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(56) Documents Cited:
EP 1394463 A3 **US 5207248 A**
Abstract for JP 60222177 A
WPI Abstract, Acc. No. 1989-147333 & JP 1090069 A

(58) Field of Search:
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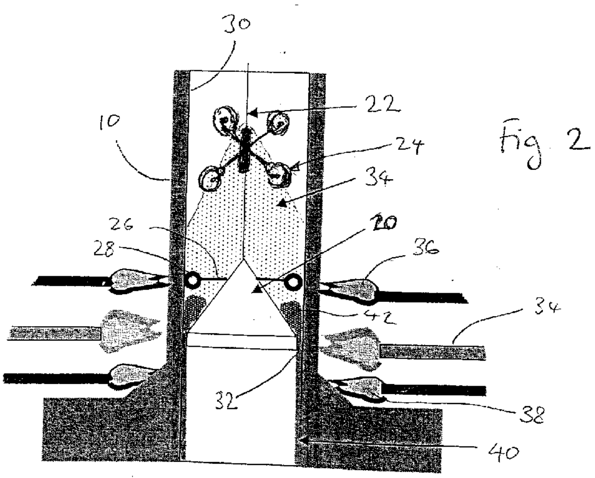
INT CL7 **B05C, B05D, F16L**
Other: **Online: EPODOC, WPI.**

(54) Abstract Title: **Internal coatings for pipes**

(57) A pipe 10 is lined by introducing an applicator body 20 into the pipe interior; spacing the applicator body away from the pipe interior wall to define an annular gap 32; supplying a molten thermoplastic material 42 which enters the annular gap, and moving the applicator body and the pipe relative to each other so that the applicator body passes along the pipe interior. The thermoplastic material exited or exiting from the annular gap is solidified to form the lining 40. Pipes such as christmas tree flowloops having a complex bent geometry may be lined in this way. The melt 32 may be formed from a charge 34 of pulverulent thermoplastic material by a heater 34 that moves with the applicator body 20. Cooling jets 36, 38 may also be provided. Alternatively the melt 42 can be supplied from an extruder, along a flexible conduit passing through the pipe 10 (Fig. 4).



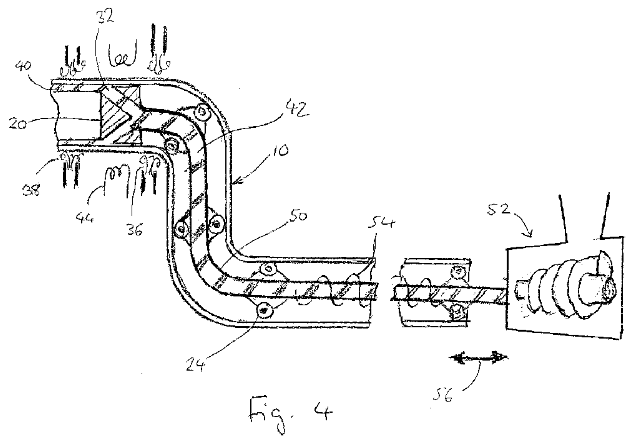


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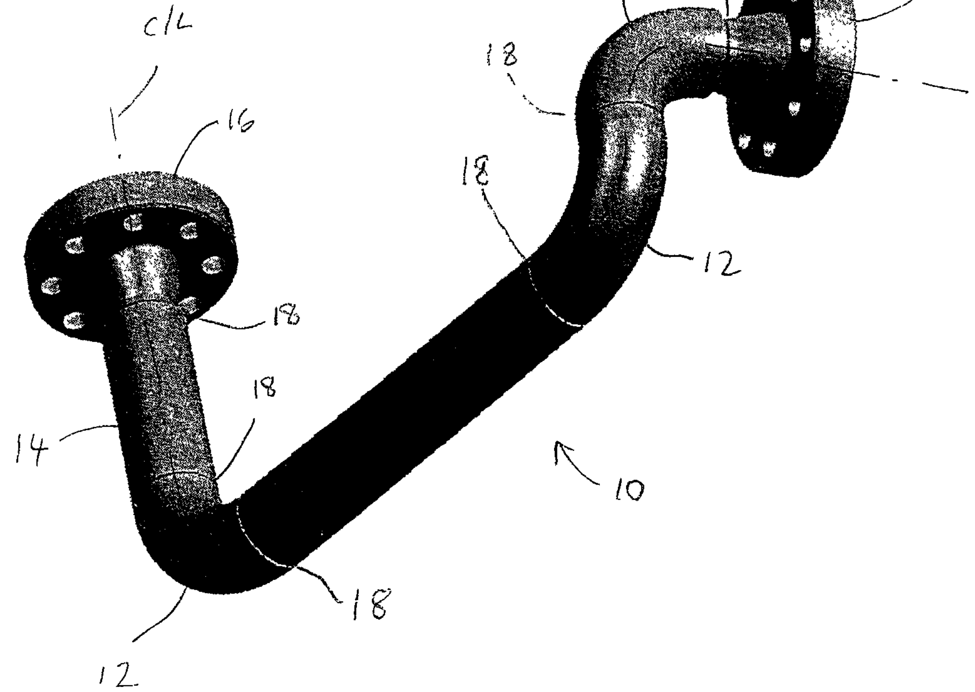
Fig. 1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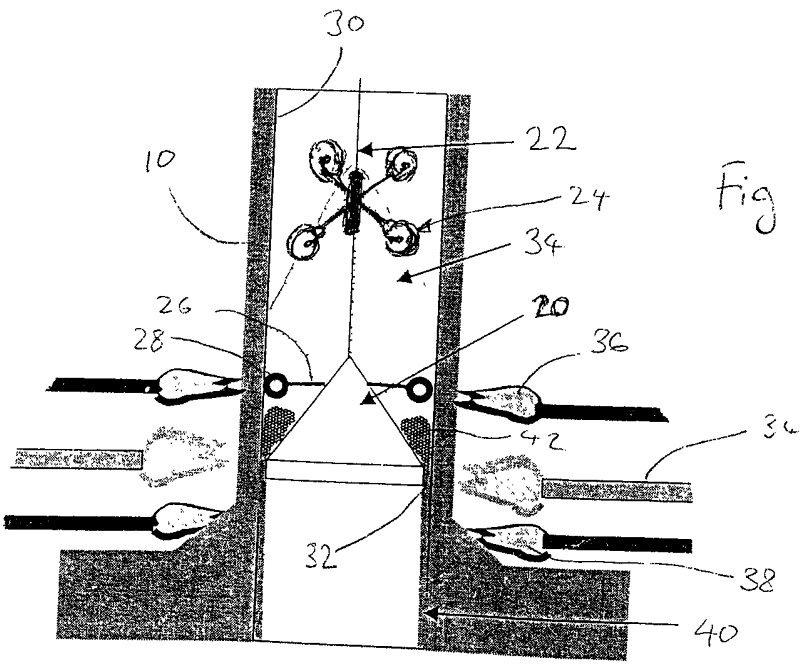
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Fig 2

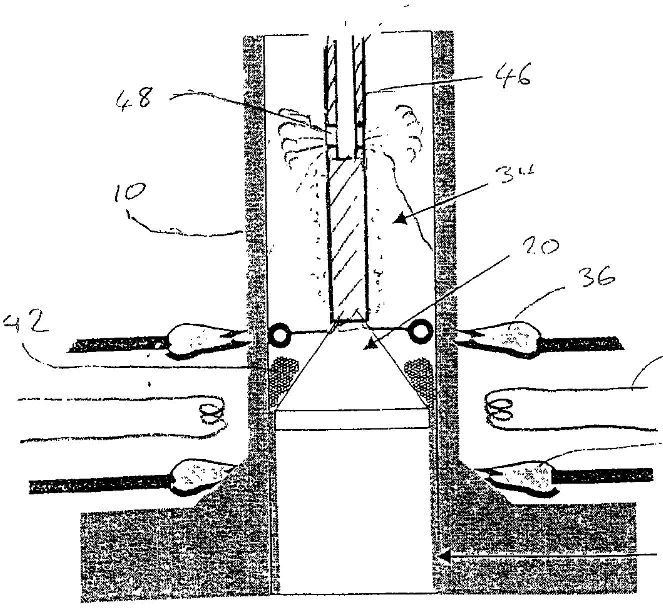

Fig. 3

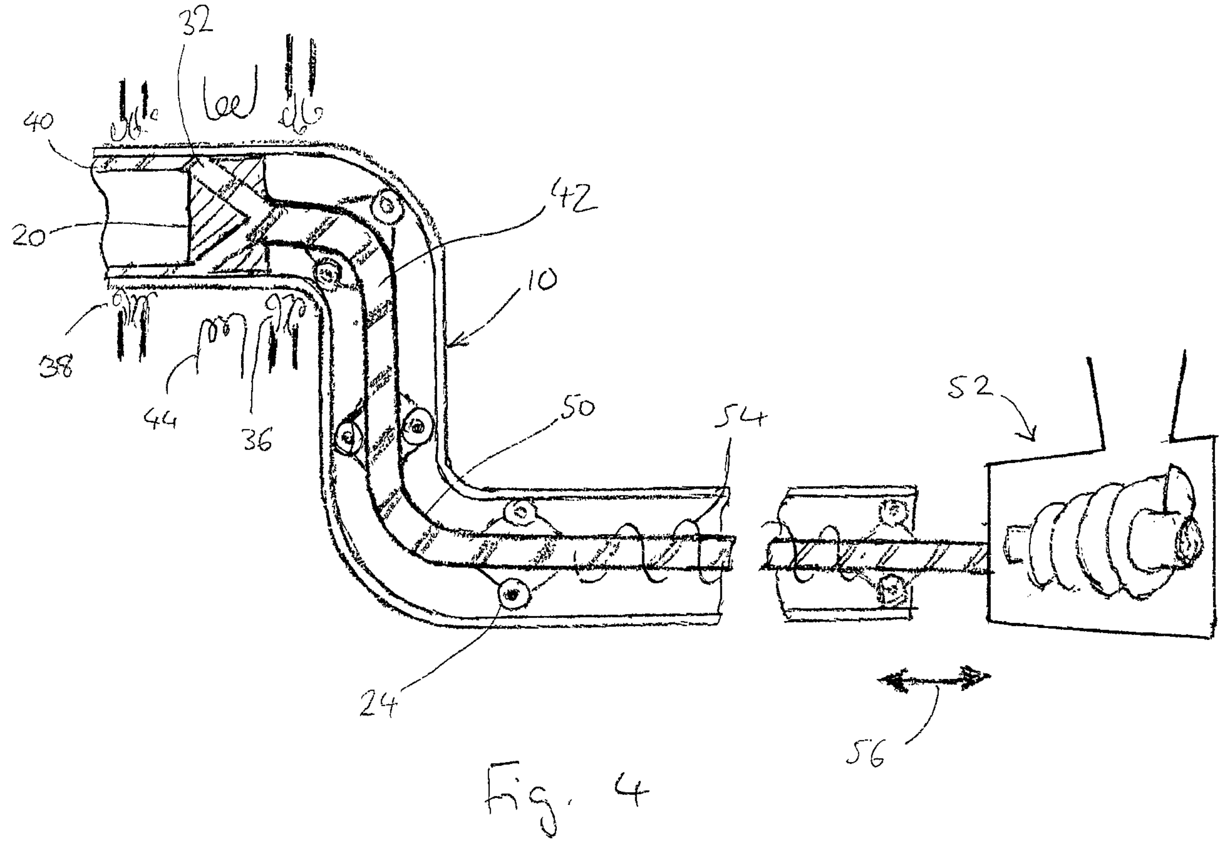

Fig. 4

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INTERNAL COATINGS FOR PIPES

Field of the Invention

This invention relates to a method of applying a coating to the inner surface of a pipe or tube (hereafter "pipe"), and to apparatus for carrying out the method. It is particularly concerned with such a method and apparatus that is effective in internally coating pipes and pipework of restricted diameter or containing sharp or plural bends. An example of such pipework is a flowloop used on a christmas tree for oil and gas production. For brevity, much of the following description is confined specifically to christmas tree flowloops, although the invention is of more general applicability.

Problem to be Solved

Flowloops on christmas trees and other pieces of oilfield equipment are often in contact with highly corrosive fluids which are produced from, or injected into, oil and gas wells. Such flowloops with thick wall sections, complex three dimensional shapes and tight radii of curvature, are fabricated from short lengths of straight pipe welded to bends and flanges. All of these items are either pre-formed form a relatively expensive corrosion resistant material such as super-duplex steel or a nickel based alloy, or are created by weld-overlaying carbon steel with a corrosion resistant alloy. Although it saves on expensive materials, weld-overlaying is itself an expensive and time consuming operation. If a cheaper method could be found of providing a corrosion resistant skin on the inside of a carbon steel pipe, then the cost of producing christmas tree flowloops and other corrosion resistant pipework could be reduced.

Technology exists which allows inexpensive carbon steel pipe to be coated internally with a corrosion resistant polymer. Irrespective of the type of coating, the method of application tends to be the same: coating material is sprayed on to the inside of a pipe using a lance fitted with a rotating spray head. Following spraying, the coating is allowed to cure producing an even dry film along the pipe's length.

The problem with the traditional method of application is that it does not permit the coating of pipework which features either a restricted bore or tight bends. Alternatives have been tried such as using a brush or rollers or by filling the pipe with fluid and allowing this to drain off. Although these can successfully apply the coating round corners there are problems in controlling coating thickness. Additionally pipes with complex geometry present problems with obtaining full curing of the polymer coating, due to volumes of trapped air becoming saturated with solvent vapour.

If a method could be found of controlling the application of the polymer so that full coverage can be obtained, and if this method could also control the coating thickness and simultaneously solidify the coating then a significant technical and commercial advantage could be realised. This would apply not only to lining pipework for resistance to corrosion/erosion/chemical attack, but also when lining pipework for other purposes such as to provide smooth or sanitary finishes, or electrical or thermal insulation.

Summary of the Invention

The present invention provides a method of lining a pipe comprising the steps of:
introducing an applicator body into the pipe interior;
spacing the applicator body away from the pipe interior wall to define an annular gap;
supplying a molten thermoplastic material which enters the annular gap, and
moving the applicator body and the pipe relative to each other so that the applicator body passes along the pipe interior;
and in which method the thermoplastic material exited or exiting from the annular gap is solidified to form the lining. The applicator body thus acts to spread the molten thermoplastic material onto the pipe interior wall and maintains a gauged coating thickness until the coating has solidified. Preferably the applicator body is relatively short in the direction measured along the pipe axis, compared to the transverse dimension of the applicator body, so that it can pass around sharp bends. To maintain an even coating thickness in a pipe of circular cross section, the cross section of the applicator body will also be circular. Other applicator body cross sections can be used to produce even coatings in pipes of other corresponding cross sections. The applicator body can be used to apply a greater range of coating thicknesses (depending on the gap size) than previously known methods capable of coating narrow or highly bent pipes. It also provides improved control of the coating thickness.

The thermoplastic material may be supplied as a charge of pulverulent solids ahead of the applicator body, and which is melted for supply to the gap. The charge may be sufficient to line the entire pipe. However if necessary the charge can be topped up as the lining operation proceeds. This can be by simply feeding further material along the pipe by gravity. Alternatively a flexible conduit or hose can be used to convey further material as a fluidised stream used to top up the charge. The conveyor conduit can extend through the pipe from in front of the applicator body, or it can extend from the other end of the pipe and through the applicator body.

The axis of the annular gap is preferably maintained sufficiently vertical, so that the thermoplastics melt runs into the gap under gravity. Bent pipes are therefore manipulated as the applicator body moves through them, changing the pipe orientation to maintain the gap axis sufficiently vertical.

The applicator body may be drawn through the pipe interior on a tether. This can be provided with a friction reducing coating, balls or rollers, to enable it to be more easily drawn around pipe bends. For long or particularly complex pipe shapes, the applicator body can be drawn through the pipe by a self-propelled pig.

As a further alternative, the thermoplastic material can be supplied as an extruded melt. An extruder may be connected to a flexible conduit extending through the pipe interior to supply the molten material to enter the gap. With this arrangement, there is no need to maintain the annulus axis substantially vertical. Therefore there is no need for pipe orientation manipulation: the pipe and extruder can simply be moved steadily apart to provide an even coating of the thermoplastics material. The conduit may be provided with a friction reducing coating, balls or rollers, like the tether described above. It may also incorporate heaters (e.g. of the electrical resistance type) to maintain the melt at the correct temperature. The conduit may be constructed from a reinforced high melting point polymer such as PTFE, or as a series of articulated metal segments.

The applicator body may be centralised in the interior of the pipe by spider or other supports contacting the pipe and/or solidified liner inner circumference. The applicator body may also comprise coating thickness measuring probe. This may be used for quality control purposes or even to provide feedback signals in a system which actively maintains the applicator body centred within the pipe bore. The thickness probe may for example measure the electrical resistance of the coating at one or more points around the pipe circumference.

The pipe may be heated locally, for example by induction heating, to maintain a melt zone in the thermoplastic material entering the gap. The pipe may be cooled ahead of the melt zone, so as to control the melt zone's size and position. The pipe may be cooled behind the melt zone to assist in solidifying the coating emerging, or that has emerged from, the gap.

Correspondingly, the invention provides pipe lining apparatus comprising:
an applicator body introduced into the pipe interior in use and spaced away from the pipe interior wall to define an annular gap;
a supply of a molten thermoplastic material which enters the annular gap in use, and
means for moving the applicator body and the pipe relative to each other so that the applicator body passes along the pipe interior;
and in which the thermoplastic material exited or exiting from the annular gap is solidified to form the lining.

Illustrative embodiments of the invention are described below with reference to the drawings.

Brief Description of the Drawings

Figure 1 shows a pipe to be lined
Figure 2 is a diagrammatic representation of pipe lining apparatus forming a first embodiment of the invention;
Figure 3 shows a modification of the lining apparatus of Figure1, and
Figure 4 is a diagrammatic representation of pipe lining apparatus forming a second embodiment of the invention.

The pipe lining method and apparatus of the present invention can be used to line pipes 10 of relatively complex geometry as shown in Figure 1, in which the pipework centreline C/L extends in three dimensions. The pipework may be used for example to form a christmas tree flowloop. It is fabricated from a number of bends 12 and straight sections 14, and a pair of connector flanges 16, all united by circumferential welds 18. Alternatively the pipework can be formed by induction bending or any other suitable means.

The lining apparatus shown in Figure 2 comprises a conical applicator body 20 which is drawn through the pipe 10 to be lined, by a tether 22 threaded through the pipe interior. The point of the cone faces in its direction of travel. The tether 22 has a low-friction coating and/or is provided with sets of balls or rollers 24 at intervals along its length, allowing it to be pulled more easily around bends in the pipe 10. The applicator body 20 is centralised in the bore of the pipe 10 by a spider 26 carrying rollers 28 which run along the inside surface 30 of the pipe 10. In this position, an even, annular gap 32 exists between the periphery of the applicator body 20 and the adjacent inside surface of the pipe 10

A charge 34 of powdered or granular thermoplastic material, for example a polymer, is introduced into the pipe interior, so as to lie on top of the applicator body 20. Heat is applied to the pipe by any suitable means; a ring of gas burners 34 being indicated in Figure 1. The pipe is thus heated locally until the melting point of the thermoplastic material 34 has been reached. If required, jets of cooling fluid 36, 38 can play on the outer surface of the pipe above and below the source of the heat. These, together with the intensity of the heat source, control the size of the melt zone 42 in the thermoplastic material. The pipe temperature in the region of the applicator body 20 may be monitored and controlled for this purpose.

The applicator body 20 is then slowly drawn through the pipe 10 interior, while simultaneously moving the source of heat and the cooling jets along the outside of the pipe so as to retain them in alignment with the applicator body 20. The molten thermoplastic is thereby drawn into the radial gap 32 between the applicator body 20 and the pipe inner surface 30 of the pipe 10, and adheres to this surface. The thickness of the resulting coating 40 is controlled by the size of the gap 32. The lower cooling jets 38 help to solidify the coating 40, either before or shortly after it emerges from the gap 32. If required, resistance probes (not shown) can be fitted to the trailing edge of the applicator body 20 and by this means the thickness of the coating can be monitored. If required, further powdered or granular thermoplastics material can be poured down the pipe 10 as the coating process continues, so as to maintain the charge 34.

As the applicator body 20 passes through a bend, the pipe is swivelled so that the cone always points upwards, so ensuring the correct deposition of the powdered material 34, and also ensuring that the melt 42 is drawn evenly into the annular gap 32.

In the modification shown in Figure 3, the gas burners 34 are replaced by an induction heating coil 34. A flexible conduit 46 is also provided for supplying fluidised granular or powdered thermoplastic material entrained in a fluid stream such as compressed air. The fluid stream and entrained material leaves the conduit 46 through apertures 48 so that the thermoplastic particles settle to form the charge 34. The conduit 46 replaces the tether 22 and is used to draw the applicator body through the pipe 10. It may therefore incorporate similar anti-friction measures (not shown) to the tether 22.

An alternative embodiment of the invention is shown in Figure 4. Here the thermoplastics melt 42 is supplied to the applicator body 20 through a flexible conduit 50. This is run through the interior of the pipe 10 and connected to an extruder 52 of known kind. The conduit 50 is provided with anti-friction measures such as rollers 24 at intervals along its length, allowing it to be drawn around bends in the pipe 10 more easily. An electrical resistance heater may be wrapped around the conduit 42 along part or all of its length, as indicated in part at 54, to maintain the melt 42 at the correct temperature.

The pipe 10 and extruder 52 are then moved linearly apart at a steady speed (as indicated by double headed arrow 56), so as to draw the applicator body 20 through the pipe 10 at that speed. The feed rate of the extruder and/or this separation speed is controlled so as to maintain the correct melt pressure and flow rate at the entrance to the annular gap 32. Optionally, heaters and cooling jets 36, 44, 48 may follow the applicator body 20 along the outside of the pipe 10. However the heater 54 in combination with the heating provided in the extruder 52 may be enough to maintain the plastics melt 42, and the resulting coating can be allowed to cool and solidify naturally. In this embodiment, the orientation of the annular gap 32 is largely immaterial, so there is no need for complex manipulation of the pipe 10 as the applicator body 20 is drawn through the pipe bends.

Many modifications will be apparent within the scope of the claims. For example different features of the various described embodiments may easily be combined in ways not specifically described above. The applicator body 20 itself may be heated (e.g. electrically) and/or incorporate passages for cooling fluid, to form or maintain the melt and then cool it before it exits the annular gap 32 to form the lining 40. The necessary power cables and cooling fluid circulation hoses can be incorporated into the tether 22 or conduit 50, or can extend out of the pipe behind the applicator body 20.

CLAIMS

1. A method of lining a pipe comprising thc steps of:
introducing an applicator body into the pipe interior;
spacing the applicator body away from the pipc interior wall to define an annular gap;
supplying a molten thermoplastic material which enters the annular gap, and
moving thc applicator body and the pipe relative to each other so that the applicator body passes along the pipc interior;
and in which method the thermoplastic material exited or exiting from the annular gap is solidified to form the lining.

2. A method of lining as defined in claim 1, in which the applicator body is relatively short in the direction measured along the pipe axis, compared to the transverse dimension of the applicator body.

3. A method of lining as defined in claim 1 or 2 in which the thermoplastic matcrial is supplied as a charge of pulverulent solids ahcad of the applicator body

4. A method of lining as defined in claim 3 in which the charge is topped up as the lining opcration proceeds

5. A method of lining as defined in claim 4 in which further pulverulent solids are fed along thc pipe by gravity.

6. A method of lining as defined in claim 4 in which a flexible conduit is used to convey further material as a fluidised stream used to top up the charge.

7. A method of lining as defined in any preceding claim in which thc axis of the annular gap is maintained sufficiently vertical, so that the thermoplastics melt runs into the gap under gravity.

8. A method of lining as dcfined in claim 7 in which bent pipes are manipulated to change the pipe orientation as the applicator body moves through them.

9. A method of lining as defined in any preceding claim in which the applicator body is drawn through the pipe interior on a tether.

10. A method of lining as defined in claim 9 in which the tether is provided with a friction reducing coating, balls or rollers.

11. A method of lining as defined in any of claims 1 - 8 in which the applicator body is drawn through the pipe by a self-propelled pig.

12. A method of lining as defined in claim 1 or 2, in which the thermoplastic material is supplied as an extruded melt.

13. A method of lining as defined in claim 12 in which an extruder is connected to a flexible conduit extending through the pipe interior to supply the molten material to enter the gap.

14. A method of lining as defined in claim 13 in which the conduit is provided with a friction reducing coating, balls or rollers.

15. A method of lining as defined in claim 13 or 14 in which the conduit comprises a heater.

16. A method of lining as defined in any preceding claim in which the applicator body is centralised in the interior of the pipe by supports contacting the pipe and/or the solidified liner inner circumference.

17. A method of lining as defined in any preceding claim in which the applicator body comprises coating thickness measuring probe.

18. A method of lining as defined in any preceding claim in which the pipe is heated locally to maintain a melt zone in the thermoplastic material entering the gap.

19. A method of lining as defined in any preceding claim in which the pipe is cooled ahead of the melt zone.

20. A method of lining as defined in any preceding claim in which the pipe is cooled behind the melt zone to assist in solidifying the coating.

21. Pipe lining apparatus comprising:
an applicator body introduced into the pipe interior in use and spaced away from the pipe interior wall to define an annular gap;
a supply of a molten thermoplastic material which enters the annular gap in use, and
means for moving the applicator body and the pipe relative to each other so that the applicator body passes along the pipe interior;
and in which the thermoplastic material exited or exiting from the annular gap is solidified to form the lining.

22. Pipe lining apparatus as defined in claim 21, in which the applicator body is relatively short in the direction measured along the pipe axis, compared to the transverse dimension of the applicator body.

23. Pipe lining apparatus as defined in claim 1 or 2 in which in use the thermoplastic material is supplied as a charge of pulverulent solids ahead of the applicator body.

24. Pipe lining apparatus as defined in claim 3 in which in use the charge is topped up as the lining operation proceeds.

25. Pipe lining apparatus as defined in claim 4 in which in use further pulverulent solids are fed along the pipe by gravity.

26. Pipe lining apparatus as defined in claim 4 in which a flexible conduit is used to convey further material as a fluidised stream used to top up the charge.

27. Pipe lining apparatus as defined in any preceding claim in which in use the axis of the annular gap is maintained sufficiently vertical, so that the thermoplastics melt runs into the gap under gravity.

28. Pipe lining apparatus as defined in claim 7 in which in use bent pipes are manipulated to change the pipe orientation as the applicator body moves through them.

29. Pipe lining apparatus as defined in any preceding claim in which in use the applicator body is drawn through the pipe interior on a tether.

30. Pipe lining apparatus as defined in claim 9 in which the tether is provided with a friction reducing coating, balls or rollers.

31. Pipe lining apparatus as defined in any of claims 1 - 8 in which in use the applicator body is drawn through the pipe by a self-propelled pig.

32. Pipe lining apparatus as defined in claim 1 or 2, in which the thermoplastic material is supplied as an extruded melt.

33. Pipe lining apparatus as defined in claim 12 in which an extruder is connected to a flexible conduit extending through the pipe interior to supply the molten material to enter the gap in use.

34. Pipe lining apparatus as defined in claim 13 in which the conduit is provided with a friction reducing coating, balls or rollers.

35. Pipe lining apparatus as defined in claim 13 or 14 in which the conduit comprises a heater.

36. Pipe lining apparatus as defined in any preceding claim in which the applicator body is centralised in the interior of the pipe in use by supports contacting the pipe and/or the solidified liner inner circumference.

37. Pipe lining apparatus as defined in any preceding claim in which the applicator body comprises coating thickness measuring probe.

38. Pipe lining apparatus as defined in any preceding claim in which the pipe is heated locally in use to maintain a melt zone in the thermoplastic material entering the gap.

39. Pipe lining apparatus as defined in any preceding claim in which the pipe is cooled ahead of the melt zone in use.

40. Pipe lining apparatus as defined in any preceding claim in which the pipe is cooled behind the melt zone in use to assist in solidifying the coating.

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Amendments to the claims have been filed as follows

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1. A method of lining a pipe comprising the steps of:
introducing an applicator body into the pipe interior;
spacing the applicator body away from the pipe interior wall to define an annular gap;
supplying a molten thermoplastic material which enters the annular gap, and
moving the applicator body and the pipe relative to each other so that the applicator body passes along the pipe interior;
in which method the thermoplastic material exited or exiting from the annular gap is solidified to form the lining, and in which the applicator body is relatively short in the direction measured along the pipe axis, compared to the transverse dimension of the applicator body, so that the applicator body can pass around sharp bends in the pipe.

2. A method of lining as defined in claim 1 in which the thermoplastic material is supplied as a charge of pulverulent solids ahead of the applicator body

3. A method of lining as defined in claim 2 in which the charge is topped up as the lining operation proceeds

4. A method of lining as defined in claim 3 in which further pulverulent solids are fed along the pipe by gravity.

5. A method of lining as defined in claim 3 in which a flexible conduit is used to convey further material as a fluidised stream used to top up the charge.

6. A method of lining as defined in any preceding claim in which the axis of the annular gap is maintained sufficiently vertical, so that the thermoplastics melt runs into the gap under gravity.

7. A method of lining as defined in claim 6 in which bent pipes are manipulated to change the pipe orientation as the applicator body moves through them.

8. A method of lining as defined in any preceding claim in which the applicator body is drawn through the pipe interior on a tether.

9. A method of lining as defined in claim 8 in which the tether is provided with a friction reducing coating, balls or rollers.

10. A method of lining as defined in any of claims 1 - 7 in which the applicator body is drawn through the pipe by a self-propelled pig.

11. A method of lining as defined in claim 1, in which the thermoplastic material is supplied as an extruded melt.

12. A method of lining as defined in claim 11 in which an extruder is connected to a flexible conduit extending through the pipe interior to supply the molten material to enter the gap.

13. A method of lining as defined in claim 12 in which the conduit is provided with a friction reducing coating, balls or rollers.

14. A method of lining as defined in claim 12 or 13 in which the conduit comprises a heater.

15. A method of lining as defined in any preceding claim in which the applicator body is centralised in the interior of the pipe by supports contacting the pipe and/or the solidified liner inner circumference.

16. A method of lining as defined in any preceding claim in which the applicator body comprises coating thickness measuring probe.

17. A method of lining as defined in any preceding claim in which the pipe is heated locally to maintain a melt zone in the thermoplastic material entering the gap.

18. A method of lining as defined in any preceding claim in which the pipe is cooled ahead of the melt zone.

19. A method of lining as defined in any preceding claim in which the pipe is cooled behind the melt zone to assist in solidifying the coating.

20. Pipe lining apparatus comprising:
an applicator body introduced into the pipe interior in use and spaced away from the pipe interior wall to define an annular gap;
a supply of a molten thermoplastic material which enters the annular gap in use, and
means for moving the applicator body and the pipe relative to each other so that the applicator body passes along the pipe interior;
in which the thermoplastic material exited or exiting from the annular gap is solidified to form the lining, and in which the applicator body is relatively short in the direction measured along the pipe axis, compared to the transverse dimension of the applicator body so that the applicator body can pass around sharp bends in the pipe.

21. Pipe lining apparatus as defined in claim 20 in which in use the thermoplastic material is supplied as a charge of pulverulent solids ahead of the applicator body.

22. Pipe lining apparatus as defined in claim 21 in which in use the charge is topped up as the lining operation proceeds.

23. Pipe lining apparatus as defined in claim22 in which in use further pulverulent solids are fed along the pipe by gravity.

24. Pipe lining apparatus as defined in claim 22 in which a flexible conduit is used to convey further material as a fluidised stream used to top up the charge.

25. Pipe lining apparatus as defined in any of claims 20-24 in which in use the axis of the annular gap is maintained sufficiently vertical, so that the thermoplastics melt runs into the gap under gravity.

26. Pipe lining apparatus as defined in claim 25 in which in use bent pipes are manipulated to change the pipe orientation as the applicator body moves through them.

27. Pipe lining apparatus as defined in any of claims 20-26 in which in use the applicator body is drawn through the pipe interior on a tether.

28. Pipe lining apparatus as defined in claim 27 in which the tether is provided with a friction reducing coating, balls or rollers.

29. Pipe lining apparatus as defined in any of claims –20-26 in which in use the applicator body is drawn through the pipe by a self-propelled pig.

30. Pipe lining apparatus as defined in claim 20, in which the thermoplastic material is supplied as an extruded melt.

31. Pipe lining apparatus as defined in claim 30 in which an extruder is connected to a flexible conduit extending through the pipe interior to supply the molten material to enter the gap in use.

32. Pipe lining apparatus as defined in claim 31 in which the conduit is provided with a friction reducing coating, balls or rollers.

33. Pipe lining apparatus as defined in claim 31 or 32 in which the conduit comprises a heater.

34. Pipe lining apparatus as defined in any of claims 20-33 in which the applicator body is centralised in the interior of the pipe in use by supports contacting the pipe and/or the solidified liner inner circumference.

35. Pipe lining apparatus as defined in any of claims 20-34 in which the applicator body comprises coating thickness measuring probe.

36. Pipe lining apparatus as defined in any of claims 20-35 in which the pipe is heated locally in use to maintain a melt zone in the thermoplastic material entering the gap.

37. Pipe lining apparatus as defined in any of claims 20-36 in which the pipe is cooled ahead of the melt zone in use.

38. Pipe lining apparatus as defined in any of claims 20-37 in which the pipe is cooled behind the melt zone in use to assist in solidifying the coating.

Application No: GB0509003.0 **Examiner:** Dr Richard Gregson

Claims searched: 1-40 **Date of search:** 2 August 2005

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	X: 1,3,4,5,18,21,23,24,26,38, Y: 9,10,,14,29,30,34	Abstract for JP 60222177 A (DKK) - see diagram and English language abstract.
X,Y	X: 1,2,13,15,16,21,26,32,33,35, Y: 9,10,14,29,30,34	WPI Abstract, Acc. No. 1989-147333 & JP 1090069 A (KUBOTA) - see diagram and English language abstract.
Y	9,10,14,29,30,34	EP 1394463 A3 (FORMAR) - see diagrams in particular.
A	n/a	US 5207248 A (SEKI et al) - see diagrams, abstract and column 3, lines 14-60 in particular.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

B2E; B2L

Worldwide search of patent documents classified in the following areas of the IPC^{07}

B05C; B05D; F16L

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI