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(54) **Fuel injector.**

(57) A fuel injector, eg for a gas turbine engine, has a hollow cylindrical body (12) with a downstream outlet end (18). The body (12) has an inner annular wall (24) with an outwardly flared inner surface (26) defining a downstream end region of an inner air passage (28). The body (12) also has an outer annular wall (30) defining an inner surface of an outer air passage (36). An annular fuel passage (32) is defined between the inner and outer walls (24 and 30). Fuel is supplied to the annular fuel passage (32) via a series of holes (46) provided in the inner wall (24), such fuel being supplied to the holes (46) by bore (52) and groove (50). The outwardly flared inner surface (26) of the inner wall (24) terminates adjacent the downstream outlet end (18) and is directed towards the downstream end (34) of the outer annular wall (30) so that air from the inner air passage (28) meets a fuel film on the inner surface of the outer annular wall (30) at or closely adjacent to the downstream outlet end (18) of the body (12).

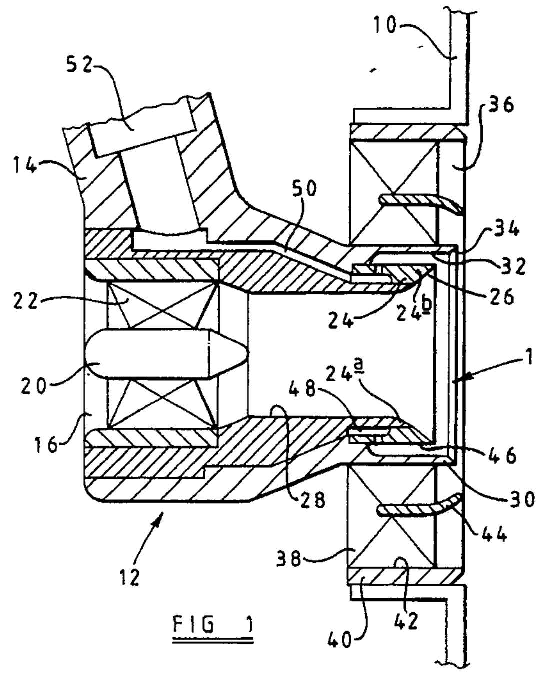

FIG 1

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This invention relates to a fuel injector and is particularly, though not exclusively, concerned with a fuel injector for a gas turbine engine.

In US Patent 4170108, there is disclosed a fuel injector comprising a hollow, generally cylindrical body having a downstream outlet end, an inner annular wall or sleeve having an outwardly flared inner surface defining a downstream end region of an inner air passage in the body, an outer annular wall surrounding the inner annular wall and spaced therefrom so as to define a thin annular fuel passage between the said walls. The outer annular wall has a downstream end terminating at the downstream outlet end of the body and having an outer surface defining part of the inner surface of an outer air passage. A plurality of inclined fuel supply holes open into the annular fuel passage whereby, in use, fuel having a swirl imparted thereto is discharged into the annular fuel passage. In US Patent 4170108, the inclined fuel supply holes are provided in the outer annular wall and discharge from the outside inwardly into the annular fuel passage with the object of providing a substantially single annular flow of fuel on the internal surface of the outer annular wall. The swirling fuel then proceeds as a film along the annular fuel passage to contact air from the inner air passage at a location which is substantially half way between the position of the fuel supply holes and the downstream end of the outer wall. The film of fuel then continues along the inner surface of the outer annular wall along with the air from the inner air passage before being discharged through the downstream outlet end of the body and atomised as a result of a shearing effect between air which has passed through the inner air passage and air which has passed through the outer air passage. There remains, however, the need for an even greater atomization of fuel.

In US Patent 4373325, similar problems to those outlined above for the fuel injector of US Patent 4171018 can also arise. Furthermore, it is undesirable for a thin film of fuel travelling over a relatively long distance before atomization to be exposed to the very high temperatures which exist in a gas turbine flame tube. Under these conditions, it is possible for the fuel to decompose or "crack", thereby leading to the formation of carbon deposits which can seriously disrupt the desired fuel pattern. Also shedding of carbon deposits can lead to turbine blade damage.

It is an object to the present invention to obviate or mitigate the above disadvantages.

According to the present invention, there is provided a fuel injector comprising a hollow, generally cylindrical body having a downstream end, an inner annular wall having an outwardly flared inner surface defining a downstream end region of an inner air passage in the body, an outer annular wall surrounding the inner annular wall and spaced therefrom so as to define an annular fuel passage between said walls, said outer annular wall having a downstream end terminating at the downstream outlet end of the body and having an outer surface defining an inner surface of an outer air passage, and one or more inclined fuel supply holes opening into the annular fuel passage whereby, in use, fuel having a swirl imparted thereto is discharged into the annular fuel passage, forms a film on the inner surface of the outer wall and is subsequently mixed with air passing through the inner and outer air passages; wherein the fuel supply holes are provided in the inner wall so as to discharge outwardly of the latter into the annular fuel passage, and wherein the outwardly flared inner surface of the inner wall terminates adjacent said downstream outlet end of the body and is directed towards the downstream end of the outer annular wall whereby, in use, air from the inner air passage meets the fuel film at or closely adjacent to the downstream outlet end of the body.

With the above described fuel injector, the arrangement of fuel supply hole(s) which discharge outwardly into the annular fuel passage causes the fuel to impinge against the inner surface of the outer annular wall which lies opposite the holes so that a more effective film of fuel on said inner surface can be established. Additionally, the termination of the outwardly flared inner surface of the inner wall at or closely adjacent the downstream end of the body ensures that the film of fuel does not have to travel in an exposed condition for a long distance, with the result that carbon formation is mitigated. Furthermore, the above-described arrangement enables the air from the inner air passage to meet the fuel at or adjacent the location at which the fuel meets the air from the outer air passage, thereby leading to improved atomization of the fuel.

In one embodiment, the inner surface of the outer annular wall is substantially cylindrical.

In another embodiment, the inner surface of the outer annular wall tapers slightly inwardly towards the outlet end of the body. In such an embodiment, it is preferred for the distance between the inner and outer annular walls to reduce towards the outlet end of the body. The outer surface of the outer annular wall may also converge towards the outlet end of the body.

The present invention is particularly applicable to fuel injectors wherein means are provided for imparting a swirl to at least the air which passes through the inner air passage and, more preferably, both air passages. Such swirl may be in the same or opposite sense to the swirl imparted to the fuel.

The fuel supply holes, which may take the form of bores, slots or gaps in the inner annular wall, are inclined so as to impart a swirl to the fuel passing therethrough in the circumferential direction relative to the annular fuel passage. In addition, such fuel supply holes may be directed so as to discharge fuel into the annular fuel passage in an upstream direction, or they may discharge fuel outwardly against a region of the outer surface of the fuel passage which lies in the same plane as the fuel supply holes.

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

Fig. 1 is an axial section through one embodiment of fuel injector according to the present invention,

Fig. 2 is a cross-section through part of the fuel injector illustrated in Fig. 1,

Fig. 3 is an axial section through a second embodiment of fuel injector according to the present invention, and

Fig. 4 is a cross-section through part of the fuel injector of fig 3.

Referring now to Figs 1 and 2 of the drawings, the fuel injector illustrated therein is for mounting in a wall 10 of a combustor of a gas turbine engine. The fuel injector comprises a composite, generally cylindrical hollow body 12 having a support arm 14. The body 12 has an inner air inlet 16 at an upstream end thereof and a downstream outlet end 18. Adjacent the inner air inlet 16 there is provided a central boss 20 carrying a series of swirler blades 22 disposed so as to impart a swirl to air entering the body 12 through the inlet 16.

The body 12 further comprises a relatively thick inner annular wall 24 having an outwardly flared inner surface 26 defining a downstream end region of an inner air passage 28 passing through the body 12 from the inlet 16 to terminate just short of the outlet end 18 of the body 12. The inner wall 24 is defined partly by inner wall part 24a and partly by inner wall part 24b.

The body 12 further includes a relatively thin outer annular wall 30 which surrounds the inner annular wall 24 and is spaced therefrom so as to define an annular fuel passage 32 therebetween. The outer annular wall 30 has a shallow flared downstream end 34 terminating at the outlet end 18 of the body 12. The inner surface of the outer annular wall 30 is cylindrical for most of its length, with the axis of the cylinder being coincident with the longitudinal axis of the body 12. The outer surface of the outer annular wall 30 defines the inner surface of an outer air passage 36 defined between swirler blades 38 mounted so as to extend between the outer annular wall 30 and an outer annular sleeve 40. The outer annular sleeve 40 serves to locate the downstream end of the fuel injector in the wall 10. In this embodiment, the inner surface 42 of the sleeve 40 is cylindrical, having its axis coincident with the longitudinal axis of the injector. In this embodiment, an annular splitter 44 is mounted on the blades 38 between the outer wall 30 and the sleeve 40. The splitter 44 has a downstream end region which is curved inwardly.

The outer surface of the inner wall 24 is also cylindrical with its longitudinal axis coincident with that of the fuel injector. However, as can be seen from Fig. 1, the outer surface of the inner wall 24 does not extend as far downstream as the inner surface of the outer wall 30, but nevertheless terminates adjacent to the outlet end 18 of the body 12. The outwardly flared inner surface 26 lies on substantially the same frustconical surface as the flared end 34 of the outer annular wall 30.

The annular fuel passage 32 has a closed upstream end defined by a curved internal surface region of outer wall 30. A series of four discrete fuel discharge holes 46 in the form of bores are provided through part of the inner annular wall 24, although a larger or smaller number of holes 46 may be provided. These holes 46 extend in a common plane which is perpendicular to the longitudinal axis of the fuel injector. However, within such plane, the holes 46 are skewed (as shown in Fig. 2) so as to discharge against regions of the outer cylindrical surface of the fuel passage 32 which lie in such plane, but nevertheless impart a swirl to fuel discharge onto such surface. The holes 46 communicate at their inner ends with a common chamber 48 in the inner wall 24 fed with fuel in use by groove 50 and bore 52 in arm 14.

In use, liquid fuel is passed through bore 52 and groove 50 into common chamber 48 from where it passes through the holes 46 so as to have a swirl imparted thereto before being discharged outwardly against the cylindrical outer surface of the annular fuel passage 32. This action is very effective in producing a thin film of liquid fuel which progresses in a helical fashion along the outer surface of the annular fuel passage 32 towards the outlet end 18. Simultaneously with this, air entering the inlet 16 has a swirl imparted thereto by blades 22 and travels along the passage 28. The positioning of the outwardly flared inner surface 26 in the manner described above causes such inner swirling air stream to be discharged as a conically expanding stream which impinges against the fuel passing along the inner surface of the outer wall 30 at or just before the fuel reaches the flared end 34. It will be appreciated that, because of the above-described arrangement, the fuel does not have to travel a relatively great distance whilst exposed to the heat of the combustion chamber before it reaches the flared downstream end 34 of the outer sleeve 30. At the same time also, air passes through the outer air passage 36 and has a swirl imparted thereto by the blades 38 before being discharged through the downstream end of the injector as a swirling airstream. Because of the above-described design, the outer swirling airstream and the inner swirling airstream impinge against the liquid fuel substantially simultaneously and thereby promotes very efficient atomization of the liquid fuel into very fine droplets which are carried into the combustor and burnt efficiently therein. The splitter 44 serves to impart a slight inward movement of part of the air passing through the outer air passage 36 so as to enhance further the interaction between the outer swirling air and the fuel.

Referring now to the fuel injector illustrated in Figs 3 and 4, this is similar to that illustrated in Figs. 1 and 2 and similar parts are accorded the same reference numerals but in the 100 series.

In this embodiment, the outer surface of annular fuel passage 132 converges slightly so as to be of frusto-conical form rather than cylindrical form, with the frusto-conical surface converging in the direction of outlet end 118. The outer surface of outer annular wall 130 curves slightly inwardly so that downstream end 134 of wall 130 is defined by an annular line rather than a frusto-conical surface. The end 134 lies a short distance downstream of the downstream end of inner annular wall 124. As can be seen from Fig. 3, the continuation of inner surface 126 of wall 124 intersects the inner surface of wall 130 at a location which is just upstream of end 134.

Fuel discharge holes 146 are not only skewed as shown in Fig. 4 to impart a swirl to the fuel passing therethrough, but are also inclined outwardly in the upstream direction (see Fig. 3) so as to discharge fuel against the curved upstream end of annular fuel passage 132. Inner surface 142 of outer annular sleeve 140 is frusto-conical rather than cylindrical and tapers inwardly in the downstream direction. These changes are designed to promote an even more effective atomization of fuel and to reduce even further the risk of carbon building up as a result of decomposition or "cracking" of the fuel under the extreme temperatures experienced in the combustor in service. In a further modification, an upstream region of the surface 142 is cylindrical (like surface 42) whilst the remaining downstream region tapers inwardly.

In both of the above-described embodiments, the air flows have a swirl imparted thereto which is in the same direction as that imparted to the fuel. However, it is within the scope of the invention to arrange for the air flows to have a swirl imparted thereto which is in the opposite direction to that imparted to the fuel

If desired, the flow splitter 44 or 144 may be omitted.

The injectors described above produce a conical air/fuel stream which is very stable and shows no tendency to flicker or oscillate, and produce very fine droplets.

Claims

1. A fuel injector comprising a hollow, generally cylindrical body (12;112) having a downstream outlet end (18;118), an inner annular wall (24;124) having an outwardly flared inner surface (26;126) defining a downstream end region of an inner air passage (28;128) in the body, an outer annular wall (30;130) surrounding the inner annular wall (24; 124) and spaced therefrom so as to define an annular fuel passage (32; 132) between said walls (24,30;124,130), said outer annular wall (30;130) having a downstream end (34;134) terminating at the downstream outlet end (18;118) of the body (12;112) and having an outer surface defining an inner surface of an outer air passage (36;136), and one or more inclined fuel supply holes (46;146) opening into the annular fuel passage (46;146) whereby, in use, fuel having a swirl imparted thereto is discharged into the annular fuel passage (32;132), forms a film on the inner surface of the outer annular wall (30;130) and is subsequently mixed with air passing through the inner and outer air passages (28 and 36; 128 and 136); wherein the fuel supply holes (46;146) are provided in the inner annular wall (24;124) so as to discharge outwardly of the latter into the annular fuel passage (32;132), and wherein the outwardly flared inner surface (26;126) of the inner annular wall (24;124) terminates adjacent said downstream outlet end (18;118) of the body and is directed towards the downstream end (34;134) of the outer annular wall (30;130) whereby, in use, air from the inner air passage (28;128) meets the fuel film at or closely adjacent to the downstream outlet end (18;118) of the body (12;112).

2. A fuel injector as claimed in claim 1, wherein the inner surface of the outer annular wall (30) is substantially cylindrical.

3. A fuel injector as claimed in claim 1, wherein the inner surface of the outer annular wall (130) tapers inwardly towards the outlet end (118) of the body (112).

4. A fuel injector as claimed in claim 3, wherein the distance between the inner and outer annular walls (124 and 130) reduces towards the

outlet end (118) of the body (112).

5. A fuel injector as claimed in claim 3 or 4, wherein the outer surface of the outer annular wall (130) converges towards the outlet end (118) of the body (112).

6. A fuel injector as claimed in any preceding claim, further including means (22;122) for imparting a swirl to the air which passes, in use, through the inner air passage (28;128).

7. A fuel injector as claimed in any one of claims 1 to 5, further including respective means (22 and 38; 122 and 138) for imparting a swirl to air which passes in use through the inner and outer air passages (28 and 36; 128 and 136).

8. A fuel injector as claimed in any preceding claim, wherein the fuel supply holes (46;146) are inclined so as to impart a swirl to the fuel passing therethrough in the circumferential direction relative to the annular fuel passage (32;132).

9. A fuel injector as claimed in any preceding claim, wherein the fuel supply holes (146) are directed so as to discharge fuel into the annular fuel passage (132) in an upstream direction.

10. A fuel injector as claimed in any one of claims 1 to 8, wherein the fuel supply holes (46) are directed so as to discharge fuel outwardly against a region of the outer surface of the annular fuel passage (32) which lies in the same plane as the fuel supply holes (46).

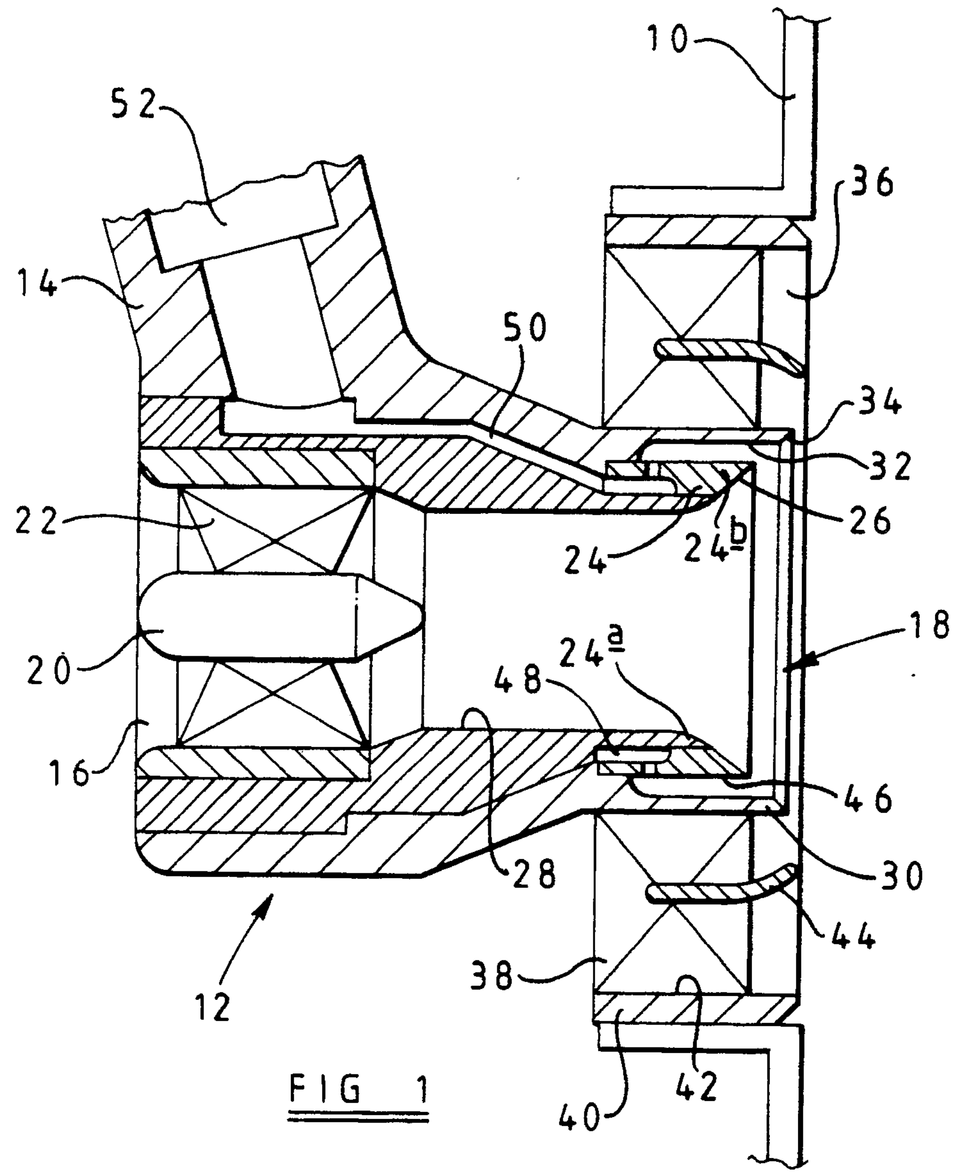
10
36
52
14
50
34
32
22
26
24
24b
18
24a
20
48
16
46
30
28
44
38
12
40
42

FIG 1

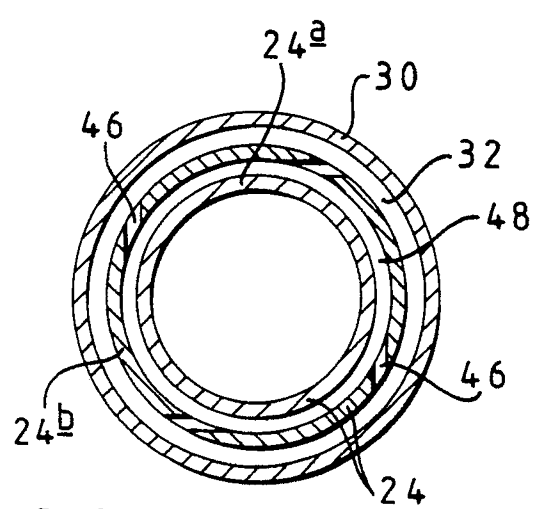
24a
30
46
32
48
46
24b
24

FIG 2

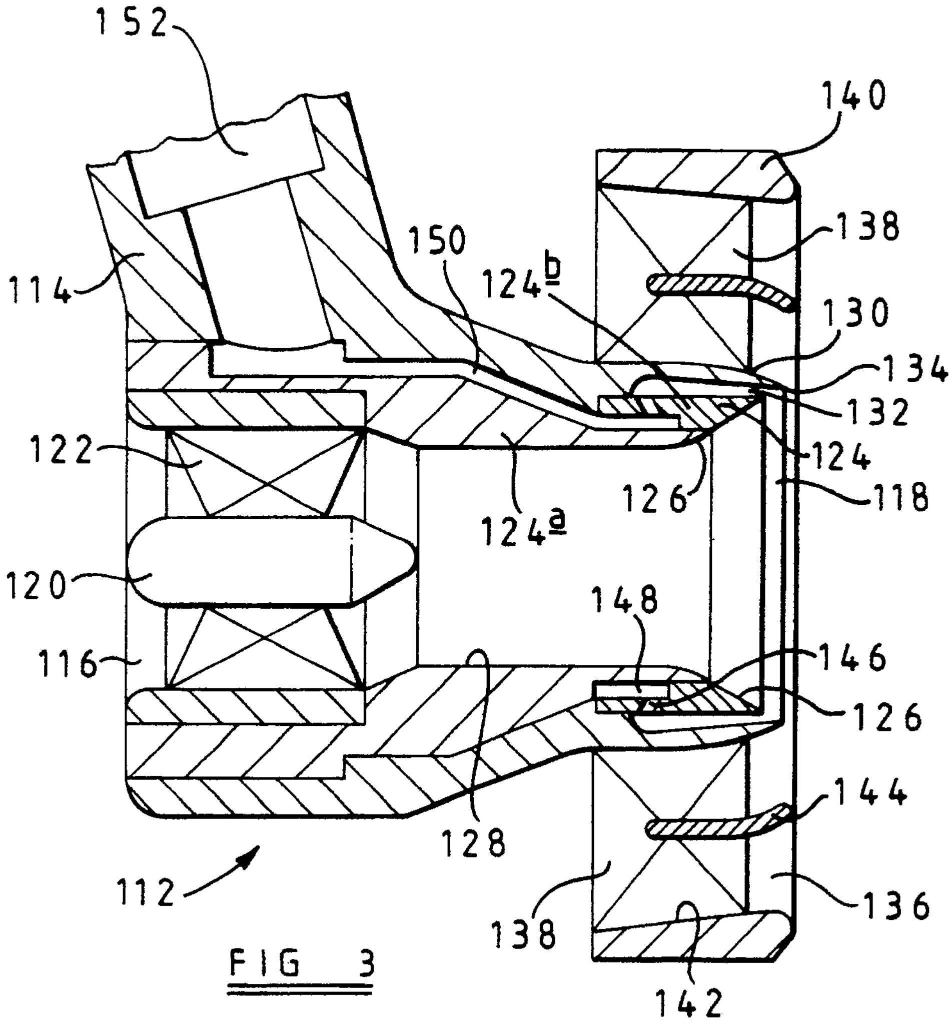
152
140
138
114
150
124b
130
134
132
122
124
126
118
124a
120
148
146
116
126
144
128
112
136
138
142

FIG 3

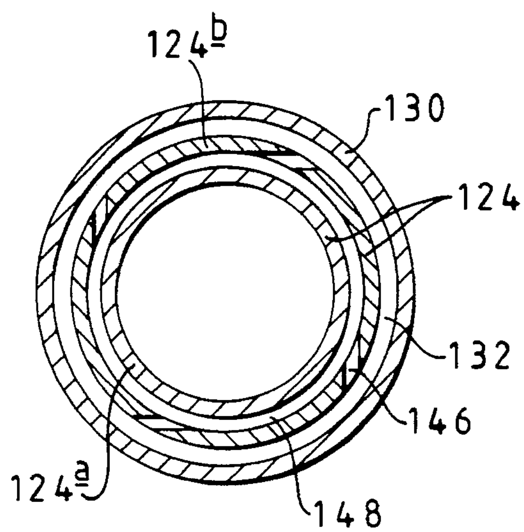
124b
130
124
132
146
124a
148

FIG 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91301296.9

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US - A - 4 170 108 (MOBSBY) * Totality *	1-3, 5-9	F 02 C 7/22
Y	US - A - 4 216 652 (HERMAN et al.) * Totality *	1-3, 5-9	
A	US - A - 3 980 233 (SIMMONS et al.) * Fig. 1-3 *	1,3, 5-7	
D,A	US - A - 4 373 325 (SHEKLETON) * Totality *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F 02 C 7/00
F 23 R 3/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	08-05-1991	PIPPAN

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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