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(71)(72) Applicant and Inventor: ELISCHER, Julius, William [AU/AU]; 28 Kingsay, Nedlands, W.A. 6009 (AU).

(74) Agent: MOORE CHRYSILIOU, Kerry; Chrysiliou Moore Chrysiliou, P.O. Box 373, Collaroy Beach, NSW 2097 (AU).

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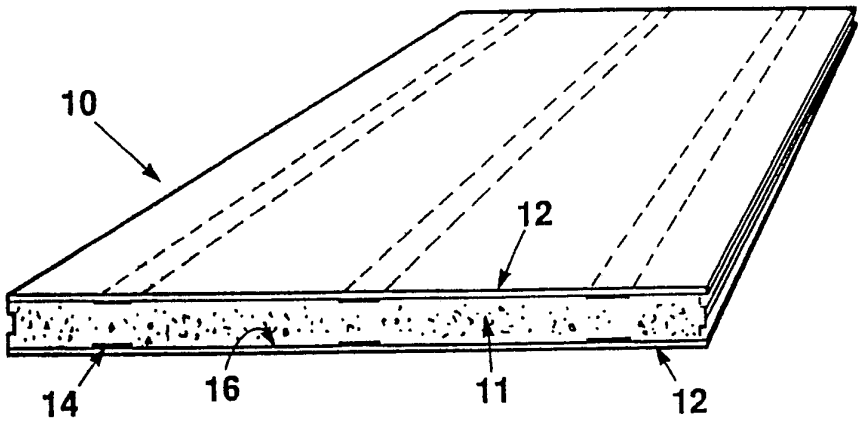
(54) Title: IMPROVED BUILDING PANEL



(57) Abstract

A building panel (10) having a slab (11) of lightweight concrete or the like has adhered to each of its opposed faces a number of flat structural metal strips (14). Optionally, the slab (11) and metal strips (14) are sandwiched between a pair of facing sheets (12), each facing sheet (12) being bonded to the slab (11) substantially through adhesion of the cement in the slab (11) to the inner face (16) of each sheet (12). There is also provided a method of producing the building panel.

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IMPROVED BUILDING PANEL

FIELD OF THE INVENTION

This invention relates to an improved building panel. More particularly, this invention relates to a reinforced building panel, of the type having a slab of lightweight concrete or the like, optionally sandwiched between a pair of facing sheets and to a method of production thereof.

BACKGROUND OF THE INVENTION

My Australian Patent No. 448,474 of 1971 disclosed a laminated building panel which had a core of lightweight concrete sandwiched between asbestos cement sheets. This type of laminated panel has been manufactured in several countries and marketed under the name STYROCON (Registered Trade Mark).

In most countries the use of asbestos fibres has been eliminated because of the health hazards involved. The asbestos reinforcement in cement sheets has been replaced by other fibres, in most cases a cellulose fibre; but unfortunately the resultant sheets are weaker than those made with asbestos cement. However, even before asbestos was eliminated, it had been found that in cyclonic or other special conditions the panels would require extra strengthening.

It was already known to reinforce dense concrete with steel

mesh, steel rods or the like. Because steel is highly susceptible to corrosion, the conventional steel reinforcement must be not only totally embedded in the concrete but also sufficiently remote from the surface of the concrete that water absorbed into the surface of the concrete will not reach the steel. For this reason, it has been regarded as highly undesirable to use steel anywhere near the concrete surface. Thus, in thin panels such as those sold under the Trade Mark STYROCON, only steel mesh in the central core - a rather ineffective position - would be considered. In addition, when conventional steel reinforcement has been used in lightweight concrete such as that comprising a panel core, say 600 kg/cubic metre, it has proven unsatisfactory. The steel has a tendency to pull out of the concrete, because the surface area of the steel is not sufficient to give enough shear strength in the weak concrete.

In the mid-1970s, many experiments were carried out to find a satisfactory way of reinforcing panels, without much success.

DISCLOSURE OF THE INVENTION

It has now been found that the strength of composite building panels of the type described above can be substantially increased by reinforcing the sheets with strips of metal, especially structural flat steel, fastened

to the inner face of the sheets, thus in fact outside the concrete core.

Accordingly, this invention provides, in one aspect thereof, a building panel comprising a slab of lightweight concrete or the like having a pair of opposed faces characterised in that a number of flat structural metal strips is secured by means of suitable adhesive to each opposed face of said pair.

This is very much contrary to the normal requirement that metal such as steel should be properly embedded in the concrete and to the accepted practice of using round steel reinforcement.

While it was known that very light metal strips or wires have been use to reinforce paper or foil products, the use of flat metal bonded to the surface of a structural building element is novel.

To illustrate, if the slab is of 600 kg/cubic metre lightweight concrete, this will require a surface more than 200 mm wide to transfer the shear loads. That is, the flat metal (e.g., steel) is first bonded to the external sheet which is in turn bonded to the slab material. If the slab material is, for example, 1400 kg/cubic metre, a 60 mm wide flat steel surface, bonded to the concrete, would be able to carry the shear loads. Dealing with a dense concrete of 2000 kg/cubic metre, a 8 mm rod could give enough grip to the

concrete to carry the shear moment of the loading. However, a flat steel member can be placed in the most structurally advantageous position to give the maximum lever arm and can be successfully waterproofed. The round rod, however, because of its shape, creates weaknesses in the concrete near the edges and would be in a structurally less advantageous position.

DETAILED DESCRIPTION OF THE INVENTION

The slab of lightweight concrete or the like is preferably foamed concrete and/or concrete containing a lightweight aggregate, such as expanded polystyrene foam beads, expanded vermiculite, expanded shale, any of the many accepted lightweight aggregates or mixtures thereof. Instead of concrete, a material such as plaster, as well as lightweight plaster, may be used.

The preferred slab thickness relates to the overall panel thickness, as described later.

In one particularly preferred embodiment of the invention, a facing sheet is bonded to each said opposed face of the slab, over the metal strips.

The facing sheets may be constructed of any suitable material. Preferably, the facing sheets consist of fibre reinforced cement, fibre reinforced plaster, plaster faced with paper, or plywood. Any other accepted sheet lining is within the scope of this invention.

In this embodiment, the panel of the invention may be based on the STYROCON panel having fibre reinforced cement facing sheets, with added reinforcement provided by the metal strips. The panel of the invention may also be based on a similar lightweight panel for internal use only, described in Australian Patent No. 473,993 of 1973. This panel has been manufactured in several countries under the Registered Trade Mark STYROPLAST and comprises a lightweight plaster core with paper-lined plaster sheets on the outside. Such a metal-strip reinforced STYROPLAST panel may be useful in some situations; however, in most applications the metal-strip reinforced STYROCON panel will be preferred.

In the case of the STYROCON panel, the facing sheets vary in thickness between 3 mm and 6 mm. In special cases, the thickness may be 9 mm. The overall thickness of the panels in the past has been between 30 mm and 100 mm.

The structural metal strips used in the building panel of the invention are preferably steel strips. These may be galvanised if desired or coated, but galvanisation or coating is not necessary if waterproofing can be guaranteed by other means, such as by suitable choice of the adhesive (see below). Steel is preferred because besides its suitable properties it has a low price, but other metals may also be used if they have the appropriate properties. It is important, however, that the metal does not elongate within the range of permitted workloads, because if this happens

the tensile stress will be transferred to any facing sheets, which will break up. In addition, metal should have a co-efficient of expansion similar to that of the concrete slab.

When the metal is steel, a preferred range of thickness is 1.0 to 2.5 mm, with the strips being at least 25 mm wide; 50 mm is a preferred width. Factors to be taken into account when determining the thickness and width of the metal include the shear strength of the slab.

The length of the strips will normally be chosen to approximate that of the panels. However, it may be convenient to have the strips a little shorter than the panels, to facilitate on-site adjustments to panel length.

The advantage of using flat strip steel reinforcement in relatively thin panel constructions which have slab material of reduced strength to hold the reinforcement as compared, for example, with dense concrete, will become clear when looking at Table 2, referred to herein in connection with Figure 5 of the Drawings (see below).

If desired, the metal strips may be corrugated or grooved transversely to the length of the strips, to provide for better adhesion between the strips and the slab and to hold the strips against movement in the longitudinal direction.

The adhesive for securing the metal strips needs to be suited to the application described, bearing in mind the

following requirements. The adhesive must be sufficiently waterproof under the conditions in which the building panel will be utilised, so that the adhesive will continue in its role of securing the metal strips to the inner faces of the sheets. In addition, where the metal is susceptible to rust or other deterioration through contact with moisture (e.g., where the metal is steel), and where the metal is not otherwise waterproofed - for example, by galvanising - the adhesive should serve as a waterproof coating for the metal and the inner face of the sheet. Further, the adhesive should not soften under the types of ambient temperature to be encountered by the panel of the invention. For example, where the panel is to be used for building construction in hot or tropical areas, the adhesive should be able to withstand ambient temperatures of 110 degrees Celsius or so.

When the panel does not include facing sheets, the adhesive should be applied to all surfaces of the metal strips. It should be noted that in the panel which includes facing sheets there is no necessity to provide adhesive between the metal strips and the slab material, although application of the adhesive to all or substantially all the surface area of the strips will give additional strength and safeguard against rusting, particularly if latex cement adhesive is used.

It is preferred to use a cementitious adhesive, especially a latex cement adhesive, since this will not adversely affect the fire-rating of the building panels of the

invention and will give permanent compliance with all the above requirements.

It has been found that concretes, particularly lightweight concretes, when poured against a set or semi-set latex cement surface, will give a good bond.

A polymer cement adhesive may also be suitable, for example.

As indicated, in the panel of the invention the metal strips are secured to opposite sides of the slab. It is preferred that the metal strips are of substantially uniform thickness, weight and strength and that they are disposed in a parallel manner on each side of the slab, with each strip being balanced by a strip placed substantially opposite. This gives an even degree of strength to the panel and fulfils the requirement of "balanced skins".

However, it is also possible to construct the panel of the invention using metal strips of different thicknesses, for example, and to dispose the strips in a different manner, such as by staggering the strips on each side of the slab. It is not necessary that there be an identical number of strips on each side of the slab, although they have to be balanced by weight and positioning. The number of strips will depend on the desired strength of the panel.

In another aspect, this invention provides a method of producing a building panel comprising:

coating a number of flat structural metal strips with a suitable adhesive,

placing the coated metal strips in spaced positions in a mould,

delivering lightweight concrete or the like into the space between the strips to form a slab so that the strips will, upon curing of the concrete, bond to the slab, and

curing the concrete slab.

In a preferred embodiment, the invention provides a method of producing a building panel comprising:

securing by means of a suitable adhesive a number of flat structural metal strips to each inner face of a pair of facing sheets,

placing the sheets in spaced positions in a mould,

delivering lightweight concrete or the like into the space between the sheets to form a slab so that the inner face of each sheet will, upon curing of the concrete, bond to the slab, and

curing the concrete slab.

In the embodiment described, the sheets with the attached metal strips are placed in the mould in a vertical position.

The building panel so formed may be stripped from the mould after, say, 16 to 24 hours. In this event, the panel should be maintained in a vertical position during the whole curing process, which continues after removal of the panel from the mould. The panel should be wetted down for 4 to 5 days to aid even curing.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to certain embodiments thereof, as shown in the accompanying drawings, in which:

Fig. 1 is a perspective view of a panel constructed in accordance with the invention;

Fig. 2 is a section of the panel prepared for testing, showing detail;

Fig. 3 is a diagrammatic view showing the loading of the test section of panel;

Fig. 4 is a diagrammatic view showing the deflection of the test section of panel;

Fig. 5 is a sectional view of part of a test panel constructed with round reinforcing rods; and

Fig. 6 is a sectional view of part of a test panel constructed with flat steel reinforcement, in accordance with the invention.

Referring first to Fig.1 of the drawings, the panel, indicated generally at 10 comprises a slab 11 of lightweight concrete composed of a mixture of concrete and expanded polystyrene beads faced with sheets 12 formed of fibre reinforced cement, such as those marketed in Australia under the Registered trade mark "Hardiflex" or in Malaysia under the trade mark "Supaflex".

In accordance with the invention, strips 14 of steel are secured to the inner face 16 of the sheets 12 by means of a suitable adhesive which is a latex-based cement. The strips are in the order of 1.0 to 1.6 mm in thickness and approximately 50 mm wide. The strips 14 extend the full length of the sheets 12 and are equally spaced across the width of the panel 10. The number of strips 14 and their dimensions may be varied, depending on the degree of strength required in the panel 10.

The slab 11 has a thickness of approximately 41 mm.

In the embodiment of the invention wherein the panel omits the facing sheets, the panel 10 would resemble that in Fig 1, except that the sheets 12 would not be included.

TESTS:

Many trial tests have been carried out. Indicative are the results in Table 1, below, which sets out the deflections of test panels (refer Fig. 2) with 3.2 mm Supaflex facing

sheets and lightweight concrete slab (approx. 600 kg/cubic metre), supported on 2300 mm and with evenly distributed load placed over them. The loading of the panels and the method of measuring the deflection is illustrated in Figs 3 and 4, respectively.

TABLE 1

Panel Thickness	Reinforce-ment	Total Dist. Load	Deflectn	Result
50 mm	nil	154.5 kg	17 mm	FAILED
50 mm	50 x 1 mm	396.0 kg	27 mm	FAILED
50 mm	50 x 1.6 mm	434.0 kg	22 mm	(No failure
75 mm	50 x 1 mm	684.0 kg	16 mm	(after 2 (weeks

The increase in strength in the panels of the invention as indicated by the small deflection under load is readily apparent from a comparison of the results shown.

Turning now to Figs 5 and 6, laminated panels are illustrated having a slab or core of lightweight concrete 11 and facing sheets 12. In Fig. 5, round reinforcing rods 18 are shown towards the outside of the slab 11, while in Fig. 6 flat steel strips 14 are adhered to facing sheets 12.

The advantage in using flat strip steel reinforcement is shown in Table 2:

TABLE 2

8 mm round reinforcing rod	area: 50.26 square mm circumference: 25.14 mm
10 mm round reinforcing rod	area: 78.54 square mm circumference: 31.42 mm
50 mm x 1 mm flat steel	sectional area: 50 sq mm perimeter: 102 mm
50 mm x 1.6 mm flat steel	sectional area: 80 sq mm perimeter: 103.2 mm

Assuming an overall panel thickness of 50 mm, with 4.5 mm skins and a 41 mm slab, using 10 mm diameter rods close to the external lining, the lever arm is 31 mm. Using 1.6 mm flat steel, the lever arm is 39.4 mm.

The slab materials, because of weight limitations, are very weak. The reinforcing steel is fixed to the external face of the slab over its whole surface area , which in the samples illustrated is 50 mm in width. Assuming that the 50 mm reinforcement is placed at 300 mm centres, this means that when a bending moment is applied to the panel, the shear force between the reinforcing steel and any lining sheet is transferred between the sheet and the slab material on a 250 mm width. In addition, if there is adhesion between the steel and the slab material a further 50 mm width is create to transfer the stresses from the slab to the steel.

In any laminated panel, the shear moments decide the minimum strength which the slab has to have to enable it to use its tensile and compressive members when bending moments are applied, not dissimilarly to a truss where the top and bottom chords can be used to capacity only so long as the web members can withstand the force applied.

It will be appreciated that the building panel of this invention provides a measure of strength combined with light weight in a form hitherto unknown. It will also be appreciated that the scope of the invention is not limited to the embodiments described above but only by the attached claims.

CLAIMS:

1. A building panel comprising a slab of lightweight concrete or the like having a pair of opposed faces, characterised in that a number of flat structural metal strips is secured by means of suitable adhesive to each opposed face of said pair.

2. A building panel as claimed in claim 1, wherein a facing sheet is bonded to each said opposed face of the slab, over the metal strips.

3. A building panel as claimed in claim 1 or 2, wherein the slab is chosen from the group consisting of foamed concrete and/or concrete containing a lightweight aggregate.

4. A building panel as claimed in claim 3, wherein the aggregate is selected from expanded polystyrene foam beads, expanded vermiculite, expanded shale and mixtures thereof.

5. A building panel as claimed in any one of claims 2 to 4, wherein the facing sheets consist of fibre-reinforced cement, fibre-reinforced plaster, plaster faced with paper, or plywood.

6. A building panel as claimed in any one of claims 1 to 5, wherein the adhesive is a waterproof, heat-tolerant adhesive.

7. A building panel as claimed in any one of claims 1 to 6, wherein the adhesive is a latex cement adhesive or a polymer cement adhesive.

8. A building panel as claimed in any one of claims 1 to 7, wherein the adhesive is applied to substantially all surfaces of the metal strips.

9. A building panel as claimed in any one of claims 1 to 8, wherein the metal strips are steel strips.

10. A building panel as claimed in any one of claim 1 to 9, wherein the metal strips are grooved or corrugated transversely to their length.

11. A building panel as claimed in any one of claims 1 to 10, wherein the metal strips are of substantially uniform thickness, weight and strength and are disposed in a parallel manner on each side of the slab, with each strip being balanced by a strip placed substantially opposite.

12. A method of producing a building panel comprising:

coating a number of flat structural metal strips with a suitable adhesive,

placing the coated metal strips in spaced positions in a mould,

delivering lightweight concrete or the like into the space between the strips to form a slab so that the strips will, upon curing of the concrete, bond to the slab, and

curing the concrete slab.

13. A method of producing a building panel comprising

securing by means of a suitable adhesive a number of flat structural metal strips to each inner face of a pair of facing sheets,

placing the sheets in spaced positions in a mould,

delivering lightweight concrete or the like into the space between the sheets to form a slab so that the inner face of each sheet will, upon curing of the concrete, bond to the slab, and

curing the concrete slab.

14. A method as claimed in claim 13, wherein the sheets are placed in the mould in a vertical position, with the metal strips also standing vertically.

15. A building panel substantially as herein described, with reference to Fig 1 or 2 of the accompanying Drawings.

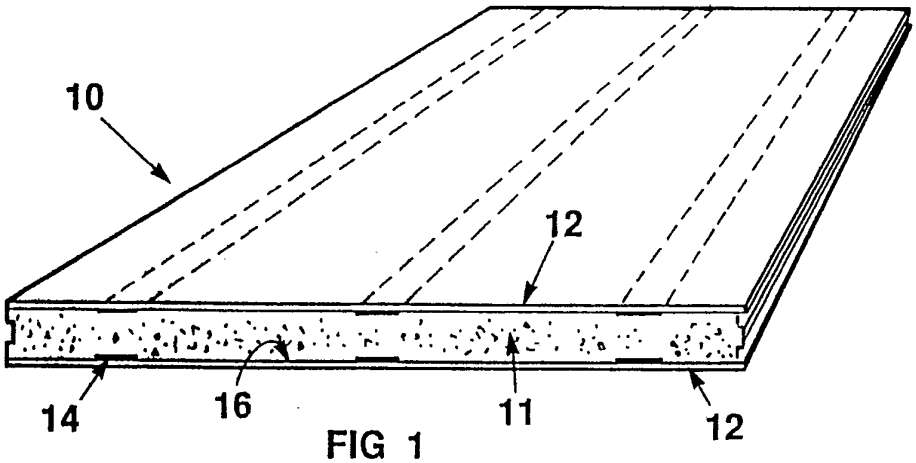

FIG 1

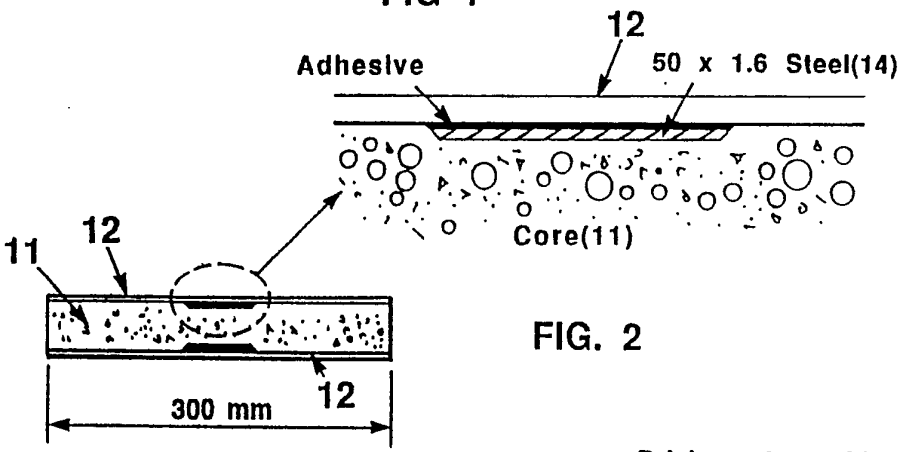

FIG. 2

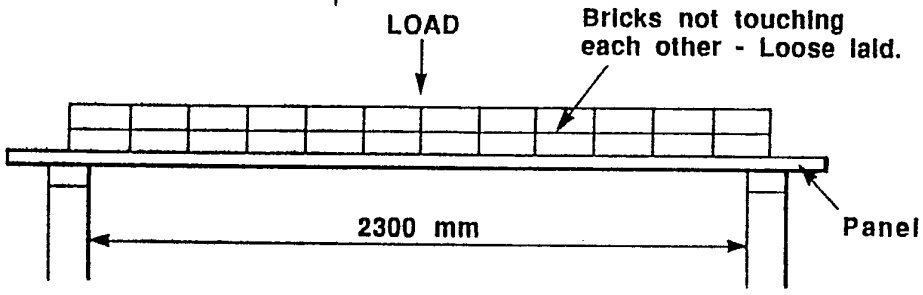

FIG. 3

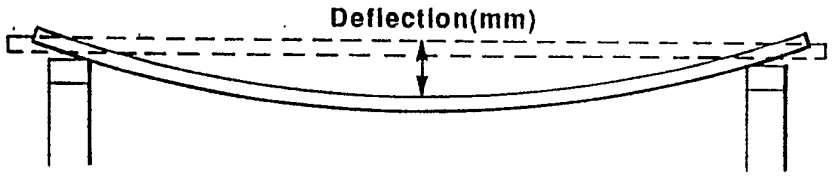

FIG. 4

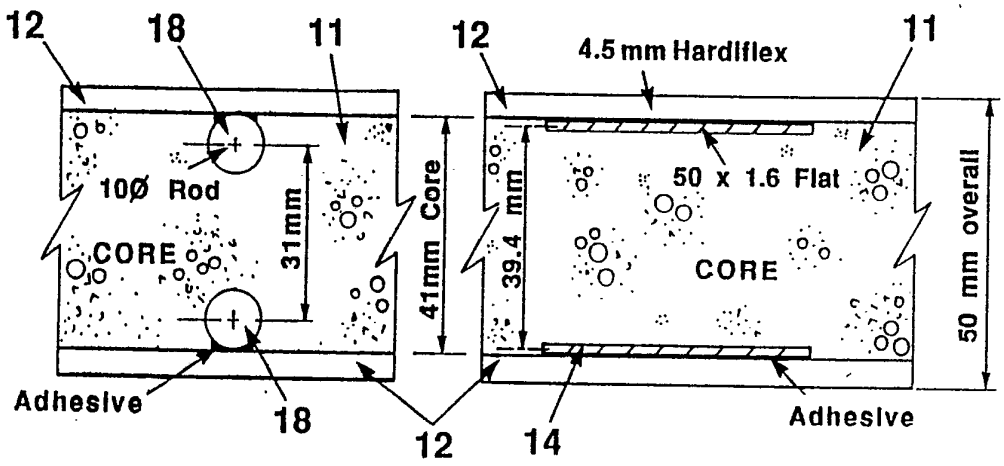
12
18
11
10Ø Rod
CORE
31mm
41mm Core
Adhesive
18
12

FIG. 5

12
4.5 mm Hardiflex
11
50 x 1.6 Flat
39.4 mm
CORE
50 mm overall
14
Adhesive

FIG.6

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 91/00092

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] E04C 2/06, 2/26

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	E04C 2/06, 2/26

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

AU : IPC as above, B32B 13/06, 13/10, B28B 1/16, 1/30, 23/02

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
A	US,A, 1719200 (SCHUMACHER) 2 July 1929 (02.07.29)	
A	US,A, 1333553 (MARTINET) 9 March 1920 (09.03.20)	
A	US,A, 1808976 (WUNDERLICH) 9 June 1931 (09.06.31)	
A	GB,A, 1528816 (EUROC ADMINISTRATION AB) 18 October 1978 (18.10.78)	

* Special categories of cited documents: 10

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
18 June 1991 (18.06.91))	20 June 1991
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	D.R. LUM

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. [ ] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 1

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.[ ] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2.[ ] Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.[ ] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 2

This International Searching Authority found multiple inventions in this international application as follows:

1.[ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.[ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.[ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 91/00092

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members
GB 1528816	DE 2600080, SE 7500197, DK 34/76, FR 2297303