(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 569 808 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: **93107123.7**

(22) Date of filing: **03.05.93**

(51) Int. Cl.^{5}: **F28F 9/00**, F28F 9/22, F28F 19/00, F28F 21/06

(30) Priority: **09.05.92 GB 9210069**
25.07.92 GB 9215853

(43) Date of publication of application:
18.11.93 Bulletin 93/46

(84) Designated Contracting States:
DE FR GB

(71) Applicant: **BTR INDUSTRIES LIMITED**
Silvertown House
Vincent Square
London, SW1P 2PL(GB)

(72) Inventor: **Hughes, Stephen John**
45 Stroud Road,
Shirley
Solihull, West Midlands B90 2JU(GB)

(74) Representative: **Treves, Barry William**
BTR Group Patent & Trade Mark Service
P.O. Box 504,
Fort Dunlop
Erdington Birmingham B24 9OH (GB)

(54) **Heat exchanger.**

(57) A heat exchanger such as a fuel/oil heat exchanger for use in an aircraft operates in an environment whereby the heat exchanger is caused to vibrate. This causes the various components to move relative to one another, for example the tubes (3,33) move relative to the baffle plates (5,15) and results in tube wear known as fretting. In the extreme perforation (failure) of the tubes occurs.

In the heat exchanger of the present invention an internal member such as a baffle plate (5,15) or a distance tube (7) against which the fuel tubes (3,13) move are made of polyetheretherketone (PEEK) (trade name: ARLON) or polyamide imide (trade name: TORLON), which has a low coefficient of wear. It also has the required structural rigidity and strength properties within the operating temperature. Furthermore the coefficient of thermal expansion of the material of the internal member is greater than that of the material e.g. aluminium alloy, of the remaining components.

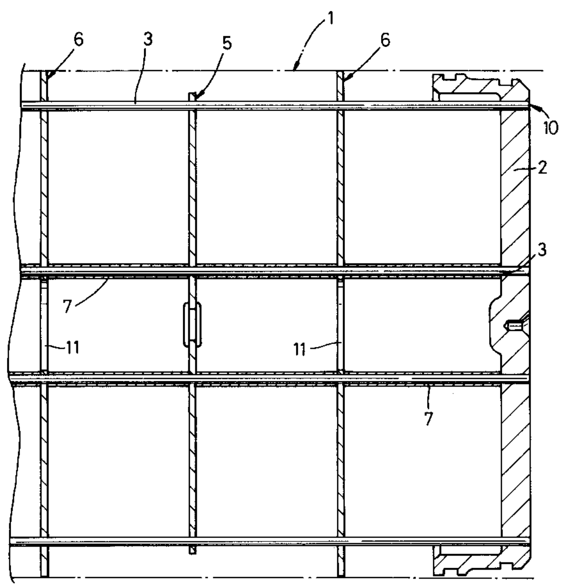

Fig. 1

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This invention relates to a heat exchanger. In particular this invention relates to a shell and tube type heat exchanger such as are used in aircraft in association with the aircraft engines, for example to cool the engine oil or to pre-heat aviation fuel. The tubes of the heat exchangers have to be thin-walled to provide the necessary heat transfer properties and to keep weight to a minimum. A typical tube has a diameter of 2.5 mm and a wall thickness of 0.25 mm.

One problem encountered with the tubes of aircraft heat exchangers is that of wear. The tubes each pass through a hole in a baffle and/or a distance tube, which baffle or distance tube helps to define the flow path of fluid around the tubes and provide support for the tubes. However, because of external vibration the tube moves relative to the baffle and distance tube and a groove can be worn in the tube surface. In the extreme, the tube may be punctured allowing the two heat exchange fluids, one outside and the other inside the tubes, to mix.

It is an object of the present invention to provide a heat exchanger in which the above mentioned wear problem is reduced or overcome.

In accordance with the invention an internal member of a heat exchanger has a low coefficient of wear. The member preferably comprises polyetheretherketone (PEEK) thermoplastic material, which may be reinforced. An alternative preferred material for the member is polyamide imide material, which may be reinforced. These materials each have a relatively low coefficient of wear and/or friction so the wear caused by movement of the heat exchange tube against the member is reduced and also a higher coefficient of thermal expansion than aluminium alloy used for the main components of the heat exchanger. The materials provide sufficient structural rigidity and strength over the required working temperature range of approximately minus 65 °F to plus 400 °F (minus 55 °C to plus 235 °C) and are inert to the fluids e.g. oil or aviation fuel passing through the heat exchanger. The materials also have suitable creep resistance.

Two examples of an internal member in accordance with the invention are a baffle and a distance tube.

The invention also includes a heat exchanger incorporating an internal member as aforesaid.

Two embodiments of the invention will now be described by way of example only with reference to the accompanying drawings of which:-

Figure 1 shows a partial longitudinal cross-sectional view of a heat exchanger for use in an aircraft;

Figure 2 shows a plan view of a baffle plate of the heat exchanger shown in Figure 1;

Figure 3 shows a partial longitudinal cross-sectional view of another heat exchanger for use in an aircraft; and

Figure 4 shows a cross-section on line A-A of Figure 3.

The first embodiment, shown in Figures 1 and 2, is a heat exchanger for use in an aircraft, comprising a cylindrical shell (shown in dotted outline at 1) an end plate 2, a plurality of thin-walled tubes 3 (only one shown) baffle plates 5 and 6 and distance tubes 7.

The thin-walled tubes 3 of suitable aluminium alloy are mounted in conventional manner in holes 10 in the end plate 2 (also of aluminium alloy) and passed parallel to one another along the length of the exchanger to another plate at the other end of the exchanger.

The tubes also pass through holes in baffles 5 and 6. The baffles referred to at 5 have a smaller diameter than the internal periphery of the shell 1, are made of aluminium alloy or PEEK (polyetheretherketone) and ensure that fluid passing around the tubes has to pass between the internal surface of the shell 1 and periphery of the baffle 5.

The other baffles shown at reference number 6, have a larger diameter than the baffles 5 and are made of PEEK (polyetheretherketone) as above. Each baffle 6 has an outer diameter which is the same as or slightly less than the internal diameter of the shell, is formed with a plurality of holes through which the thin-walled tubes 3 pass and are supported thereby. Each baffle 6 is further formed with a large central hole 11. Heat exchange fluid passing outside the thin-walled tubes 13 is thus directed through the central hole 11 rather than passing around the outer periphery of this baffle 6.

The baffles 5 and 6 are spaced apart from one another and from the end plates 2 by means of distance tubes 7 mounted coaxially on some of the thin-walled tubes 3. These distance tubes are also made of PEEK but of lower grade since they do not have to provide the same level of support as the baffle 6.

The second embodiment, shown in Figures 3 and 4, comprises a heat exchanger for use in an aircraft comprising a cylindrical shell (shown in dotted outline at 111) end plates 12, a plurality of thin-walled tubes 13 (only some shown) and baffle plates 15. In use aviation fuel flows through the tubes and oil around the outside of the tubes.

The thin-walled tubes 13 of suitable aluminium alloy are mounted in conventional manner in holes in the end plates 12 (also of aluminium alloy) and passed parallel to one another along the length of the exchanger from one end plate to the other.

The tubes 13 also pass through holes in the baffles 15, each made of polyamide imide and sold under the trade name TORLON (Amoco Chemicals Ltd). The baffles 15 each have an outer diameter which is the same as or slightly less than the internal diameter of the shell 111, are each formed with a plurality of holes through which the thin-walled tubes 13 pass and are supported thereby. Each baffle 15 has a segment cut away and the baffles are arranged so that alternate baffles have cut-away portions at the top and then the bottom of the exchanger. The oil thus flows along the tortuous path as shown in Figure 3.

The baffles 15 may be spaced apart from one another and from the end plates 12 by means of distance tubes (not shown) mounted coaxially on some of the thin-walled tubes 13. These distance tubes are also made of polyamide imide material.

In use if either of the heat exchangers described above is subject to vibration, thereby causing the thin-walled tubes to move relative to the baffles and/or distance tubes, wear is reduced because of the low wear and/or friction property of PEEK or polyamide imide. In addition the coefficient of thermal linear expansion of the Peek or polyamide is greater than that of aluminium alloy of the shell and heat exchange tubes. Thus, at elevated, operating temperatures the distance tubes, having expanded more than the alloy tubes, press against the baffles and end plates. The baffles (6 in Figure 1 or 15 in Figure 3), on expansion, form an interference fit with the interior of the shell. Thus the overall stiffness of the structure is increased and the resonant vibrational frequency of the structure changes. Again, wear is reduced.

The values of the coefficient of thermal expansion of a typical aluminium alloy, PEEK and polyamide imide are set out below:-

Aluminium Alloy:-
13×10^{-6} inches per °F
$\equiv 5.94 \times 10^{-4}$ mm per °C
Polyamide imide:-
17×10^{-6} inches per °F
$\equiv 7.77 \times 10^{-4}$ mm per °C
PEEK (up to 290°F [143°C]):-
26×10^{-6} inches per °F
$\equiv 11.89 \times 10^{-4}$ mm per °C
PEEK (over 290°F [143°C]):-
60×10^{-6} inches per °F
$\equiv 27.43 \times 10^{-4}$ mm per °C

Claims

1. An internal member (7,11,15) of a heat exchanger characterised by having a low coefficient of wear.

2. An internal member (7,11,15) of a heat exchanger according to Claim 1, characterised by said member comprising polyetheretherketone thermoplastic material.

3. An internal member (7,11,15) of a heat exchanger according to Claim 1, characterised by said member comprising polyamide imide material.

4. An internal member (7,11,15) of a heat exchanger according to any one of the preceding claims, characterised in that the material of the member is reinforced.

5. An internal member (7,11,15) of a heat exchanger according to any one of the preceding claims characterised in that the material of the member provides sufficient structural rigidity and strength over the working temperature range of approximately minus 55°C to plus 235°C.

6. An internal member (7,11,15) of a heat exchanger according to any one of the preceding claims, characterised in that the material of the member is inert to fluids such as oil or aviation fuel passing through the heat exchanger.

7. An internal member (7,11,15) of a heat exchanger according to any one of the preceding claims characterised in that the member comprises a baffle (11,15).

8. An internal member (7,11,15) of a heat exchanger according to any one of Claims 1-6 characterised in that the member comprises a distance tube (7).

9. A heat exchanger characterised by incorporating an internal member according to any one of Claims 1-8.

10. A heat exchanger according to Claim 9 characterised in that the coefficient of thermal expansion of the material of the internal member is greater than that of the material of the remaining components of the heat exchanger.

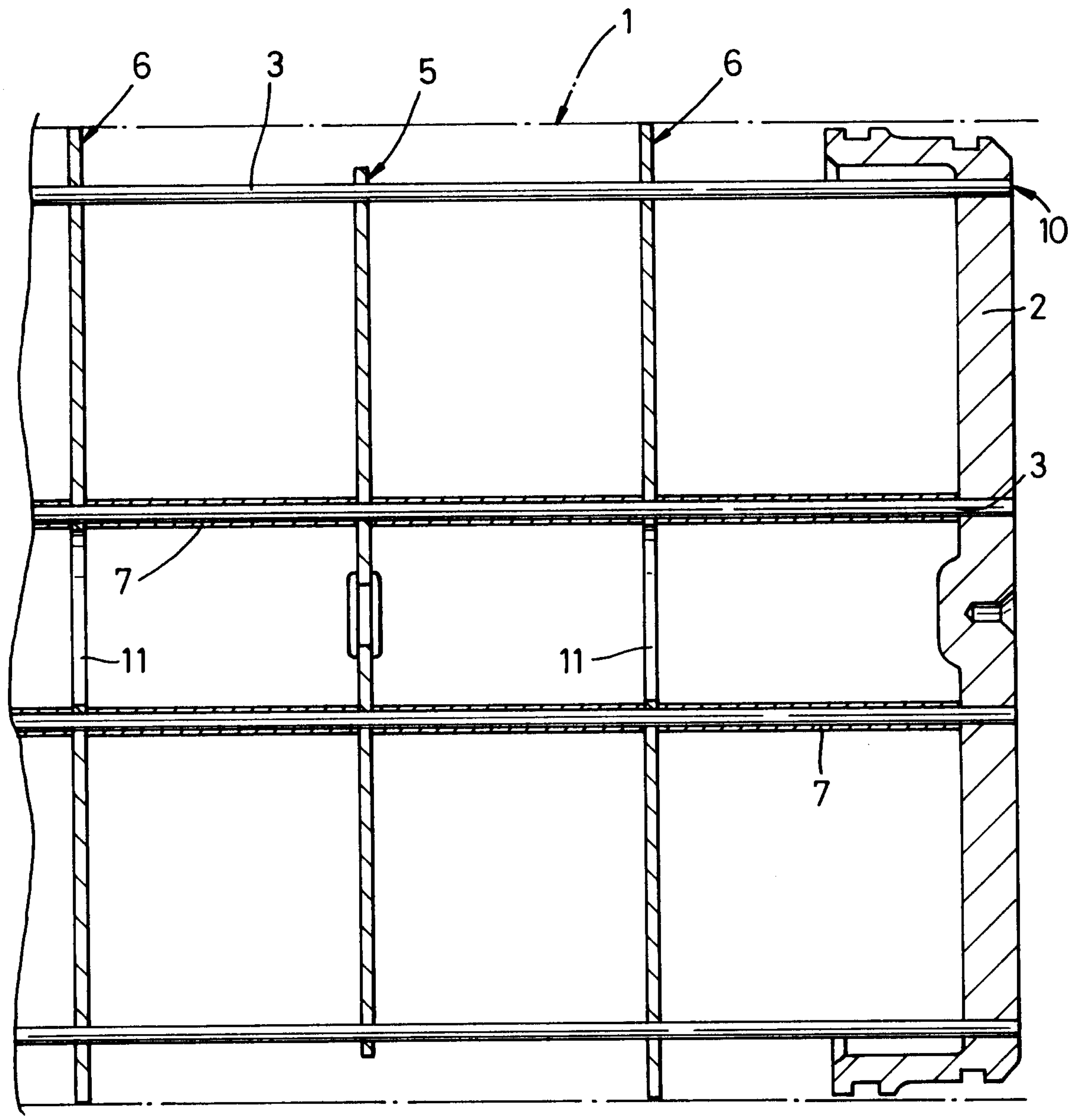

Fig. 1

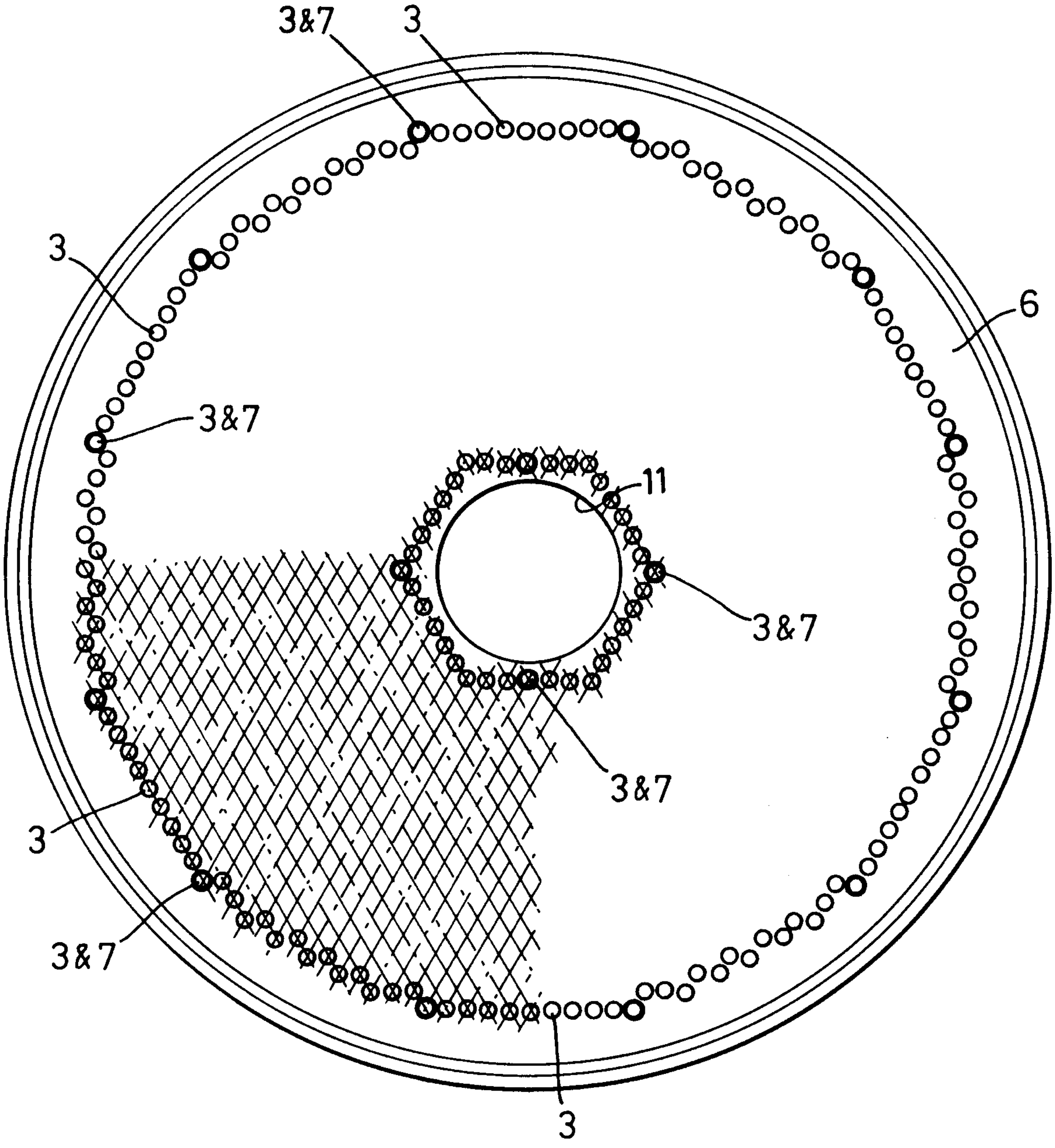

Fig. 2

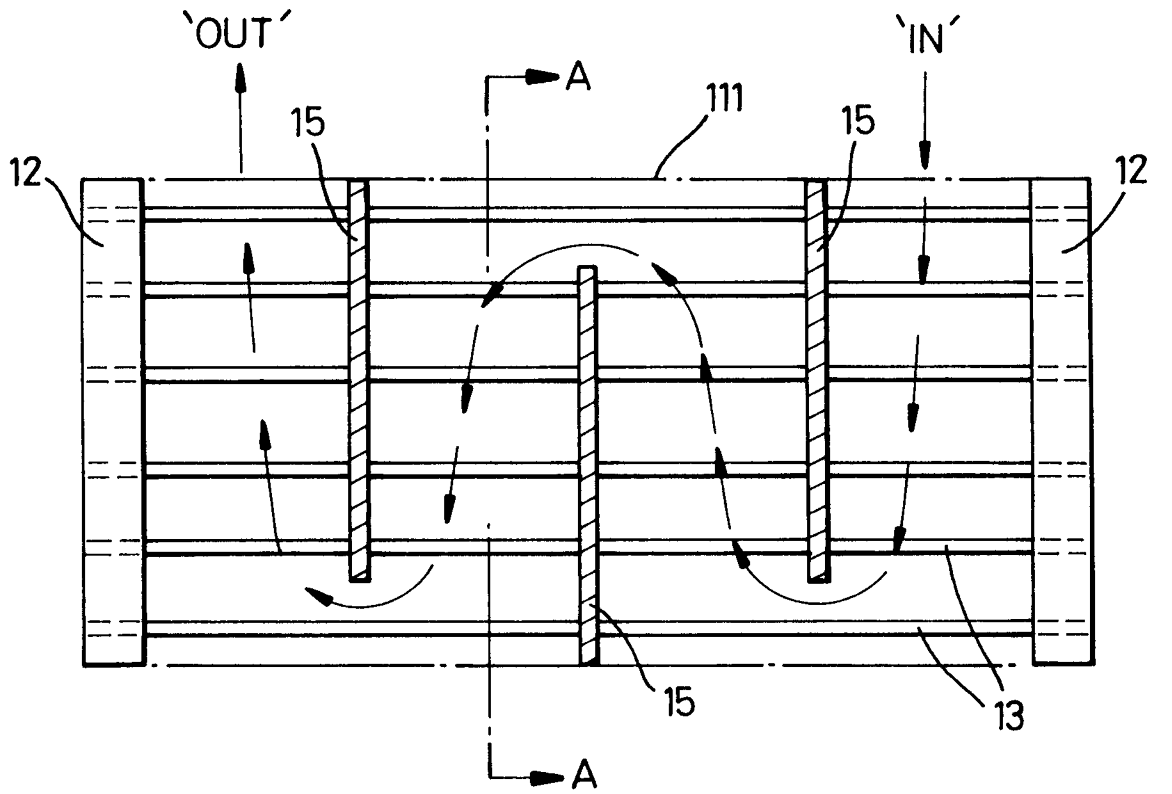

Fig. 3

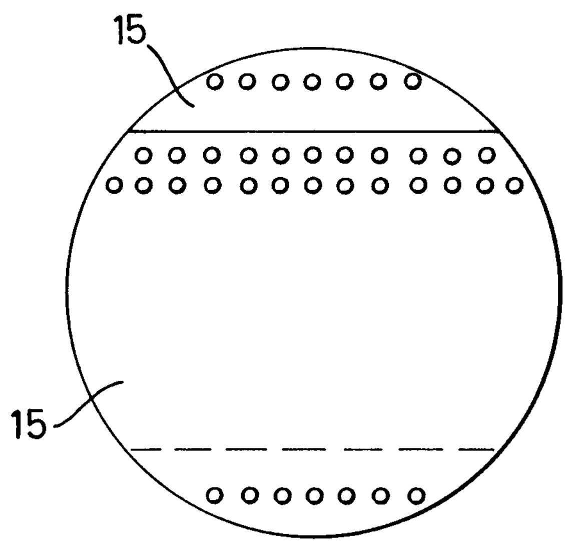

Fig. 4

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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)
X	GB-A-2 117 503 (WESTINGHOUSE ELECTRIC CORP.) * page 2, line 57 - page 2, line 93 * * page 2, line 114 - page 3, line 9; figure 2 *	1,9	F28F9/00 F28F9/22 F28F19/00 F28F21/06
Y		2,3	
Y	PATENT ABSTRACTS OF JAPAN vol. 15, no. 336 (M-1151)26 August 1991 & JP-A-03 129 120 (YASKAWA ELECTRIC MFG CO LTD) 3 June 1991 * abstract *	2	
Y	PATENT ABSTRACTS OF JAPAN vol. 10, no. 331 (M-533)11 November 1986 & JP-A-61 136 027 (HITACHI CHEM CO LTD) 23 June 1986 * abstract *	3	
X	US-A-4 294 659 (CAMPBELL) * column 2, line 60 - column 3, line 14; figure 2 *	1,7,9	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
X	WO-A-8 300 381 (TURBINE METAL TECHNOLOGY INC.) * page 8, line 1 - page 9, line 28; figures 1-3 *	1,5-7,9	F28F F28D
X	US-A-3 856 077 (SIEGLA) * column 3, line 51 - column 4, line 5; figure 3 *	1	
A		3	
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 242 (C-721)23 May 1990 & JP-A-02 064 137 (SUMITOMO CHEM CO LTD) 5 March 1990 * abstract *	1,4	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 AUGUST 1993	BELTZUNG F.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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)
A	EP-A-0 390 429 (BTR INDUSTRIES LTD) * column 3, line 2 - column 3, line 24; figure 1 * -----	1,8	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

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THE HAGUE	26 AUGUST 1993	BELTZUNG F.C.

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