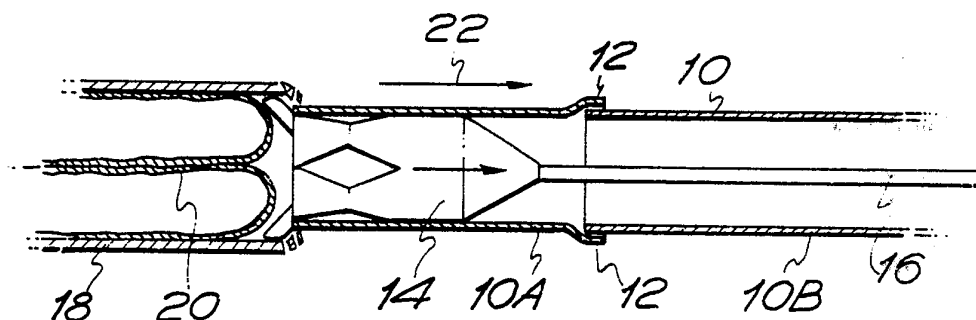




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/GB90/00322 <b>(22) International Filing Date:</b> 1 March 1990 (01.03.90)  <b>(30) Priority data:</b> 8904824.3                      2 March 1989 (02.03.89)                      GB 8904969.6                      3 March 1989 (03.03.89)                      GB  <b>(71) Applicant (for all designated States except US):</b> INSITU-FORM GROUP LIMITED [GB/GB]; 3/4 Hill Street, Douglas, Isle of Man (GB).  <b>(72) Inventor; and</b> <b>(75) Inventor/Applicant (for US only) :</b> WOOD, Eric [GB/GB]; Witchs Mill, Arbory Road, Castletown, Isle of Man (GB).  <b>(74) Agent:</b> DENMARK, M.; 5 York Place, Leeds LS1 2SD (GB).		<b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), NO, SE (European patent), SU, US.  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

**(54) Title:** IMPROVEMENTS RELATING TO THE LINING OF PIPELINES OR PASSAGEWAYS



**(57) Abstract**

The invention provides that an underground pipeline or passageway (12) is lined by everting a flexible lining tube into same, the flexible lining tube being applied immediately behind a means (24) which either increases the diameter of an existing pipeline or passageway or forms a new pipeline or passageway underground. The flexible lining tube may include a resin impregnated layer and the resin subsequently hardens to form a rigid lining on the pipeline or passageway surface.

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IMPROVEMENTS RELATING TO THE LINING OF PIPELINES OR  
PASSAGEWAYS

This invention relates to the lining of pipelines or  
passageways wherein the known technique of everting a  
flexible lining tube into the pipeline or passageway is  
adopted. This technique however is used in combination  
5 with a technique either for the increasing of the  
pipeline or passageway diameter or for a creation of a  
pipeline or passageway with considerable novel effect.

With existing pipelines or passageways, when they have  
10 reached a particular state of disrepair, it is often  
required that the repair of such pipeline or passageway  
involves the increasing of the size of the pipeline or  
passageway. For example in the case of a pipeline, a  
technique involving bursting of the existing pipe by  
15 means of a hydraulic expander or impacter may be  
involved, and following the bursting of the existing  
pipeline, it is known to jack new pipeline sections into  
the enlarged passageway to form a new pipe therein. A  
call for pipeline expansion may also take place where an  
20 existing pipeline is of insufficient capacity to handle  
certain conditions. For example, a sewer pipeline may  
be of insufficient capacity to handle flood conditions,  
and such problem may be capable of solution by a  
relatively small increase in the pipeline or passageway  
25 diameter.

It so happens that in the United Kingdom, public  
authority funds allocated to the sewerage systems in the  
country are largely allocated to projects which have as  
30 their object to relieve flooding conditions, and a  
relatively small proportion is in fact allocated to  
repair and renovation of existing sewers, although the  
need for effecting repair and renovation is in fact  
acute.

35

The Insituform (registered trademark) process for  
effecting renovation and repair of existing sewers has  
shown itself to be extremely effective and successful,

- 2 -

and it involves everting a flexible lining material into and along a sewer pipe. The lining material is absorbent felt and is impregnated with a curable synthetic resin. When the lining has been everted into position it is held by a fluid pressure against the sewer inner surface, until the resin cures, when the lining becomes a free-standing pipe lining the sewer surface.

It is also known to form underground passageways using mould tools, drills, or plough devices, and when such passageways are formed, it is conventional to insert in such passageways suitable lining pipes. However, the technique involves creating a passageway which is substantially larger in diameter than the pipe to be inserted and consequently the method has difficulties especially if the pipe is to be pulled into position in the passageway. In any event when the pipe is installed there will be a clearance between the pipe and the created passageway which may have to be filled with grouting material or the like.

To increase the applicability of Insituform, considerable advantage results when a pipe increasing (expanding or excavating) or a passageway creating technique is used in conjunction with an eversion lining technique such as Insituform, and in accordance with the present invention, a pipeline or passageway is lined by a process involving the increase or creation of the pipeline or passageway by suitable means, followed immediately by the application of a flexible lining tube by everting same along the increased or created pipeline or passageway immediately behind the said means.

Where an existing pipe is burst by a hydraulic expander or impact expander, the advantage of following the expanding means is that broken pieces of pipe which result from the expanding operation, are held in

- 3 -

position by the everted tube and the lining operation such as an Insituform lining operation can take place readily so that the broken pieces of pipe will not be able to alter the base of the pipeline or passageway.

5

Instead of expanding the pipeline or passageway diameter by the utilisation of an expanding tool, an excavating type tool may be used which serves to break or cut the existing pipeline or passageway, and in such case there is preferably there is also means for removing the resulting debris ahead of the cutting or excavating tool. Immediately behind the tool follows a lining operation whereby a flexible lining tube is everted onto the new pipeline or passageway surface.

10 The lining tube may be a flexible film which is everted into the pipeline or passageway by air-pressure, or it may be a resin impregnated Insituform type tube which is held in position until the resin cures, completing the lining operation. Where a flexible film is used, this

15 may be followed by the application of a resin impregnated lining tube which is caused to cure hard in order to complete the lining operation.

20

Where the cut debris is removed ahead of the cutting or excavating tool this may be effected by pumping a viscous high specific gravity fluid or material into the pipeline or passageway in order to force the debris out of the pipeline or passageway by floatation method.

25

The cutting or excavating tool or hydraulic or impacted expander may be pulled through the pipeline or passageway by means of a winch and appropriate rope or cable.

30

In the case where the passageway is created, the flexible lining may be everted into the passageway created by the tool immediately after creation of the passageway by the tool, or alternatively following

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- 4 -

behind the tool there may be inserted by eversion a flexible lining tube which serves as a temporary lining layer, this being followed by the inversion of the impregnated lining layer or layers.

5

In one example, where the tool created an underground passageway, a first lining tubular film is everted into the passageway behind the tool, and that is followed by the pooling into the passageway of an impregnated lining tube, which is followed by the eversion into the inside of the lining tube in order to inflate same by fluid pressure of an inflation tube. The inflating medium may be gaseous or liquid or a combination of gaseous and liquid mediums. This technique can also be used where an existing pipeline or passageway is increased.

15

In one example the tool is a mole or plough former which is driven or pulled through the ground, whilst in another arrangement an elongated drill drilled a hole underground from a first location to a second location. The drill is retracted so that its free end moves from the second location back to the first location, leaving the passageway free, and as the drill is retracted, so the everting lining tube is applied to the passageway surface.

25

The invention is not limited to the utilisation of a flexible lining tube which is an Insituform tube although it is preferred that a resin impregnated tube be used to form the lining pipe after the expansion or creation of the pipeline or passageway.

30

Various embodiments of the invention will now be described by way of example, with reference to the accompanying diagrammatic drawings wherein:-

35

Fig 1 shows a cross-sectional view of a pipeline or passageway which is being enlarged and re-lined;

Fig 2 is a view similar to Fig 1, but showing an alternative arrangement;

Fig 3 shows the cutting apparatus of Fig 1 in perspective elevation;

Fig 4 is a perspective view showing another method of enlarging and lining a pipeline or passageway.

Fig 5 is a sectional elevation of the arrangement shown in Fig 4;

Fig 6 is a perspective view also showing the arrangement of Fig 4, but in addition indicating the ground level equipment used in the method;

Figs 7 to 10 illustrate in a step-wise fashion a preferred process of expanding and lining an underground pipeline or passageway;

Fig 11 illustrates a method according to another embodiment of the invention; and Fig 12 illustrates another method according to yet another embodiment of the invention.

Referring now to the drawing in detail, in Fig 1 an underground pipeline (10) is formed by a plurality of pipe lengths (10A) (10B) (Fig 2) etc. each of which has a bell mouth (12) so that the pipe lengths can interfit at joints as shown. It is assumed that the pipeline (10) requires to be expanded, and to effect this an expanding tool (14) is pulled along the inside of the pipeline by a suitable cord (16) cable or the like. The cord or cable (16) also provides a hydraulic connection or an air connection to the expander (14), and the expander (14) either operates on the principle of being expanded hydraulically or it may embody air hammers which are operated by compressed air. In any event the

expander (14) has the effect of increasing the size of the pipeline (10) to the extent indicated by reference (18), and in this embodiment of the invention the portions of the broken pipelength are held in position in that immediately following the expander (14) along the pipeline or passageway is an everting flexible tubular member (20) which may be an Insituform lining or may simply be a flexible film. This everting tube is inserted by fluid pressure which may be gaseous or liquid. The entire assembly moves along the pipeline (10) in the direction of the arrow (22).

In the arrangement of Fig 2, instead of the expander (14) being used, a driven cutting head (24) is used, and the cutting head as shown in Fig 3 comprises a rotary drum (26) provided with cutting blades (28A) which cut the pipe lengths (10A) (10B) in order to expand the pipeline or passageway diameter. The resulting debris is in this example allowed to fall into the pipeline or passageway and is displaced by the use of a jet cleaner (27) which is attached to the cutting assembly which is indicated in perspective elevation in Fig 3. The cutting assembly has rollers or wheels (28) to enable it to be supported by and to roll on the pipe lengths (10A) (10B).

The jet cleaner (27) is supplied by feeding water through pipe (30), and oil go and return pipes (32) and (34) are supplied to a hydraulic motor in the drum (26) for the driving of same to rotate the cutter blades (28) about the axis of the pipe (10). When the drum rotates in a cutting direction the blades (28) move outwardly to perform the cutting, but when the drum rotation is reversed the blades retract to enable the drum to be removed from the pipe 10.

Following behind the cutting head (24) is a lining tube (20) which is everted into position lining using fluid

pressure in the new enlarged pipeline or passageway.

In the arrangement of Fig 4 an enlarging head (34) has a plurality of reciprocal hammers (36) which are driven back and forward in the direction of the arrow (38) in order to punch and break the old pipe sections (10A) and (10B) from the pipeline in order to increase the pipeline diameter. The hammers (36) are driven by pressure air through a high pressure air line (40) which also forms the means for pulling the head (34) along the pipeline or passageway. A jetting head (42) similar to the head (26) serves for the cleaning of the pipe of debris and for the forcing of the debris along the pipeline or passageway (10) to an outlet ahead of the breaking operation.

Fig 5 shows the arrangement of Fig 4 in sectional elevation, and the following everting flexible tube (20) is shown. The area of the head (34) may be shaped as indicated at (44) so that the tube (20) will smoothly evert.

It is to be noted that the front of the excavating head (34) is cup shaped so that the ends of the pipe sections (10A) (10B) will effectively enter the recess and be engaged by and destroyed by the hammers (36). The hammer ends are scalloped as shown in order to provide the bursting effect, and to push the portions of the broken pipe towards the pipeline or passageway access.

Fig 6 shows the operation as it proceeds between two manholes (46) and (48). A vehicle (50) provides the means to enable the lining (20) to be everted along the pipeline or passageway (10) after expansion of same by the head (34), and the vehicle (52) provides for the winching of the head (34) along the pipeline or passageway (10), for the supply of suction through the suction head (54) to remove the jetted debris, and a

compressor (56) provides for the supply of compressed air through the pipe (40).

5 It is to be noted that in each case the bursting or cutting head is such as to enable the enlargement of the diameter of the pipeline or passageway (10) to an extent greater than the diameter of the pipe joint (12), especially where the pipe is excavated as in the cases of Figs 2 to 6.

10 Furthermore, instead of using a water jet for the cleaning of the debris in such embodiments, it is possible to use bentonite which is a viscous liquid of high specific gravity which will cause the debris to  
15 float thereon and be ejected from the manhole. The pipeline can in effect be flooded with bentonite.

In the arrangement shown in Figs 7 to 10, the expander or excavator is indicated generally by a reference  
20 numeral (60), and lining is taking place again between manholes (48) and (46). The expander (60) increases the size of the pipeline or passageway (10) as shown, and the lining operation involves following the expander with a lining tube (20) which may be a flexible film,  
25 and when the lining tube (20) is fully inserted, a main Insituform lining tube (62) is pulled in by virtue of the attachment of a pulley (64) to the trailing end of the tube (20) as shown in Fig 8. When the tube (62) has been fully inserted as shown in Fig 9, an inflating tube  
30 (66) is everted into the tube (62) in order to inflate same. The everting tube (66) may be a flexible plastics material film, or it could be a second Insituform lining tube impregnated with synthetic resin.

35 Fig 10 shows the arrangement wherein the inflating tube (66) has been fully inserted, and Fig 10 shows that illumination sources (68) have positioned inside the lining tubes for the curing of the impregnating resin,

which will be a light cure resin. The light curing resin, the lights used and the materials for the Insituform lining tubes may be as set forth in our U.S. patent 4581247.

5

The embodiments described provide improved methods for the enlargement and lining of underground pipelines or passageways. It is to be noted from Fig 5 that the lateral connection (70) preferably is cut as indicated at (72) prior to the pipe removal operation described. This can be performed with a cutting machine provided with a robot arm to enable the cut (72) to be effected from inside the pipeline or passageway.

15 Several other embodiments are shown in Figs 11 and 12. Referring to Fig 11, the ground level is indicated by reference (110), and the apparatus indicated is to serve to produce an underground passageway (112) which passes under a culvert or other waterway (114). This is  
20 achieved by using a drilling apparatus (116). The drilling apparatus (116) is provided with a guided drill which can form the passageway (112) and the end of the drill bit emerges through ground level in the region (118). As the drill is pulled back by the apparatus  
25 (116), a tubular lining is everted into the resulting passageway from the inversion tower (120) so that the tubular lining will line the passageway. If the lining is impregnated with synthetic resin, it is held in inflated condition until the resin cures whereby a rigid  
30 resin pipe lines the passageway rendering same permanent as described in previous embodiments.

In the arrangement of Fig 12, a similar objective is achieved. The ground level is again indicated by  
35 reference (110), and a tractor vehicle (122) is provided with a trailing hitch (124) to which is connected a plough sheer (126) having a mole blade (128) on the lower end thereof, and the mole blade is followed by an

expander (130). As this assembly proceeds in the direction of arrow (132) so a passageway (134) is created. In order to line this passageway, following behind the expander (130) is an everting lining tube (126) which is a tube impregnated with synthetic resin and which is held in inflated condition until the resin cures thereby forming a hard lining tube in the passageway (134) resulting in a permanent underground passageway.

5

It is to be noted that any of the features in any of the embodiments described in relation to Figs 1 to 10 can be embodied in the arrangements of Figs 11 and 12 if appropriate.

10

15

1. Method of lining a pipeline or passageway comprising increasing or creating an underground pipeline or passageway by suitable means, followed immediately by the application of a flexible lining tube by everting same along the increased or created pipeline or passageway immediately behind said means.
2. A method according to Claim 1, wherein an existing pipe is burst by a hydraulic expander and the broken pieces of pipe which result from the expanding operation are held in position by the everted tube.
3. A method according to Claim 1, wherein said means comprises an excavating tool which serves to break or cut an existing pipeline or passageway, and including a means for removing the resulting debris ahead of the cutting or excavating tool.
4. A method according to Claim 3, wherein the debris is removed ahead of the cutting or excavating tool by pumping a viscous high specific fluid or material into the pipeline or passageway in order to force the debris out of the pipeline or passageway by a flotation.
5. A method according to any of Claims 2, 3 and 4 wherein the cutting or excavating tool is pulled through the pipeline or passageway by means of a winch and appropriate rope or cable.
6. A method according to Claim 1, wherein said means comprises a tool which creates an underground pipeline or passageway.
7. A method according to Claim 6, wherein the flexible

lining tube is applied immediately behind the tool after it is withdrawn from the pipeline or passageway which it has created.

8. A method according to any preceeding Claim, wherein said flexible lining tube comprises a resin impregnated tube which forms a hard lining tube on the increased or created pipeline or passageway when the resin cures to a hard condition.
9. A method according to any of Claims 1 to 7 wherein the flexible lining tube is a flexible film, and the method includes the additional step of introducing a resin impregnated tube into the flexible lining tube after it has been applied to the passageway or pipeline surface enforcing the resin impregnated tube onto the flexible lining tube until the resin cures forming a hard lining tube in the pipeline or passageway surface.

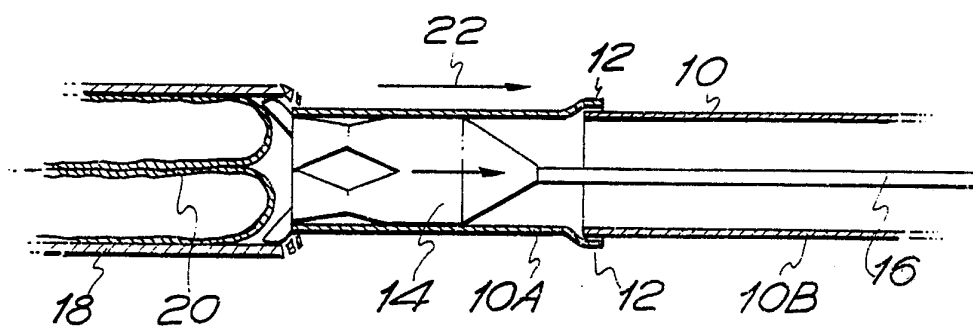


FIG. 1

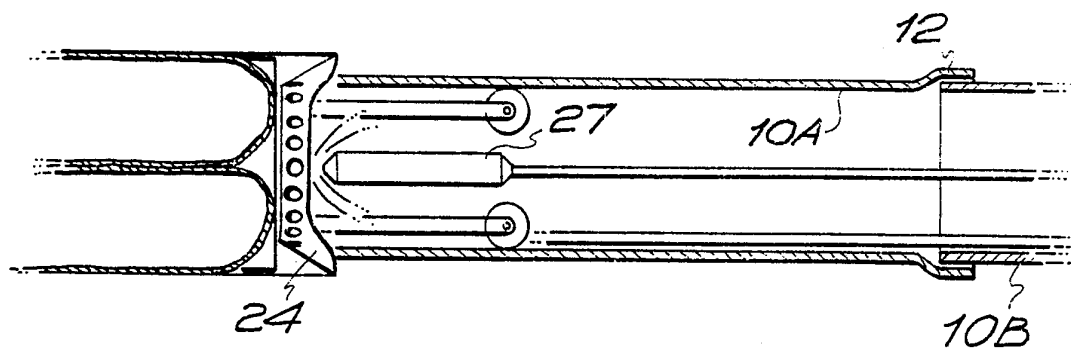
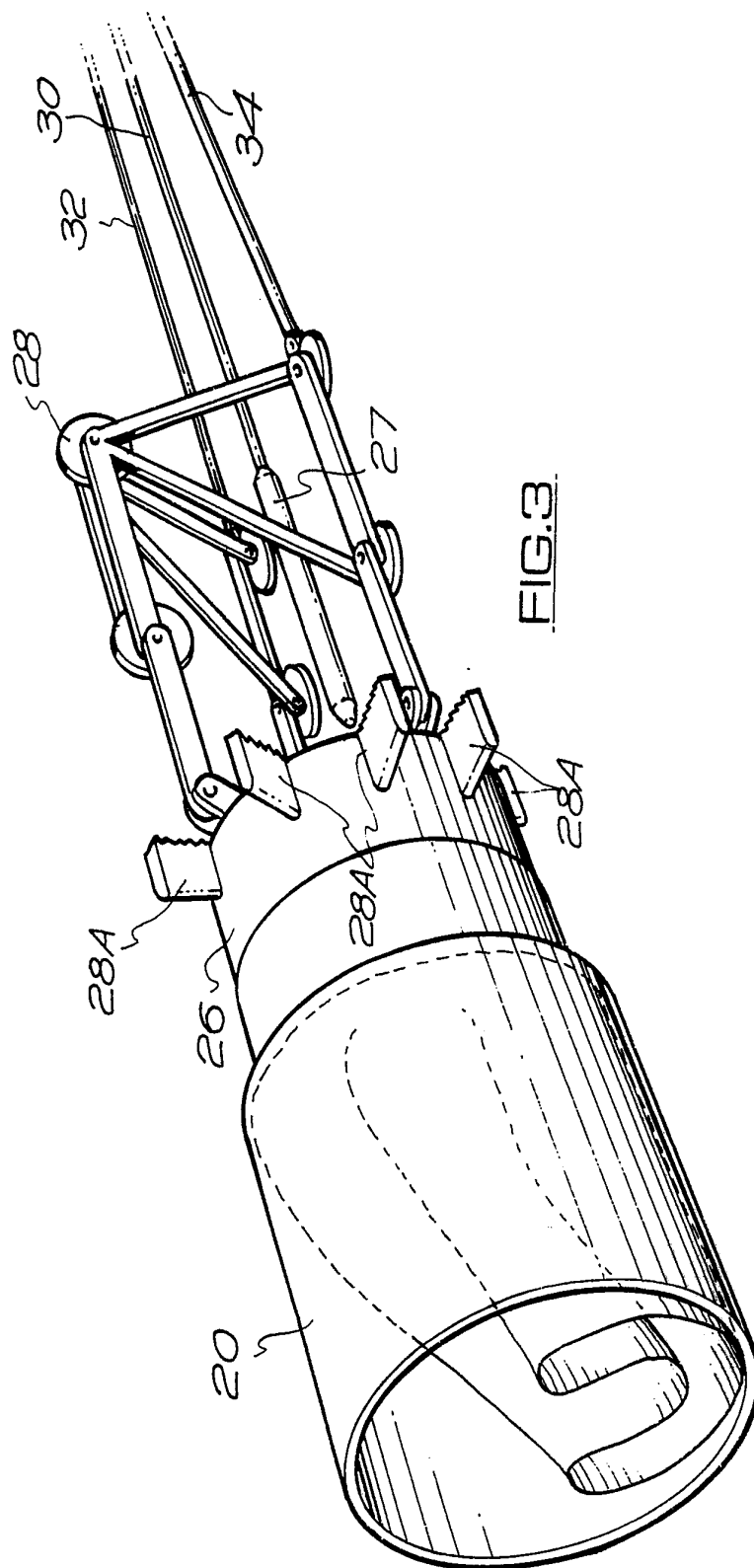
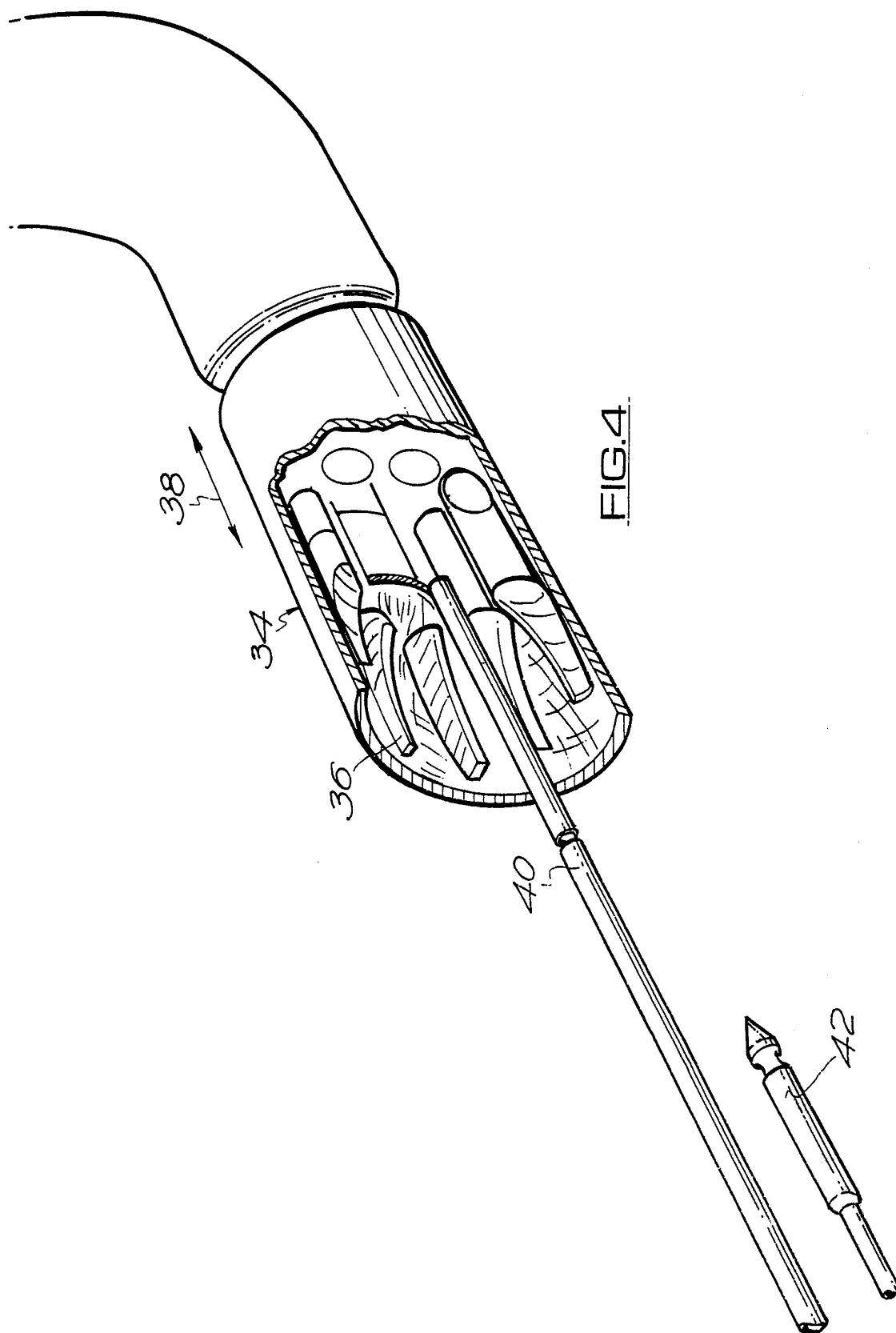
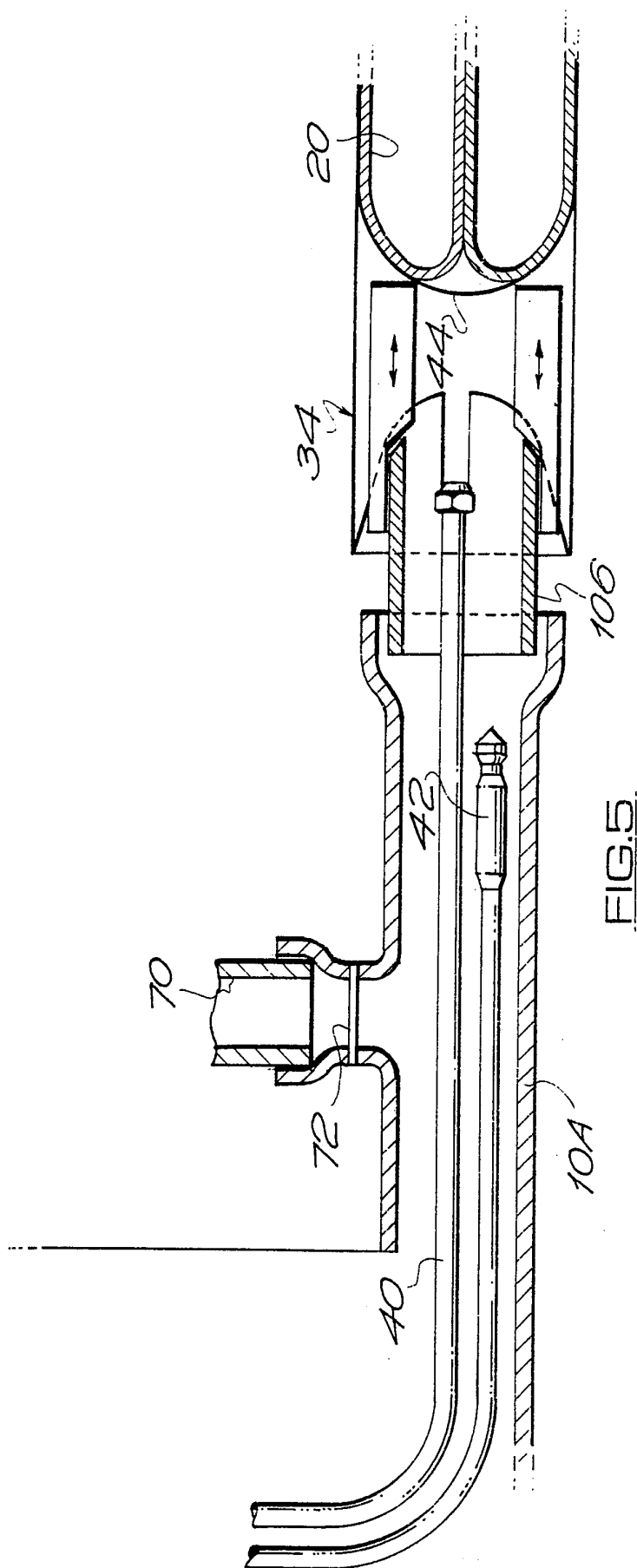


FIG. 2



SUBSTITUTE SHEET





SUBSTITUTE SHEET

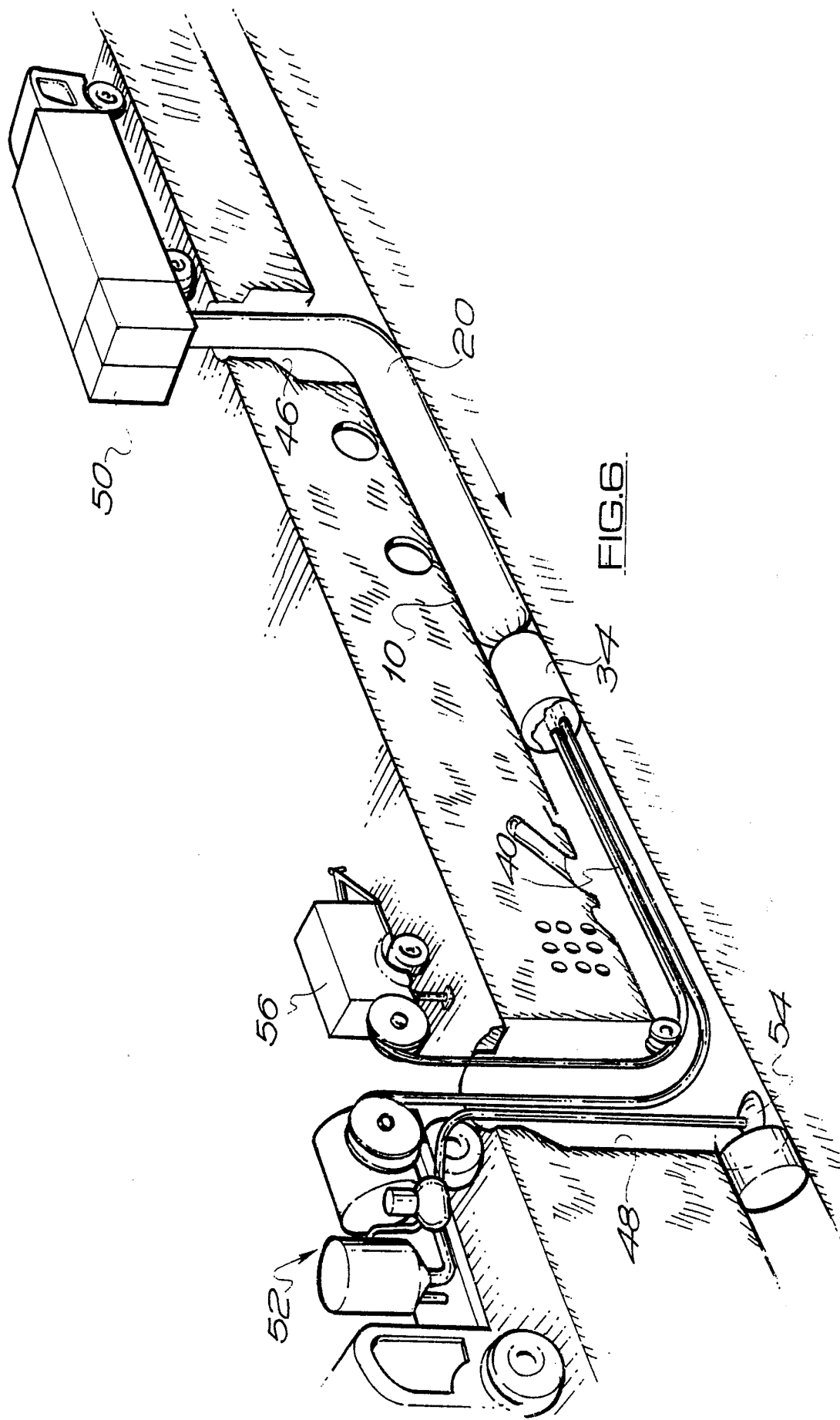


FIG. 6

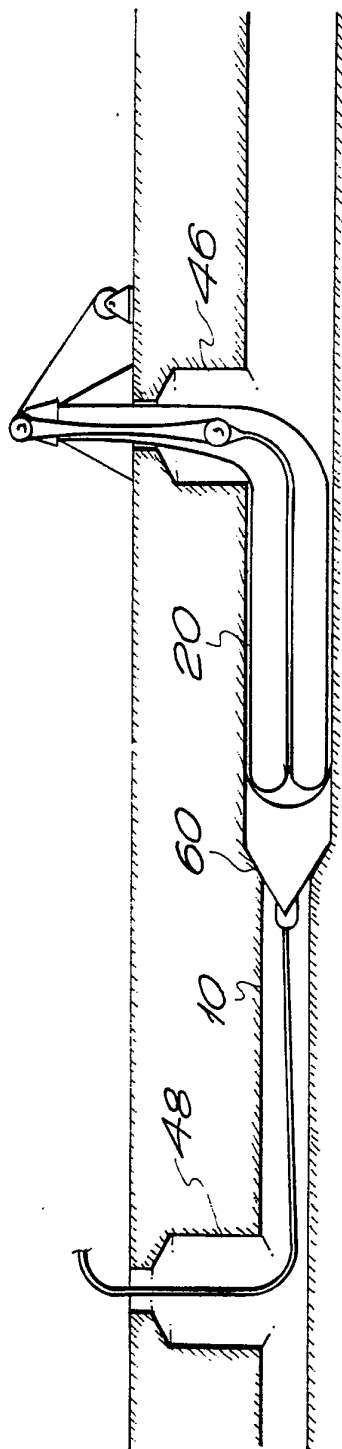


FIG. 7

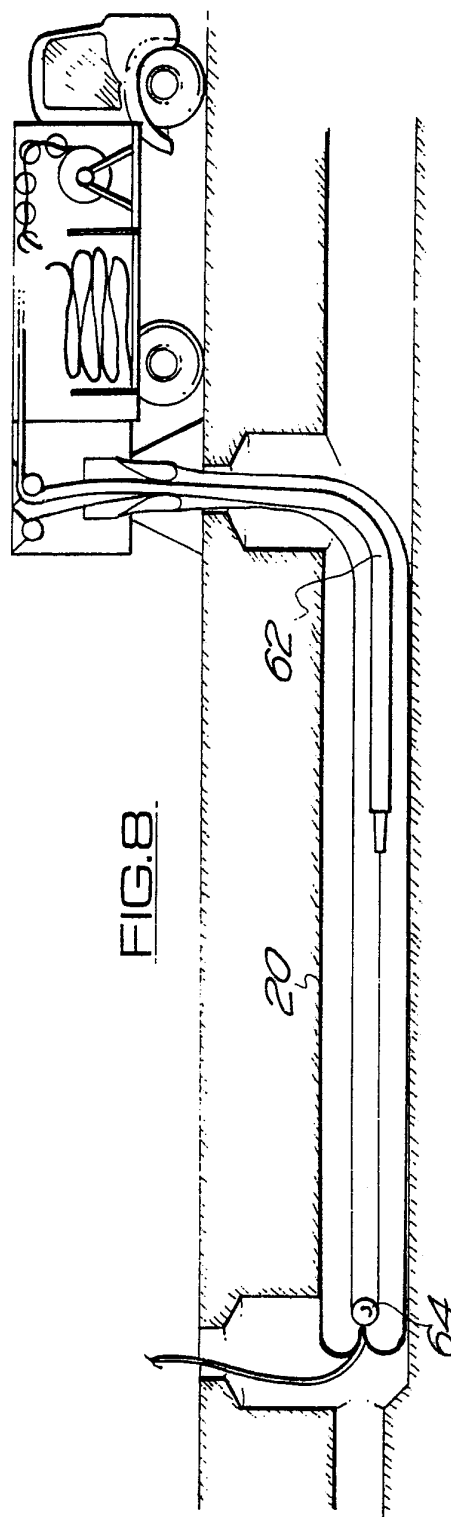


FIG. 8

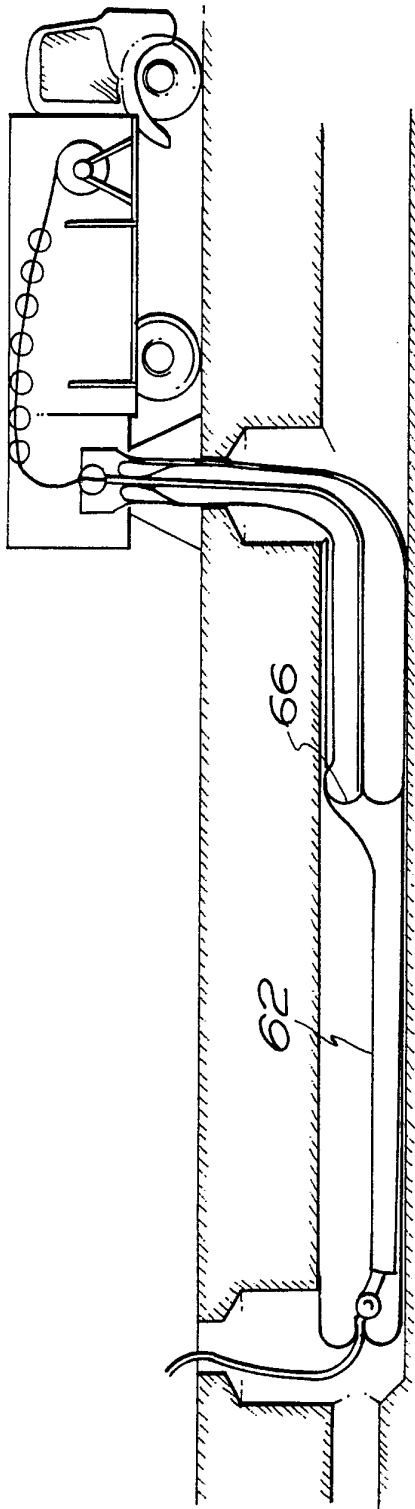


FIG. 9

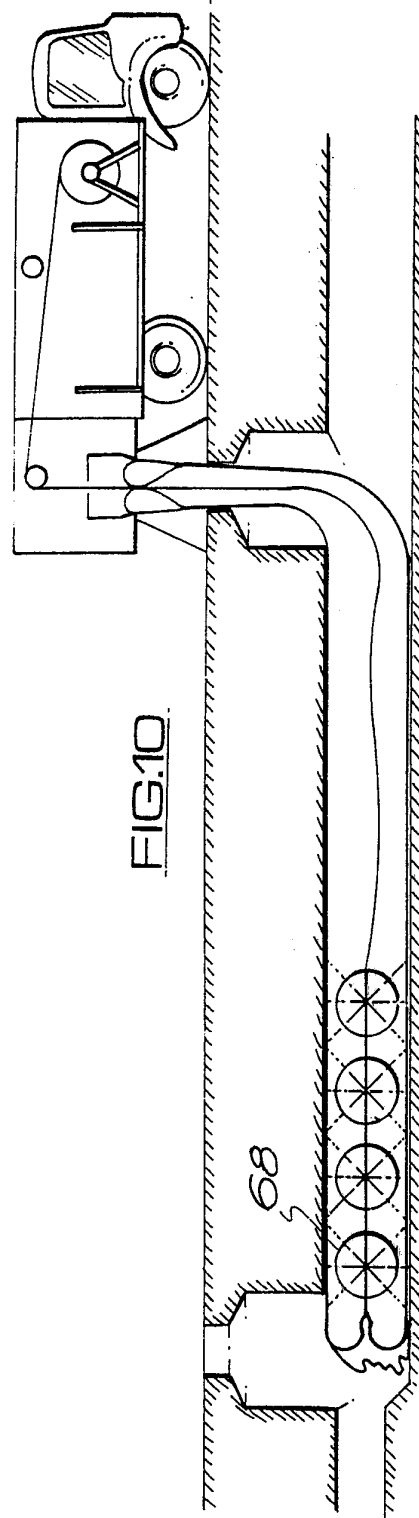


FIG. 10

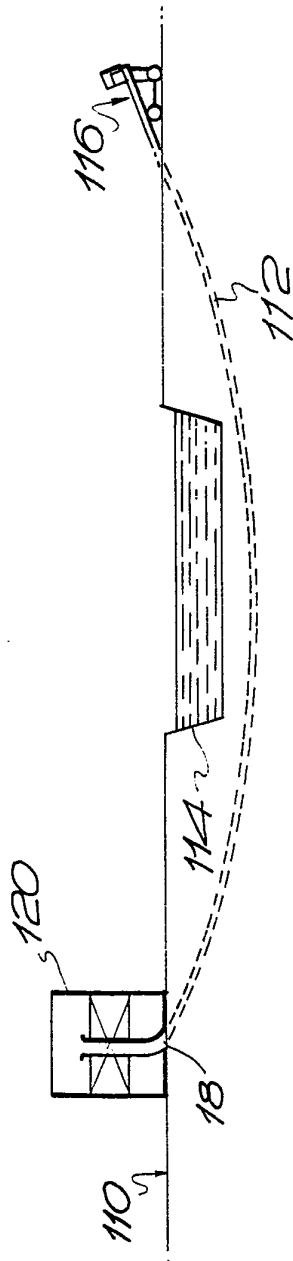


FIG. 11

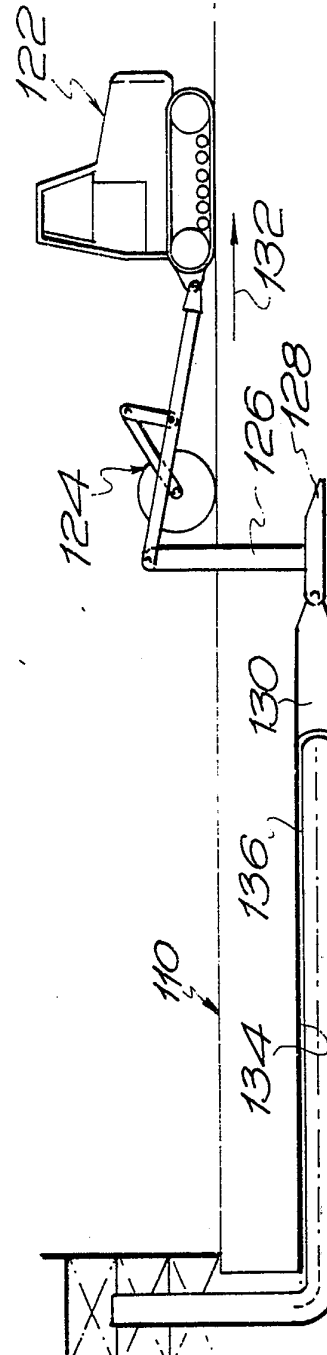
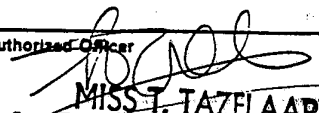


FIG. 12

# INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/00322

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>6</sup> According to International Patent Classification (IPC) or to both National Classification and IPC IPC <sup>5</sup> : F 16 L 55/165		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC <sup>5</sup>	F 16 L, E 21 B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	US, A, 4758115 (SHISHKIN et al.) 19 July 1988 see the whole document  --	1,6,7,8
A	GB, A, 2133438 (MITSUI KENSETSU K.K.) 25 July 1984 see abstract  --	1,3
A	GB, A, 2206173 (KURIMOTO LTD) 29 December 1988 see abstract; figures  --	1,5
A	EP, A, 0146331 (I.R. YARNELL) 26 June 1985 see abstract; figures  --	1,2,5
./.		
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>14</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
29th May 1990		26. 06. 90
International Searching Authority		Signature of Authorized Officer
EUROPEAN PATENT OFFICE		 MISS T. TAZELAAR

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	EP, A, 0260341 (H. MÜLLER) 23 March 1988 see figures  --	8,9
A	US, A, 4581247 (E. WOOD) 8 April 1986 see figures (cited in the application)  -----	8

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9000322

SA 34741

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 18/06/90  
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