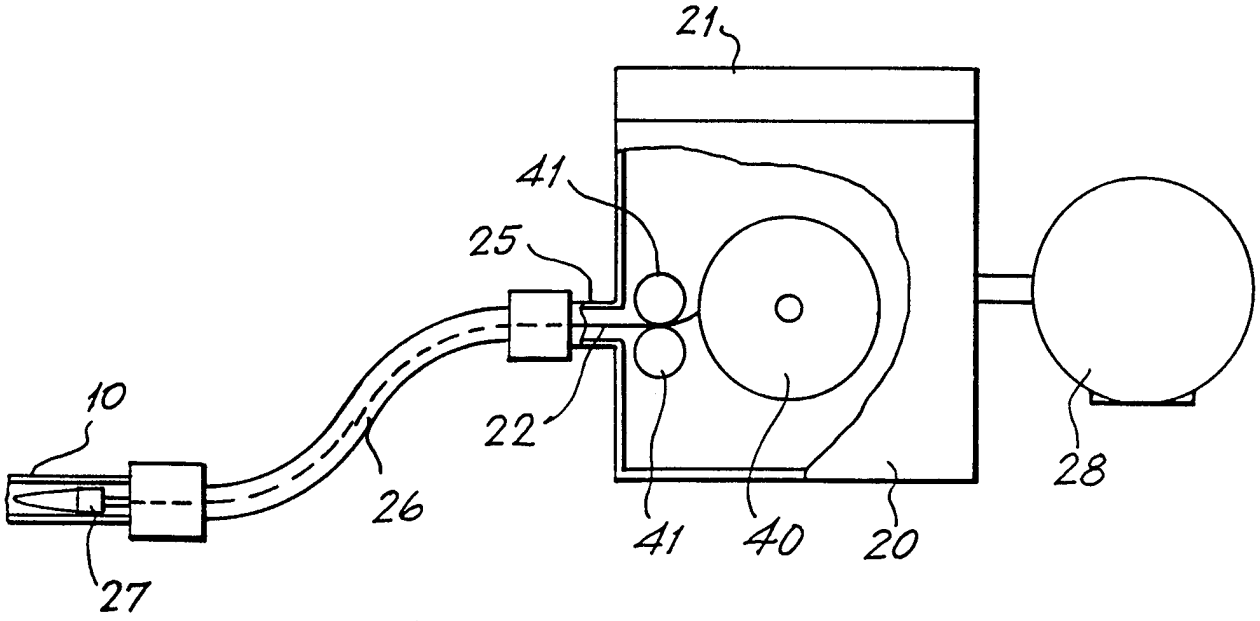

FIG.2

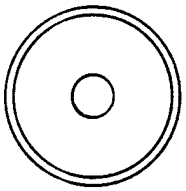

FIG. 5

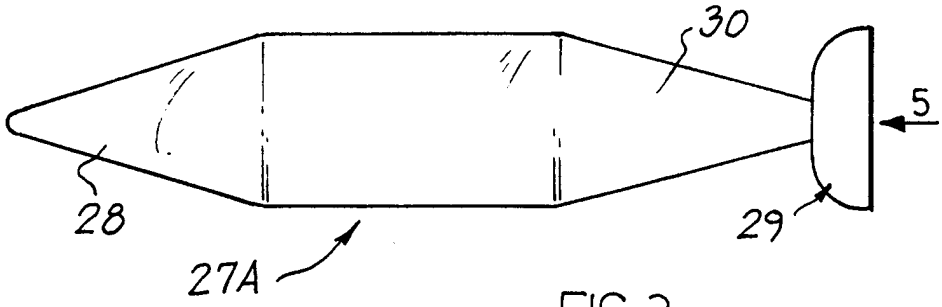

FIG. 3

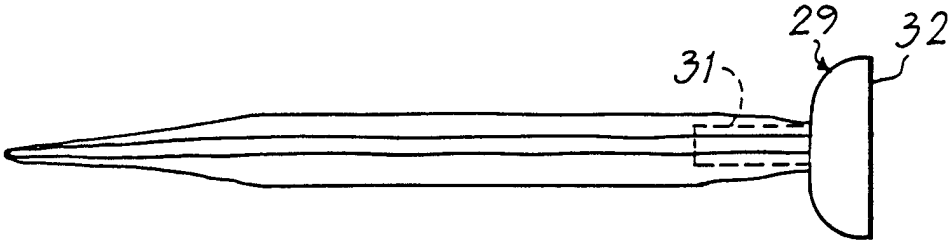

FIG4

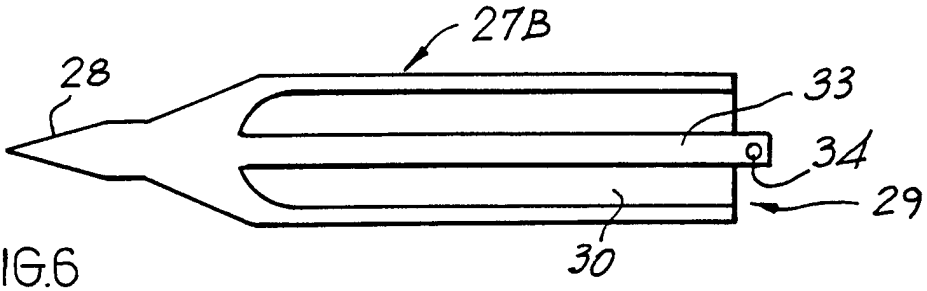

FIG.6

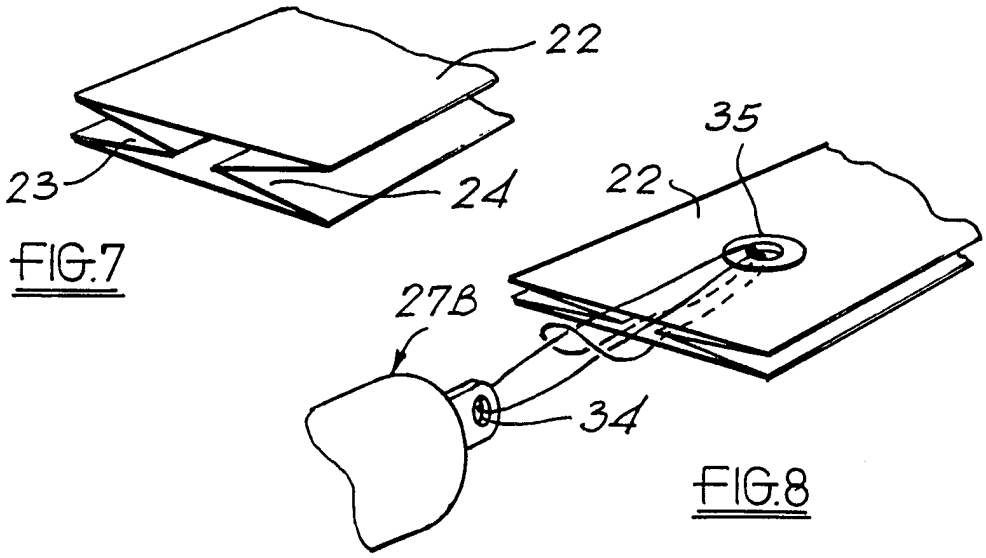

FIG.7

FIG.8

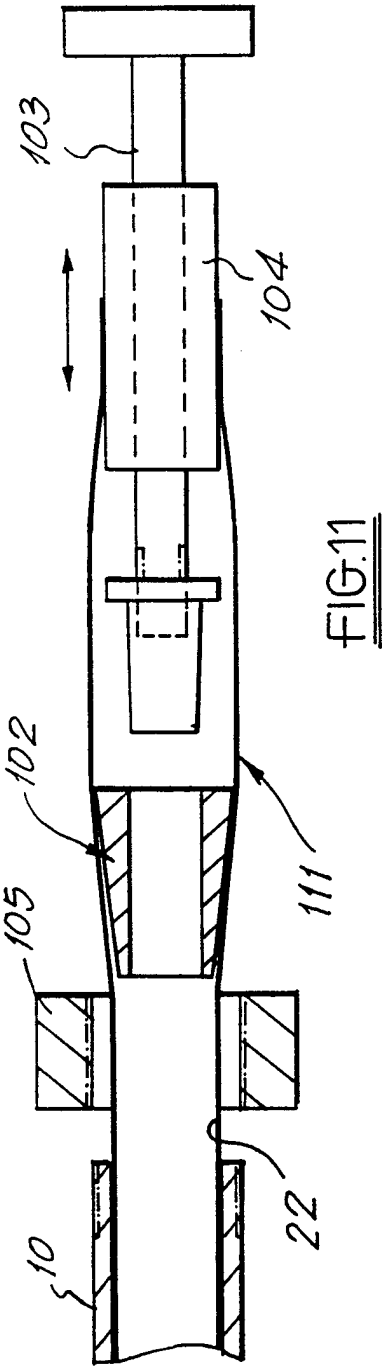

FIG.11

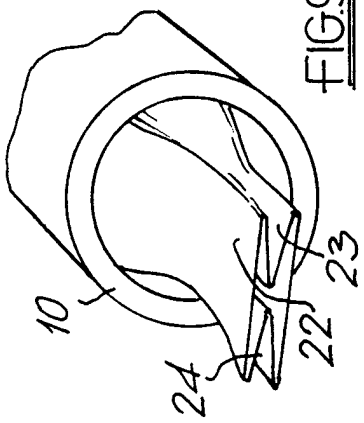

FIG.9

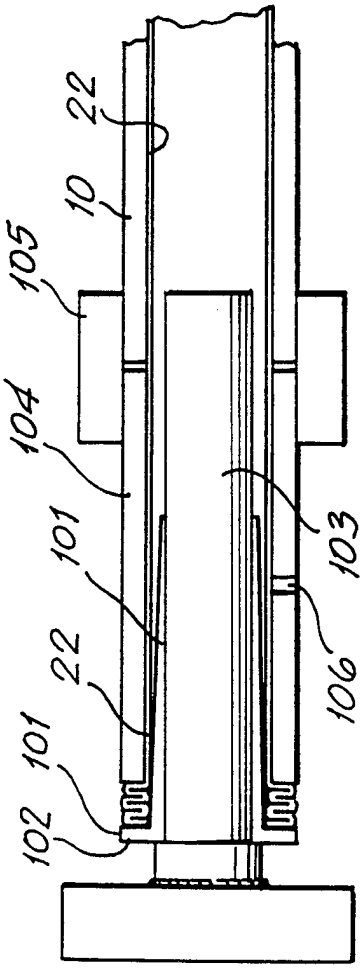

FIG.10

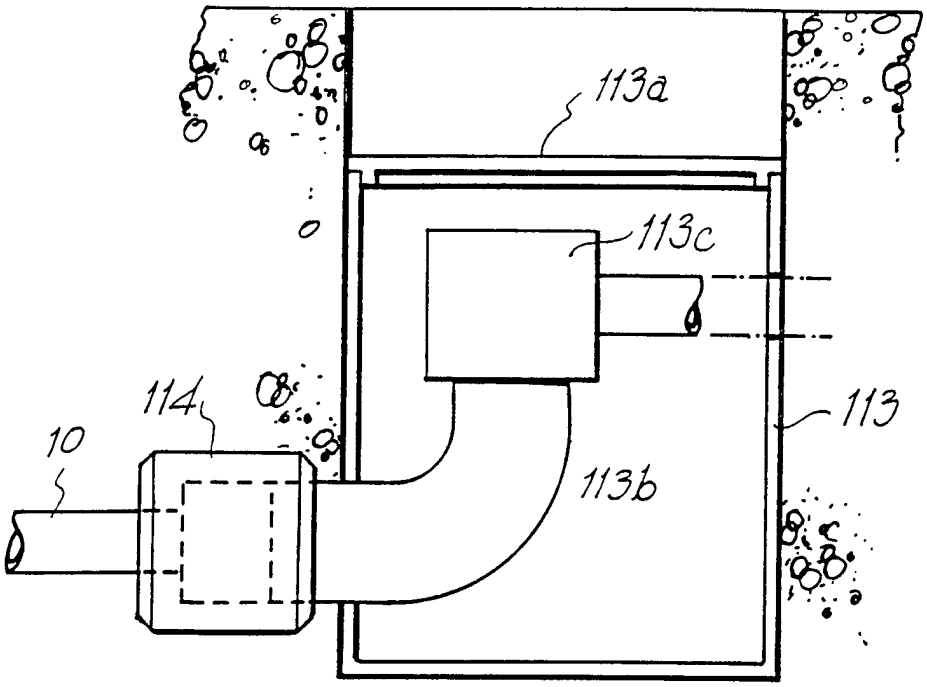

FIG.12

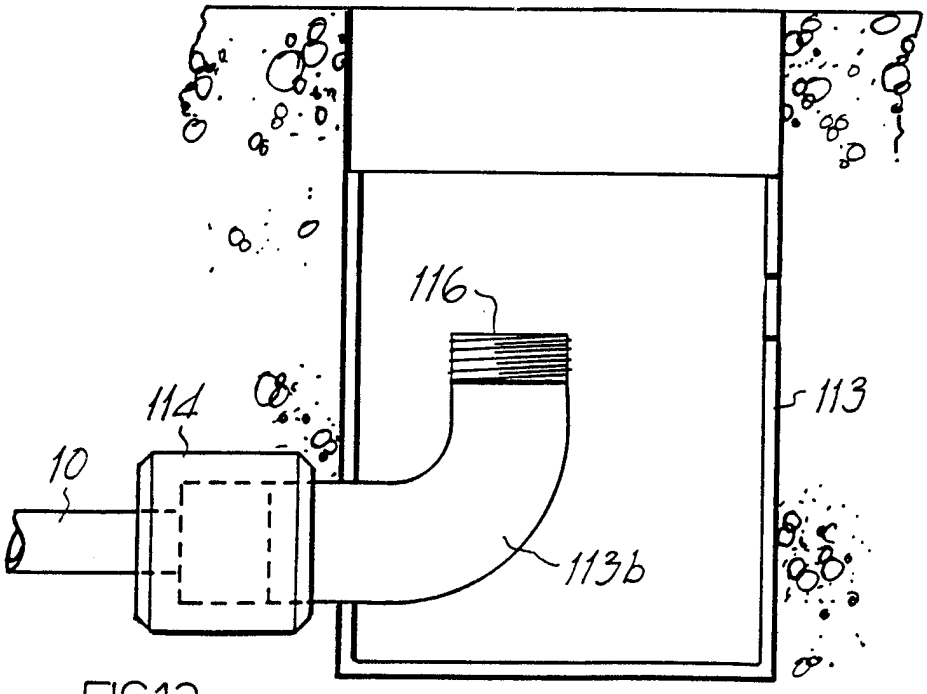

FIG.13

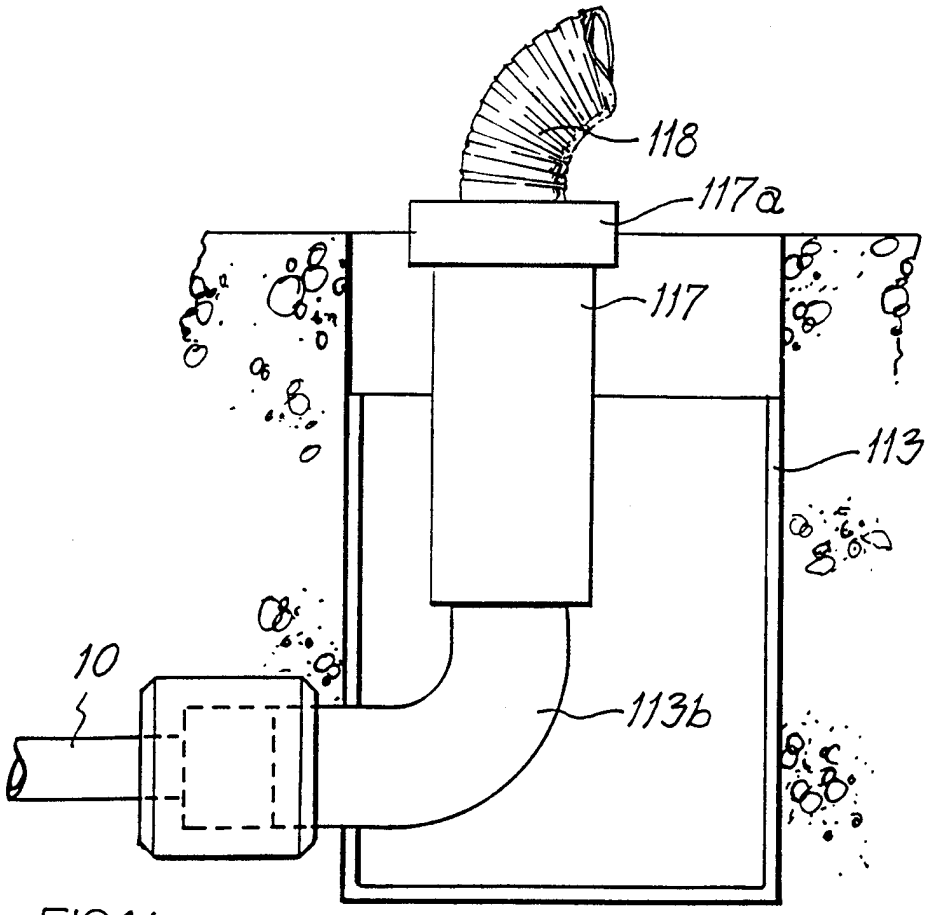

FIG.14

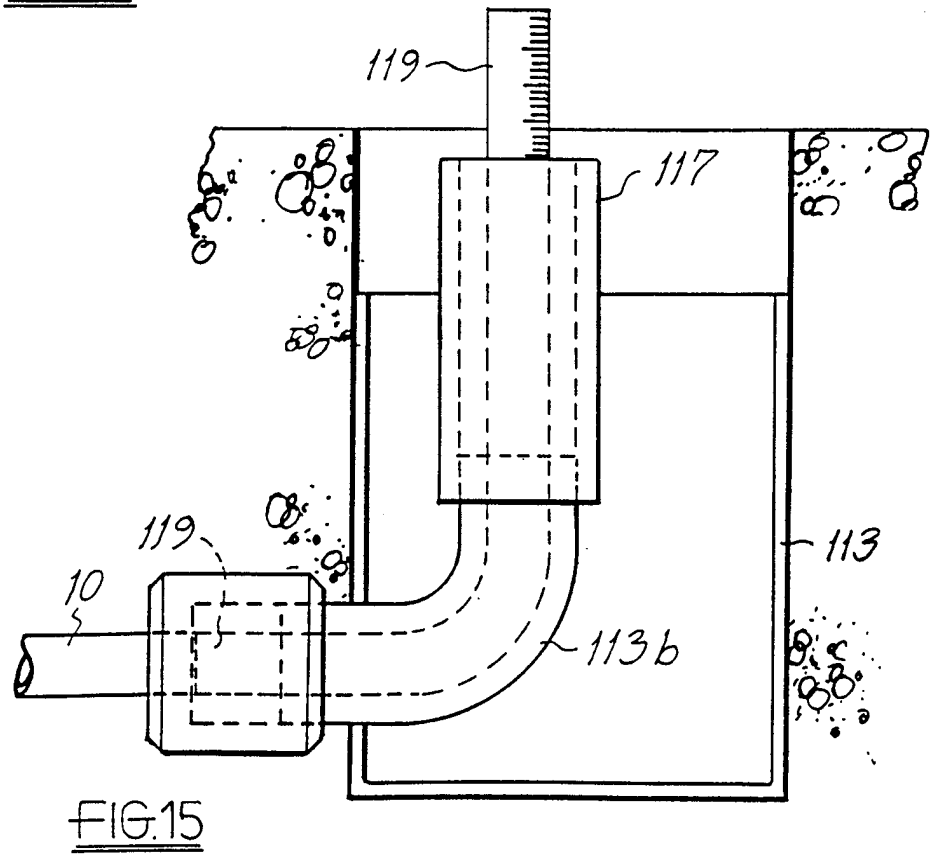

FIG.15

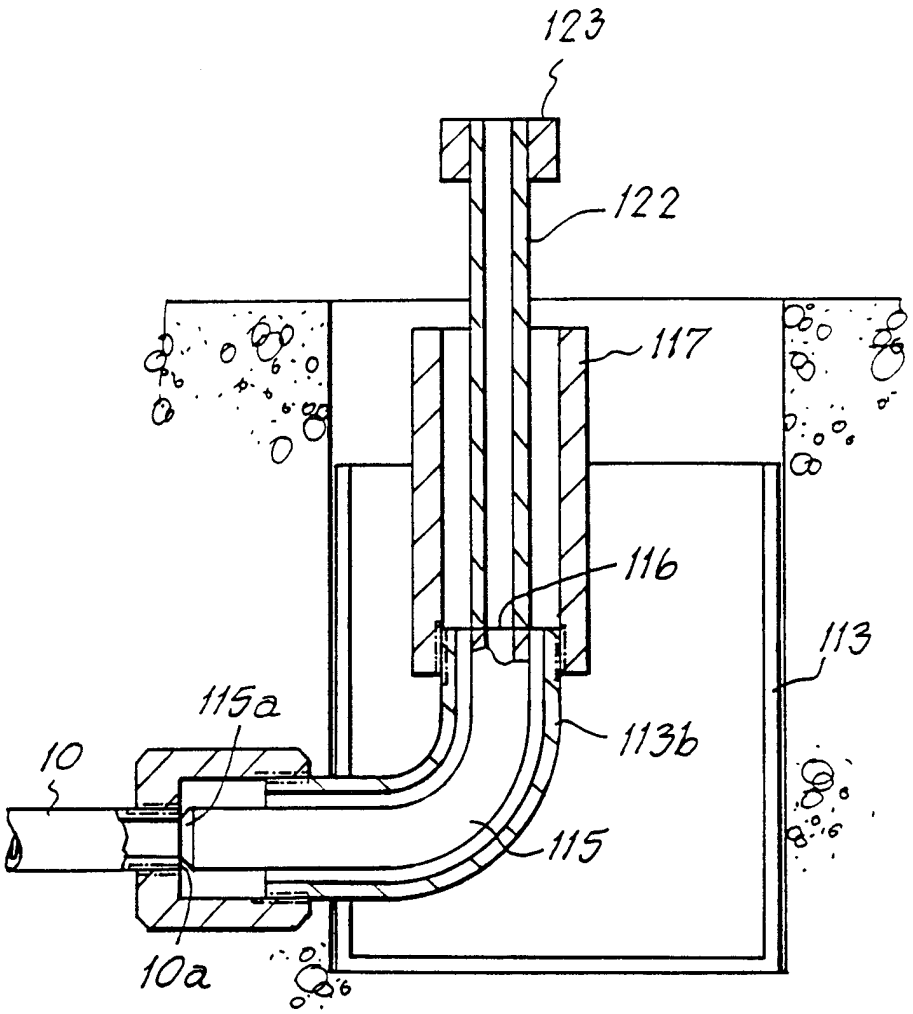

FIG.16

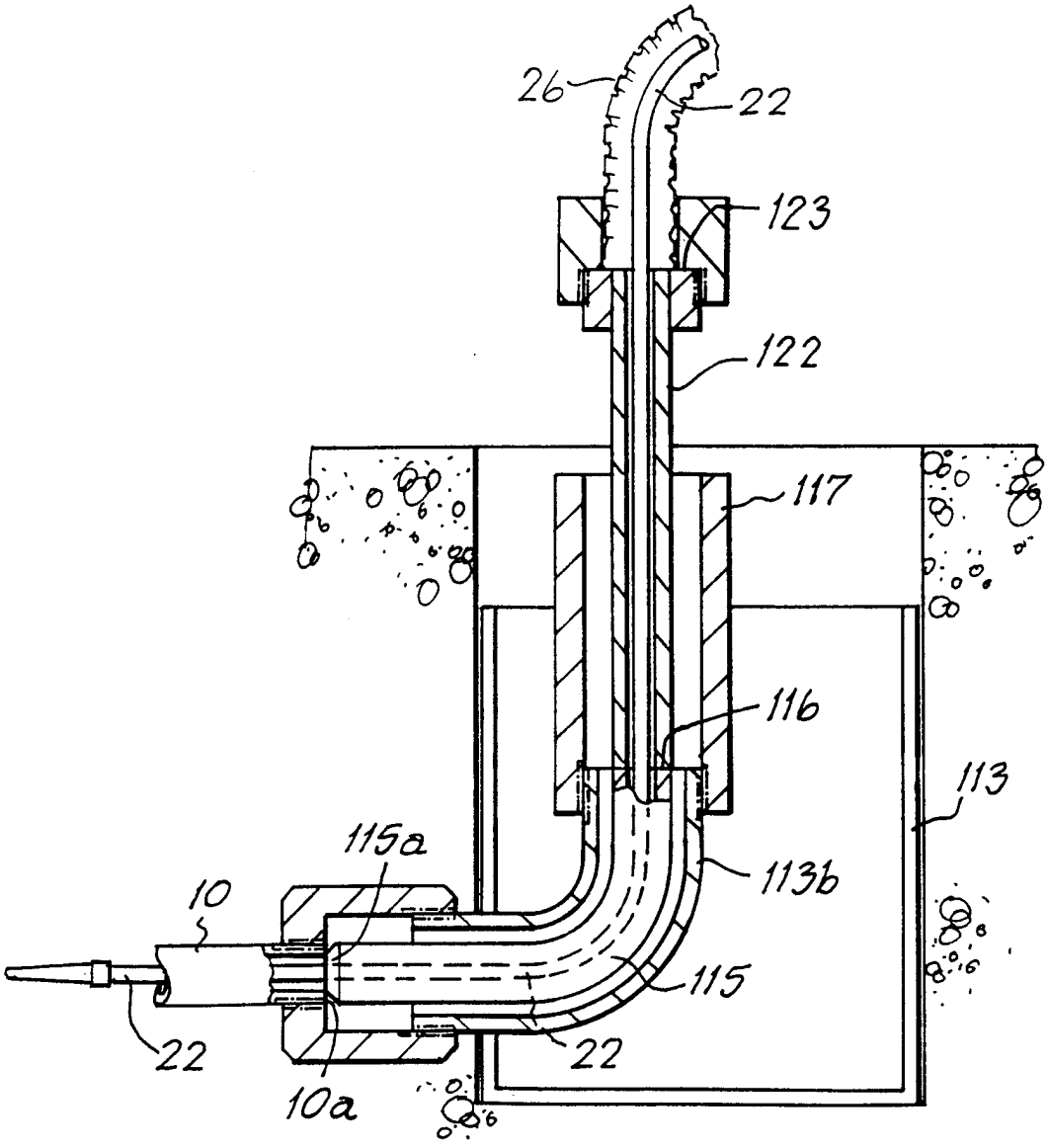

FIG.17

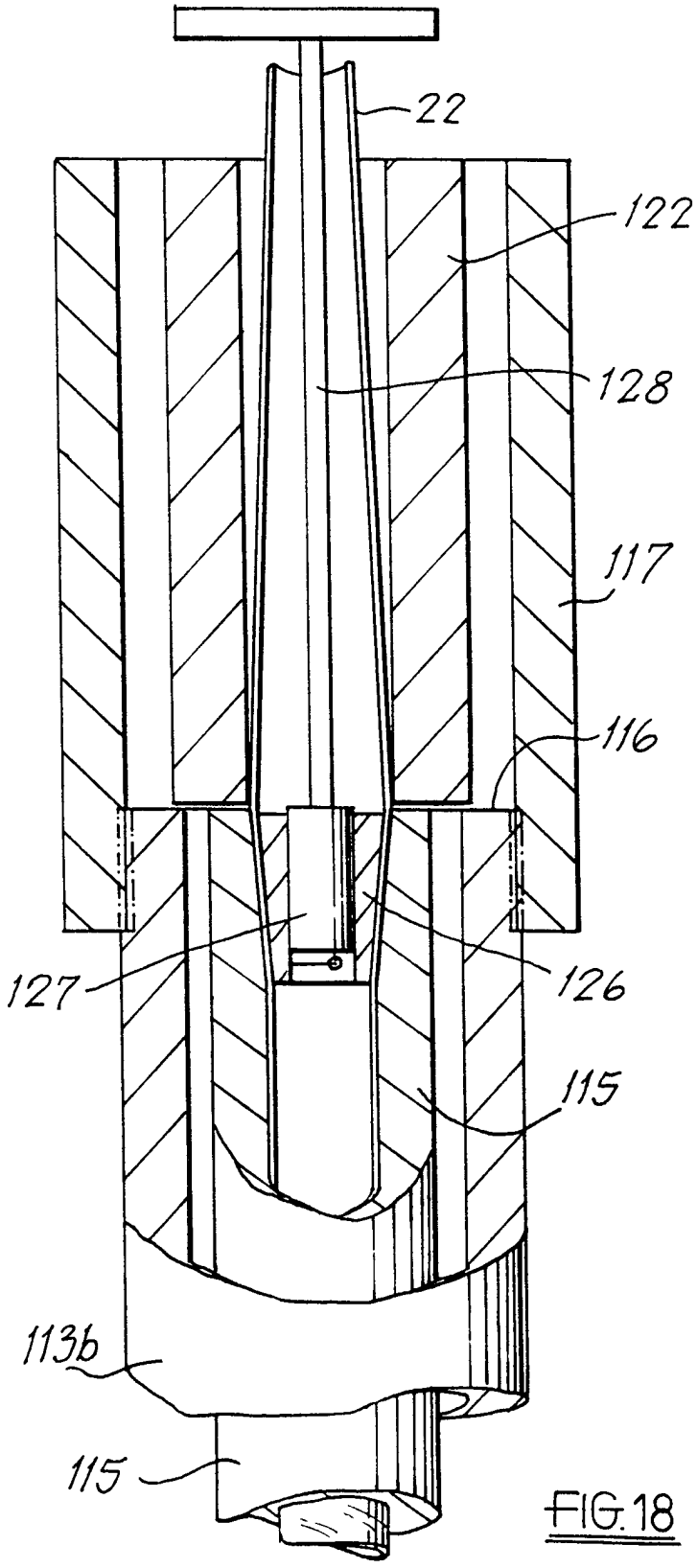

FIG.18

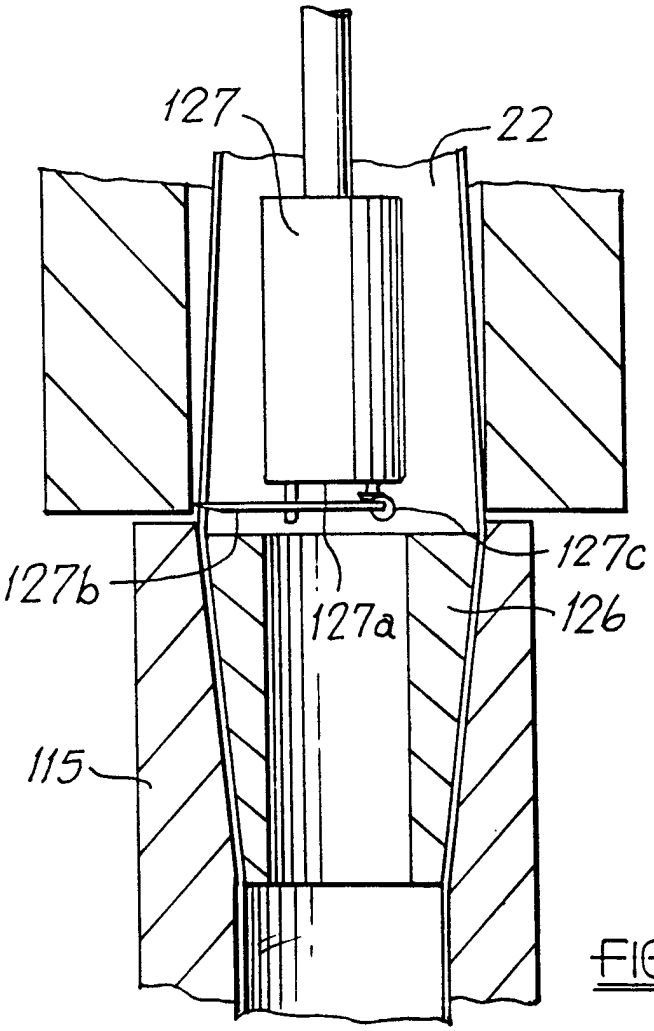

FIG.19

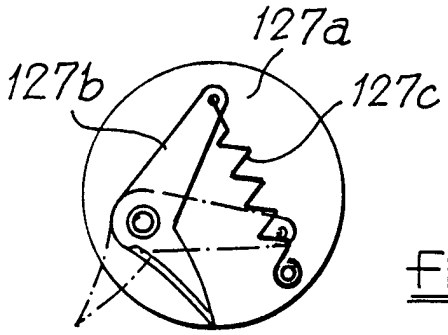

FIG.20

INTERNATIONAL SEARCH REPORT

Interna l Application No
PCT/GB 97/03326

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F16L55/165 F16L58/10 F16L55/38 B29C63/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F16L B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 92 01189 A (WAVIN BV) 23 January 1992 see page 5, line 30 - page 7, line 28; figures 1-3	1,17,18, 32,44
A	GB 2 151 414 A (KAO CHIANG TENG) 17 July 1985 see page 1, line 34 - page 2, line 45; figures 1-5	1,3-11, 13,15, 16,18, 20-26
A	US 4 498 659 A (BROCKELSBY III PETE) 12 February 1985 see abstract; figures 1,2	1,5,6,9, 11,15, 16,18, 21,22,25

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search
23 March 1998

Date of mailing of the international search report
09.04.98

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INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/GB 97/03326

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	see column 4, line 25 - column 4, line 32; figures 5-9	28-31
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