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(54) Title: PIPE COUPLING

(57) Abstract

A pipe coupling comprising a tubular spigot (1) and a sleeve (3). In use, a free end of the spigot (1) is inserted into an open end of tubular pipe and sleeve (3) is pushed over the end of the pipe so that the pipe is gripped between a spigot (1) and the sleeve (3). The outer surface of the spigot (1) defines a plurality of circumferential ribs (4) and grooves. The outside diameter of the ribs (4) increases in a direction away from the free end of the spigot (1). Each groove is dimensioned such that the groove volume is at least as great as the volume of material displaced as a result of the adjacent rib (4) being forced into the pipe wall as a coupling is assembled. The arrangement is such that an end load on the coupling is distributed between the different grooves regardless of whether or not the pipe wall is relatively thick.

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PIPE COUPLING

The present invention relates to a pipe coupling.

Plastics pipes are widely used in, for example, fuel gas and water distribution networks where it is important that all connections between pipes and between pipes and various applications are very reliable. The connections must be leak proof and strong enough to prevent them from being pulled apart as a result of any end load on the pipe. Such an end load may result from thermal expansion or contraction in the pipes length.

Plastics pipes are generally interconnected end to end by one of a variety of welding processes, it being unnecessary to provide an intermediate coupling of for example metal. There are many instances however where plastics pipes have to be coupled to appliances and in such circumstances the interconnection between the plastics pipe and an appliance spigot pushed into an end of the plastics pipe must be able to resist high end loads. In the British gas industry, couplings are only acceptable if when on test and the being subjected to an end load the plastics pipe fails before the plastics pipe is torn from the coupling.

Medium density polyethylene pipes have been widely used in gas distribution networks and such pipes have generally been interconnected using couplings of the type described in British Patent No. GB 1596112. These couplings essentially comprise a sleeve which is slid over the end of the pipe to be connected and a circumferentially grooved and ribbed tubular spigot which is pushed into the pipe end. The ribs on the spigot have an external diameter greater than the internal diameter of the pipe, whereas the sleeve has an internal diameter approximately the same as the external diameter of the pipe. The coupling is assembled by pulling the sleeve on to the end of the pipe containing the spigot, thus deforming the pipe which is compressed between the sleeve and spigot. Some of the plastics material in the pipe end is forced into the circumferential grooves in the spigot, thereby forming a very strong and leak proof connection. The spigot may of course be integral with an appliance to which the pipe is to be connected, or integral with a coupling body supporting one or more service spigots to enable the interconnection of pipes in any appropriate manner.

There are of course many couplings which are available and which it might be expected would be sufficiently reliable for interconnecting medium density polyethylene pipes in potentially high risk situations such as gas distribution networks. In practice however the alternative couplings have not proved capable of meeting the rigorous test requirements outlined above. It is possible that one reason is that although couplings of a variety of designs can provide acceptable results when used with components of very tightly controlled dimensional accuracy to interconnect pipes with a very accurately controlled wall thickness, where polyethylene pipes are manufactured in large volume there are inevitably variations in the pipe wall thicknesses. As a result the coupling designer cannot be sure that the compression applied to a pipe end can be predicted with accuracy. In the case of the coupling according to British Patent No. GB 1596112, this problem has not caused such severe difficulties as it has been found in practice that an acceptable range of pipe wall thicknesses can be accommodated providing the pipe wall thickness is not so small as to result in only a small volume of material entering the grooves between the circumferential rib. If on the other hand the pipe wall is relatively thick, such that the grooves cannot accommodate all of the material displaced as a result of the ribs being pressed into the inner surface of the pipe wall, the medium density polyethylene is in effect pushed forward by the sleeve along the length of the spigot. A wide groove may be provided to accommodate such longitudinally displaced material.

The development of higher strength polymer materials, e.g. high density polyethylene, has resulted in higher performance pipes now being offered to the gas and water industries for use in their distribution networks. Such pipes have significant operational advantages over medium density polyethylene pipe, but as the pipe is capable of operating at higher stresses and hence, higher pressures, the loads to which the couplings are subjected are significantly higher. The higher stresses and possibly thinner wall sections, have altered the geometrical load distribution within the joint and this can, in certain circumstances, make it difficult to provide couplings which are capable of meeting the type of stringent end load requirements initially drafted for application to couplings using medium density polyethylene pipes. Couplings of the type described in British Patent No. GB 1596112 do provide acceptable results in most circumstances but it has been found on occasions when subjecting such couplings to the standard end load tests that the high density polyethylene pipe fails in the vicinity of the first rib on the spigot, that is the rib closest to the free end of the spigot which is inserted into the pipe end during the coupling assembly procedure. It is thus apparent that the characteristics of the known coupling when used with medium density polyethylene pipes are not precisely reproduced when used with high density polyethylene pipes.

It is an object of the present invention to provide an improved pipe coupling which is capable of obviating or mitigating the problem outlined above.

According to the present invention there is provided a pipe coupling comprising a tubular spigot a free end of which in use is inserted into an open end of a tubular pipe, and a sleeve which in use is pushed onto the pipe end into which the spigot has been inserted so that the pipe end is gripped between the spigot and the sleeve, the outer surface of the spigot defining a plurality of circumferential ribs separated by circumferential grooves, wherein the rib outside diameter increases from the rib nearest to the spigot free end to the rib farthest from the spigot free end, and each groove is dimensioned such that, given a pipe end having a wall thickness equal to the maximum wall thickness with which the coupling is intended to be used, the groove volume is at least as great as the volume of material displaced as a result of the adjacent rib which is closest to the spigot free end being forced into the pipe wall.

As a result of the rib diameter increasing from one end of the spigot to the other, the compressive forces applied to the pipe wall by the first rib, that is the rib nearest to the free end of the spigot which is first pushed into the pipe, is less than the compressive forces resulting from the ribs of greater outside diameter. Thus whether or not the pipe wall is relatively thick, the end load is distributed between the different grooves. Furthermore, as the groove volume is sufficiently large to receive material displaced by the ribs, there is no tendency for material to be forced a considerable distance longitudinally relative to the spigot and this again reduces the stresses to which the pipe is subjected adjacent the radial outer edges of the ribs. It has been found that as a result couplings in accordance with the invention can be used with high density polyethylene so as to achieve good end load resistance. Furthermore the force required to push the sleeve onto the tube end into which the spigot has been inserted is not excessive.

Preferably in each adjacent pair of ribs the rib nearest to the spigot free end has a smaller outside diameter than the other rib of the pair. The difference in outside diameter between one pair of adjacent ribs may be the same as the difference in outside diameter between any adjacent pair of ribs.

Each groove may be defined between two side walls of the immediately adjacent pair of ribs and a base which is parallel to an axis about which the spigot is rotationally symmetrical. Each rib may define a sharp radially outer edge or the rib may be shaped to avoid defining a sharp edge by for example providing a flat radially outer surface. Each rib may be generally conical in cross-section, the cone coming to a point if a sharp rib edge is defined or being truncated to form a frusto-conical cross-section if the radially outer surface of the rib is flat. All the ribs may have substantially the same cone angle in cross section.

The sleeve may define a cylindrical inner wall surface or a frusto-conical inner wall surface. Alternatively the sleeve may define a partially cylindrical inner wall surface, the cylindrical inner surface being joined to a frusto-conical inner wall surface.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a cross-sectional view of a first embodiment of the invention illustrating the relative dimensions of the coupling components and of various possible pipe ends;

Figure 2 illustrates the relative dimensions of adjacent ribs and grooves in the embodiment of Figure 1;

Figure 3 illustrates a second embodiment of the invention in which ribs are provided with flat radially outer surfaces:

Figure 4 illustrates a third embodiment of the present invention in which a tapered sleeve is provided; and

Figure 5 illustrates a fourth embodiment of the invention in which the sleeves have a part cylindrical and part frusto-conical inner surface.

Referring to Figure 1, the illustrated coupling comprises a spigot 1 extending from a flange 2, the flange 2 being intended for connection to any appropriate appliance. A sleeve 3 having chamfered ends may be slipped over the spigot so as to assume the position shown in the fully assembled coupling. In assembling the coupling, the sleeve 3 is first pushed onto and away from the pipe end, this being relatively easy to achieve as the cylindrical inner surface of the sleeve 3 has a diameter equal to the maximum outer diameter of any pipe with which the coupling is intended to be used. After the sleeve has been pushed on to the pipe, the spigot is pushed into the pipe end, causing the pipe end to expand to a relatively small extent. The sleeve is forced back onto the pipe end so as to compress the pipe end and force each of a series of six ribs 4 defined on the outer surface of the spigot into the inner wall of the pipe. The pipe end is thus gripped between the spigot 1 and the sleeve 3.

The outside diameters of the ribs 4 increase progressively from the free end of the spigot 1, that is the end of the spigot remote from the flange 2. It can be seen that the difference in outside diameter between any pair of adjacent ribs is substantially the same for all of the adjacent pairs of ribs. It should also be noted that the width of the grooves defined between adjacent pairs of ribs increases away from the spigot free end. This is to ensure that material displaced by any one rib can be accommodated in the groove which is on the side of that rib remote from the spigot free end.

Figure 1 indicates by line 5 the maximum outside diameter of any pipe which complies with the dimensional tolerances intended to be accommodated by the illustrated coupling. The line 6 indicates the minimum acceptable outside diameter of the pipe, the line 7 the maximum acceptable inner diameter of the pipe and the line 8 the minimum acceptable inner diameter of the pipe. The pipe wall dimensions are also maintained between maximum and minimum wall thicknesses, the distance between line 5 and line 7 corresponding to the minimum wall thickness and the distance between lines 6 and 8 corresponding to the maximum wall thickness. Thus it can be seen that there is a substantial difference in the volume of material to be accommodated in the coupling represented by the difference in the maximum and minimum wall thicknesses.

The width of the grooves between the ribs 4 is selected such that, given a pipe which has a wall thickness corresponding to the maximum acceptable wall thickness, each groove is capable of just accommodating all the material displaced by the immediately adjacent rib on the free spigot end side thereof. This is illustrated in Figure 2. In Figure 2, the line 9 represents the surface of a cylinder located radially inwards from the inner surface of the sleeve 3 of Figure 1 by a distance equal to the maximum pipe wall thickness. The areas labelled 10 are of the same cross-sectional area, and the areas labelled 11 are of the same cross-sectional area. This relationship is maintained along the full length of the spigot. Thus, assuming that any material displaced by a groove is always displaced by the advancing sleeve on to the far side of that groove when viewed in the direction of advance of the sleeve, none of the material displaced by one rib is forced to flow over the crest of the next rib.

Tests conducted with the coupling illustrated in Figures 1 and 2 using high density polyethylene pipe have been found to meet all current test requirements, and in particular the current end-load test requirements as applied in the gas and water distribution industries.

It can be seen from Figure 2 that the base 12 of the groove nearest to the spigot free end is narrower than the base 13 of the next groove which in turn is narrower than the base 14 of the next groove. This increase in base width is necessary to maintain the capacity of each groove to receive material displaced by the adjacent rib on the side nearest to the spigot free end, given the dimensional relationships of the grooves and ribs, that is each rib defining a cone in cross-section with the cone angle being the same for each rib, and each groove having a flat base with all the groove bases lying on a common cylindrical surface centred on the spigot axis. It will of course be appreciated that if desired different ribs and grooves can have different configurations, providing the rib outside diameters increase in the direction away from the spigot free end, and providing each groove is capable of receiving material displaced by the immediately adjacent rib on the side thereof closer to the spigot free end.

It can be seen from Figure 2 that although each rib 4 does not terminate in a radially outer point it is relatively sharp. It is thought that couplings used with certain grades of high density polyethylene will not be adversely affected by such relatively sharp ribbed edge but certain grades may be more prone to a stress cracking phenomena and therefore it may be preferred, in some of these applications, to provide a kerb or flat surface of significant dimensions at the radially outer end of each rib to avoid such potential hazards. Such an arrangement is shown in Figure 3. It should be realised however that given that the effective cross-sectional area of each rib for a particular rib height has been increased, it is also necessary to increase the width of the grooves provided between each adjacent pair of ribs. This is illustrated in Figure 3. It will be noted that in all of the drawings the same lines have been incorporated to illustrate the relative dimensions of the ribs and of the pipe ends. Reference numerals have not been included in Figures 3 to 5.

Referring now to Figure 4, this illustrates a coupling incorporating a spigot identical to that of Figure 1 but a sleeve which has an internal frusto-conical surface rather than a cylindrical surface. Thus the sleeve shown in Figure 4 defines an inner surface which is of slightly greater diameter adjacent the flange as compared with the spigot free end. Such an arrangement could be used to reduce maximum compressions and ease of assembly. It might also be possible with such an arrangement to reduce the overall coupling length.

Referring now to Figure 5, this again shows a spigot and flange arrangement identical to that of Figure 1 but in use with a sleeve having a section adjacent the flange which has a frusto-conical inner surface and a section remote from the flange which has a cylindrical inner surface. Thus the arrangement of Figure 5 exhibit features common to both Figures 1 and 4.

The precise dimensions of the ribs and grooves of an embodiment of the present invention must be selected to take account of the characteristics of the pipe with which the coupling is to be used. Those characteristics include the acceptable manufacturing tolerances which will not be exceeded in any pipe delivered for use. To explain one example of the calculation of the dimensions of a coupling of the type illustrated with reference to Figures 1 and 2, an example is given below of the characteristics of a coupling in accordance with the present invention intended for use with a high density polyethylene pipe having a nominal outside diameter of 125 mm. Currently available high density polyethylene pipe having a nominal outside diameter of 125 mm is manufactured so as to comply with the following tolerances:

Nominal Outside Diameter	125 mm
Maximum Outside Diameter	125.6 mm
Minimum Wall Thickness	11.4 mm
Maximum Wall Thickness	12.7 mm

Given pipe dimensions and tolerances as above, it is then necessary to determine the sleeve internal bore so as to provide a clearance to ensure that the sleeve can be readily pushed onto the pipe end before the spigot is inserted. Appropriate dimensions for the sleeve internal diameter may be selected:

Sleeve Minimum Diameter	125.8 mm
Sleeve Maximum Internal Diameter	125.9 mm

If we assume that the spigot has an internal diameter of 90.9 mm and a wall thickness of 3.2 mm, then the outside diameter of the base of each of the grooves is 97.3 mm. It is then necessary to calculate the height of the first rib such that given a pipe which is just within the maximum tolerances set out above the penetration of the first rib does not exceed a predetermined limit. Tests have shown that an appropriate penetration depth maximum of 13% of the wall thickness is appropriate.

Using this 13% limit, the outside diameter of the pipe when constrained by the sleeve is at least 125.8 mm. Given the maximum wall thickness of 12.7 mm, once the pipe end has been expanded by insertion of the spigot and then pressed down onto the spigot by the sleeve, the pipe would have an internal diameter of 100.4 mm if none of the pipe material was displaced. A 13% penetration of a wall 12.7 mm thick represents a penetration of 1.65 mm and thus the maximum outside diameter of the first groove should be 100.4 mm + 3.3 mm to give a total of 103.7 mm.

Assuming a regular increase in height of the ribs such that the first rib has a maximum outside diameter of 103.7 mm and each subsequent ribs has an outside diameter which is greater than its predecessor by 1.32 mm, similar calculations to that set out above can be conducted to produce the following information assuming use of the coupling with a pipe end of the maximum tolerated wall thickness:

First Rib Max O/D	103.7	Max Penetration	13%
Second Rib Max O/D	105.0	Max Penetration	18.2%
Third Rib Max O/D	106.3	Max Penetration	23.4%
Fourth Rib Max O/D	107.7	Max Penetration	28.6%
Fifth Rib Max O/D	109.0	Max Penetration	33.8%
Sixth Rib Max O/D	110.3	Max Penetration	39%

Assuming a manufacturing tolerance for the outside diameter of the ribs to be 0.1 mm, then if the ribs have the maximum outside diameter stated above it could be that a coupling when produced has grooves with minimum outside diameters of 0.1 mm less than the figures quoted. Assuming these dimensions, and assuming the coupling is used with a pipe having the minimum wall thickness, the following figures can be calculated:

First Rib Minimum O/D	103.6	Minimum Penetration	2.2%
Second Rib Minimum O/D	104.9	Minimum Penetration	8.0%
Third Rib Minimum O/D	106.2	Minimum Penetration	13.8%
Fourth Rib Minimum O/D	107.6	Minimum Penetration	19.6%
Fifth Rib Minimum O/D	108.9	Minimum Penetration	25.3%
Sixth Rib Minimum O/D	110.2	Minimum Penetration	31.1%

It is necessary to calculate the groove widths to ensure that material displaced by any one rib can be accommodated in the immediately adjacent groove. In the case of the example outlined above, assuming the first rib has an outside diameter of 103.7, and its maximum width, that is the width of the rib where it contacts the base of the adjacent groove, is 2.2 mm, then a groove width of 2.2 mm is required giving a pitch of 4.4 mm. Similar calculations can be made for all of the ribs and grooves yielding the following figures:

First Groove	Tooth Width 2.2,	Groove Width 2.2,	Pitch 4.4
Second Groove	Tooth Width 2.9,	Groove Width 3.2,	Pitch 6.2

Third Groove	Tooth Width 3.7,	Groove With 4.6,	Pitch 8.3
Fourth Groove	Tooth Width 4.5,	Groove Width 6.3,	Pitch 10.8
Fifth Groove	Tooth Width 5.2,	Groove Width 8.3,	Pitch 13.6
Sixth Groove	Tooth Width 6.0,	Groove Width 10.7,	Pitch 16.7

Thus the coupling described in detail above is capable of dealing with the full range of pipe wall thicknesses and other dimensions in the case of 125 mm pipes. Similar calculations can be conducted for other pipe dimension, the calculation procedure following the routine set out below:

1. Obtain pipe dimensions and tolerances.
2. Determine sleeve bore to give a clearance on the maximum outside diameter of the pipe.
3. Determine the initial outside diameters of the base of the grooves.
4. Calculate the maximum outside diameter of the first rib using the maximum pipe conditions and a maximum interference of for example 13%.
5. Determine the first rib minimum outside diameter by applying normal manufacturing tolerances.
6. Calculate steps sizes for subsequent grooves based on minimum pipe conditions and experimental results to ensure that with the minimum pipe conditions adequate penetration of the pipe by the ribs is achieved.
7. Calculate the minimum and maximum rib outside diameters for all of the ribs and calculate the penetration and the percentage penetrations for each of the ribs.
8. Determine the rib width and groove width to ensure that material displaced by one rib can be received by the adjacent groove and calculate the pitch therefrom based on maximum pipe conditions.

It will be appreciated that although in the example described above the difference in height of grooves and the initial percentage penetration has been predetermined in a relatively arbitrary manner, it is a simple matter to conduct tests to determine for any particular pipe the percentage penetrations which are appropriate. For example tests can be conducted by testing the end load resistance of a pipe engaged on only the first rib, and then engaged on the first and second ribs, and so on until all six ribs have been engaged. Users can thus have full confidence that the particular dimensions, number of ribs, changes in outer diameters of adjacent ribs etc. will ensure the required performance in all circumstances providing the pipe is within the accepted manufacturing tolerances.

It will be appreciated that it is not necessary for there to be a progressive increase in rib height. For example two adjacent ribs could have the same outside diameters.

CLAIMS:

1. A pipe coupling comprising a tubular spigot a free end of which in use is inserted into an open end of a tubular pipe, and a sleeve which in use is pushed onto the pipe end into which the spigot has been inserted so that the pipe end is gripped between the spigot and the sleeve, the outer surface of the spigot defining a plurality of circumferential ribs separated by circumferential grooves, wherein the rib outside diameter increases from the rib nearest to the spigot free end to the rib farthest from the spigot free end, and each groove is dimensioned such that, given a pipe end having a wall thickness equal to the maximum wall thickness with which the coupling is intended to be used, the groove volume is at least as great as the volume of material displaced as a result of the adjacent rib which is closest to the spigot free end being forced into the pipe wall.

2. A pipe coupling according to claim 1, wherein in each adjacent pair of ribs the rib nearest to the spigot free end has a smaller outside diameter than the other rib of the pair.

3. A pipe coupling according to claim 2, wherein the difference in outside diameter between one pair of adjacent ribs is the same as the difference in outside diameter between any adjacent pair of ribs.

4. A pipe coupling according to any preceding claim, wherein each groove is defined between two side walls of the immediately adjacent pair of ribs and a base which is parallel to an axis about which the spigot is rotationally symmetrical.

5. A pipe coupling according to any preceding claim, wherein each rib defines a sharp radially outer edge.

6. A pipe coupling according to any one of claims 1 to 4, wherein each rib defines a flat radially outer surface.

7. A pipe coupling according to any preceding claim, wherein each rib is generally conical in cross-section.

8. A pipe coupling according to claim 7, wherein all the ribs have substantially the same cone angle in cross-section.

9. A pipe coupling according to any preceding claim, wherein the sleeve defines a cylindrical inner wall surface.

10. A pipe coupling according to any one of claims 1 to 8, wherein the sleeve defines a frusto-conical inner wall surface.

11. A pipe coupling according to any one of claims 1 to 8, wherein the sleeve defines a frusto-conical inner wall surface at the leading end of the sleeve as it is pushed over the spigot and a cylindrical inner wall surface at the other end of the sleeve.

12. A pipe coupling as hereinbefore described with reference to Figures 1 and 2, Figure 3, Figure 4 or Figure 5 of the accompanying drawings.

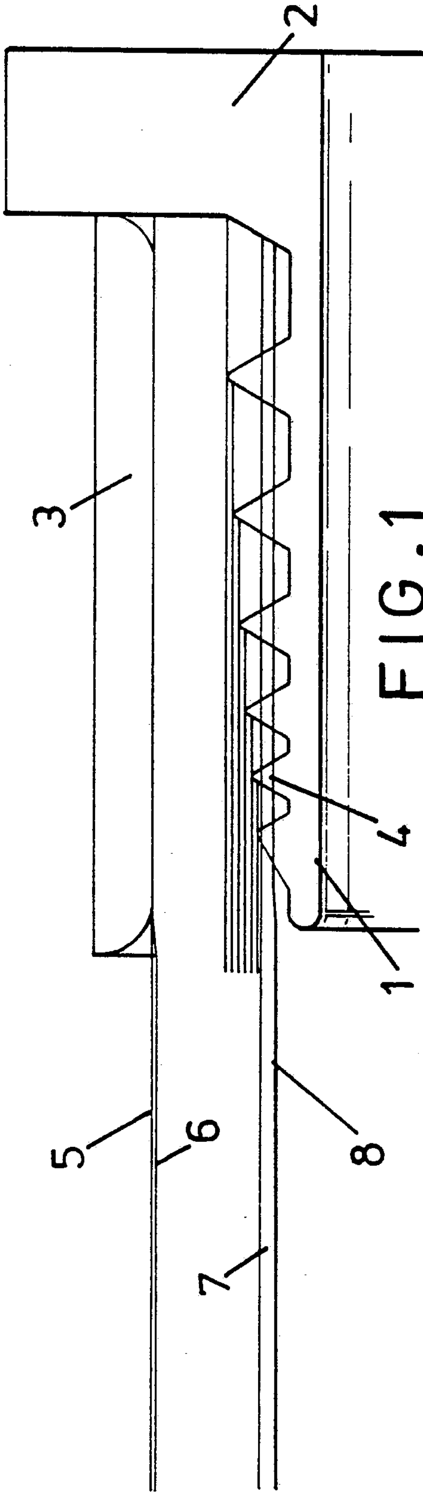

FIG.1

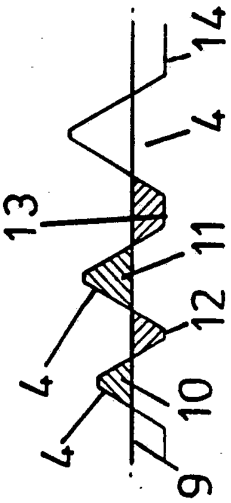

FIG.2

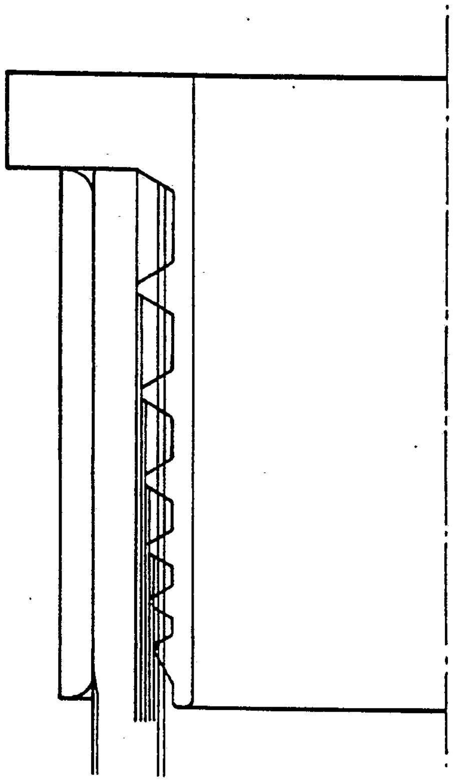

FIG.3

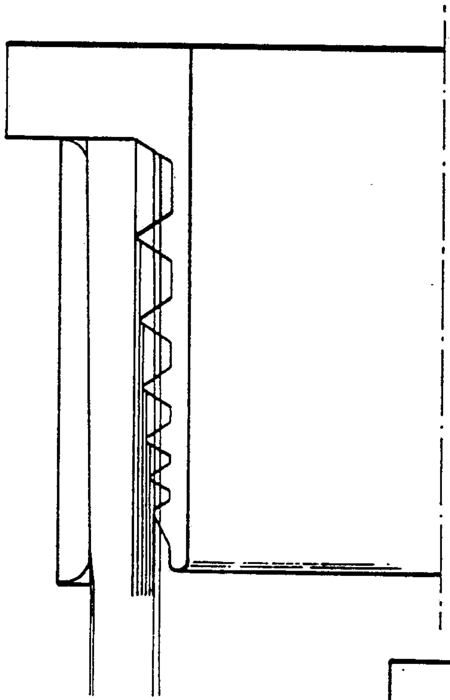

FIG. 4

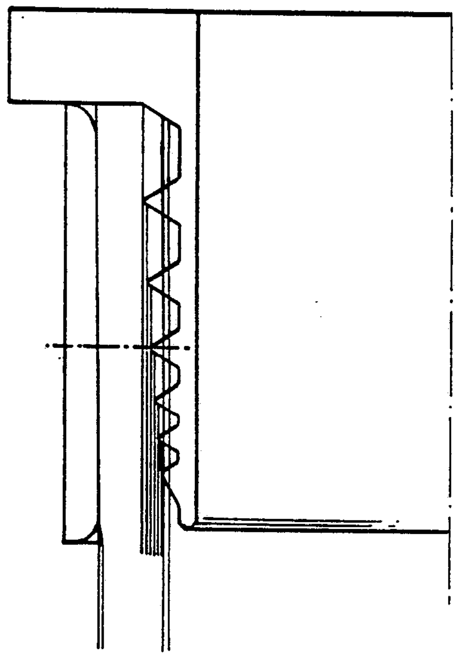

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/00537

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 F16L33/22

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	F16L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
X	US,A,4 257 629 (STEVEN E. MAPLE) 24 March 1981 see the whole document	1
A		2-12
P,A	WO,A,9 216 782 (WASK-RMF LTD) 1 October 1992 see the whole document	1-12
A	EP,A,0 066 742 (RASMUSSEN GMBH) 15 December 1982 see page 4, line 16 - page 8, line 17; figures 1-3	1
A	GB,A,1 185 220 (FREDERICK RUSSELL DUFFIELD) 25 March 1970 see claims 1-7; figures 1-4	1

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° Special categories of cited documents : [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
22 JUNE 1993	09 -07- 1993
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	HENNINGSEN O.

1

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,4 817 997 (THOMAS L. INGRAM) 4 April 1989 see claims 1-13; figures 1-5 -----	1

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

GB 9300537
SA 71927

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 22/06/93
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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WO-A-9216782	01-10-92	AU-A- 1379292	21-10-92
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US-A-4817997	04-04-89	None	

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