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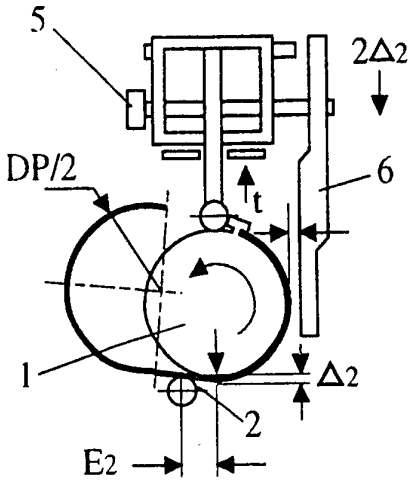
(54) Title: PIPE FORMING MACHINE

(57) Abstract

An improved process and apparatus for forming pipe from a flat steel plate by curving the plate around a rotatable mandrel (1) in which the ratio of plate length and width is relatively high comprising the process steps and apparatus of applying abutment members (6) against the sides of the mandrel and creating a horizontal component of force between the mandrel, plate and supporting rolls which horizontal component of force is opposed by said abutment member (6) acting to stabilize the mandrel at most times and at least during the final stages of forming the pipe.



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PIPE FORMING MACHINE

The present invention relates to mandrel type pipe forming machines as described in my US patent No. 3879994 and WO90/10510 hereby incorporated herein by a cross reference.

SUMMARY OF THE PRIOR ART

Machines are now required to manufacture pipes in a wide range of diameters and plate thicknesses. In the latter specification referred to above, there is described a method of forming cylindrical or tapered pipes of various diameters and including means to apply deflection limiting forces against the mandrel particularly in small diameter pipes having large wall thickness. Further reference is made to my application No. WO90/10511 also hereby incorporated herein by cross reference.

Thus the application of forces laterally against the sides of the mandrel and at the top and bottom thereof is described in an endeavour to maintain deflection of the mandrel within allowable limits during a forming operation.

Problems have been encountered in the forming of long pipes having comparatively thick plate and small diameter (high D/t ratio where D = diameter and t = thickness). These problems have not previously been addressed insofar as I am aware. Also there are problem in relation to achieving satisfactory forming of plates of high strength steel wherein the length/diameter ratio falls between 15 and 50 where L the length of the pipe divided by D the diameter of the pipe is a factor in the range of 15 to 50.

Problems arise particularly in the final steps of forming the pipe where it is necessary to provide some lateral stability to the mandrel whilst applying strong vertical forces to the mandrel from the top and bottom pressure rolls. Lateral stability is also necessary at various stages of the pipe forming process for pipes of the above type. In this regard reference is made to Figure 4 of my application referred to No. WO90/10510 in which some lateral stability is provided by buttress 18 preventing lateral movement of the pipe and mandrel to the right.

It will be appreciated that the buttress 18 on the right side of the mandrel must be removed to allow free travel of the curved plate 10 around the mandrel during forming of the latter half of the pipe.

OBJECTS OF THE PRESENT INVENTION

It is an objective of the present invention to provide improved lateral stability in a mandrel pipe forming machine particularly useful in the forming of long pipe using relatively thick plate of either high or low strengths.

It is a further objective to provide apparatus and a process useful in the forming of pipes of relatively small diameter when compared with the length of the pipe for example having a length to diameter ratio of up to 50.

According to the present invention there is provided in a process for forming a pipe from flat steel plate having a relatively high length to width ratio including the steps of engaging flat plate with a gripper rib mounted on a rotatable mandrel with the edge of the plate in the gripper rib, curving the plate around the mandrel as the mandrel is rotated, applying laterally moveable pressure roll means beneath the mandrel to apply a squeezing force to the plate and mandrel as the mandrel is rotated, the improvement including the step of applying abutment means against at least one side of the mandrel during at least partial formation of each half of the plate.

In a further aspect of the inventive process the opposing edge of the half curved plate is engaged with the gripper rib and is curved around the mandrel as the mandrel is rotated to complete the curvature of the plate to form a substantially cylindrical section, wherein an abutment means is applied against the mandrel and plate during said curving step, and said pressure roll means is laterally and vertically offset relative to the mandrel so that a horizontal component of force is applied which is opposed by said abutment means to stabilize the mandrel at least during the final stages of said curving operation.

Conveniently the pressure roll means is laterally offset during forming of the first half and second half of the plate during which said abutment means is applied to both sides of the mandrel.

Conveniently the pressure roll means is a single roll applied to the top and bottom of the mandrel.

A particular feature of the present invention is the positioning of the pressure roll means relative to the mandrel during the final stages of the forming operation to provide a horizontal force component which is opposed by the abutment means applying a lateral force to the mandrel.

BRIEF DESCRIPTION OF THE DRAWINGS

The practical arrangement of the process will now be described having reference to the annexed drawings in which:

Figure 1 and Figure 1a represents step 1 of the plate forming process and the associated force diagram,

Figure 2 and Figure 2a represents step 2 of the plate forming process and the associated force diagram,

Figure 3 and Figure 3a represents step 3 of the plate forming process and the associated force diagram,

Figure 4 and Figure 4a represents step 4 of the plate forming process and the associated force diagram,

Figure 5 and Figure 5a represents step 5 of the plate forming process on the second part of the plate and the associated force diagram,

Figure 6 and Figure 6a represents step 6 of the pipe forming process and the associated force diagram,

Figure 7 and Figure 7a represents step 6A of the pipe forming process and the associated force diagram,

Figure 8 and Figure 8a represents step 6B of the pipe forming process and the associated force diagram,

Figure 9 and Figure 9a represents step 7 of the pipe forming process, and

Figure 10 represents the formation of the finished pipe released from the gripper rib.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to Figure 1, this shows step 1 of the process in which the edge of the plate is engaged with the gripper rib 3 on the mandrel. The plate is supported on a bed 9 and is pushed toward the gripper rib 3 by a pusher mechanism 10 schematically shown.

Side bolster members 5 and 6 are extended downwardly to make contact with each side of the mandrel to stabilize the mandrel whilst engagement of the gripper rib with the plate is taking place.

Figure 1a represents a schematic force diagram with

F2 representing an upward force applied by the lower roller 2

F4 the downward force applied by roller 4

F10 is the force applied by the pusher 10 and

F5 and 6 is the force applied to stabilize the mandrel location.

The mandrel 1 is rotatably mounted on a machine (now shown) having overhead structures supporting an overhead roll 4 and side bolster abutments 5 and 6. Additional movable stays 7 and 8 are provided for use as necessary to provide lateral support for the top roller 4 especially when the gripper is passing beneath the roller 4 and acting to force the roller 4 upwards.

The abutments 5 and 6 are retained in position as shown in Figures 1 and 2 to maintain the mandrel straight and stabilized during the first half of the formation of the plate. The position of bolster abutment 6 is such that the mandrel can deflect slightly to the right by approximately 2 times the plate thickness (2_t) so that the gripper is allowed to pass between the mandrel and the abutment 5. Roller 4 is engaged by the gripper in the 12 o'clock position and forced upwards at which time the abutment 5 provides a reaction force and stabilizes the mandrel until the formation of the first half of the plate as shown in Figure 3 at step 3.

With reference to Figure 3, the side abutment members 5 and 6 are retracted and the roller members 2 and 4 are moved relatively to the mandrel by a distance Δ_1 to apply forces to the plate in the final stages of the formation of the first half, these forces shown and represented as references F4 and F2 in Figure 3a.

With reference to Figure 4, the top roll 4 and the mandrel 1 are raised together with a slightly anti-clockwise rotation of the mandrel to allow release of the plate from the gripper as shown.

With reference to Figure 5, showing step 5 of the process, the other edge of the plate is fitted to the gripper rib 4 with a lower pressure roll 2 positioned off centre a distance e1 as shown Figure 5. The curved part of the plate is contacted by an abutment member 11 to force the edge of the plate into engagement with the gripper. Simultaneously bolster members 5 and 6 are located against the mandrel to stabilize its position resulting in a force diagram as shown in Figure 5a with vertical forces F4, F2 and horizontal force components F11H, F6 and F5. The side abutment member 5 is positioned in a similar manner to side abutment 6 was positioned in step 2 as shown in Figure 2 previously described to allow passage of the gripper at the 3 o'clock position past the abutment 6. Therefore the mandrel is able to deflect to the left by a distance of twice the plate thickness (2_t) whilst the gripper is at the 3 o'clock position.

This position is clearly shown in Figure 6 of the drawings representing step 6.

With reference to Figure 7 illustrating step 6A of the process abutment 6 provides the opposite reaction force as that provided by abutment 5 in step 2 described above to allow the roller 4 to be forced upwardly by the passage of the gripper at the 12 o'clock position at this point as shown in Figure 7 abutment 5 must be retracted to allow clearance for the previously formed plate edge as the final half of the plate is formed.

In Figure 8 and Figure 8a the mandrel is forced down a distance of Δ_2 with the lower roll laterally offset a distance e2 whereby forces F2H and F2V are applied against the plate as it is being curved around the mandrel. Reference to the force diagram in Figure 8a reveals that there is a horizontal component of force F2H from the left applied to the plate and mandrel acting as a lateral stabilizing force on the mandrel during the final steps of curving which is opposed by the reactive force F6 applied by the right abutment member 6. This horizontal force component F2H is required to stabilize the mandrel in the forced absence of abutment 5 during the final stages of forming of the plate.

Figure 9 representing step 7 shows the completed pass with the lower roller 2 being again moved into alignment or almost into alignment with the centre line of the mandrel so that the lower roller 2 can adequately match the high forces required in the final stages of rolling of the plate. That is distance e3 is almost 0 depending on the D/t ratio, the yield strength of the steel plate and other factors affecting the spring back of the steel.

Figure 11 shows step 8 of the process which illustrates the release of the curved plate from the gripper rib and the completion of the curving operation of the plate ready for welding of the joint in the cylindrical section to form a finished pipe.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. In a process for forming a pipe from flat steel plate having a relatively high length to width ratio including the steps of engaging flat plate with a gripper rib mounted on a rotatable mandrel with the edge of the plate in the gripper rib, curving the plate around the mandrel as the mandrel is rotated, applying laterally moveable pressure roll means at least beneath the mandrel to apply a squeezing force to the plate and mandrel as the mandrel is rotated, the improvement including the step of applying abutment means against at least one side of the mandrel during at least partial formation of each half of the forming of the plate.

2. In a process for forming a pipe from flat steel pipe having a relatively high length to width ratio as claimed in claim 1 including the steps of engaging the opposing edge of the steel plate, curving the plate around the mandrel as the mandrel is rotated to complete the curvature of the plate to form a substantially cylindrical section, wherein an abutment means is applied against the mandrel and plate during said curving step, and said pressure roll means is laterally and vertically offset relative to the mandrel so that a horizontal component of force is created which is opposed by said abutment means to stabilize the mandrel at least during the final stages of said curving operation.

3. Apparatus for carrying out the process steps of claim 1 or claim 2 comprising a rotatable mandrel, top and bottom pressure roll means, movable laterally upwardly and downwardly relative to said mandrel, the mandrel including a gripper rib for gripping an edge of a plate as defined to curve the plate around the mandrel to form substantially a cylindrical pipe wherein side bolster members are positionable relative to said mandrel to stabilize the mandrel at lest against lateral forces applied by said top and bottom rollers.

4. Apparatus as claimed in claim 3 wherein the bolster abutments are laterally movable a predetermined distance during traverse of the gripper rib past the bolster member.

5. Apparatus as claimed in claim 3 wherein the top and bottom roller and mandrel are relatively movable by a predetermined distance with the bottom roller being laterally offset to create a horizontal force component which is opposed by a corresponding abutment bolster.

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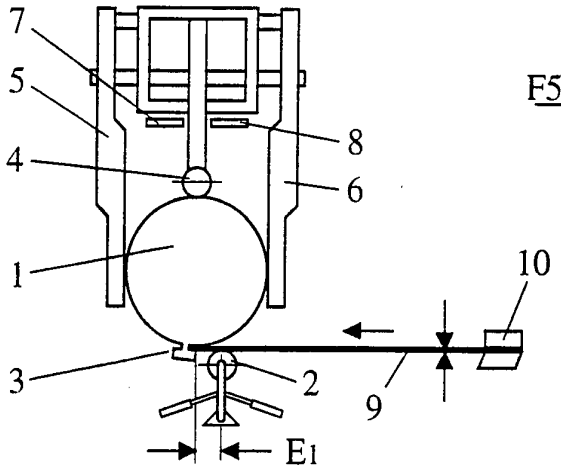

Fig. 1.

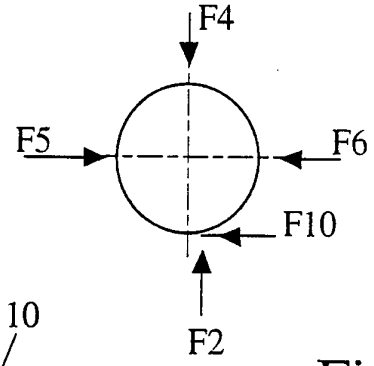

Fig. 1a.

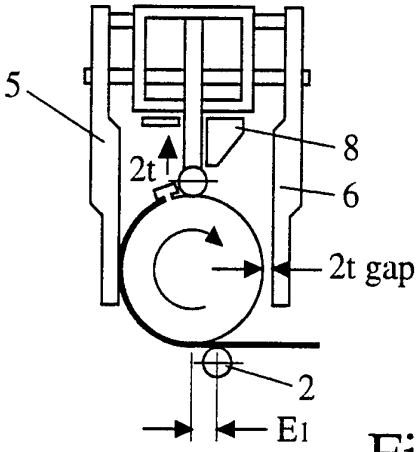

Fig. 2.

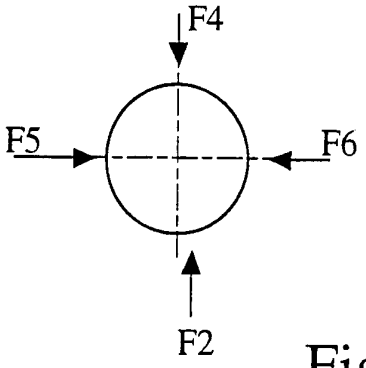

Fig. 2a.

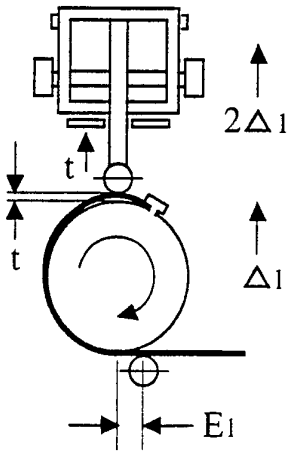

Fig. 3.

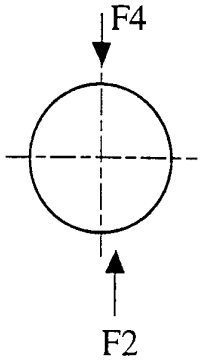

Fig. 3a.

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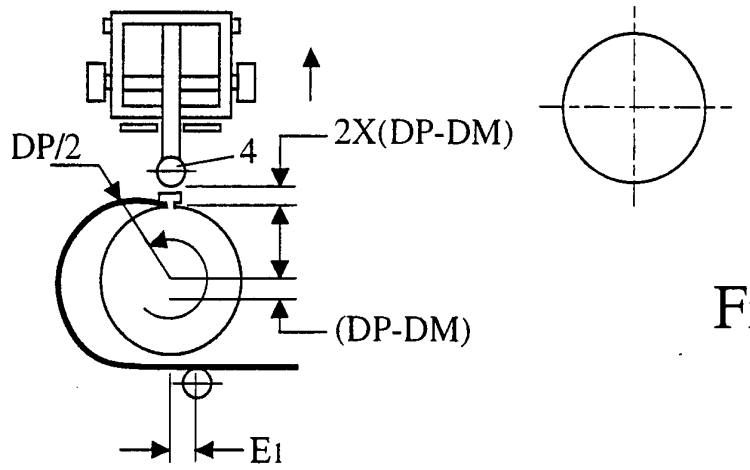
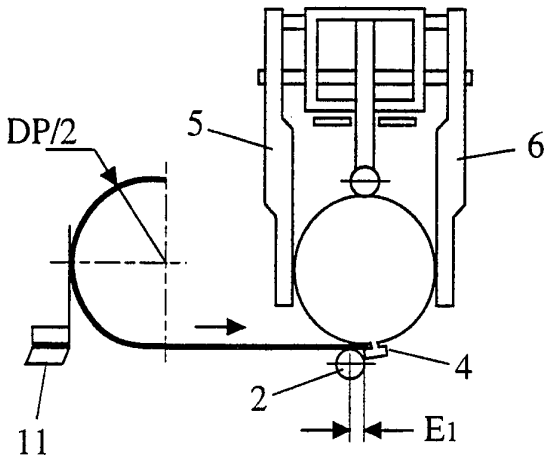


Fig.4a.

Fig.4.



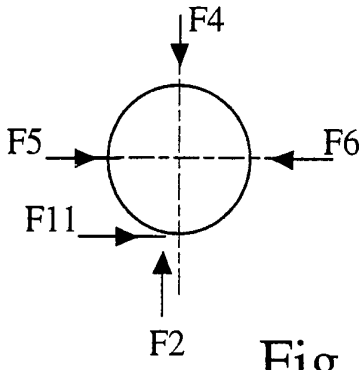
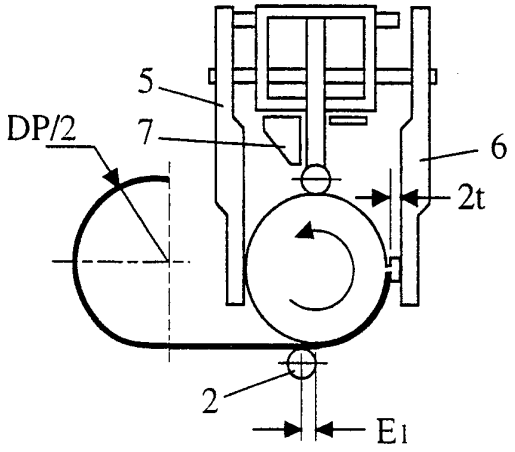


Fig. 5a.

Fig. 5.



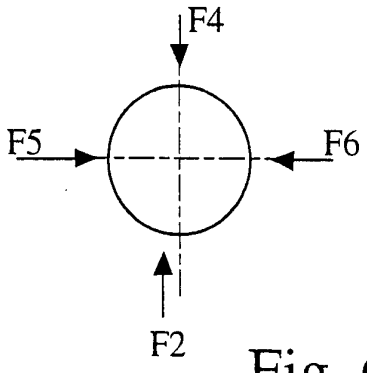


Fig. 6a.

Fig. 6.

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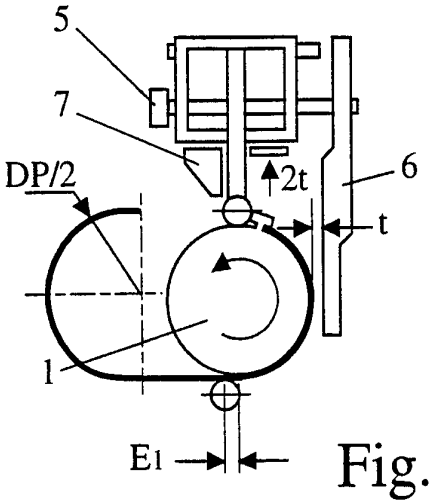

Fig. 7.

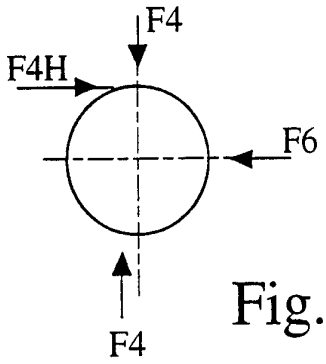

Fig. 7a.

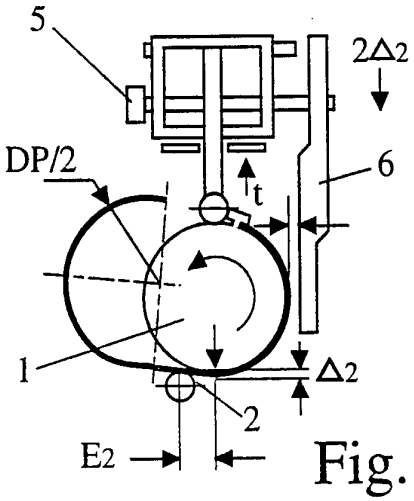

Fig. 8.

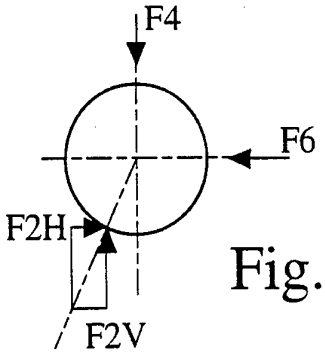

Fig. 8a.

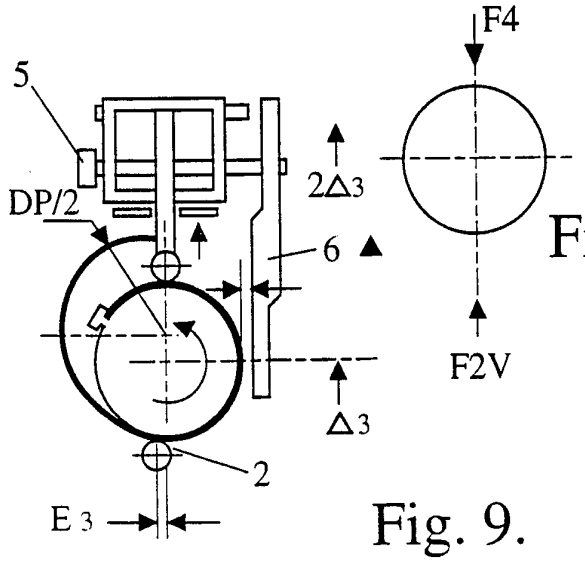

Fig. 9.

Fig. 9a.

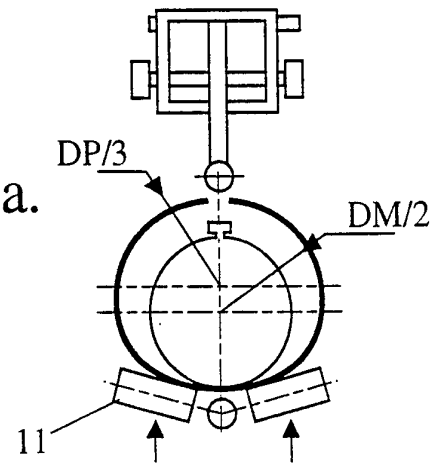

Fig. 10 .

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 94/00161

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[5] B21D 5/12// B21C 37/08 37/18

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)

IPC B21D 5/12 B21C 37/08 37/18

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

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	AU,B, 52734/90 (634220) (HUME) 9 October 1990 (09.10.90) refer platedeflection limiters 18,19,20,21 -figure 1	1-5
X	AU,A, 52840/90 (HUME) 20 September 1990 (20.09.90) refer deflection limiting device 20,21,22 -figure 4a	1-5
A	US,A, 3879994 (HUME) 29 April 1975 (29.04.75) entire document	

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Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	DE,A, 2133016 (FERRANTI) 5 January 1972 (05.01.72) entire document	
A	EP,A, 29345 (HUME) 27 May 1981 (27.05.81) entire document	
A	AU,B, 64420/80 (544314) (HUME) 21 May 1981 (21.05.81) entire document	
A	AU,B, 75578/81 (549490) (HUME) 25 March 1982 (25.03.82) entire document	

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Patent Document Cited in Search Report		Patent Family Member					
AU	52734/90	CA	2049293	EP	463039	US	5245849
		WO	9010510	WO	9010511		
AU	52840/90	CA	2049293	EP	463039	US	5245849
		WO	9010510	WO	9010511		
US	3879994	DE	2343367				
DE	2133016	FR	2097182				
EP	29345	AR	225199	CA	1138761	JP	56111524
		MX	154267	NZ	195554	PH	23274
		ZA	8007076				
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