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(74) Agent: **FISHER ADAMS KELLY**; GPO Box 1413, Brisbane, QLD 4001 (AU).

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(71) Applicant (for all designated States except US): **SMORGON STEEL LITESTEEL PRODUCTS PTY LTD** [AU/AU]; 650 Lorimer Street, Port Melbourne, VIC 3207 (AU).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **BARTLETT, Ross John** [AU/AU]; 1-11 Canberbury Drive, Mundoolun via Beaudesert, QSD 4285 (AU). **NOLLER, Alexander** [DE/AU]; 5 Teresa Court, Springwood, QLD 4127 (AU). **YOKOYAMA, Keiji** [JP/JP]; 3-28-5 Fujiwara, Funabashi, Chiba T 273-0047 (JP).

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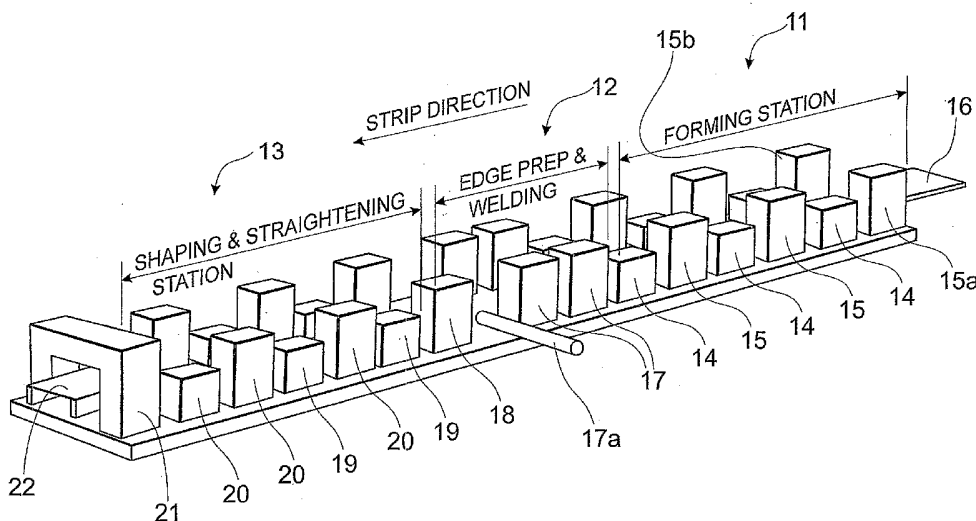
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(54) Title: IMPROVEMENTS IN WELDING HOLLOW FLANGE MEMBERS



(57) Abstract: An apparatus for in-line ERW welding of hollow flange steel members in a cold forming mill comprises a seam roll stand (60) rotatably supporting at least one seam roll (68) adapted in use to guide a free edge (34a, 34b) of a contoured metal strip (30) into linear alignment with a predetermined weld axis spaced from said free edge on a surface of the metal strip. The apparatus also includes a weld box stand (61) supporting at least one pair of squeeze rolls (84a, 84b), in use, adapted to urge the free edge (34a, 34b) when heated to a predetermined temperature into fused engagement with a correspondingly heated weld axis on the surface of the strip (30). The squeeze rolls (84a, 84b) co-operate to guide the free edge through a predetermined linear trajectory substantially along an incidence axis of a subsequent weld junction between the free edge (34a, 34b) and the surface of the metal strip (30) whereby energy imparted to the cold formed member is focussed by a proximity effect along the predetermined weld axis.

TITLE

"IMPROVEMENTS IN WELDING HOLLOW FLANGE MEMBERS"

FIELD OF THE INVENTION

5 This invention is concerned with the manufacture of cold formed hollow flange members by an improved welding process.

The invention is concerned particularly although not exclusively with the manufacture of cold formed, dual welded, hollow flange structural members.

BACKGROUND OF THE INVENTION

10 Although there are many configurations of structural beams illustrated in an extensive array of prior art disclosures, the majority of these beams have been designed with a specific end use in mind. A number of these prior art disclosures have however sought to provide a general purpose structural beam which could compete with the more common
15 general purpose structural beams such as timber including laminated timber beams and hot rolled I-beams, H-beams and hot rolled channels.

Examples of specific purpose structural beams are shown in United States Patents 5,012,626, 3,362,056 and 6,415,577 which describe composite beams having a corrugated web and planar or rectangular section
20 hollow flanges. Australian Patent 716272 describes a truss incorporating hollow flange chords.

Of more recent years, cold formed purlins of C-, Z- and J-shaped cross-section have found favour in relatively low load bearing situations as a replacement for hot rolled sections as generally they have a

superior section capacity per unit mass. Such cold formed purlins do have significant limitations in moment capacity as the length of the beam increases due to a number of differing buckling modes of failure. British Patents 2 093 886 and 2 102 465 illustrate respectively cold formed J- and I- or H-sections while International Publication 96/23939 describes a C-section member.

In an endeavour to improve on the section efficiency of cold formed purlin-like sections, it was proposed to employ hollow-flange members to increase the flange section without a consequent or at least significant penalty in beam mass per unit length.

Examples of hollow flanged bearings are shown in United States Patent 3,342,007, Russian Inventor's Certificate 827723 and United States Patent 3,698,224, all of which described hollow flanged beams of triangular cross-section with "open" flanges i.e., they were not formed with continuous weld seams to optimize the torsional strength of the flange elements.

United States Patents 5,163,225 and 5,373,679 to the present assignee as successor in title thereto, described for the first time cold formed hollow flange beams produced by a dual welding process to produce "closed" flanges of a circular cross-sectional shape where the free edges of the flanges were welded along the edges of the central web member. The generally circular flanges could then be shaped after welding to produce hollow flanges with a variety of cross-sectional shapes such as rectangular, hexagonal, triangular, or the like. Hollow flanged beams having triangular

cross-section flanges were known in the marketplace as "Dogbone" (Registered Trade Mark) beams.

Although generally satisfactory for its intended purpose, the dual welding process adopted for the manufacture of "Dogbone" beams suffered a number of shortcomings, in particular weld stability and a limitation in the range of flange cross-sectional sizes due to excessive tooling costs. In one embodiment stress failures in the weld were caused by excessive working of the hardened weld zone in the shaping section of the mill.

As used herein the expression "ERW" refers to electrical resistance or induction welding using either contacts or induction coils/impeders to create a current in the member and other forms of electrical resistance welding.

Accordingly, it is an aim of the present invention to overcome or alleviate at least some of the shortcomings of the prior art "Dogbone" dual welding process and to provide a welding process suitable for the production of hollow flanged cold formed steel members.

SUMMARY OF THE INVENTION

According to one aspect of the invention there is provided a process for in-line welding of hollow flange steel members in a cold forming mill, said process comprising the steps of:-

forming a contoured surface adjacent at least one edge of a metal strip;

welding, by a ERW process, a free edge of said metal strip adjacent said contoured surface to a surface of said metal strip to form a

hollow flange extending along a side of a web, said process characterized in that said free edge is aligned linearly with a predetermined weld axis on said surface of said strip and said at least one free edge is guided through a predetermined linear trajectory along an incidence axis of a subsequent weld
5 junction between said at least free one edge and said surface whereby energy imparted to said cold formed member is focussed by a proximity effect along said predetermined weld axis on said surface prior to fusing said free edge thereto.

If required, said free edge is aligned with said weld axis by one
10 or more seam rolls each having a circumferential shoulder providing an abutment for said free edge.

Said free edge of said metal strip may be urged into abutment with said circumferential shoulder by a contoured guide roll.

Suitably, said metal strip is supported centrally by opposed
15 cylindrical roll surfaces adjacent said weld region as said free edge is urged into abutment with said circumferential shoulder

The seam rolls may be adjustably mounted to guide said free edge toward said closure region at a predetermined angle relative to said strip surface.

20 Preferably, said free edge of said metal strip is guided through said predetermined trajectory by a contoured squeeze roll extending over said contoured surface of said metal strip between spaced substantially parallel contact faces of said contoured squeeze roll.

Weld energy may be imparted to said free edge and said

predetermined weld region by an induction coil coupled to a source of electric current, said coil extending substantially around said metal strip in a plane substantially perpendicular to a longitudinal axis thereof.

If required, an elongate rod-like induction impeder supported at one end may extend within a hollow interior cavity of said contoured surface to a region adjacent a said closure region where said free edge is fused to said surface of said metal strip.

According to another aspect of the invention there is provided an apparatus for in-line ERW welding of hollow flange steel members in a cold forming mill, said apparatus comprising:-

a seam roll stand rotatably supporting at least one seam roll adapted, in use, to guide a free edge of a contoured metal strip into linear alignment with a predetermined weld axis spaced from said free edge on a surface of said metal strip; and,

a weld box stand rotatably supporting at least one pair of squeeze rolls, in use, to urge said free edge when heated to a predetermined temperature into fused engagement with a correspondingly heated said weld axis on said surface, said pair of squeeze rolls co-operating, in use, to guide said free edge through a predetermined linear trajectory substantially along an incidence axis of a subsequent weld junction between said free edge and said surface of said metal strip whereby energy imparted to said cold formed member is focussed by a proximity effect along said predetermined weld axis on said surface.

Suitably, said electrical current is induced in said free edge and

said weld region by electrical contactors slidably engaging said metal strip adjacent said free edge and said weld region.

Preferably, said electrical current is induced in said free edge and said weld region by an induction coil transversely surrounding said metal strip in a plane perpendicular to a direction of travel of said metal strip therethrough.

Preferably, at least one of said pair of squeeze rolls is angularly adjustable in a plane perpendicular to a direction of travel of said metal strip therebetween.

At least one of said pair of squeeze rolls may be adjustable relative to the other of said pair in a direction perpendicular to a rotational axis of said at least one of said pair of squeeze rolls.

Suitably, said weld box includes web support rolls rotatable about parallel respective axes perpendicular to a direction of travel of a metal strip member therebetween.

If required, a web support roll may have a contoured outer edge to function as one of said pair of squeeze rolls.

The apparatus may include more than one seam roll stand.

If required, at least one of said seam roll stands includes a seam roll having a circumferential shoulder thereon, said circumferential shoulder, in use, providing an abutment for said free edge of said metal strip.

Suitably, a contoured guide roll is provided, in use, to urge said free edge of said metal strip into abutment with said circumferential shoulder.

If required, a rod-shaped impeder supported at one end

thereof, upstream of said one or more seam roll stands, extends into a hollow interior of a contoured edge region of said metal strip.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more fully understood and put into practical effect, reference will now be made to preferred
5 embodiments illustrated in the accompanying drawings in which:-

FIG. 1 shows schematically a cold roll forming mill for hollow flange members;

FIG. 2 shows schematically a prior art dual weld process;

10 FIG. 3 shows schematically a prior art squeeze roll region in a weld box of a cold roll forming mill;

FIG. 4 shows schematically an enlarged part cross-sectional view of the weld box roll configuration of FIG. 3;

15 FIG. 5 shows a side elevational view of portion of a cold forming mill incorporating forming roll, seam roll and weld box stands;

FIG. 6 shows portion of a forming flower pattern of a hollow flange beam from the latter stages of forming to just prior to entry into the weld box;

20 FIGS. 7a and 7b show schematically from rear and front views, the configuration of the seam guide roll stand;

FIG. 8 shows schematically the configuration of the weld box stand;

FIG. 9 shows schematically the configuration of the rolls in the weld box stand of FIG. 8;

FIG. 10 shows schematically a phantom perspective view of the rolls in the weld box stand of FIG. 8;

FIG. 11 shows schematically the configuration and relationship of an inductor coil and impeters;

5 FIG. 12 shows schematically a cross-sectional view of the inductor coil/impeder assembly of FIG. 12, in use, with a hollow flange section therein; and

FIGS. 13-16 show cross-sections of hollow flange members made pursuant to the method and apparatus according to the invention.

10 Through the drawings, where appropriate, like reference numerals are employed for like features for the sake of clarity.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 shows schematically a typical general configuration of a roll forming mill which may be employed in the manufacture of hollow flange members as exemplified in FIGS. 11 to 14. Simplistically, the mill comprises
15 a forming station 11, a welding station 12, and a shaping station 13.

Forming station 11 comprises alternative drive stands 14 and forming roll stands 15. Drive stands 14 are coupled to a conventional mill drive train (not shown) but instead of employing contoured forming rolls to
20 assist in the shaping process, plain cylindrical rolls are employed to grip steel strip 16 in a central region corresponding to the web portion of the resultant beam. The forming roll stands 15 are formed as separate pairs 15a, 15b each equipped with a set of contoured rollers adapted to form a hollow flange portion on opposite sides of the strip of metal 16 as it passes through

the forming station. As the forming roll stands 15a,15b do not require coupling to a drive train as in conventional cold roll forming mills, forming roll stands are readily able to be adjusted transversely of the longitudinal axis of the mill to accommodate hollow flange beams of varying width.

5 When formed to a desired cross-sectional configuration, the edge formed strip 16 enters the welding station 12 wherein the free edges of edge formed portions are guided into contact with the web at a predetermined angle of approach in the presence of an ERW welding apparatus. To assist in location of the free edges relative to a desired weld
10 region on the strip surface, the formed strip is directed through seam guide roll stands 17 into the region of the ERW apparatus shown schematically at 17a. After the strip edges and the weld seam line region on the face of the strip are heated to fusion temperature, the strip passes through a weld box stand 18 to urge the heated portions together to fuse closed flanges. The
15 welded hollow flange section then proceeds through a succession of drive roll stands 19 and shaping roll stands 20 to form the desired cross-sectional shape of the member and finally through a conventional turk's head roll stand 21 for final straightening and thence to issue as a dual welded hollow flange beam 22. The ERW welder imparts a current into the free edges of
20 the strip and respective adjacent regions of the web due to a proximity effect between a free edge and the nearest portion of the web. Because the thermal energy in the web portion is able to dissipate bi-directionally compared with a free edge of the flange, additional energy is required to induce sufficient heat into the web region to enable fusion with the free edge.

Hitherto it was found that by using conventional roll forming techniques and an ERW process employing the quantity of energy required to heat the inner strip portion to fusion temperature is such as to cause the free edge to become molten and to flow as molten globules away from the edge. As a result of this strip edge loss, the cross-sectional area of the flange was reduced significantly and control of the strip edge into the weld point became more difficult.

FIG. 2 shows schematically a prior art technique for high frequency ERW welding.

In FIG. 2, the web 30 was formed in an arcuate cross-sectional shape in an endeavour to minimize the extent to which the hollow flanges 31 had to be formed to bring the free edges into contact with the edge of the web 30. Pairs of contactors 32,33 coupled to respective sources 34 of high frequency alternating current electricity were located adjacent the free edge 34 of each flange 31 and adjacent the edge of the web at which a weld seam was to be formed. As can be seen, the free edge 34 of each hollow flange 31 approached the weld seam line 35 at an angle thereto, both in a vertical plane and a horizontal plane.

FIG. 3 illustrates a typical prior art weld box roll configuration wherein side rolls 36 urge the shaped flanges 31 inwardly in a horizontal direction while contoured squeeze rolls 37, co-operating with lower support roll 38 urge the heated free edges of the flanges into contact with a heated region at the edge of web 30 to effect fusion therebetween.

The combined forces applied to the free edges of the flanges

by the side rolls 36 and squeeze rolls 37 is effectively to roll the entire flange section whilst effectively reducing its diameter.

FIG. 4 is an enlarged cross-sectional view through the weld box roll assembly shown in FIG. 3. Prior to entry into the weld box roll assembly shown generally at 39, the free edges 34 of flanges 31 are spaced above an ultimate weld seam locations 40 on metal strip 30 as shown in the cutaway region in a somewhat exaggerated manner in phantom. As the roll formed section proceeds through the weld box roll assembly 39, the free edges 34 of the hollow flanges 31 are urged downwardly and outwardly by the combined pressures of the co-operating rolls 36,37,38 whereby the free edges 34 "sweep" across the surface of web 30 until they contact the surface thereof at respective weld seam positions 40.

During the "sweeping" motion of the free edges 34, the heat "shadow", induced in the web by the proximity of the free edges 34 was caused to move outwardly from a position 41, represented by the shortest distance between the free edge 34 and the upper surface of the web, towards the weld seam position 40 at which fusion occurred. Because of the inability to focus the heat induced by the proximity effect in the ultimate weld seam site, a substantial amount of heat energy was dissipated in the web and the adjacent regions of hollow flanges.

In order to overcome energy dissipation, the electrical energy input was increased to compensate for heat energy losses however this tended to overheat the free edge of the web to the extent that molten metal was lost from the free edge of the flange by melting. Moreover, the

requirement to overheat the flange edges to induce sufficient heat into the web edge to obtain adequate weld integrity was exacerbated by edge buckling which resulted in loss of weld stability.

It has now been discovered that the aforementioned difficulties
5 can be overcome by aligning the free edge of the flange with the intended weld line as it is heated and then urging the free edge of the strip into contact with the heated web region along a straight pathway in a direction corresponding to a desired angle of incidence between the web portion and the region of flange edge in the vicinity of the weld seam. By guiding the free
10 edge of the flange edge along this predetermined trajectory, the "sweeping" effect caused by the rotation of the flange in the squeeze rolls of the weld box avoided the problem of inducing heat into an unnecessarily wide path extending away from the desired weld seam line as the free edge was brought into alignment with the desired weld seam line.

15 The far greater control of the high frequency electrical resistance or induction welding process has led to improved production efficiencies and significantly improved manufacturing tolerances on the dual welded hollow flange members made in accordance with the process and apparatus according to the invention.

20 FIG. 5 shows a side elevational view of portion of a cold roll forming mill incorporating portion of the forming station 11 and the edge preparation and welding station 12 of FIG. 1.

In FIG. 5, a mill bed 50 supports a driven forming roll 51, an idler stand 52, an undriven edge forming stand 53, a further idler stand 54,

an impeder bracket 55, an undriven edge forming stand 56, a further undriven edge forming stand 57, a driven forming roll stand 58 with side rolls 59, a six roll seam guide roll stand 60 and a four roll weld box stand 61. Located between stands 60 and 61 is a work coil 62.

5 FIG. 6 is illustrative of a flower pattern for a hollow flange member produced in the mill portion shown in FIG. 5.

Section 6A is illustrative of the shape emerging from roll stand 53, section 6B is illustrative of the shape emerging from roll stand 58, section 6C is illustrative of the shape emerging from seam guide roll stand 60 and
10 section 6C is illustrative of the shape of the roll formed section prior to entry into weld box stand 61. As can be seen the trajectory of the free edge 34 of hollow flange 31 follows a path of least distance between edge 34 and the edge 40 of web 30 and as the section approaches the seam guide roll stand 60, the cross-sectional shape of the hollow flange as shown at 6C has
15 adopted a somewhat ovoid shape. It also will be seen that the position of the flange edge 34 has been fixedly located relative to the edge 40 of web 30 in the region of the induction coil 62.

FIG. 7 shows schematically the configuration of the seam guide roll stand 60 of FIG. 5 in which FIG. 7a is a downstream elevational view and
20 FIG. 7b is an upstream elevational view.

FIG. 7a shows schematically a downstream elevational view of the seam roll stand 60 in FIG. 5. Roll stand 60 comprises a support frame 65, on the downstream face of which are mounted a pair of independently mounted, contoured support rolls 66, 66a each journaled for rotation about

aligned rotational axes 67,67a and seam guide rolls 68,68a rotatably
journalled on respective inclined axes 69,69a. Seam guide rolls 68,68a serve
to guide the free edges 34a,34b of hollow flanges 31,31a into longitudinal
alignment with a desired weld seam line as the cold formed section
5 approaches the squeeze rolls of the weld box 61.

Located about the inner edges of seam guide rolls 68,68a are
peripheral beaded edges 70 which serve as an abutment against which the
free edges 34 of the hollow flanges may be urged to align those flange
edges with the edges 40 of web 30.

10 Both seam guide rolls 68,68a and support rolls 66,66a are
axially adjustable to accommodate hollow flange members of differing sizes.
Similarly, seam guide rolls 68,68a are pivotally mounted on support frame
65.

FIG. 7b is an upstream view of the seam guide roll support
15 stand 60.

Located within the arched frame 65 are a cylindrical seam
guide roll 71 and a cylindrical support roll 72, each rotatably journalled about
respective rotational axes 73,74. Support roll 72 includes contoured end
regions 72a to accommodate portion of the hollow flanges 31 while beaded
20 ends 75,76 of seam guide roll locate over the inner edges 40 of web 30 with
the free edges 34 of hollow flanges 31 abutting against the planar ends of
roll 71. Web 30 is firmly clamped between the cylindrical portions of rolls 71
and 72 to prevent buckling thereof, particularly adjacent edges 40.

FIG. 8 shows the configuration of the four roll weld box 61 in

FIG. 5.

Weld box 61 comprises a cylindrical top roll 80 and a cylindrical lower roll 81 with contoured edges 81a, each of rolls 80,81 being rotatably journaled about respective rotational axes 82,83. Contoured squeeze rolls 84a,84b rotatable about respective inclined axes 85a,85b are adapted to urge the heated free edges 34a,34b of hollow flanges 31 into respective heated weld seam line regions along the opposed boundaries 40 of web 30 to effect fusion therebetween to create a continuous weld seam. It will be noted that the cavities defined between squeeze rolls 84a,84b and respective contoured edges 81a of cylindrical support roll 81 are ovoid in shape similar to the cross-sectional shape of the hollow flanges 31 represented by section 6D of FIG. 6.

The free edges 34a,34b are urged toward respective weld lines in a linear fashion perpendicular to the respective rotational axes 85a,85b of squeeze rolls 84a,84b without a transverse "sweeping" action thereby maintaining stable induction "shadows" or pathways on or at the desired position of the weld seams between respective free edges 34a,34b and the opposed boundaries 40 of web 30.

Cylindrical rollers 80,81 are adjustably mounted for movement in an upright plane by adjustment screws 86,87 respectively, the screws 86,87 being coupled to roll carriages 88,89 respectively, slidably mounted in support frame 90.

Squeeze rolls 84a,84b are slidably mounted in respective carriages 91,92 of squeeze roll support frames 93,94 respectively for slidable

adjustment along respective sliding axes 95,96 by means of adjustment screws 97. Squeeze roll support frames 93,94 are, in turn, adjustably mounted for transverse movement by a screw 98 coupling mountings for support frames 93,94 by a threaded shaft 99 and for upright movement by
5 screws 100. Preferably, roll support frames are pivotally mounted on frame 90 for pivotal movement about respective axes parallel to the direction of movement of a hollow flanged member moving through weld box stand 61.

The adjustable roll mounting enables a wide range of hollow flange members of varying dimensions and cross-sectional configurations to
10 be welded in the weld box with extremely precise control over the trajectory through which the free edges of the hollow flanges travel towards a precisely located weld seam line adjacent or at the edges of the member web.

FIG. 9 shows schematically the configuration of the rolls in weld box 61 of FIG. 8 to more clearly illustrate the guidance of the free edges of
15 the hollow flanges into the weld seams along the edges of the web.

In the drawing a somewhat exaggerated position of the formed hollow flanges 31 and their respective free edges 34 is shown in phantom. As the formed section approaches the roll combination, hollow flanges 31 are urged inwardly towards the contoured ends 81a of separate rollers 81
20 which correspond to the movement of rollers 84a,84b along respective sliding axes 95,96 as shown in FIG. 8.

Importantly, it can be seen that about half of the outer portion of the hollow flanges which terminate in the free edges 34 is urged in the direction shown by arrows 101 whereby the almost flat region of the flange

adjacent the free edge 34 and a corresponding portion of the opposite side of the flange are driven together as a unitary portion towards roll 81 whereby deformation of the remaining portion of the flange adjacent the edge 40 of the web 30 is accommodated in the contoured edges 81a of rolls 81.

5 Equally, it will be seen that the free edge 34 of the web 31 travels in a straight line trajectory to the edge 40 of web 30 where the weld seam is formed.

FIG. 10 shows schematically in phantom an enlarged perspective view of the relationship of the squeeze rolls 84a,84b to upper and lower support rolls 80,81 as the free edges 34 of flanges 31 are guided
10 into fusion with the boundaries 40 of web 30. In the embodiment shown, lower support roll 81 is illustrated as separately journalled roll elements, each with a contoured outer edge 81a.

FIGS. 11 and 12 show schematically the high frequency
15 electrical energy induction apparatus 100 employed with the apparatus according to the invention.

Apparatus 100 comprises an inductor coil assembly 101 having a shaped sheet copper coil 102 which substantially surrounds a hollow flange beam 103 as it travels between the seam guide roll station and the
20 weld box. Coil assembly 101 is supported at opposite ends by copper mounting brackets 104 with a layer of insulating material 105 therebetween.

Formed over the surface of coil 102 and brackets 104 are copper tubes 106 with inlet and outlet ports 107 for circulation of cooling water therein. Coil 102 is coupled to an oscillator (not shown) having a

capacity of 400-800 Kw AC output at 400 KHz.

Located within the hollow cavities of hollow flanges 109 of beam 103 are elongate impeder support rods 110 having cylindrical impeders 111 attached thereto. As shown in FIG. 5, impeder support rods 110 are supported on a bracket 55 upstream of the welding station 12 by members (not shown) extending into the flange cavities 108 via the gap between the free edge of the hollow flange 109 and the adjacent side of the web. Coolant circulation tubes 112 and an air tube 113 extend through the gap between the free edge of the flange 109 and the adjacent side of the web to supply a recirculating liquid coolant and a stream of cool air to impeders 111 containing ferrite rods (not shown).

FIGS. 13 to 16 show a non-limiting range of examples of hollow flange members able to be manufactured in accordance with the process and the apparatus of the invention.

FIG. 13 shows a hollow flange member 120 having a pair of circular cross-section hollow flanges 121 located along the edges 122 of web 123. Member 120 may be employed as a structural member as it is or it may be used as a precursor to hollow flange beams having flanges of non-circular cross-sections.

FIG. 14 shows a hollow flange beam of the "Dogbone" (Registered Trade Mark) configuration as described generally in United States Patent 5,163,225.

FIG. 15 shows a hollow flange beam with rectangular flanges according to co-pending Australian Patent Application 2003903142.

FIG. 16 shows a hollow flange beam with rectangular flanges for use as chords in a composite truss beam structure. The welding process and apparatus according to the invention is particularly advantageous for deep or narrow channel sections such as that illustrated. While it might otherwise be difficult to weld the free edge of a hollow flange to the surface of a web intermediate its side edges when formed inwardly of the web because of an inability to control the free edges' deep in the channel with seam guide rolls, forming the hollow flanges outwardly of the web greatly simplifies the welding process due to precise flange edge control.

It readily will be apparent to a person skilled in the art that many modifications and variations may be made to the various aspects of the present invention without departing from the spirit and scope thereof.

For example, the configuration of the forming rolls, the seam guide rolls and the squeeze roll combination may be adapted to permit differing angles of approach of a free edge of a hollow flange to a weld seam to ensure that, as far as possible, in the subsequent shaping of the hollow flange to a desired cross-section, little or no stress is imposed on the weld seam which could lead to stress failure.

CLAIMS:

1. A process for in-line welding of hollow flange steel members in a cold forming mill, said process comprising the steps of:-
forming a contoured surface adjacent at least one edge of a
5 metal strip;
welding, by an ERW process, a free edge of said metal strip adjacent said contoured surface to a surface of said metal strip to form a hollow flange extending along a side of a web, said process characterized in that said free edge is aligned linearly with a predetermined weld axis on said
10 surface of said strip and said free edge is guided through a predetermined linear trajectory along an incidence axis of a subsequent weld junction between said at least free one edge and said surface whereby energy imparted to said cold formed member is focussed by a proximity effect along said predetermined weld axis on said surface prior to fusing said free edge
15 thereto.
2. A process as claimed in claim 1 wherein said free edge is aligned with said weld axis by one or more seam rolls each having a circumferential shoulder providing an abutment for said free edge.
3. A process as claimed in claim 2 wherein free edge of said
20 metal strip is urged into abutment with said circumferential shoulder by a contoured guide roll.
4. A process as claimed in claim 2 wherein said metal strip is supported centrally by opposed cylindrical roll surfaces adjacent said weld axis as said free edge is urged into abutment with said circumferential

shoulder.

5. A process as claimed in claim 2 wherein said seam rolls are adjustably mounted to guide said free edge toward said closure region at a predetermined angle relative to said strip surface.

5 6. A process as claimed in claim 1 wherein said free edge of said metal strip is guided through said predetermined trajectory by a contoured squeeze roll extending over said contoured surface of said metal strip between spaced substantially parallel contact faces of said contoured squeeze roll.

10 7. A process as claimed in claim 1 wherein weld energy is imparted to said free edge and said predetermined weld axis by an induction coil coupled to a source of electric current, said coil extending substantially around said metal strip in a plane substantially perpendicular to a longitudinal axis thereof.

15 8. A process as claimed in claim 1 wherein weld energy is imparted to said free edge and said predetermined weld axis by one or more contactors coupled to a source of electric current.

9. A process as claimed in claim 7 wherein an elongate rod-like induction impeder supported at one end extends within a hollow interior
20 cavity of said contoured surface to a region adjacent a said closure region where said free edge is fused to said surface of said metal strip.

10. An apparatus for in-line ERW welding of hollow flange steel members in a cold forming mill, said apparatus comprising:-

a seam roll stand rotatably supporting at least one seam roll

adapted, in use, to guide a free edge of a contoured metal strip into linear alignment with a predetermined weld axis spaced from said free edge on a surface of said metal strip; and,

a weld box stand rotatably supporting at least one pair of
5 squeeze rolls, in use, to urge said free edge when heated to a predetermined temperature into fused engagement with a correspondingly heated said weld axis on said surface, said pair of squeeze rolls co-operating, in use, to guide said free edge through a predetermined linear trajectory substantially along an incidence axis of a subsequent weld junction between said free edge and
10 said surface of said metal strip whereby energy imparted to said cold formed member is focussed by a proximity effect along said predetermined weld axis on said surface.

11. An apparatus as claimed in claim 10 wherein said electrical current is induced in said free edge and said weld region by electrical
15 contactors slidably engaging said metal strip adjacent said free edge and said weld region.

12. An apparatus as claimed in claim 10 wherein said electrical current is induced in said free edge and said weld region by an induction coil transversely surrounding said metal strip in a plane perpendicular to a
20 direction of travel of said metal strip therethrough.

13. An apparatus as claimed in claim 10 wherein at least one of said pair of squeeze rolls is angularly adjustable in a plane perpendicular to a direction of travel of said metal strip therebetween.

14. An apparatus as claimed in claim 10 wherein at least one of

said pair of squeeze rolls is adjustable relative to the other of said pair in a direction perpendicular to a rotational axis of said at least one of said pair of squeeze rolls.

15. An apparatus as claimed in claim 10 wherein said weld box
5 includes web support rolls rotatable about parallel respective axes perpendicular to a direction of travel of a metal strip member therebetween.

16. An apparatus as claimed in claim 15 wherein at least one of said web support rolls has a contoured outer edge to function as one of said pair of squeeze rolls.

10 17. An apparatus as claimed in claim 10 including more than one seam roll stand.

18. An apparatus as claimed in claim 10 wherein at least one of said seam roll stands includes a seam roll having a circumferential shoulder thereon, said circumferential shoulder, in use, providing an abutment for said
15 free edge of said metal strip.

19. An apparatus as claimed in claim 18 wherein a contoured guide roll is provided, in use, to urge said free edge of said metal strip into abutment with said circumferential shoulder.

20. An apparatus as claimed in claim 12 wherein a rod-shaped
20 impeder supported at one end thereof, upstream of said one or more seam roll stands, extends into a hollow interior of a contoured edge region of said metal strip.

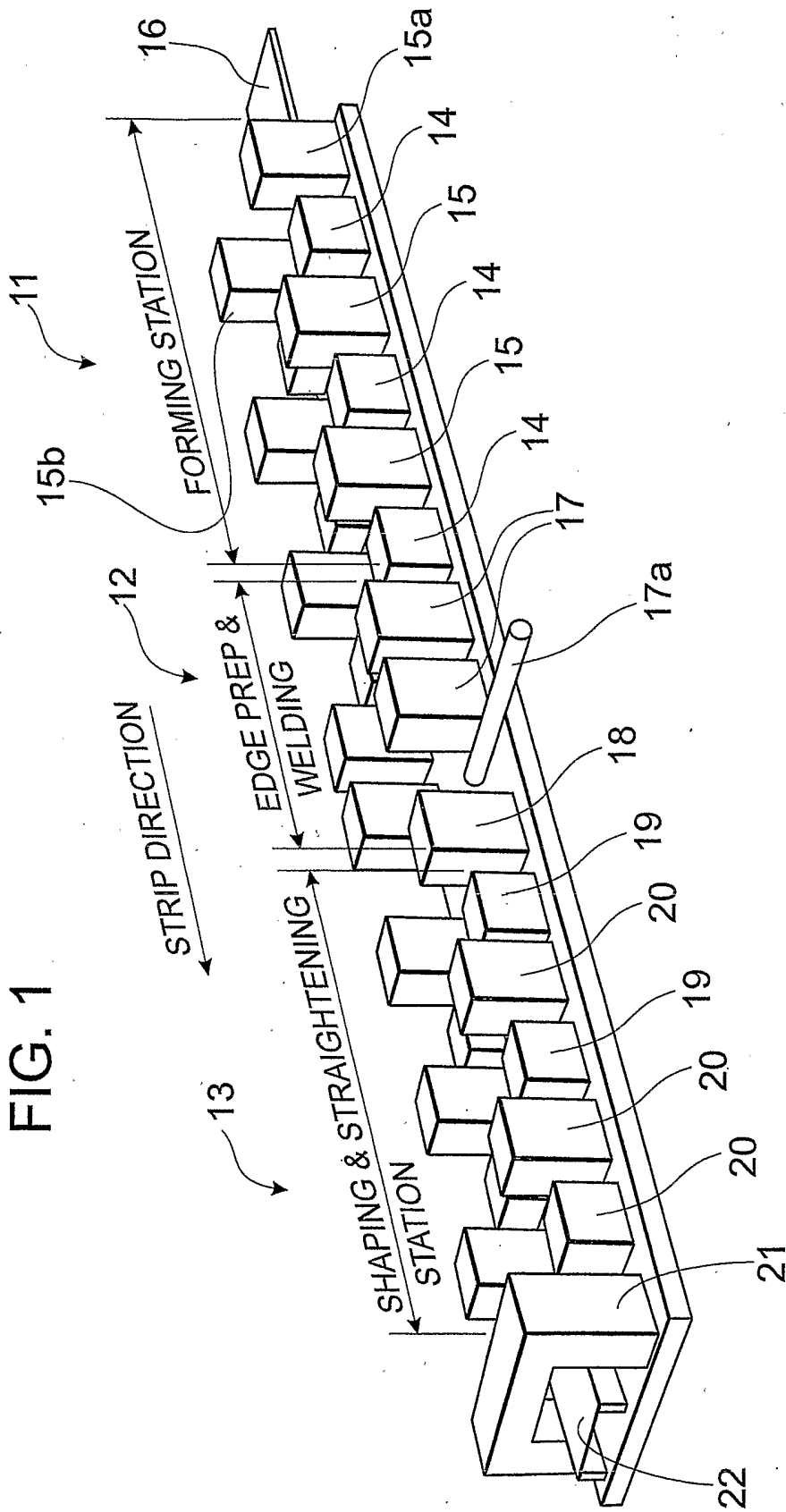
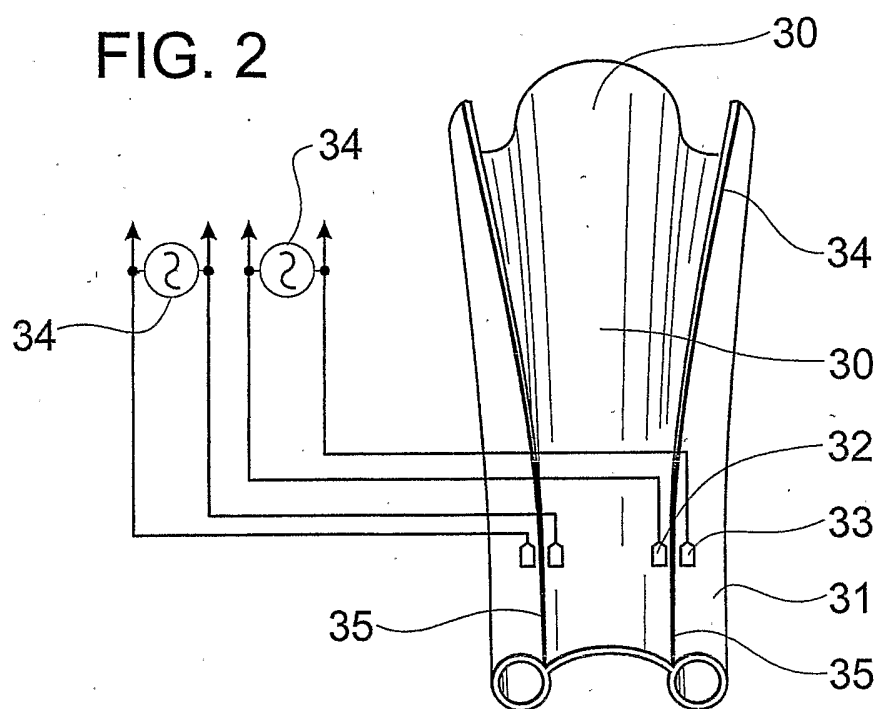
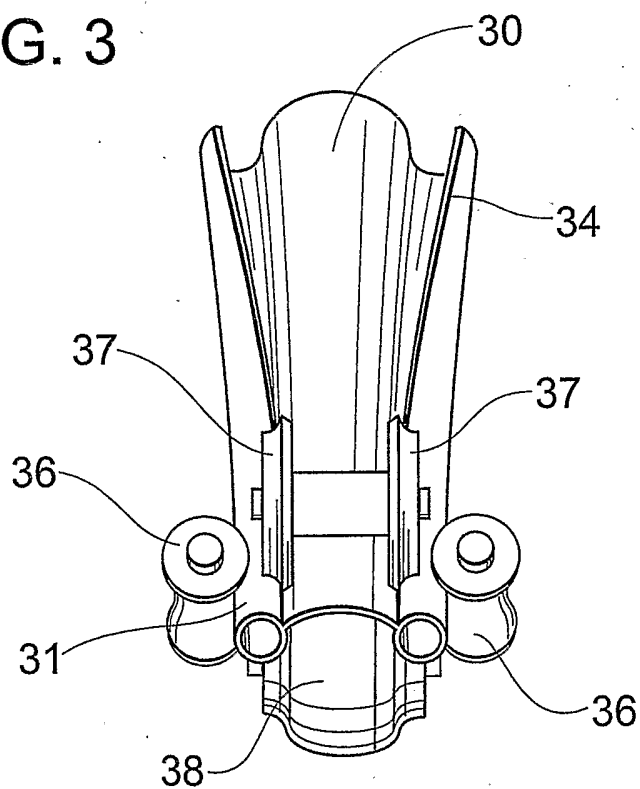


FIG. 2



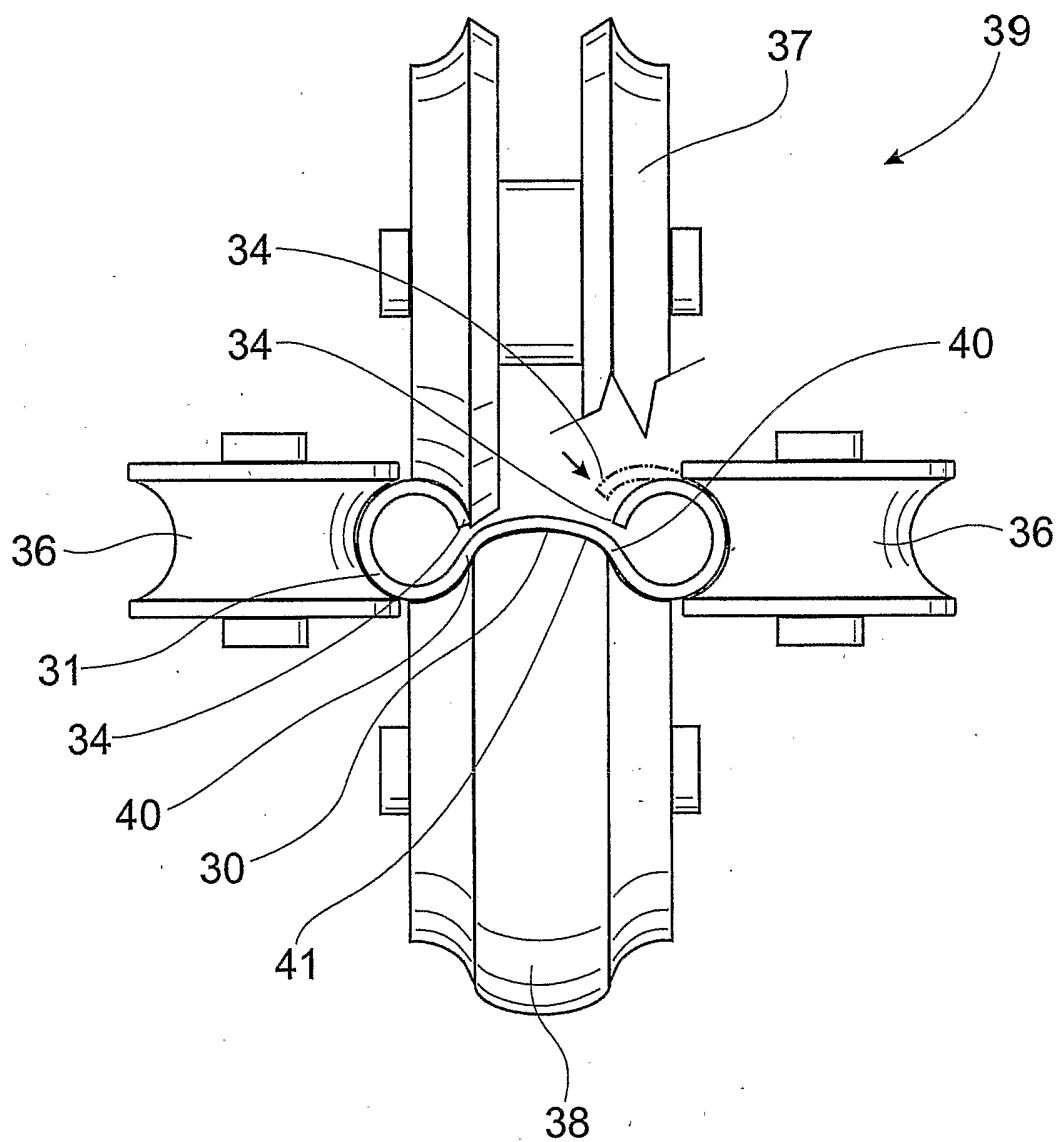
PRIOR ART

FIG. 3



PRIOR ART

FIG. 4



PRIOR ART

FIG. 5

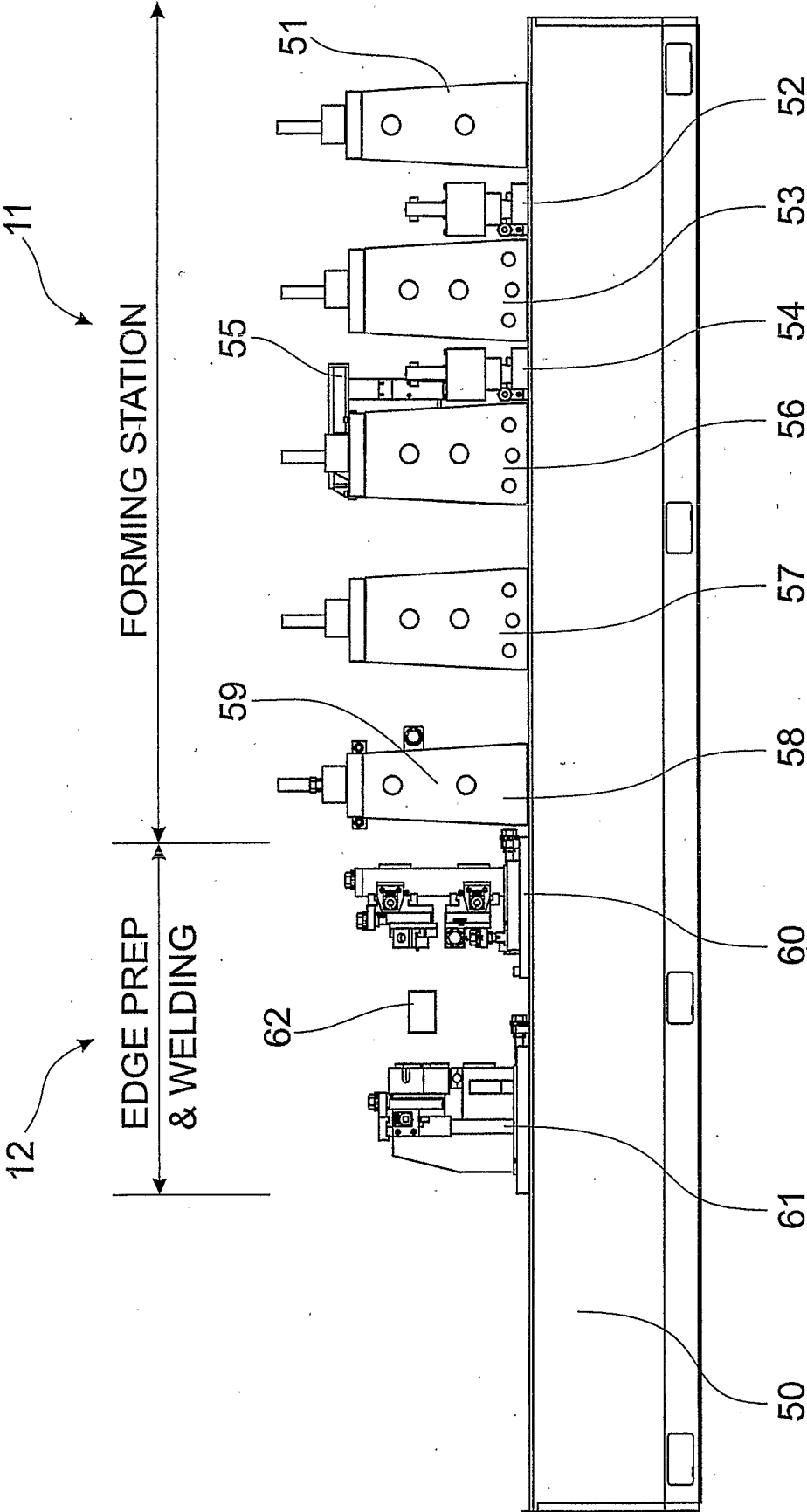
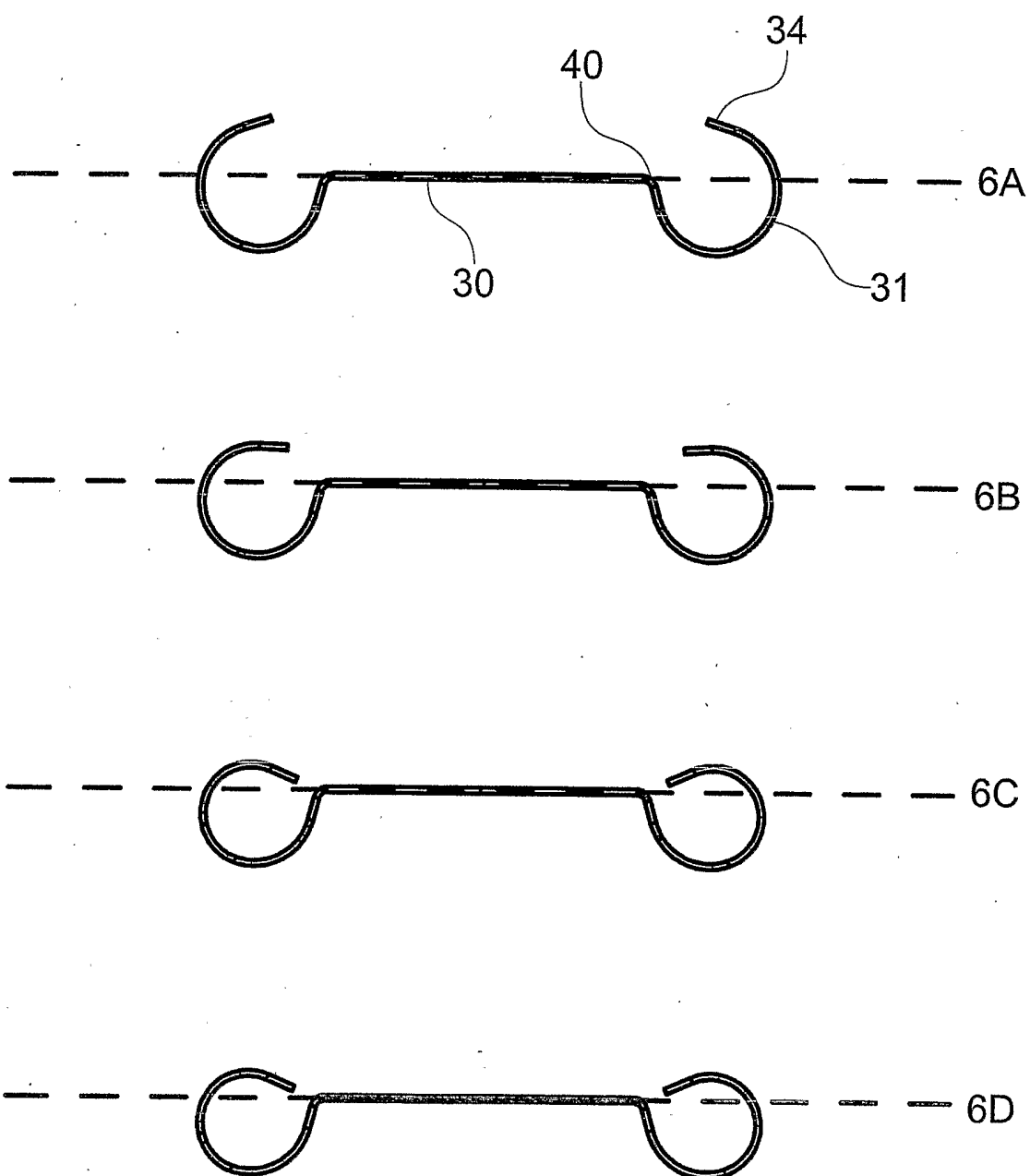


FIG. 6



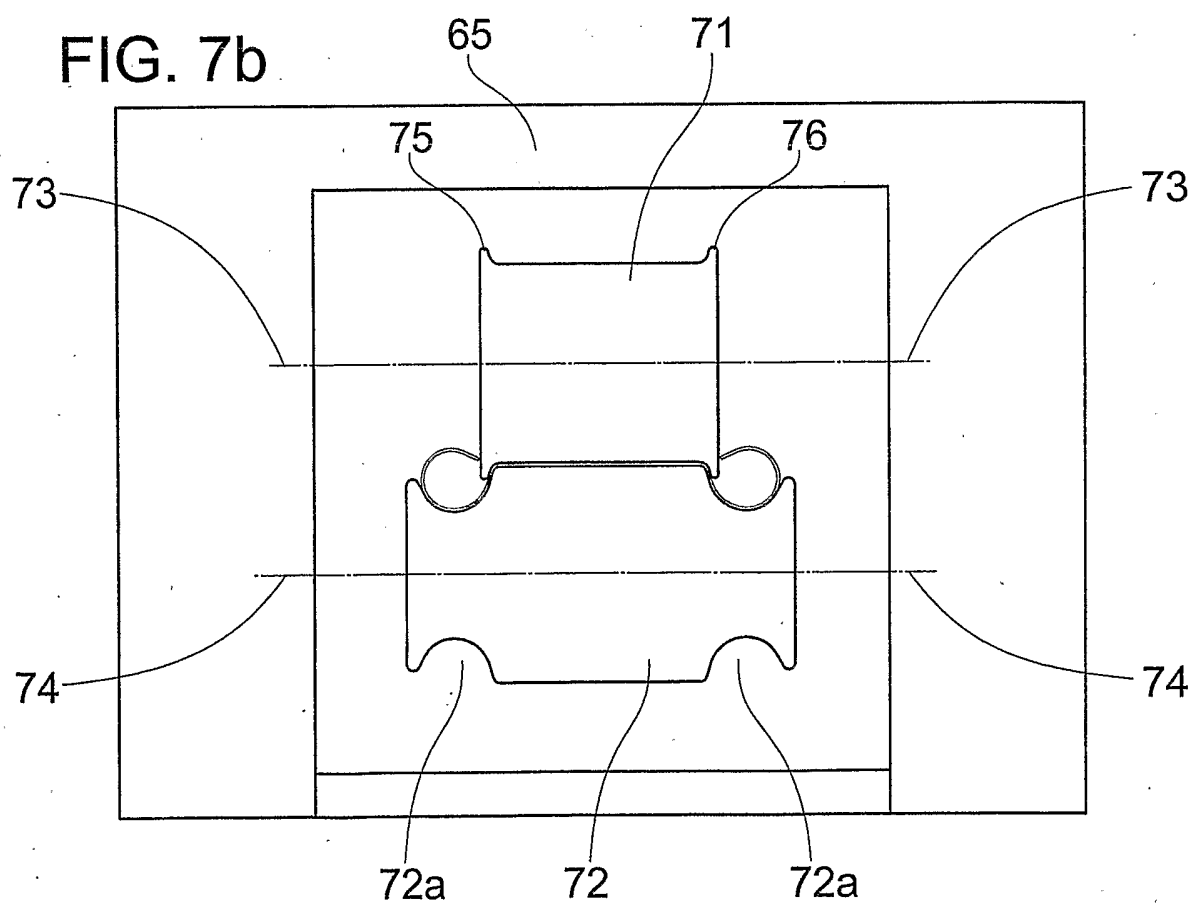
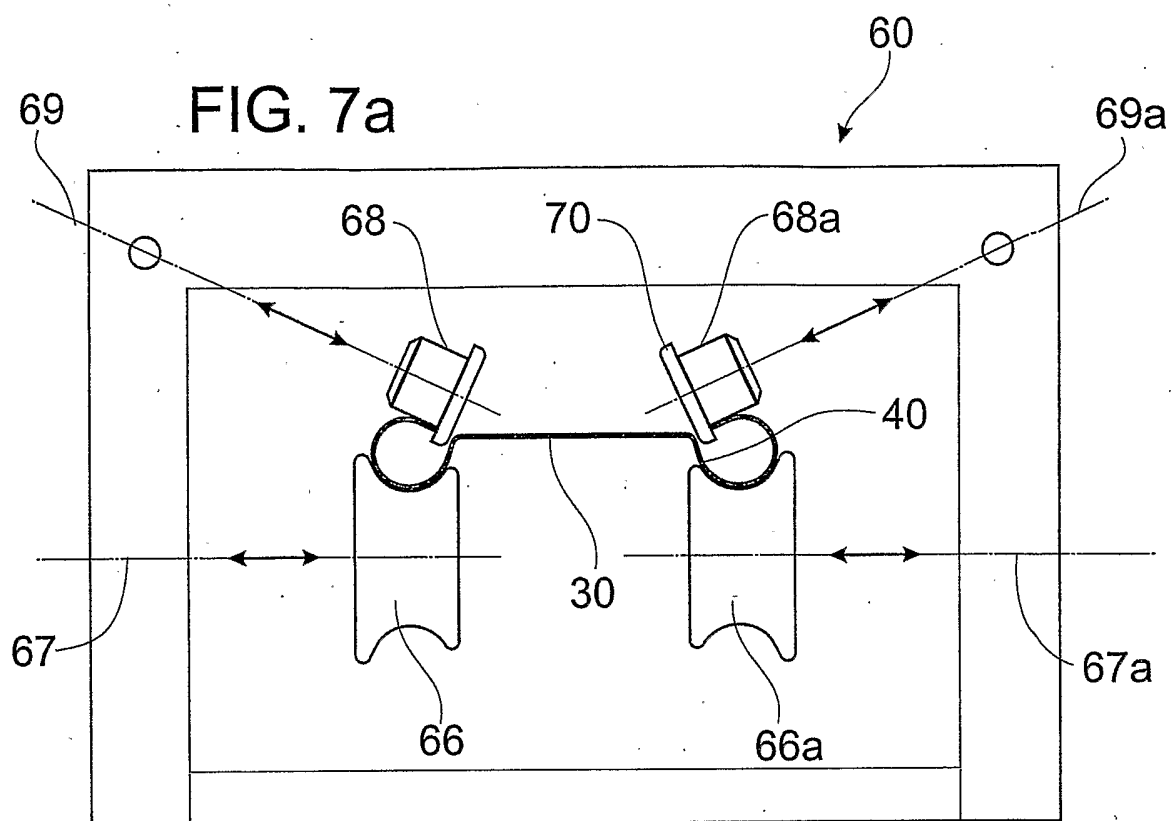


FIG. 8

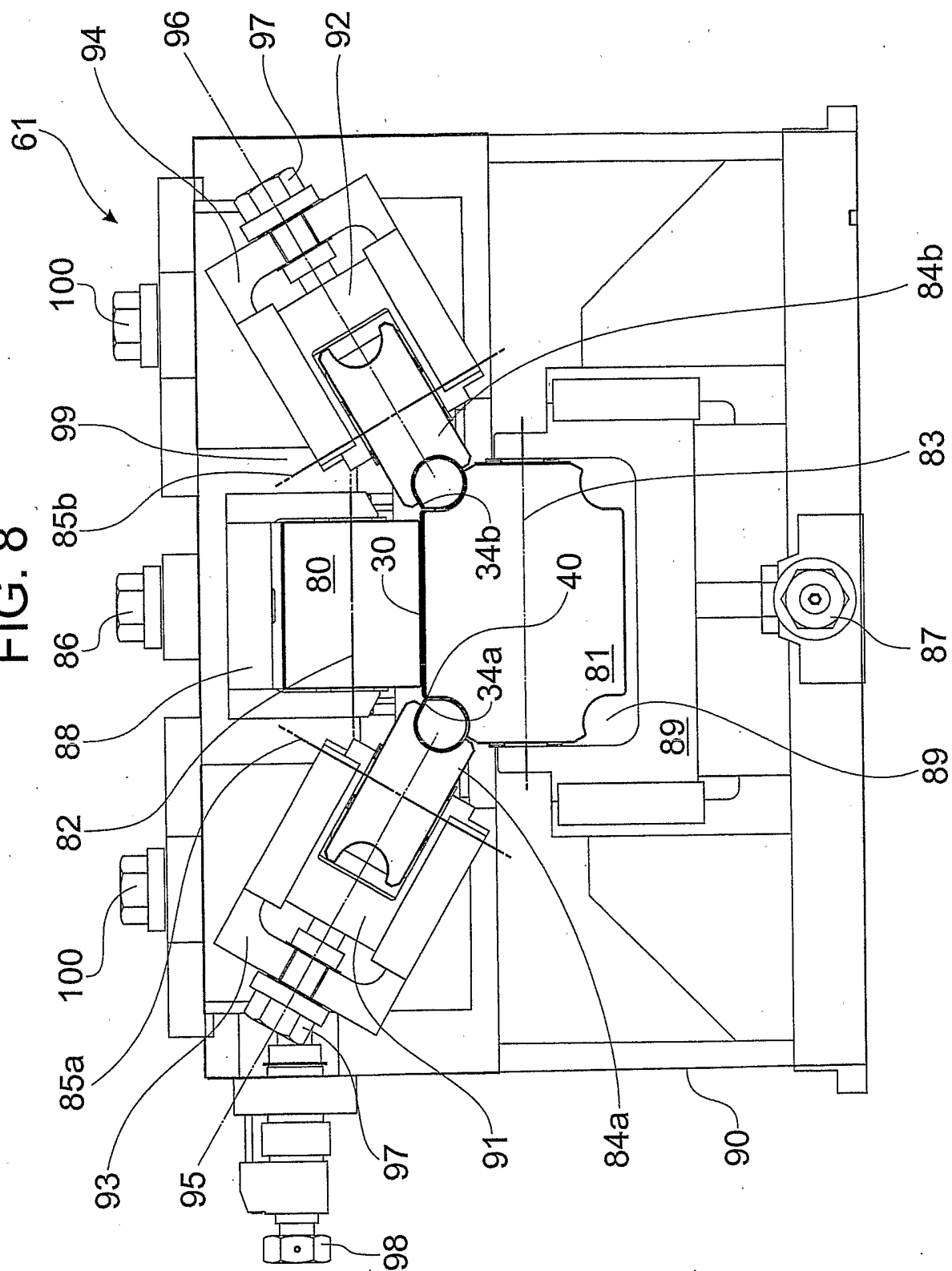


FIG. 9

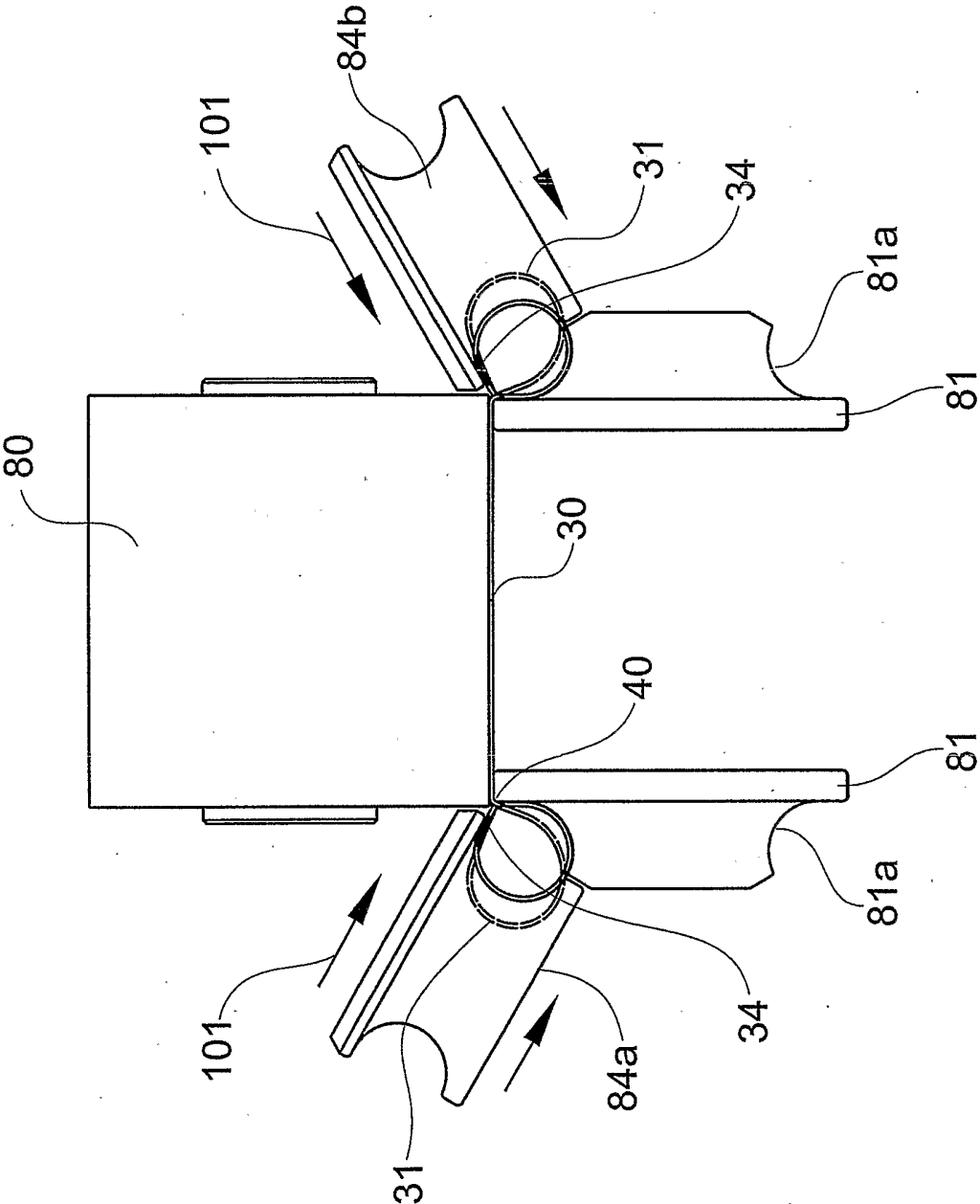


FIG. 10

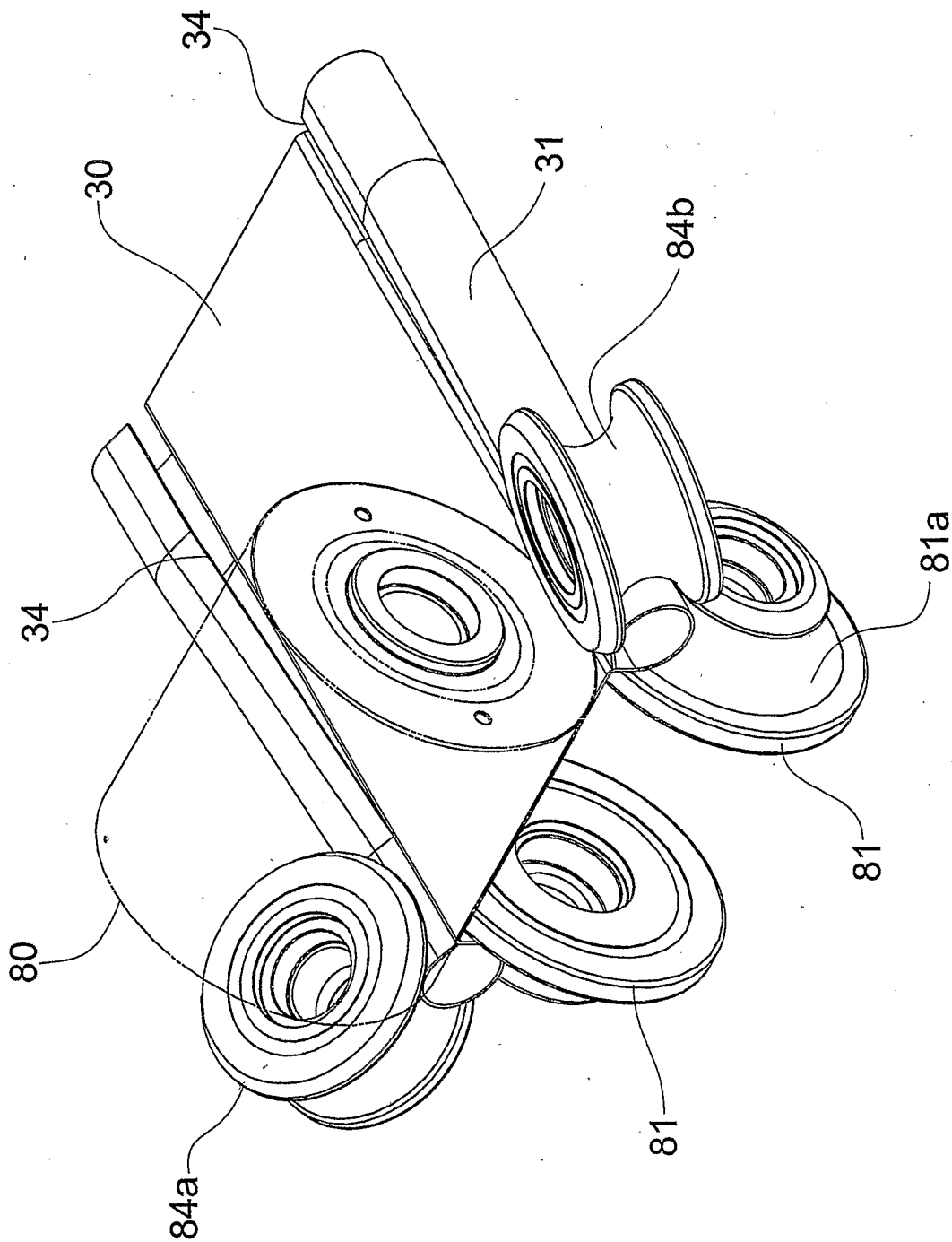


FIG. 11

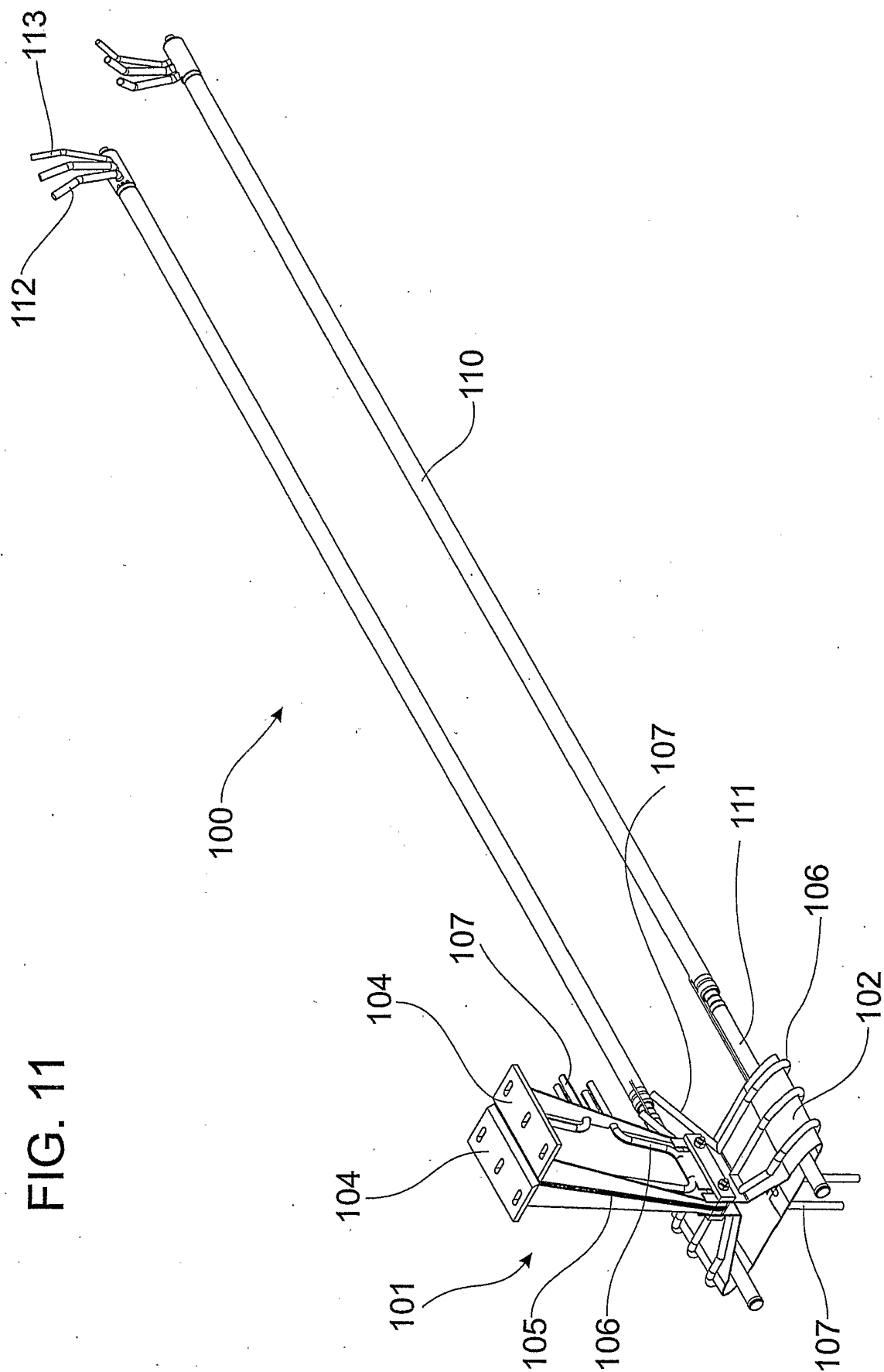


FIG. 12

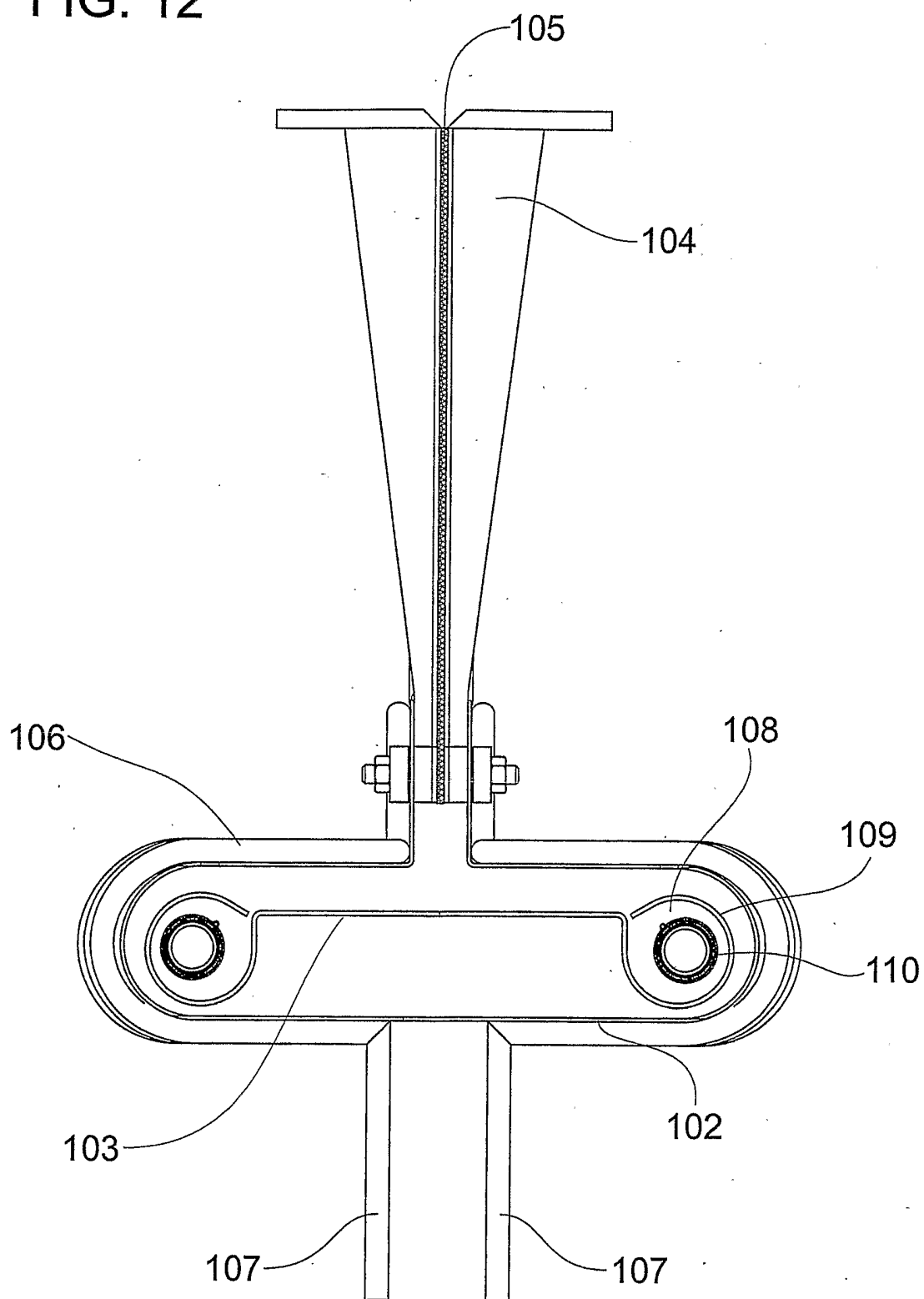


FIG. 13

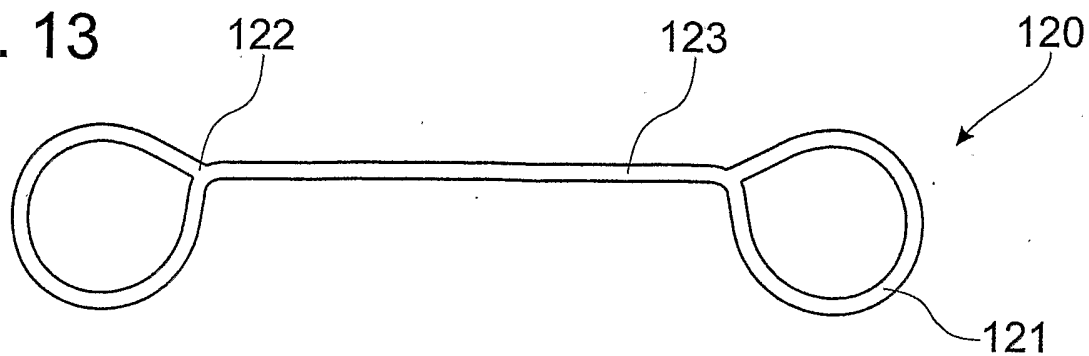


FIG. 14

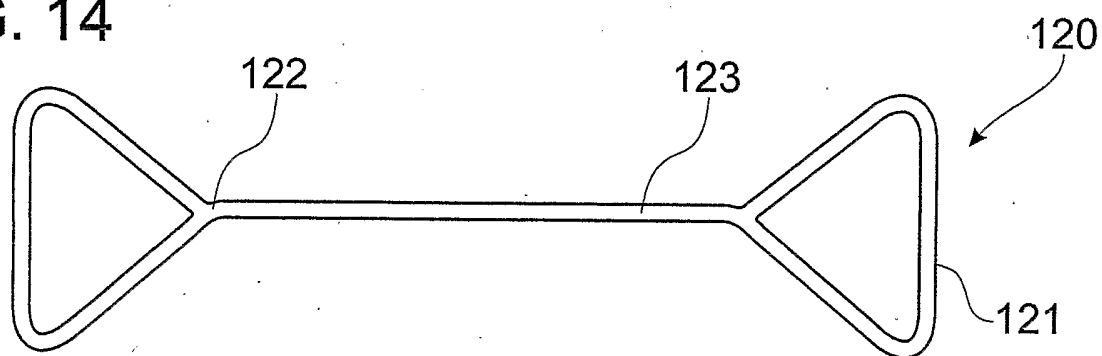


FIG. 15

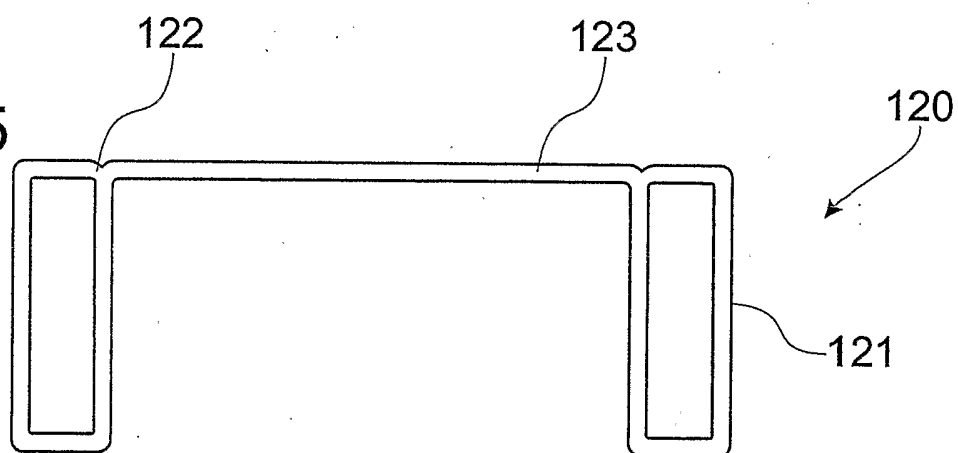
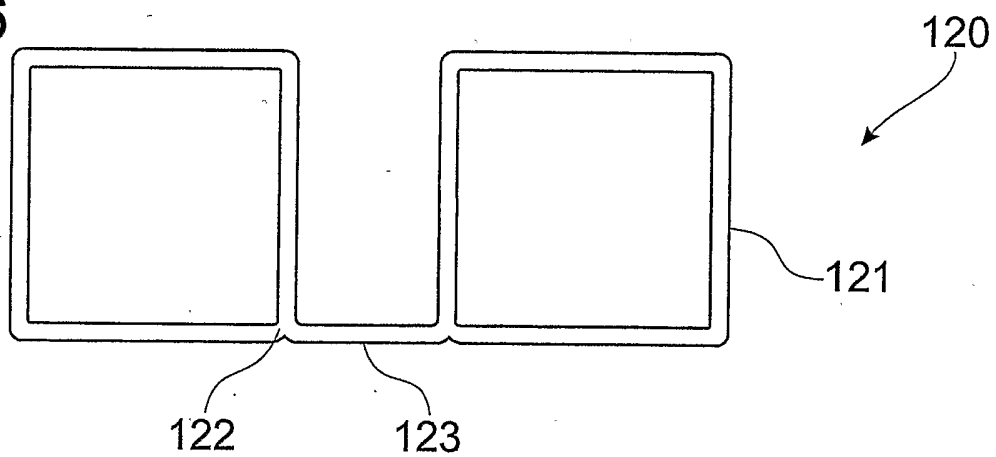


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.

PCT/AU2005/000897

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl. ⁷ : B21D 19/02, 19/04, 19/06, B23K 11/00		
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)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) DWPI IPC B21D 19/02, 19/04, 19/06, B23K 11/- and Keywords (weld, flange, strip, beam) and like terms		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3391267 A (RUDD) 2 July 1968 Whole document	1 - 20
A	US 5403986 A (GOLEBY) 4 April 1995 Whole document	1 - 20
A	FR 2290985 A (LE METAL DEPLOYE) 11 June 1976 Whole document	1 - 20
<input type="checkbox"/> Further documents are listed in the continuation of Box C <input checked="" type="checkbox"/> See patent family annex		
* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed	
Date of the actual completion of the international search 31 August 2005		Date of mailing of the international search report 05 SEP 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929		Authorized officer E.J. MARTYN Telephone No : (02) 6283 2332

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2005/000897

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 Member			
US	5403986	AU	85446/91	BR	9106901	CA	2092809
		EP	0550564	FI	931314	NO	931122
		SG	79182	WO	9205895		
FR	2290985						
US	3391267	BE	667815	ES	321871	GB	1102745
		LU	49251	NL	6510115	NL	144510
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
END OF ANNEX							