



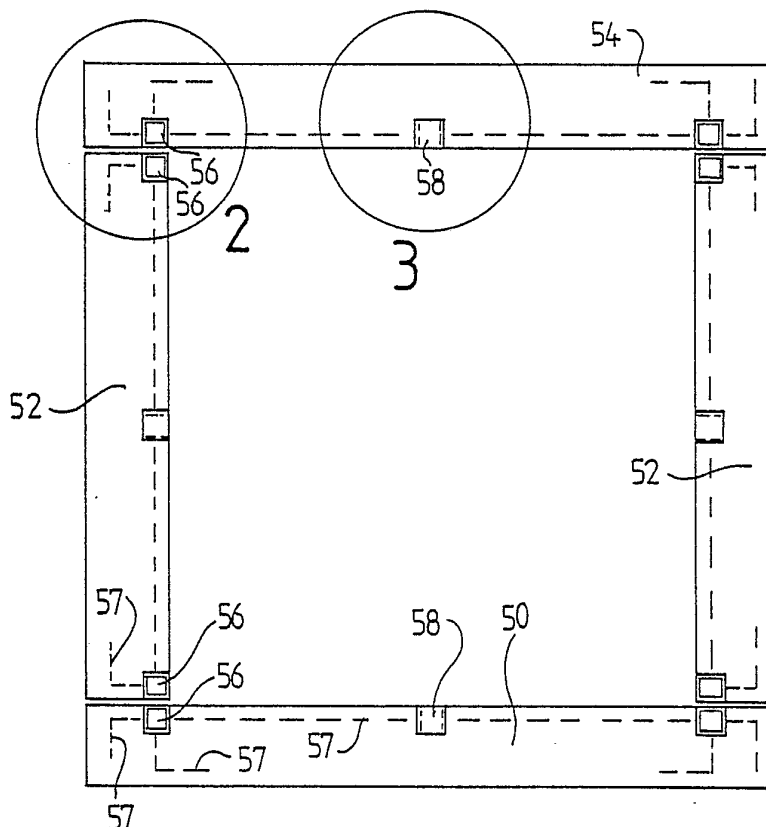
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/AU86/00059 <b>(22) International Filing Date:</b> 12 March 1986 (12.03.86)  <b>(31) Priority Application Number:</b> PG 9809 <b>(32) Priority Date:</b> 19 March 1985 (19.03.85) <b>(33) Priority Country:</b> AU  <b>(71) Applicant (for all designated States except US):</b> ALLAN INTERNATIONAL MANUFACTURING PTY. LTD. [AU/AU]; 19th Floor, S.G.I.O. Building, Albert Street, Brisbane, QLD 4000 (AU).  <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only) :</b> PURSSEY, Ronald [AU/AU]; 79 Cunningham Street, Taringa, QLD 4068 (AU). PORTEOUS, Robert, Douglas [GB/AU]; 31 Killara Avenue, Hamilton, QLD 4007 (AU).		<b>(74) Agents:</b> HIND, Raymond, Stenton et al.; Davies & Collison, 1 Little Collins Street, Melbourne, VIC 3000 (AU).  <b>(81) Designated States:</b> AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.  <b>Published</b> <i>With international search report.</i>

**(54) Title:** THE CONSTRUCTION OF TUNNELS OR PIPES FOR USE IN CIVIL ENGINEERING WORKS

**(57) Abstract**

A tunnel or pipe section, for example for use as a box culvert comprises panels of reinforced concrete (52) connected to form a closed figure. The connection is provided by tubular connectors (56) anchored into each panel by being bolted to the reinforcement of the panel (57), with the connectors of adjacent panels being bolted together.



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"THE CONSTRUCTION OF TUNNELS OR PIPES FOR USE  
IN CIVIL ENGINEERING WORKS"

The present invention relates to the construction of tunnels or pipes for use in civil engineering works, and more particularly to the construction of box culverts.

5       Box culverts are conventionally fabricated from reinforced concrete in the form of complete pipe sections, for example of rectangular form. Considerable expertise is involved in the casting of these sections, and the cast sections themselves are  
10       bulky and give rise to difficulties in transportation to the site and handling on the site.

      According to the present invention there is provided a tunnel or pipe section comprising a plurality of building panels connected to form a  
15       closed figure, wherein each panel comprises a plurality of tubular connectors anchored within the panel and secured to - connectors of the or each adjacent panel by securing - extending through apertured walls of the aligned connectors.

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

Figure 1 is a front elevation of a tunnel or pipe section formed by several connected panels;

Figure 2 shows, to an enlarged scale, a detail of a connection marked '2' in Figure 1;

5        Figure 3 shows, to an enlarged scale, a detail of a connector marked '3' in Figure 1;

Figure 4 is a side elevation of a resilient washer incorporated in the connections between adjacent panels shown in Figures 2 and 3;

10       Figure 5 is a fragmentary side elevation showing two abutting tunnel or pipe sections of the type shown in Figure 1;

Figure 6 shows to an enlarged scale a detail of a connection marked '6' in Figure 5, and formed by two  
15       connectors as shown in Figure 3;

Figure 7 is an elevation in the direction of arrow 'A' in Figure 6;

Figure 8 is a fragmentary front elevation of a tunnel or pipe section similar to that of Figure 1,  
20       but assembled by means of connectors differently arranged in the panels;

Figure 9 shows, to an enlarged scale, a detail of a connection marked '9' in Figure 8;

Figure 10 is a front elevation of a tunnel or  
25       pipe section of circular form composed of curved building panels; and

Figure 11 is a front elevation showing a tunnel or pipe section similar to that of Figure 10, but with the building panels assembled by means of differently  
30       arranged connectors;

Figure 1 shows a tunnel or pipe section of square or other rectangular form constituted by a base panel 50, two upright, opposed, side wall panels 52, and a roof panel 54, the panels each being of rectangular form and each preferably being of reinforced concrete. The adjacent panels in the section are connected by bolting together tubular connectors 56 of square or other rectangular section arranged with their longitudinal axis aligned in the length direction of the panel. The respective side walls of each connector 56 are provided with holes, slots, or other apertures to receive the end portion of anchoring means 57 by which the connector is anchored within the panel or to receive a bolt by which the adjacent connectors of adjacent panels are bolted together, the apertures being in the central portion of each respective side wall. The anchoring means 57 are preferably constituted by the threaded reinforcing rods of the panel which extend into the connector through the holes and which carry nuts to secure the connector. Alternatively, the anchoring means may comprise bolts welded or otherwise fixed to the reinforcing rods.

The connection between two adjacent panels in the tunnel or pipe section is shown in detail in Figure 2, with the adjacent abutting faces of the two connectors being bolted together. Preferably, and as shown in Figure 2, a resilient washer 138 is used in the bolted connection. Such a resilient washer is shown in Figure 4 and comprises a laminate consisting of an annular body 140 of rubber, plastics or other

resiliently compressible material, sandwiched between outer washers 142 of metal or plastics, the washers, when of metal, being galvanised or otherwise resistant to corrosion.

5           Reinforced concrete panels are often erected while the concrete is still in a green state, with the result that the panels tend to contract during curing, while they are in situ within the structure. In addition, after curing the panels are subject to  
10 thermal expansion and contraction. The resilient washers 138 permit contraction upon curing, and subsequent thermal expansion and contraction, without the panels cracking within the structure.

          The tubular connectors shown in Figures 1 and 2  
15 lie adjacent one axial end of the tunnel or pipe section and open onto that end to provide access for insertion of the connecting bolts, similar connectors being provided at the other axial end in order to connect the adjacent panels also at the other end. If  
20 required, tubular connectors may also be provided at one or more positions along the axial length of the panel. It will be noted from Figures 1 and 2 that the connectors 56 lie immediately adjacent the inner faces of the panels and extend only part way into the  
25 thickness of the panel, for example into 1/3 or 1/2 of the panel thickness.

          In Figure 1, a connector 58 is shown at an intermediate position along the width of each panel with the connector being orientated so that its axis  
30 is perpendicular to the length of the panel and so that it opens onto the inner face of the panel. One

such connector 58 is shown in detail in Figure 3 and these connectors serve to join adjacent tunnel or pipe sections as shown in Figures 5 to 7. Although in Figure 1 a single such connector 58 is shown placed centrally along the width of each panel, the connector may be placed at any required position along the width of the panel, and each panel may incorporate more than one such connector, if required. Resilient washers 138 of the type shown in Figure 4 may be incorporated in the bolted connections between the adjacent tunnel or pipe sections, as required, possibly with a resilient gasket being interposed between the adjoining edges of adjacent sections.

When required, a suitable seal is incorporated between the adjoining edges and/or faces of the panels in each section, and between the adjoining edges of adjacent sections in order to provide a waterproof structure. When a resilient gasket is incorporated between the adjoining edges of adjacent sections as discussed above, the gasket may also serve to provide a seal against water penetration.

Figures 1 to 7 show a tunnel or pipe section assembled by means of tubular connectors adjacent the internal faces of the panels. Figures 8 and 9 show a similar tunnel or pipe section assembled by means of similar tubular connectors, but instead located adjacent the external faces of the panels. In this configuration, the tubular connectors of the base and roof panels are placed with their longitudinal axes aligned in the width direction of these panels, and the connectors of the side wall panels are placed with

their longitudinal axes perpendicular to the plane of these panels. In all other respects, the discussion concerning Figures 1 to 7 is applicable also to Figures 8 and 9.

5       A box culvert produced from a pipe section as shown in Figures 1 to 9 can be easily assembled on site from flat panels which may either be cast on site or pre-cast and then transported to site, the transportation and handling costs of pre-cast panels  
10 being substantially less than that of pre-formed box culverts. The casting of flat panels is also considerably easier than casting complete box culverts.

Figures 1 to 9 show the construction of a tunnel  
15 or pipe section of square or other rectangular form. Figures 10 and 11 show a tunnel or pipe section of circular form. The section comprises two semi-circular panels 60 preferably composed of reinforced concrete and bolted together using  
20 rectangular tubular connectors 62 of the type previously described and anchored within the panels in the manner previously described. In Figure 10, the connectors 62 are arranged adjacent to the internal faces of the panels 60 and are arranged with their  
25 longitudinal axes aligned in the length direction of the panels similarly to the arrangement shown in Figures 1 and 2, the connectors 62 being incorporated at each axial end of the panels 60.

The adjacent circular tunnel or pipe sections are  
30 bolted together using rectangular tubular connectors 64 arranged at one or more intermediate positions



around the inner periphery of the panels, the connectors 64 being arranged with their longitudinal axes aligned with the radial direction of the panels 60 in order to provide a bolted connection of the type shown in Figures 6 and 7. Resilient washers of the type shown in Figure 4 may be incorporated in the bolted connections between adjacent panels, and between adjacent sections, if required. The construction shown in Figure 11 differs from that of Figure 10 only in that the connectors 62, 64 are placed adjacent the external face of the panels 60. In a modified arrangement, the connectors may extend through the entire thickness of the panels.

In Figures 10 and 11, a circular tunnel or pipe section is produced from two semi-circular panels. It will be appreciated, however, that the circular section could also be produced by three or more curved panels of appropriate angular extent. The section need not necessarily be in the form of a circular section. By using panels of appropriate curvature, elliptical, ovoidal or other curved sections may be formed. It would also be possible to produce a section of curvilinear form, for example comprising a planar base panel and one or more arcuate or other curved panels supported from the base panel.

The tubular connectors described hitherto have been of square or other rectangular cross-section. However, this is not essential and the connectors may be of other cross-section.

The tubular connectors of any desired cross-section can be fabricated from metal or

plastics, according to requirements. For many applications the connectors will be of roll-formed steel, although they may alternatively be of extruded aluminium or extruded plastics where strength considerations permit. As discussed earlier, the walls of the tubular connectors are apertured with holes, particularly circular holes, or elongate slots, to receive the end portions of the anchoring means by which the connectors are anchored within the panels and to receive the connecting bolts by which two adjacent panels are secured. The slots, if present, permit a degree of adjustability and may also facilitate insertion of the connecting bolt. Adjustability may also be provided by forming each side of the connector with a plurality of apertures to selectively receive the connecting bolt or anchoring means.

As will be apparent from the foregoing, tubular connectors of any desired configuration may be anchored to the panels at any desired position either to provide a connection between adjacent panels, to connect a panel to another part of a structure, or to attach a component to the panel. The connectors may extend through the entire thickness of the panel or only through part of the thickness of the panel; in this latter regard, the connectors may be adjacent the inner or outer surface of the panel as has been illustrated, or they may be offset inwardly from both surfaces of the panel.

A connector capable of resisting seismic loading, may be produced by reinforcing a tubular connector

with an internal plate which closes the cross section of the connector in close proximity to the apertures in the connector walls.

5 The tunnel or pipe sections described permit reduced costs in fabrication and assembly. The tubular connectors permit the panels within each section to be easily connected while providing a secure and reliable connection.

10 The various embodiments of the invention have been described by way of example only, and modifications are possible within the scope of the invention.

## CLAIMS:-

1. A tunnel or pipe section comprising a plurality of panels connected to form a closed figure, wherein each panel comprises a plurality of tubular connectors anchored within the panel and secured to aligned connectors of the or each adjacent panel by securing means extending through apertured walls of the aligned connectors.

2. A section according to claim 1, wherein the panels are of reinforced concrete and the connectors are anchored to the reinforcement.

3. A section according to claim 2, wherein each connector comprises a plurality of apertures angularly spaced about the axis of the connector, and threaded anchoring members extend through the apertures into the interior of the connector.

4. A section according to any one of preceding claims, wherein each tubular connector opens onto an exposed surface of the section to permit access to the interior of the connector.

5. A section according to any one of the preceding claims, comprising further tubular connectors at least at one axial end of the section, the further connectors being anchored within respective panels forming the section and having apertured walls whereby two like sections may be

joined axially in end to end relation by securing means extending through the apertured walls of the further connectors.

6. A box culvert comprising a section according to any one of the preceding claims composed of four rectangular panels mutually connected at right angles one to another.

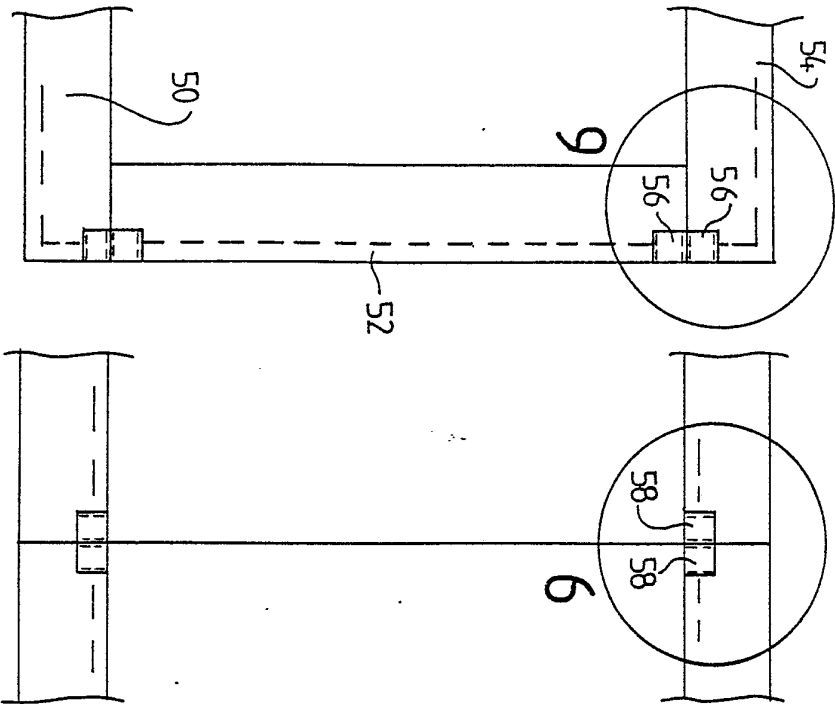


FIGURE 8

FIGURE 5

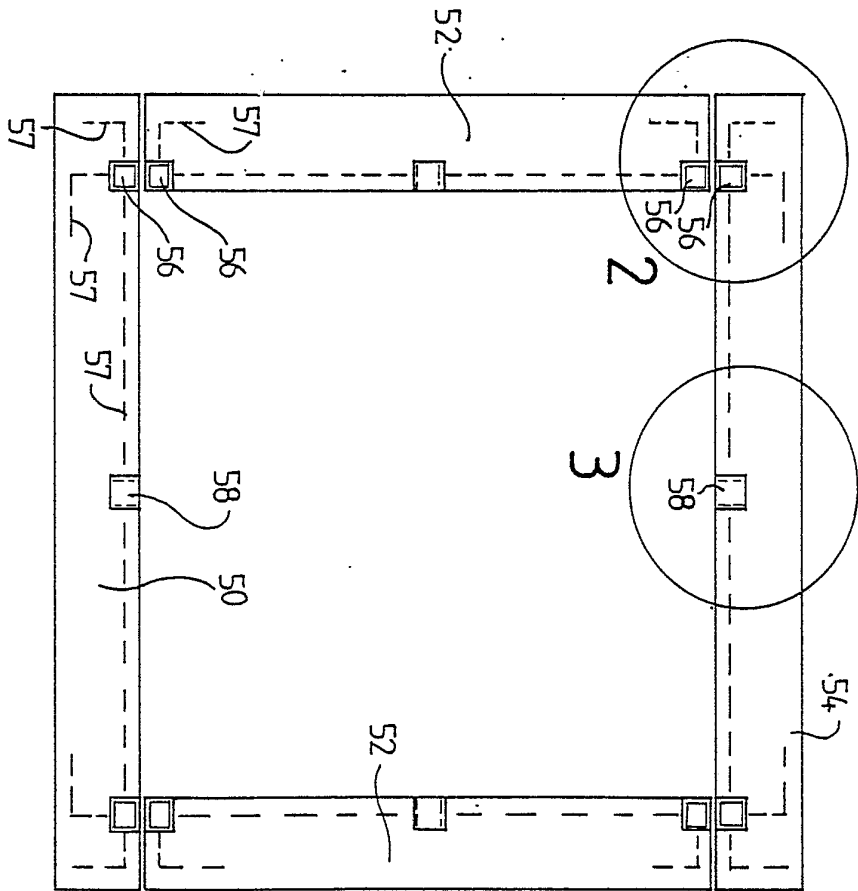
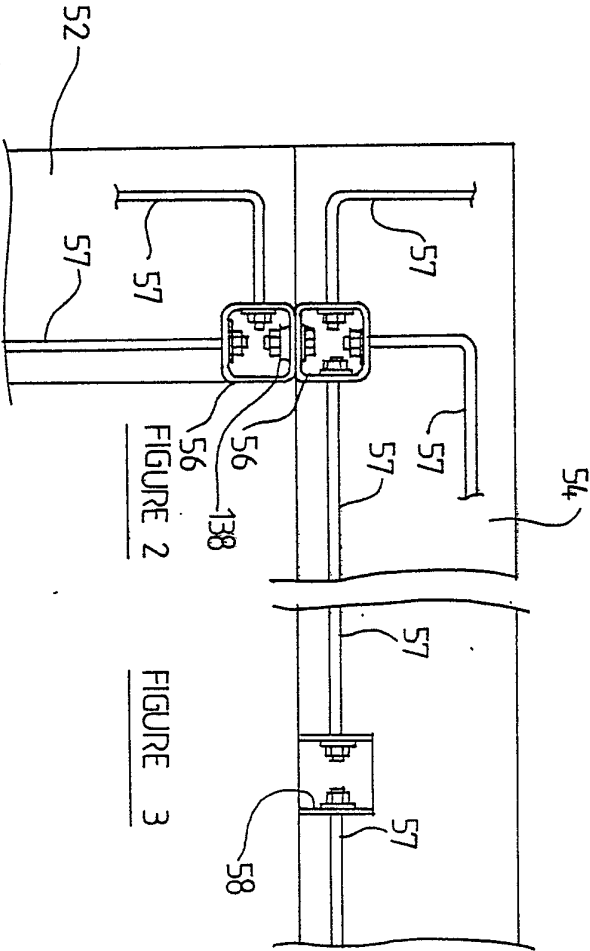


FIGURE 1



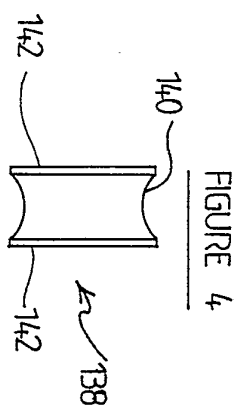
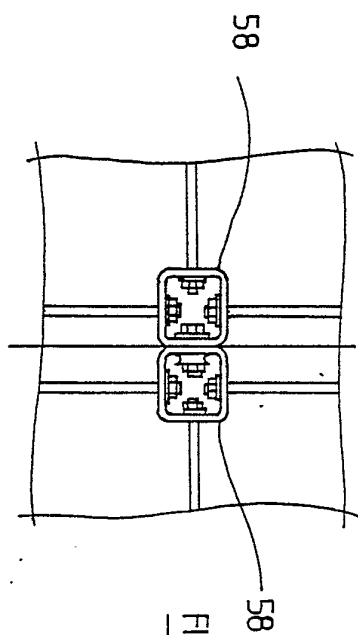
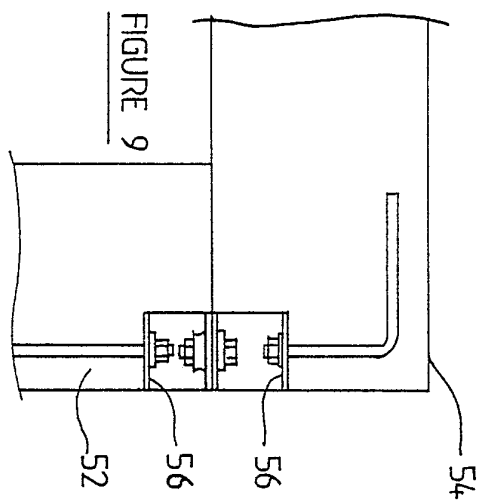
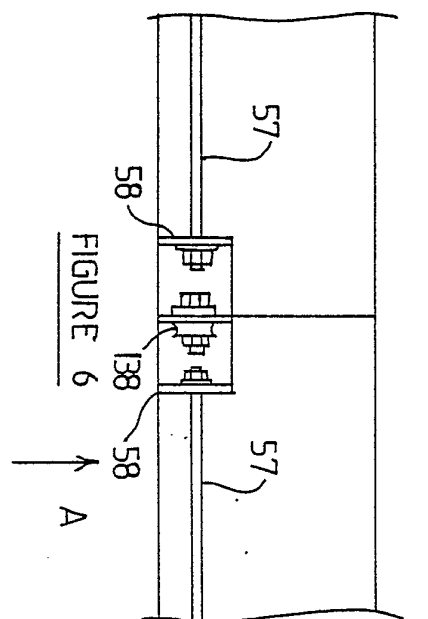




FIGURE 10

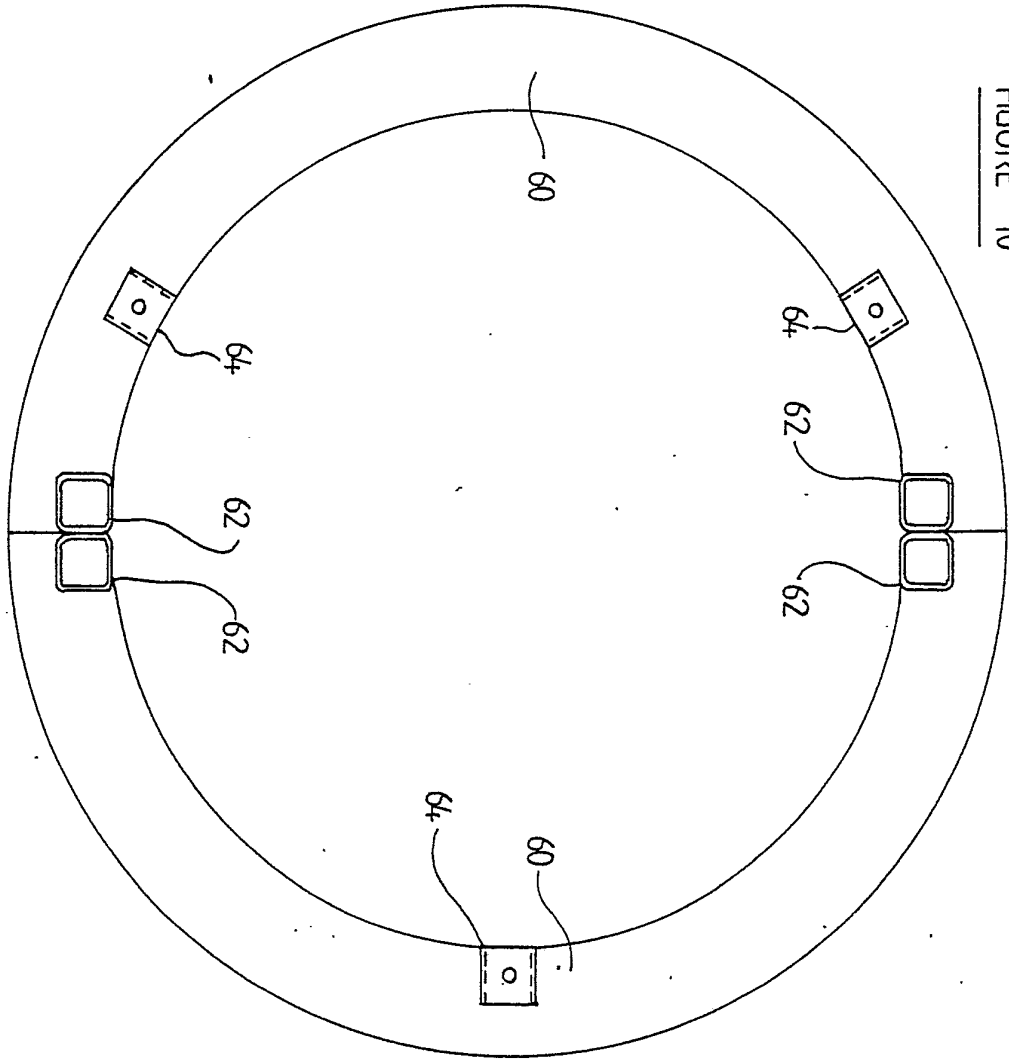
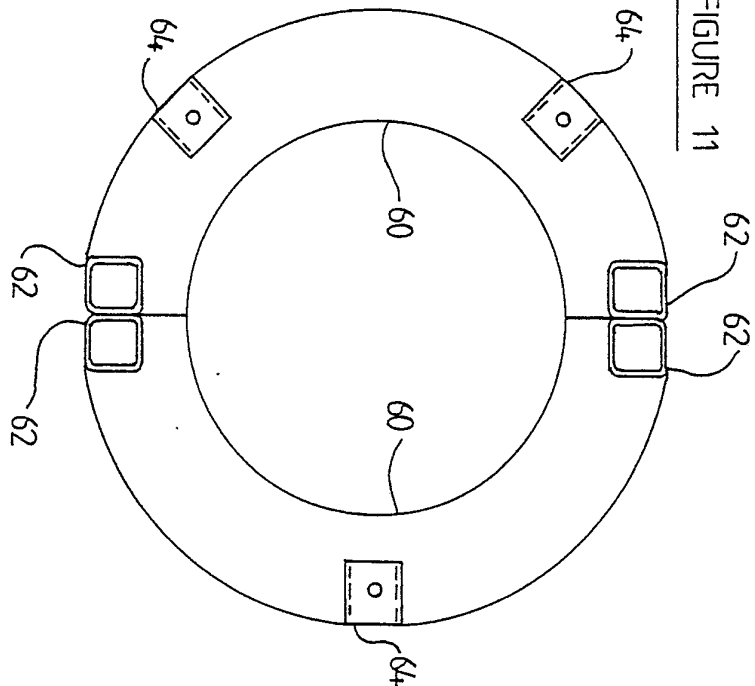


FIGURE 11



# INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 86/00059

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC Int. Cl. <sup>4</sup> E21D 11/08		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
IPC	E21D 11/08	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
AU : IPC as above		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X,Y	GB,A, 1502207 (TSUZUKI) 22 February 1978 (22.02.78)	1-6
Y	GB,A, 2055413 (FAIRCLOUGH CONSTRUCTION GROUP LTD) 4 March 1981 (04.03.81)	1,2,4,5
A	GB,A, 2026064 (CHARCON TUNNELS LTD) 30 January 1980 (30.01.80)	
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"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</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"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.</p> <p>"A" document member of the same patent family</p> </div> </div>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
20 May 1986 (20.05.86)	(02.06.86) 2 JUNE 1986	
International Searching Authority	Signature of Authorized Officer	
Australian Patent Office	J.M. SELLARS	

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON  
INTERNATIONAL APPLICATION NO. PCT/AU 86/00059

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.

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Patent Document  
Cited in Search  
Report

Patent Family Members

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GB 1502207

HK 512/81

JP 52012735

JP 52121930

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END OF ANNEX