MANUFACTURE OF ALUMINIUM BASED HEAT TRANSFER PANELS

A heat transfer panel (1) manufactured from two or more neighbouring extruded aluminium based sections (2). A first portion (4) formed along an edge of one section (2) is clipped or slid into engagement with a corresponding second portion (10) formed along an edge of a neighbouring section (2) to form a cavity (16) therebetween. A copper based pipe (18) is then inserted into the cavity (16) and is expanded radially outwards to positively engage with the first (4) and second (10) portions to ensure that the neighbouring sections (2) are securely locked together to form the panel (1), wherein a heat transfer fluid may be passed through the copper based pipe to effect heat transfer from or to the panel (1). The panel (1) may be mounted on to an existing ceiling or incorporated into a suspended ceiling to cool the air within a room. Alternatively the panel (1) can be used as a solar water-heating panel.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
Manufacture of aluminium based heat transfer panels

DESCRIPTION

5 Field of the Invention
The invention relates to the manufacture of heat transfer panels from aluminium or an aluminium alloy and, in particular, to a method of joining two or more extruded aluminium or aluminium alloy sections together to form the panel using copper pipes through which a heat transfer fluid may be passed to effect heat transfer from or to the panel.

Background Art
Aluminium is the second most widely used metal after iron. In comparison to other metals, it and its alloys are extremely lightweight, are very resistant to corrosion and exhibit excellent heat conductivity. These specific properties make the base metal or its alloys desirable materials to use in the manufacture of heat transfer or exchange panels.

For ease of reference, throughout this Specification the term "aluminium based" refers to pure aluminium or an aluminium alloy, and similarly the term "copper based" refers to pure copper, a copper alloy or alternatives to copper with similar properties.

Most commonly, aluminium based components are produced as extrusions. The basic raw material is generally in the form of billets which are heated up to a temperature of between 450°C and 500°C. Each billet then forms a heated bar which is passed through a die to give the finished extrusion. While this process is capable of producing an extrusion of unlimited length, the extrusion will generally have a limited width, typically about 150 to 200 mm. Hence, in order to manufacture a panel the user is required to join a plurality of the extrusions together edge to edge in order to achieve the required surface area. To give the fabricated panel a heat transfer capacity, copper
based pipes can be welded onto a surface of the panel. In use a heat transfer fluid can be carried in these pipes transferring heat to or away from the panel. Accordingly, there are three discrete stages in manufacturing a heat transfer panel in accordance with this method:

1) extrusion of the aluminium based material;
2) conventional jointing of a plurality of extrusions; and
3) welding of copper based pipes to the panel.

The present Applicant perceives a distinct advantage in combining the last two stages of this method to give reduced manufacturing costs, quicker throughput and a more efficient heat transfer panel.

Summary of the Invention
The invention provides a method for constructing a heat transfer panel from two or more extruded aluminium based sections comprising the steps of clipping or sliding a first portion formed along an edge of one section into engagement with a corresponding second portion formed along an edge of a neighbouring section to form a cavity therebetween, inserting a copper based pipe into the cavity, and expanding the copper based pipe radially outwards to positively engage with the first and second portions to ensure that the neighbouring sections are securely locked together, wherein a heat transfer fluid may be passed through the copper based pipe to effect heat transfer from or to the panel.

As the copper based pipe expands, it pushes into minor depressions and accurately follows the microscopic roughness of the extruded material forming the cavity. Furthermore, expansion of the copper based pipe causes it to work-harden. Accordingly, the material of the copper based pipe when deformed into the extruded material forming the cavity is both stiffer and more rigid than the base copper material. In tests, the interference between the expanded copper based pipe and the extruded material forming the cavity is such that it was impossible to remove the expanded pipe from the cavity as
the force imposed on the pipe exceeded the tensile strength of the copper based material itself and so the pipe broke rather than moved.

A pressurised fluid can be introduced into the copper based pipe to give the required radial expansion. Preferably, the pressure of the fluid is substantially 20 MPa (3000 psi).

Alternatively, if the cavity is substantially cylindrical, a ball bearing having a diameter greater than the inner diameter of the copper based pipe can be forced through the copper based pipe to produce the required radial expansion of the pipe. Other comparable mechanical means can also be used.

Preferably, the clipping together of the first and second portions is achieved by having each first portion provided with a hinge recess and a snap-fit recess and having each second portion provided with a hinge projection and a snap-fit projection. The hinge projection is initially inserted into the hinge recess to provide a pivot point and then the two portions are rotated and forced together so that the snap-fit projection clips into the snap-fit recess.

If this clip-fit method is employed then preferably the second portion defines a greater proportion of the periphery of the cavity than the first portion as this promotes a more positive engagement between the portions.

Preferably, the copper based pipe is annealed copper.

The invention also embraces a heat transfer panel constructed in accordance with the aforementioned methods. Preferably, the first and second portions of the extruded aluminium based sections extend from a first surface of the panel, the opposed surface being relatively smooth.
The heat transfer panel can be used to form a ceiling panel for mounting on to an existing ceiling or for installation in a conventional suspended ceiling frame.

Alternatively, the heat transfer panel can be used to form a solar water-heating panel. Preferably, a plurality of fins is provided on an exposed surface of the solar water-heating panel to promote solar radiation capture.

**Brief Description of the Drawings**

By way of example only, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings of which:

Figure 1 is a cross-sectional view of a heat transfer panel according to a first embodiment of the present invention;

Figure 2 illustrates how two sections of the heat transfer panel of Fig. 1 are initially clip-fitted together;

Figure 3 shows the final arrangement of the two sections shown in Fig. 2;

Figure 4 is a cross-sectional view of a ceiling panel according to a second embodiment of the present invention;

Figure 5 is a cross-sectional view of a solar panel according to a third embodiment of the present invention;

Figure 6 is a cross-sectional view of a heat transfer panel according a fourth embodiment of the present invention, the component sections being slide-fitted together;

Figure 7 is a cross-sectional view of a single section of a heat transfer panel according to a fifth embodiment of the invention;

Figure 8 is a cross-sectional view of a heat transfer panel comprising two panels according to Figure 7 locked together by an expanded tube of copper based material;

Figure 9 is an enlarged detail illustrating the initial joining together of two sections according to Figure 7;

Figure 10 is an end view of an assembled heat transfer panel of Figure 8 including end plates, pipe connectors and a thermal insulation barrier;
Figure 11 is a side view of the assembled panel of Figure 10; and Figure 12 is a perspective view of an end plate as used in Figure 10.

Detailed Description of the Preferred Embodiments

Fig. 1 shows a heat exchange panel 1 according to the invention. The panel 1 is formed from a plurality of identical extruded aluminium based sections 2 having a typical width $W$ of 150mm. Each of the sections 2 is defined at opposing edges by an arcuate female portion 4 and a corresponding arcuate male portion 10, respectively. The sections 2 are designed to be clip-fitted together by virtue of these female 4 and male 10 portions to form a cylindrical cavity 16 running the entire length of the sections 2. An annealed copper based pipe 18 having a smaller external diameter than the internal diameter of the cavity 16 is inserted into the cavity 16 and is then expanded radially outwards to securely lock the neighbouring sections 2 together. From Fig. 1 it is apparent that the female 4 and male 10 portions of the neighbouring sections 2 all extend from a first surface 20 of the sections 2 so as to leave an opposed second surface 22 relatively smooth. This is particularly desirable in some applications which will be discussed later on.

Referring to Figs. 2 and 3, the female portion 4 comprises a first arc 5 which partially defines the eventual cylindrical cavity 16. A hinge recess 6 is provided in the female portion 4 at that end of the arc 5 which is most remote from the first surface 20. The hinge recess 6 is tapered into a V-shape so that its base 6b is narrower than its opening 6a. As previously mentioned, one edge of the opening 6a of the hinge recess 6 is defined by the arc 5. The other edge opens up to a pivotal bearing surface 9. Accordingly, the hinge recess 6 separates the arc 5 from the pivotal bearing surface 9. At the other end of the arc 5, a snap-fit recess 8 is formed in the female portion 4.

The male portion 10 consists of a second arc 11 which together with the first arc 5 of the female portion 4 defines the entire cylindrical cavity 16. At that end of the second arc 11 which is remote from the first surface 20, a hinge
projection 12 extends radially outwards. This projection 12 is of uniform width which substantially matches the width of the base 6b of the hinge recess 6. The opposing end of the second arc 11 is provided with a radially outwardly extending snap-fit projection 14 which corresponds to the snap-fit recess 8 in the female portion 4.

To lock the neighbouring sections 2 together, the hinge projection 12 of the male portion 10 of one section 2 is initially inserted into the hinge recess 6 of the female portion 4 of the neighbouring section 2. As specifically illustrated in Fig. 2 in this arrangement the hinge projection 12 abuts that wall of the hinge recess 6 that is closest to the pivotal bearing surface 9 of the female portion 4. Furthermore, the pivotal bearing surface 9 itself abuts an outer surface of the second arc 11 from which the hinge projection 12 extends. In this position, there is no interference between the snap-fit projection 14 of the male portion 10 and the female portion 4.

However, because the base 6b of the hinge recess 6 is narrower than the opening 6a and the hinge projection 12 is substantially the same width as the base 6b, a pivot point is established at the base 6b of the hinge recess 6. Due to the resilient nature of the aluminium based extrusion and the specific shape of the snap-fit projection 14 on the male portion 10, it is possible to rotate the male portion 10 and associated section 2 clockwise from the initial position shown in Fig. 2 with respect to the female portion 4 of the neighbouring section 2 about the pivot point at the base 6b of the hinge recess 6. In doing so, the extruded sections 2 will undergo a small amount of elastic deformation and the snap-fit projection 14 will engage with the corresponding snap-fit recess 8 in the female portion 4, as shown in Fig. 3. Accordingly, the cylindrical cavity 16 is established between the male 10 and female 4 portions of the neighbouring sections.

Although the male 10 and female 4 portions from neighbouring sections 2 are now prevented from relative rotation, there is nothing to prevent them from
moving longitudinally with respect to each other. Furthermore, as the cylindrical cavity 16 is not fluid tight it cannot retain a heat transfer fluid. To overcome these problems, a copper based pipe 18 is introduced into the cavity 16. In order to accommodate the pipe 18, the cavity 16 necessarily must have a diameter that is greater than the external diameter of the pipe 18 as shown in Fig. 3. Once inserted, one end of the pipe is capped and a pressurised fluid is introduced through the other end. Preferably the fluid is pressurised to 20 MPa (3000 psi) which yields the required radial expansion in the copper based pipe 18. As the pipe 18 expands, it pushes into minor depressions and accurately follows the microscopic roughness of the extruded material forming the cylindrical cavity 16 along arcs 5 and 11. Furthermore, because the pipe 18 is copper based, expansion causes it to work-harden. Accordingly, the material deformed into the extruded material forming the cylindrical cavity 16 along arcs 5 and 11 is both stiffer and more rigid that the base copper material. In tests, the interference between the expanded copper based pipe 18 and the extruded material forming the cylindrical cavity 16 along arcs 5 and 11 is such that it was impossible to remove the expanded pipe 18 from the cavity 16 or even rotate the pipe 18 within the cavity 16 as the force imposed on the pipe 18 exceeded the tensile strength of the copper based material itself and so instead of moving, the pipe 18 broke.

As the copper based pipe 18 expands radially, it contracts longitudinally. Hence, the pipe 18 initially inserted into the cavity 16 should be longer than the cavity 16 itself.

It will be noted that the second arc 11 is longer than the first arc 5. This is an important design feature because it is essential that more radial force is exerted on the male portion 10 by the expanded copper based pipe 18 than the female portion 4 to ensure that the male (internal) portion 10 retains a positive engagement with the female (external) portion 4 to prevent relative rotation.
Fig. 4 illustrates a ceiling panel 30 for installation in a conventional suspended ceiling frame 32. The ceiling panel 30 is essentially the same as the heat transfer panel 1 of the previous embodiment, except that in addition to the identical sections 2 forming the heat transfer panel 1, two extruded aluminium based end sections 34 and 40 are securely locked using the same expanded copper based pipe method to the male 10' and female 4' portions at opposing edges of the heat transfer panel 1 respectively. The end section 34 on the left of Fig. 4 has a female portion 4" which engages with the male portion 10' at the left edge of the heat transfer panel 1. Similarly, the end section 40 on the right of Fig. 4 has a male portion 10" which engages with the female portion 4' at the right edge of the heat transfer panel 1. Furthermore, upwardly extending L-shaped brackets 36 are provided at exposed edges of the end sections 34 and 40 to enable easy installation into the frame 32. To improve the aesthetics of the ceiling panel 30, one or more channels 36 are formed longitudinally on the smooth downward facing surface 22 of the panel 30 in the vicinity of each joint between adjacent sections 2 making up the panel 30 so that a side wall of one of the channels 36 coincides with and thereby helps to obscure the joint.

When one or more of these panels 30 are inserted into a ceiling frame 32, and the expanded copper based pipes 18 are interconnected with a cold fluid supply, then they can have the same cooling effect as an air conditioner without the associated noise or complexity. As the warm air from within the room rises through convection it contacts the ceiling panels and a heat exchange occurs. Through the laws of convection, the resultant cooler air will automatically fall back down into the room again.

Furthermore, if the room in which the ceiling panel 30 is to be mounted does not have a suspended ceiling frame 32, the brackets 36 can be used to secure the panel 30 directly to an existing ceiling.
Although not shown in the drawings, preferably one or more layers of insulation material are provided on the first surface 20 of the ceiling panel 30 to ensure high heat transfer efficiency of the ceiling panel 30.

The heating panel 1 described with reference to Figs. 1 to 3 can also be transformed into a solar water-heating panel 50 as shown in Fig. 5. As with the ceiling panel 30, the solar panel 50 is essentially the same as the heat transfer panel 1, except that in addition to the identical sections 2 forming the heat transfer panel 1, two extruded aluminium based end sections 52 and 56 are securely locked using the same expanded copper based pipe method to the male 10' and female 4' portions at opposing edges of the heat transfer panel 1 respectively. The end section 52 on the left of Fig. 5 has a female portion 4" which engages with the male portion 10' at the left edge of the heat transfer panel 1. Similarly, the end section 56 on the right of Fig. 5 has a male portion 10" which engages with the female portion 4' at the right edge of the heat transfer panel 1. On this occasion, all exposed edges of the solar panel 50 are provided with a surrounding bracket 54 which extends both upwards and downwards. A recess 58 is formed in the bracket close to its top edge. Again, making full use of the resilient characteristics of aluminium, the bracket 54 can be deformed slightly enabling a glass pane 60 to be installed into the recess 58 to form a solar cavity 62.

To improve the efficiency of the panel 50, an insulation material 66 is layered in the insulation cavity 63 defined by the downward facing smooth surface 22 of the panel 50 and the surrounding bracket 54. Furthermore, a plurality of fins 64 is provided on the first surface 20 of the solar panel 50 to promote solar radiation capture. These fins 64 are manufactured integrally with the aluminium based sections 2, 52 and 56 as they are passed through the extrusion die.
In use, energy from the sun heats up the solar panel 50. This heat is then transferred to and raises the temperature of a cool heat transfer fluid which passes through the copper based pipes 18 of the solar panel 50.

If the solar panel 50 is mounted on a sloping roof, the panel 50 should be positioned such that the copper based pipes 18 are inclined to the horizontal and parallel to the roof and the glass pane 60 of the solar cavity 62 is exposed to the sun. Preferably, the heat transfer fluid is supplied to the base of the copper based pipes 18 because as the fluid is heated, convection will cause the fluid to rise up the pipes 18 allowing cooler fluid to take its place.

As an alternative to clip-fitting neighbouring sections 2 together, they may be redesigned and extruded so that they are capable of slide-fitting together. Such an arrangement is illustrated in Fig. 6. Each extruded aluminium based section 2' has a first portion 70 and an opposing second portion 80. The first 70 and second 80 portions from neighbouring sections 2' can be slide-fitted together form a cylindrical cavity 16. The first portion 70 of one section 2' has an outwardly extending projection 72 that fits into a corresponding recess 82 provided on the second portion 80 of a neighbouring section 2'. Similarly, at the opposing side of the cylindrical cavity 16, the second portion 80 has an outwardly extending projection 84 that engages with a corresponding recess 74 provided in the first portion 70. Once the two neighbouring sections 2' have been linked together as shown in Fig. 6, a copper based pipe 18 can be inserted into the cavity 18 and radially expanded as in the previous embodiments to securely lock the neighbouring sections together.
Although the preferred method of expanding the copper based pipes 18 is to use a pressurised hydrostatic fluid, mechanical methods are also envisaged. One such mechanical method involves the passage of a ball bearing with a larger diameter than the internal diameter of the pipe 18 through the pipe 18 to give the required radial expansion.

A fifth embodiment of the invention is illustrated in Figs. 7 to 12, and comprises a heat exchange panel made up from a number of extruded aluminium based sections 90 one of which is shown in Fig. 7. When two such sections are linked by sliding and clipping as described below they form a cavity therebetween, and that cavity receives a copper based pipe 91 as illustrated in Fig. 8. When the pipe 91 is expanded radially outwards it locks the adjacent sections securely together as described above with respect to the earlier embodiments.

The precise shape of each extruded section 90 is illustrated in Figs. 7 and 9. Each section 90 comprises a longitudinal plate portion 92 having along one long edge a first cavity-defining portion 93 and along an opposite long edge a second cavity-defining portion 94 and side arm clip 95. The first cavity-defining portion 93 has an internal arcuate surface 96 spanning approximately 180° of arc. Along the top edge of the first portion 93 is an upstanding rib 97 and along the bottom edge of the first portion 93 is a longitudinal recess 98. Along the top edge of the second cavity-defining portion 94 is a longitudinal recess 99 for receiving the rib 97 of an adjacent extruded section 90, and along the bottom edge is a depending rib 100 which in use is received in the longitudinal recess 98 of the adjacent extruded section 90, as illustrated in Fig. 8. A concave wall 101 between the recess 99 and the rib 100 is arcuate and spans approximately 180° of arc.

A pair of adjacent extruded sections 90 is slid together as illustrated in Fig. 9, which shows the left-hand section being lowered vertically onto the right-hand section in the direction of the arrow A. A side arm clip 95 is an integral part of
the extrusion of each section 91, and Fig. 9 shows the side arm clip 95 of the
left-hand section 90 straddling the cavity-defining portion 93 of the adjacent
right-hand section 90. A cantilever portion 102 integral with the second cavity-
defining portion 94 can be depressed to assist flexure of the second portion
94 as the two portions are slid vertically into inter-engagement, and the side
arm clip 95 is thus encouraged to engage resiliently around the outside of the
associated first portion 93, temporarily to hold the two extruded sections
together.

While the two sections are held together by the side arm clip 95, a copper-
based pipe 91 is slid longitudinally down the cylindrical cavity formed between
the two arcuate surfaces 96 and 101. Expansion of the copper-based pipe 91
as described above, for example by application of a hydraulic internal
pressure or by cold working from within the pipe, increases the frictional
contact between the mating ribs 97, 100 and their associated recesses 98, 99
and locks the two neighbouring sections 90 together to form a panel double
the width of each individual section 90. Moreover, the cold working of the pipe
91 causes it to harden, so that the entire structure after expansion of the pipe
91 is significantly more rigid than before expansion.

Fig. 10 shows how the copper-based pipe 91 extends from opposite ends of
the panel constructed from adjacent sections 90. The free ends of the pipe 91
receive plumbing connections 102, illustrated in Fig. 10 in push-fit 90° angle
bends.

Fig. 10 also illustrates the use of a pair of end plates 103 which finish the
opposite ends of the panel. An extruded section as illustrated in Fig. 12 has
circular apertures 104 cut or punched through an upstanding web portion 105,
each aperture 104 being positioned to receive an end of a respective pipe 91.
Although only one pipe 91 is illustrated in Fig. 8 and only two are illustrated in
Fig. 11, it will be understood that any number of parallel pipes 91 may be
provided, locking together any number of adjacent sections 90. Fig. 12 shows
four apertures 104 and would therefore be suitable for a panel made up of five adjacent sections 90 linked and locked together with four copper based pipes 91.

Fig. 10 also illustrates an optional rear heat insulation panel 106 mounted between channels 107 formed between parallel side ribs 108 and 109 extending from the web portion 105 of the end plates 103 (see Fig. 12). The insulation panel 106 can be slid into position after assembly of the heat exchange panel and is retained in place by one or more spring steel securing clips 110 which have gripping spring teeth 111 received in longitudinal channels 112 of the outermost extruded sections 90. Only one such spring steel securing clip 110 is illustrated in Fig. 11, with the insulation panel being removable by sliding it to the right as illustrated. A second spring steel securing clip 110 at the right hand end of the assembled heat exchange panel would prevent such rightward movement.

The advance of providing a rear heat insulation panel is that if the heat exchange panel is a radiator, substantially all of the radiant heat is emitted from the front surface.

Although in all of the described preferred embodiments of the invention, the cavity 16 has a substantially circular cross-section, this is not the only cross-section envisaged; any cross-section having a smooth profile would be equally acceptable.
CLAIMS

1. A method for constructing a heat transfer panel from two or more extruded aluminium based sections comprising the steps of:
   clipping or sliding a first portion formed along an edge of one section into engagement with a corresponding second portion formed along an edge of a neighbouring section to form a cavity therebetween;
   inserting a copper based pipe into the cavity; and
   expanding the copper based pipe radially outwards to positively engage with the first and second portions to ensure that the neighbouring sections are securely locked together to form the panel, wherein a heat transfer fluid may be passed through the copper based pipe to effect heat transfer from or to the panel.

2. A method according to claim 1, wherein the first and second portions are arcuate and the cavity formed therebetween is substantially cylindrical.

3. A method according to claim 2, wherein a ball bearing having a diameter greater than that of the pipe is forced through the copper based pipe to give the required radial expansion.

4. A method according to claim 1 or claim 2, wherein a pressurised fluid is introduced into the copper based pipe to give the required radial expansion.

5. A method according to claim 4, wherein the pressure of the fluid is substantially 20 MPa (3000 psi).

6. A method according to any preceding claim, wherein each first portion is provided with a hinge recess and a snap-fit recess and each second portion is provided with a hinge projection and a snap-fit projection, the hinge projection is initially inserted into the hinge recess to provide a pivot point and
then the two portions are rotated and forced together so that the snap-fit projection clips into the snap-fit recess.

7. A method according to claim 6, wherein the second portion defines more of the cavity than the first portion.

8. A method according to any preceding claim, wherein the copper based pipe is annealed copper.

9. A method for constructing a heat transfer panel from two or more extruded aluminium based sections substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

10. A heat transfer panel constructed in accordance with the method of any preceding claim.

11. A heat transfer panel according to claim 10, wherein the first and second portions of the extruded aluminium sections extend from a first surface of the panel, the opposed surface being relatively smooth.

12. A ceiling panel comprising a heat transfer panel according to claim 11 and two extruded aluminium based end sections securely locked in accordance with claim 1 to first and second portions at opposing edges of the heat transfer panel respectively.

13. A ceiling panel according to claim 12 further comprising one or more layers of insulation material provided on the first surface.

14. A ceiling panel according to claim 12 or claim 13, wherein the end sections include surrounding brackets extending from the first surface at exposed edges of the end sections to with the smooth surface facing downwards.
15. A ceiling panel according to claim 14 for mounting on to an existing ceiling, wherein the surrounding brackets enable the ceiling panel to be secured to the existing ceiling.

16. A suspended ceiling for a room comprising a frame and a plurality of ceiling panels according to any of claims 12 to 14, wherein the copper based pipes of the panels are interconnected to a cool fluid source to absorb heat from within a room.

17. A solar water-heating panel comprising the heat transfer panel according to claim 11 and two extruded aluminium based end sections securely locked in accordance with claim 1 to male and female portions at opposing edges of the heat transfer panel respectively, wherein the exposed edges of the panel and the end sections are provided with surrounding side brackets extending in both perpendicular directions, the side brackets and the smooth surface of the panel defining an insulation cavity filled with insulation material, and the side brackets and the first surface defining a solar cavity which is enclosed by a glass pane.

18. A solar water-heating panel according to claim 17, wherein the first surface is provided with a plurality of fins to promote solar radiation capture.

19. A solar water-heating panel according to claim 18, wherein the fins are integral with the aluminium based sections.

20. A method for mounting a solar water-heating panel according to any of claims 17 to 19 on a sloped roof, wherein the panel is positioned such that the copper based pipes are inclined and parallel to the roof and the glass pane of the solar cavity is exposed to the sun and a source of relatively cool fluid is provided at the base of the copper based pipes.
Fig. 6
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

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According to International Patent Classification (IPC) or to both national classification and IPC.

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

Electronic database consulted during the international search (name of database and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

### Patent family members are listed in annex.

* Special categories of cited documents:
  *A* document defining the general state of the art which is not considered to be of particular relevance
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### Date of the actual completion of the international search

12 November 2002

### Date of mailing of the international search report

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### Name and mailing address of the ISA

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