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

(11) Publication number: **0 093 572**
A1

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 83302372.4

(51) Int. Cl.³: F 23 D 11/40

(22) Date of filing: 26.04.83

(30) Priority: 28.04.82 US 372788

(43) Date of publication of application: 09.11.83 Bulletin 83/45

(84) Designated Contracting States: CH DE FR GB IT LI

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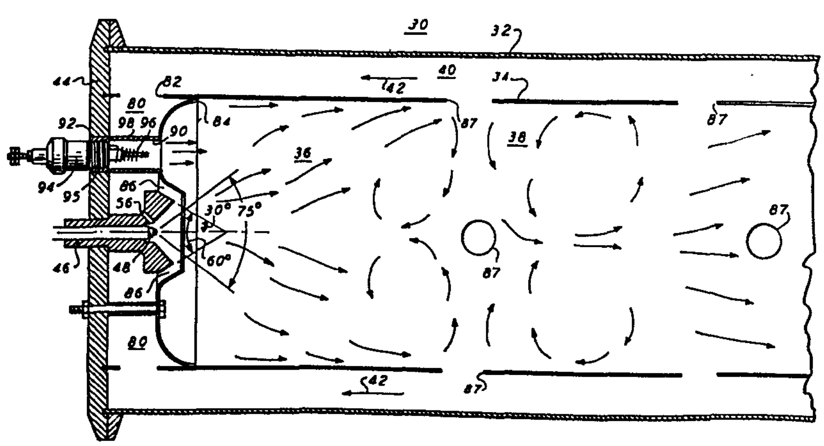
(54) **Air-fuel mixing device.**

(57) An air-fuel mixing device mixes fuel and primary combustion air in a particular configuration. Thus fuel nozzle 48 sprays the liquid fuel into the primary combustion chamber or zone 36 of a combustor 30 in a hollow conical pattern. A portion of the primary combustion air is injected toward the stream of liquid fuel in a converging annular frustrum pattern and which creates an extremely uniform fuel/air mixture and a stable flame. In a preferred embodiment, the converging annular frustrum through which primary air is injected is formed between the outer surface of the fuel nozzle means 48 and an inner flange or lip 66 of a baffle plate 60 that surrounds the fuel nozzle means 48 and is at an angle of 30° with respect to the main axis of the fuel nozzle means 48.

FIG.1



EP 0 093 572 A1

Croydon Printing Company Ltd.

AIR-FUEL MIXING DEVICE

This invention relates to an air fuel mixing device and a method for creating a stable flame, both for use in a combustor that can be used for burning liquid fuel for purposes such as gas turbine engines, heating units and/or for the vaporization of cryogenic liquids such as nitrogen.

In such combustors, a liquid fuel such as oil is introduced into a primary combustion chamber where it is combined with air to form a combustible mixture. The air is generally supplied by means of admitting primary combustion air into the combustion chamber where it mixes with the atomized liquid fuel.

Various means have been used to establish a stable flame pattern to retain the maximum control in burning and prevent uneven burning that could overheat certain parts of the liner or be so unstable as to occasionally flame out and require reignition.

In the present combustors, swirling vanes are commonly used to swirl the air as it impinges upon the stream of liquid fuel from the fuel nozzle. The number and size of holes is established as needed to obtain the proper swirl to such primary combustion air. For a description of such combustion mixing devices, note the Gas Turbine Engineering Handbook, Section 5 "Combustors" by Herbert R Hazard. As noted in that publication, the present art suggests a swirling motion of the primary air and the creation of a low pressure area at the combustion axis to continually recirculate the flame toward the fuel nozzle.

The difficulties in designing such a swirling motion are, however, intensified by the need to deal with both tangential and axial directions of flow so that the final flame pattern often requires extremely rigorous analysis to be predicted with certainty. As shown on page 73 of the above publication, the art considered many different means of approaching the problem.

It is an aim of the present invention to alleviate greatly the aforementioned difficulties in designing a mixing device or means to produce a stable flame. In essence, in the present invention a converging cone of primary combustion air is injected into and impinges upon a diverging hollow cone of liquid fuel sprayed into the primary combustion chamber by the fuel nozzle. The air fuel mixing device and method are defined in the accompaying claims.

The mixing device of the invention allows a low cost design for mixing air and liquid fuel over a wide range of fuel/air mixtures. The flame itself is very stable and is not sensitive to an inbalance in flow or pressures of numerous jets of incoming air.

By introducing the secondary combustion air further downstream of the actual flame, the flame stability is also unaffected by changes in flow of the secondary combustion air.

Since the converging cone of primary combustion air is uniform, it is able to pull the root flame away from the inner walls or surfaces of a combustor including a mixing device according to the invention and thus even the inner surfaces of such combustor can be constructed of normal steel, i.e. 50 mil. plate of 310 stainless steel and not require refractory materials.

The overall costs of manufacturing the combustor itself, with respect to materials and fabrication surrounding the mixing zone, can be reduced (in comparison with conventional combustors).

The invention will now be described by way of example with reference to the accompanying drawings.

In Fig.1, there is shown a side view, partly in section, of an oil fired combustor having a fuel/air mixing device constructed in accordance with the present invention;
Fig.2, is a side view, partly in cross section, of a nozzle holder used to retain the fuel nozzle for introducing and atomizing the liquid fuel in the combustor of Fig.1;
Fig.3, is an end view, shown partly broken away in section, of the nozzle holder of Fig.2;
Fig.4, is a side cross sectional view of a baffle plate used in the combustor of Fig.1 to create a stable flame pattern; and
Fig.5, is an end view of the baffle plate of Fig.4.

Turning first to Fig.1 there is shown a combustor 30 for use with a liquid fuel such as oil. The combustor 30 is preferably cylindrical in shape and includes an outer shell 32 generally constructed of 12 gauge stainless steel. A general description of combustors can be found in the aforementioned Gas Turbine Engineering Handbook publication.

Within the outer shell 32 and which is also cylindrically shaped and coaxial thereto, is a liner 34 constructed of relative thin (0.050 inches stainless steel) and within which is contained a primary combustion chamber (or zone) 36 and a secondary combustion chamber (or zone) 38 where the hot gases from primary combustion chamber 36 are mixed with secondary air to complete the combustion process.

In the embodiment as shown, the air for the combustion taking place in primary combustion chamber 36 and for completion of combustion in secondary combustion chamber 38 is supplied by a fan, not shown, and air passes through the annular passage 40 between liner 34 and outer shell 32 and which flow of air serves to cool the liner 34 and outer shell 32. As noted in Fig.1, the air passes through the annular passage 40 in the direction of arrows 42.

An end plate 44 closes off one end of the combustor 30 and is fitted into the ends of the liner 34 and the outer shell 32 to close the same. Centrally located through end plate 44 is a fitted nozzle holder 46 which, among other functions, channels air for determining the pattern of fuel distribution for liquid fuel injected by means of the fuel nozzle 48.

The nozzle holder 46 is more fully shown in Figs 2 and 3 in cross section and end view, respectively, and generally comprises a body 50 having an opening 52, one end of which opening 52 opens into an angled opening 54 at an angle of approximately 90^{0} about its central axis, as shown, and further comprises a plurality of radially oriented apertures 56 which open into the angled opening 54. A recess 58 is formed in body 50 in order to receive the fuel nozzle 48 (not shown in Figs 4 and 5). The fuel nozzle 48 may be of conventional commercial design as supplied by the Delavan Corporation Nozzle Model No. 27710-1 and which is rated for a fuel consumption at 50 lbs/hr of JP4 fuel oil at a supply pressure of 100 psig.

The particular fuel nozzle 48 is of a design that sprays out the atomized fuel oil in the shape of a diverging hollow cone at a total angle of approximately $75^{0} \pm 5^{0}$ about its central axis. By passing air through the apertures 56, the liquid fuel is caused to swirl and produce a vortex flow in the primary combustion chamber 36.

As shown also in Fig.1, the outer surface 57 of the nozzle holder 46 is angled with respect to its central axis at approximately 30^{0} thereto, or converges at a total angle with respect to its central axis of about 60^{0} in the shape of a truncated cone.

Surrounding the fuel nozzle 48 and nozzle holder 46 is a circular shaped baffle plate 60. The baffle 60 is shown in detail in Figs. 4 and 5, as well as shown assembled to combustor 30 in Fig.1.

In Figs. 4 and 5, the baffle plate 60 is shown as generally circular in shape having an annular dished interior 62 and a central opening 64. The inner lip 66 of annular dished interior 62 is formed at an angle of about 30^{0} to the central axis of the baffle plate 60 or a total angle of 60^{0} in a converging conical configuration.

As shown in Fig.1, the baffle plate 60 is coaxially mounted with respect to nozzle holder 46 and fuel nozzle 48 to the end plate 44 by means such as bolts 68 secured to the end plate 44 by nuts 70 and held in its predetermined position with respect to fuel nozzle 48 by spacers 72. In the preferred embodiment, three such bolts 68, spacers 72 and nuts 70 hold the baffle plate 60 in its fixed position through bolt holes 74 in baffle plate 60 and the further hole 76 in baffle plate 60 is used in connection with the incandescent ignitor assembly 78 the function of which will be later described.

As may now be seen in Fig. 1, the flow of air for use in the primary combustion chamber 36 and the secondary combustion chamber 38 proceeds as follows. The primary air, or air actually used in the combustion of the liquid fuel passes along the annular passage 40 and enters plenum chamber 80 through a plurality of openings 82 in annular passage 40. The plenum chamber 80 is thus formed behind the baffle plate 60 and air is used from that plenum chamber 80 for a variety of purposes.

A portion of the air from plenum chamber 80 passes through radially oriented apertures 56 in the nozzle holder 46 and such air used to create the swirling motion for the fuel injected into primary combustion chamber 36 from fuel nozzle 48.

A further portion of air leaks past the outer edge 84 of the baffle plate 60 and provides some cooling to the inner surface of the liner 34 and protects liner 34 from direct action or contact by the combustion gases of primary combustion chamber 36.

Most of the air, however, from plenum chamber 80 passes through the annular frustrum opening 86 to serve as primary air to supply oxygen for the combustion of the liquid fuel. As noted, due to the design angles of the outer surface 57 of nozzle holder 46 and the inner lip 66 of baffle plate 60, that annular frustrum opening 86 converges in the direction toward the primary combustion chamber 36 at a total angle of about 60^0 about the central axis of the fuel nozzle 48.

Secondary air is mixed with the hot combustion gases in secondary combustion chamber 38 to complete the combustion process and is admitted to the secondary combustion chamber 38 through a plurality of openings 87.

In operation, therefore, the fuel is injected outwardly into the primary combustion chamber 36 by the fuel nozzle 48 in the pattern of a diverging hollow cone at a total angle of about $75^0 \pm 5^0$. The fuel is atomized by the fuel nozzle 48 in such predetermined pattern into small droplets to create, in certain zones, the combustible mixture of liquid fuel and air where combustion can actually take place. The primary air for supplying oxygen for the combustible mixture impinges upon the hollow diverging cone-shaped pattern of liquid fuel through the converging annular frustrum opening 86, forming a pattern of movement generally as shown by the arrows in Fig. 1.

The pattern of liquid fuel/air mixture thereby forms a zone of combustible mixture at zone 88 and which is a relatively stable, quiet zone protected by baffle plate 60 and out of the direct stream of the liquid fuel. That zone 88 thus contains a mixture that can readily be ignited by means of the incandescent ignitor assembly 78.

The ignitor assembly 78 may be a conventional spark type of ignitor wherein a high voltage spark causes ignition of the liquid fuel/air mixture in zone 88 or, as shown, may include a cylindrical housing 90 having one end thereof fitted within an appropriate sized opening 92 in end plate 44, and the other end thereof just passing through the opening 76 in baffle plate 60. An incandescent or spark type ignitor 94 can be located within cylindrical housing 90 by means such as a threaded engagement for ease of assembly and removal at 95. As shown, the ignitor 94 includes a high resistance heating wire 96 to create a sufficiently high temperature to ignite the liquid fuel/air mixture in zone 88 within primary combustion chamber 36 and may be a commercially available glow plug such as Champion Type CH3.

As noted again by the arrows in Fig.1, once ignited, the flame maintains a very stable position and does not vary despite wide variations or chamges in levels of fuel flow. The stable flame pattern results from the primary air being supplied in the form of a converging annular frustrum that impinges in a uniform pattern around the diverging conical shaped spray of liquid fuel from fuel nozzle 48.

CLAIMS

1. A method of creating a stable flame within a combustion chmber characterised in that it comprises the steps of:

   spraying liquid fuel into the combustion chamber in the pattern of a hollow cone having a predetermined angle;

   injecting primary air into the combustion chamber in the pattern of a converging annular frustrum in the same direction of flow of said fuel spray;

   directing the converging annular frustrum of primary air to impinge uniformly upon the diverging spray of liquid fuel to produce a zone of a combustible mixture of liquid fuel and air; and

   igniting said combustible mixture in said zone to create burning.

2. A method as claimed in Claim 1, characterised in that said step of directing the converging annular frustrum includes coaxially aligning the respective axes of said hollow cone of sprayed liquid fuel and said annular frustrum of air.

3. Apparatus for providing mixing between a liquid fuel and primary air in a combustion characterised in that the apparatus comprises:

fuel nozzle means directing a spray of liquid fuel into said combustion chamber in a diverging hollow conical pattern in the direction of flow and having a predetermined angle of divergence;

means to inject primary air into said combustion chamber as a converging annular frustrum in the direction of flow and converging at a predetermined angle, to impinge upon said spray of liquid, thereby forming a zone of a combustible mixture of liquid fuel and primary air; and

ignition means to selectively cause ignition of said combustible mixture of liquid fuel and air within said combustion chamber.

4. A combustion apparatus characterised in that it comprises

a cylindrical combustion chamber;

a nozzle means in one end of said combustion chamber to spray liquid fuel into said combustion chamber in the pattern of a diverging hollow cone, said nozzle means having an external surface converging at a predetermined angle toward said combustion chamber;

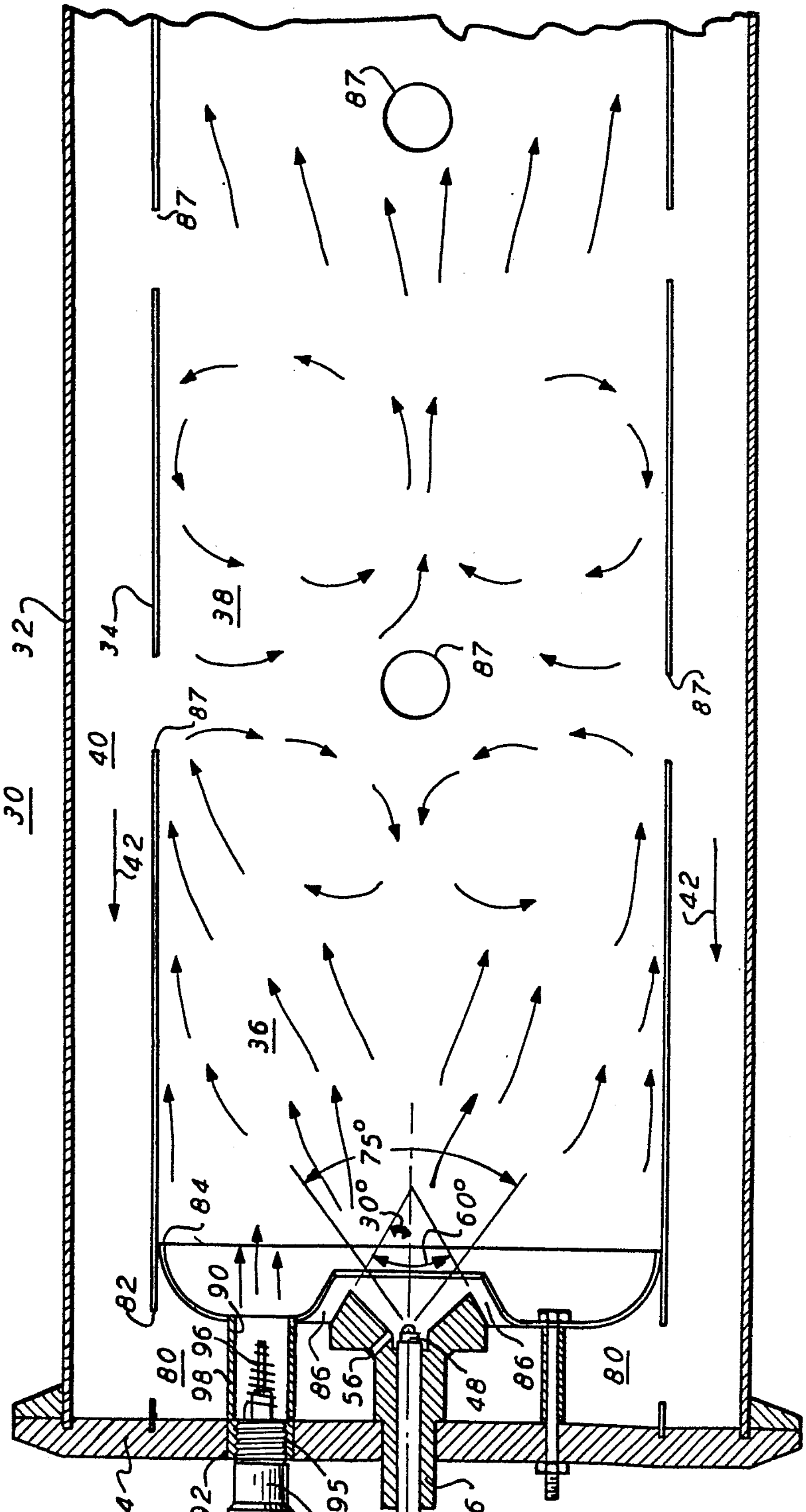
a circular baffle plate coaxial with and surrounding said nozzle means, said baffle plate having a central opening formed by a lip having its inner surface converging at a predetermined angle toward said combustion chamber, thereby forming an annular frustrum opening between said baffle plate and said nozzle means converging at a predetermined angle toward said combustion chamber;

means to introduce primary air through said annular frustrum opening to impinge said primary air on the diverging hollow cone of liquid fuel, thereby forming, within said combustion chamber, a zone of combustible mixture of liquid fuel and primary air; and igniter means to ignite said zone containing said combustible mixture to cause burning of said liquid fuel within said combustion chamber.

5. A combustion apparatus as claimed in Claim 4, characterised in that said annular frustrum opening converges in the direction of said combustion chamber at a total angle of about 60°.

6. A vaporiser for vaporising cryogenic liquid, characterised in that the vaporiser includes the mixing apparatus claimed in claim 3 or combination apparatus claimed in claim 4 or claim 5.

FIG.1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60°

FIG.4

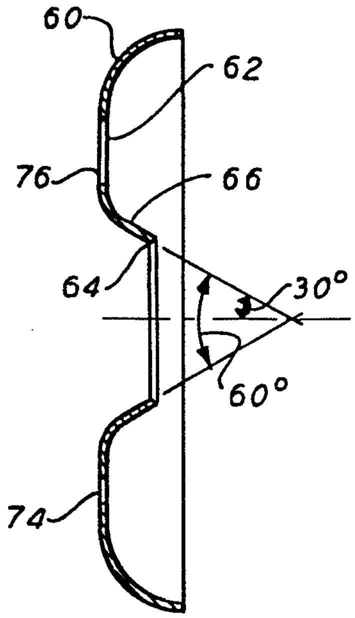


FIG.5

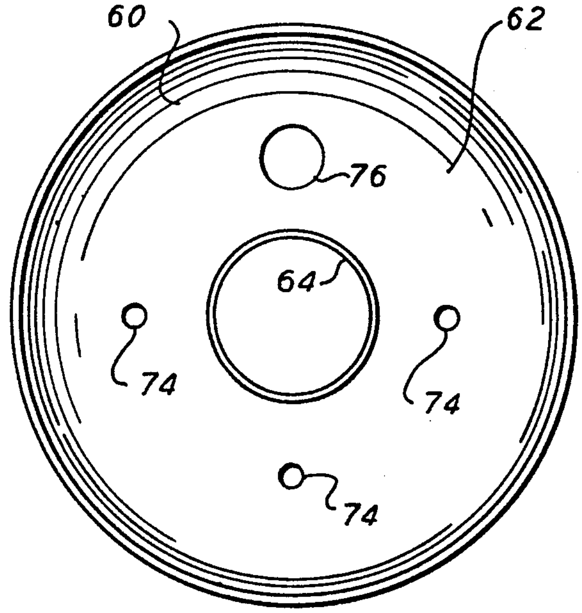


FIG. 2

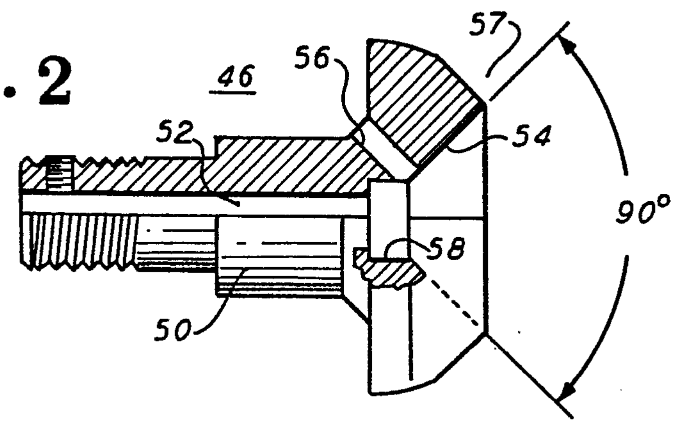
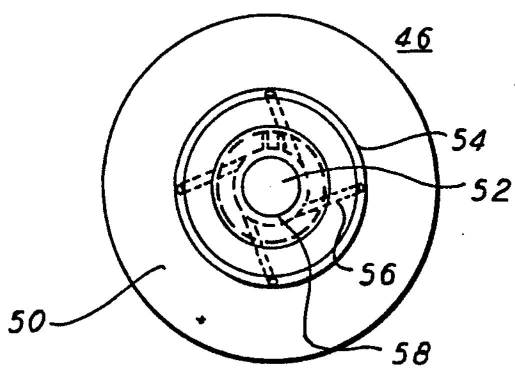


FIG. 3



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EUROPEAN SEARCH REPORT.

0093572

Application number

EP 83302372.4

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. ³)
X,Y	DE - B - 1 751 653 (GUERIN) * Totality * --	1-4,6	F 23 D 11/40
Y	RECKNAGEL/SPRENGER, "Taschenbuch für Heizung + Klimatechnik", 1981/82, 61. Ausgabe VERLAG OLDENBURG page 1402, lines 21-24 --	6	
A	DD - A - 57 168 (BIURO PROJEKTOW PRZEMYSLU CEMENTOWEGO I WAPIENNICZEGO) * Totality * --	1-4	
A	DE - B - 1 094 909 (KUHLMANN) * Totality * --	1-5	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	GB - A - 894 470 (GENERAL MOTORS) * Fig. 3 * ----	1,3	F 23 C 3/00 F 23 C 7/00 F 23 C 11/00 F 23 D 11/00 F 23 R 3/00 F 24 F 3/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	05-08-1983	TSCHÖLLITSCH

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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