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(54) **Tube and method of forming same.**

(57) A polygonal tube is produced from metal strip by forming rows of recesses (15) and projections (16) along opposite edges of the strip and then bending the strip until each projection is received in a corresponding recess to form the tube.

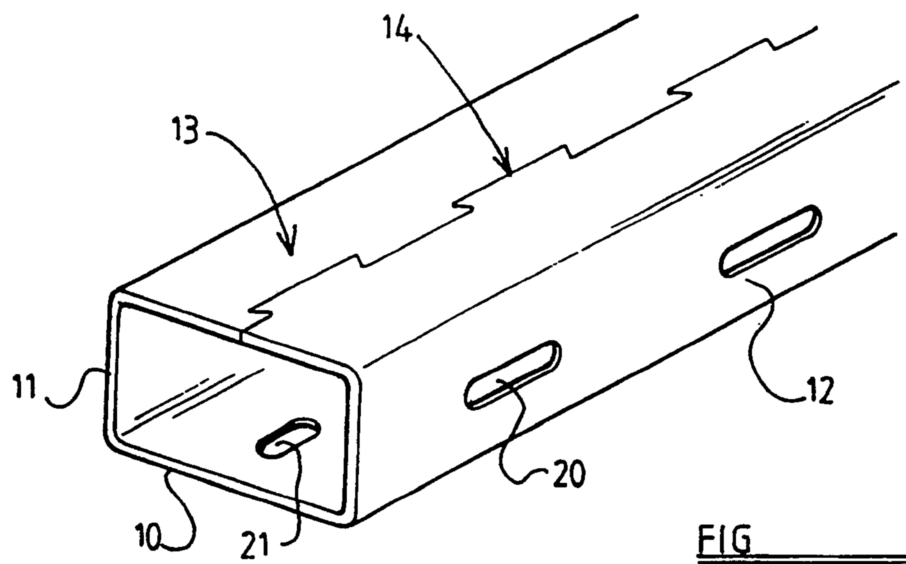

FIG 1

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TUBE AND METHOD OF FORMING SAME

From one aspect, the present invention relates to the formation of a tube of indeterminate length and which has pierced apertures, the tube being formed from metal strip by a roll-forming process.

A wide range of techniques are known for use in joining together edges of metallic materials. Some of these techniques, for example rivetting lapped joints, are best suited to substantially flat materials.

For use in tubular members, there is proposed in GB 542450 the formation of interfitting dovetail formations on opposite edges of a flat strip. The strip is stamped, whilst in a flat condition, to form these formations. The strip is then bent into a tubular form by acting on the strip along its entire length concurrently and curling the strip around an axis until the formations on opposite edges are in interfitting relation with each other. The same process is also disclosed in GB 1403823. This process can be used conveniently to form only relatively short tubular members, since the tools which bend the strip must have a length equal to the length of the strip. Furthermore, the tools which stamp out the interfitting formations have a length which is at least approximately equal to the length of the tubular member to be formed.

The method disclosed in GB 542450 and in GB 1403823 could conveniently be used in a case where the tubular member is required to have one or more pierced apertures. The or each aperture could be pierced during the step of stamping out the interfitting edge portions. However, difficulties would arise in achieving apertures of precisely predetermined size and shape. The step of bending the workpiece into tubular form would inevitably stretch the metal, at least at what will be the outer face of the tubular member. The amount of stretch will vary from one place on the workpiece to another, since parts of the workpiece adjacent to the pierced aperture or apertures will have less support than will parts of the workpiece which are spaced relative far from the edges of the workpiece and from the pierced aperture or apertures.

The skilled person is deterred from producing a relatively long tube having pierced apertures by the steps of stamping flat strip metal stock to pierce the required apertures and to form at opposite edges of the stock formations which will interfit and then concurrently bending the strip along its entire length into tubular form because this would require the provision of long tools. The cost of the tools and, more particularly, of the apparatus for operating the tools, would be excessive. The problems arising from stretching of the metal stock during bending would also deter the skilled person from using this process.

In most cases where there is a requirement to bend a relatively long strip of metal stock along its entire length to a pre-determined cross-sectional shape, the bending of the stock is performed by a roll-forming process. In a roll-forming process, the bending is commenced adjacent to one end of the stock and is carried out progressively along the length of the stock so that when the bending of a first end portion of the stock is completed the bending of an opposite end portion has not commenced and the bending of an intermediate portion of the stock has been only partly completed. In a roll-forming process, there is used a number of sets of rolls, the stock is passed through the sets in succession and the rolls of each set work the stock together.

In a case where stock is bent into tubular form by a roll-forming process, the problems associated with stretch of the stock will be greater than in a case where the stock is bent along its entire length concurrently. In a roll-forming process, the bending to which the stock is subjected at any moment varies along the length of the stock and this further promotes stretching of the material. Roll-forming has been used successfully to form into a tube stock which does not have any apertures and which does not have irregularities along its edges. The uniform nature of such stock minimises the problems associated with stretch of the material. Nevertheless, the action of the forming rolls on the stock will inevitably stretch the metal, at least locally, for example adjacent to that surface of the metal which will be the outer surface of the tube. Other parts of the stock may be compressed.

Partly because the presence of apertures in the stock would exaggerate the problems arising from stretch of the metal and partly because the piercing of apertures is generally a relative slow step, when tubes having apertures are required, the apertures are pierced in the formed tube after the tube has been cut into the required lengths.

A further technique which is known for use in joining together the edges of a tube formed from flat stock is welding of the edges. A welding process makes inefficient use of energy. Also, it is both inconvenient and expensive to provide welding equipment, in addition to the roll-forming equipment. Furthermore, the intense heating of the stock which takes place during the welding operation impairs the surface finish of the resulting tube and tends to cause distortion, particularly in a case where the tube is not uniform along it entire length. It is difficult to form a welded joint which is inconspicuous, unless material is ground from the joint after the welding process has been completed. If the tube is required to have a flat surface incorporating the joint, grinding is necessary.

A further way of joining opposite edges of metal stock to form a tube is by curling each marginal portion of the stock so that the marginal portions each define at least one 180° bend and then hooking one marginal portion into the other. In some respects, a joint formed in this way is satisfactory but the thickness of the joint exceeds the wall thickness of the tube and the joint is conspicuous. Nevertheless, tube formed in this way is accepted for many purposes, because no satisfactory alternative is available. In a case where slots or other apertures are required in the tube, these are pierced in the wall of the tube after the tube has been formed and cut to the required length. The piercing operation is relatively slow. By this, we mean that the time required to pierce each unit length of tube is considerably greater than the time required to form each unit length of tube.

There has also been used for some purposes tube wherein opposite edges of strip from which the tube is formed abut each other but are not joined to each other. This avoids some of the disadvantages of the known tubes but the strength-to-weight ratio of tube formed in this way is inferior. Such tube is accepted because the other ways in which relatively long tubes are formed are not entirely satisfactory.

For the sake of completeness, we mention GB 960464, which discloses the formation of a drainage pipe from a strip of plastics material. A row of projections is formed along one edge of the strip and a row of complementary recesses is formed along the opposite edge of the strip. When the strip is formed into a pipe, the projections at one edge are received in the recesses at the other edge. However, in this instance the projections are not required to fit accurately within the recesses. The shapes of the recesses and projections are selected to ensure that slit openings occur between the projections and recesses. These openings permit unimpeded flow of water into the drainage pipe. Formation of a drainage pipe by the same process is also disclosed in GB 969948. In this specification also, it is emphasised that there are gaps at the longitudinal joint to permit the flow of water through the joint. These disclosures are not useful in the context of forming metal tube of good appearance and good strength-to-weight ratio.

According to a first aspect of the present invention, there is provided a method of forming a metal tube which has a row of apertures which are spaced from each other along the length of the tube, the method including roll-forming strip metal stock to form the tube and being characterised in that there is formed at each of two opposite edges of the stock a respective row of formations, each row comprising alternating projections and recesses, the projections of one row being complimentary to the projections of the other row, each of at least some of the recesses having a mouth and an inner part and the length of the mouth, measured along the row, being less than the length of the inner part, also measured along the row, forming apertures of said row concurrently with the forming of formations of said rows and then roll-forming the stock to bring the edges of the stock into proximity with each other and with the projections of one row lying in the recesses of the other row.

The rows of formations and the row of apertures are preferably formed whilst the stock is substantially flat. Other formations may be pierced in the material at the same time.

According to a second aspect of the invention, there is provided a tube having along one side of the tube a row of apertures and along a further side of the tube a joint comprising two rows of formations, each latter row comprising alternating projections and recesses, the projections of one row being in the recesses of the other row, the projections of the one row complimenting the projections of the other row and each of at least some of the recesses having a mouth and an inner part, wherein the length of the mouth, measured along the row, is less than the length of the inner part, also measured along the row.

An example of a method embodying the first aspect of the invention and of a tube embodying the second aspect of the invention will now be described, with reference to the accompanying drawing, wherein:

FIGURE 1 shows an isometric view of an end portion of the tube,

FIGURE 2 shows a plan view of a part of the tube,

FIGURE 3 shows a side view of a part of the tube,

FIGURE 4 shows an end view of the tube,

FIGURE 5 shows, on an enlarged scale, formations shown in Figure 2,

FIGURE 6, 7 and 8 are views similar to Figure 5 showing alternative formations which may be used in place of the formations shown in Figure 5,

FIGURE 9 shows on a further enlarged scale further alternative formations which may be used in place of the formations shown in Figure 5,

FIGURE 10 shows a transverse cross section of the tube of Figure 1, together with tools which act on the inside of the tube and rolls which support the tube externally during a step in the process of forming the tube,

FIGURE 11 shows a plan view of a tool used in an earlier step,

FIGURE 12 illustrates by a plan view edge portions of stock, one of which edge portions is formed by the tool of Figure 11,

FIGURE 13 shows a plan view of a further tool and

FIGURE 14 illustrates by a view similar to Figure 12 alternative edge portions, one of which is also formed by the tool of Figure 11.

The tube illustrated in Figures 1 to 5 of the accompanying drawing is rectilinear and has a transverse cross sectional shape which is polygonal. The transverse cross sectional shape of the particular example shown is rectangular. Thus, as shown in Figure 1, this particular example of tube has a substantially flat bottom wall 10, opposite side walls 11 and 12, each of which is somewhat smaller than the bottom wall 10 and which are perpendicular thereto, and a substantially flat top wall 13, which is of substantially the same size as the bottom wall 10. The top wall is substantially flat and is parallel to the bottom wall. In the top wall, extending along the tube and spaced equally from the side walls 11 and 12, there is a joint 14.

The tube of Figure 1 is formed from a length of parallel-sided, metal strip (not shown) having a width which is somewhat greater than the sum of the width of the bottom wall 10, side walls 11 and 12 and the top wall 13. There is formed along each of the longitudinal edges of this strip a respective row of formations, one of which rows is shown in Figure 5. The row of formations shown in Figure 5 comprises alternating recesses 15 and projections 16. In the particular example illustrated, the recesses are all identical one with another. The projections also are identical one with another and each projection has the same size and shape as does each recess.

Each recess 15 shown in Figure 5 has a mouth 18 adjacent to an edge of the strip and extends from the mouth into the strip. The length of the inner part 17 of the recess, as measured along the row of formations, is considerably greater than is the length of the mouth 18, also measured along the row.

Each recess 15 at one edge of the strip is directly opposite a projection 16 at the opposite edge of the strip. The rows of projections and recesses are preferably formed by a pressing operation, whilst the strip is in a flat condition. Other formations may be formed in the strip during the pressing operation. In the example illustrated, a row of slots is formed in the side wall 12, one of these slots being identified by the reference numeral 20. A further row of apertures is formed in the bottom wall 10, one of these apertures being identified by the reference numeral 21. A row of slots corresponding to the slot 20 may be formed in the side wall 11 of the tube. All of these apertures are formed in the strip whilst the strip is in a flat condition. The aperture 20 is formed concurrently with one recess of the row shown in Figure 5 and one recess at the opposite edge of the strip.

After pressing, the strip is introduced into a cold roll-forming line having a number of set of rolls through which the strip passes in turn. The rolls progressively bend the flat strip into the tube shown in Figure 1. A first group of rolls bends relative to the remainder of the strip those marginal portions which will form the top wall 13. These portions are bent to respective different angles relative to the remainder of the strip, for example 80° and 85°. A second group of rolls bends those portions of the strip which will form the side walls 11 and 12 at right angles to a central portion of the strip. This brings the row of formations on one edge of the strip into a position overlying the row of formations on the opposite edge of the strip. A further group of rolls then completes formation of the tube by bending the opposite marginal portions of the strip downwardly into a parallel relation with the bottom wall 10, thereby introducing the projections on one edge of the strip into the recesses on the opposite edge. Where the projections are introduced into the recesses, the top wall 13 of the tube is supported inside the tube by a mandrel which bears on the bottom wall 10. One or more rolls may be arranged to squeeze the formations between that roll and the mandrel. The mandrel may incorporate one or more rolls to bear on the tube.

Squeezing of the formations spreads each projection, if necessary, to take up any clearance between edges of the projections and boundaries of the corresponding recesses.

It will be noted that the projections along one edge of the strip compliment those along the opposite edge of the strip so that when the projections have been introduced into the recesses, the projections collectively form a part of the top wall 13 which is substantially continuous along the entire length of the tube. There are no significant gaps in the top wall 13.

An example of an arrangement for squeezing the formations is illustrated in Figure 10. Figure 10 illustrates one set of rolls of the roll-forming line, as viewed in a direction along the line. The tube formed from the strip is identified in Figure 10 by the reference numeral 22. The bottom wall 10 is supported by a roll 23 which lies outside the tube. Inside the tube, there is a mandrel 24 carrying a support roll 25 mounted in the mandrel for rotation relative thereto about an axis which is transverse to the length of the tube and parallel to the bottom wall 10. Between the top wall 13 of the tube and the support roll 25, there is a squeezing roll 26 also supported in the mandrel for rotation relative thereto about an axis parallel to the axis of the support roll 25. The squeezing roll has a peripheral rib 27 and the support roll 25 has a complimentary groove for receiving the rib. The top wall 13 of the tube is held in firm contact with the squeezing roll 26 by a further roll 28 which lies outside the tube and is supported for rotation about an axis parallel to the axis of the support roll 25. The respective axes of the rolls 23, 25, 26 and 28 all lie in the same vertical plane.

As the tube moves along the roll-forming line, the rib 27 of the squeezing roll forms in the top wall 13 of the tube at the inside of the tube a rectilinear groove which extends along the length of the tube. This groove lies mid-way between the side walls 11 and 12 of the tube so that the groove intersects the recesses 15 and the projections 16. The roll 28 has a smooth, cylindrical surface which bears on the top wall 13 of the tube, so that the external surface of the top wall is maintained in a smooth, flat condition.

The wall of the tube shown in Figure 1 may have a thickness in excess of 1.5mm and preferably has a thickness of at least 2mm. The thickness of the wall may be several millimetre. Material having a thickness less than 1.5mm may be used. If the thickness of the strip from which the tube is formed is uniform and the projections are not squeezed to change the thickness significantly, then both the internal and external surfaces of the tube will be smooth. Painting of the tube may substantially conceal the joint.

As shown in Figure 5, the depth of each recess 15 is substantially less than the length of that recess. The ratio of the depth to the length of each recess is preferably within the range 1:3 to 1:20 and is more preferably within the range 1:5 to 1:10. The depth of each recess is preferably not less than the thickness of the wall but preferably does not exceed the thickness by a factor of more than four times.

The projection 16 shown in Figure 5 has a rectilinear edge which coincides with the edge of the strip from which the tube is formed. This rectilinear edge extends along almost the entire length of the projection. The recess 15 has a corresponding rectilinear inner boundary which extends almost along the entire length of the recess and which is parallel to the rectilinear edge of the projection. The particular recess illustrated in Figure 5 has a mouth defined between convex marginal portions of the adjacent projections and the inner part of the recess has correspondingly curved boundary portions at opposite ends of the recess. Between these curved boundary portions and the mouth of the recess, there may be rectilinear boundary portions inclined at an angle considerably less than 90° to the rectilinear boundary of the recess. This angle is preferably in the region of 45°.

The shape of the recess may be modified as shown in Figure 6. The boundaries of the recess shown in Figure 6 are all substantially rectilinear. Boundaries at ends of the recess are inclined, at an angle within the range 20° to 50°, to the rectilinear boundary which extends from one end of the recess to the other end.

A further modification to the shape of the recesses is shown in Figure 7. The ends of the recess shown in Figure 7 do not include any rectilinear marginal portions. The convex surfaces of the projection which define the mouth of the recess merge smoothly with concave marginal portions of the projections which define the ends of the inner part of the mouth. These curved boundary portions of the recess are preferably arcs of circles having the same radius and so arranged that a line joining the centres of curvature of the arcs is perpendicular to the longitudinal boundary of the recess. Figure 8 illustrates a further modification of the shape of the recess. In this case, the ends of the recess are defined by two circular arcs, similar to those of Figure 7, but the respective centres of curvature of these arcs lie on a line which is inclined to the longitudinal boundary of the recess at an angle within the range 25° to 60°. As shown in Figure 8, this angle is preferably 45°.

Figure 9 shows on an enlarged scale the joint of a modified tube. In all respects other than the shape of the joint, the tube of Figure 9 is the same as the tube of Figure 1. The method by which the tube of Figure 9 is formed is the same as that by which the tube of Figure 1 is formed.

The projection 29 at one side of the joint of the tube of Figure 9, and which is formed at one edge of the stock from which the tube is formed, has a rectilinear edge 30 which is parallel to the length of the tube. At opposite ends of the projection are curved edges 31 and 32, both of which are arcs of circles having the same radius. The projection is tapered towards each of it ends. Thus, between the rectilinear edge 30 and the arcuate edge 31, there is a further rectilinear edge 33 which is inclined to the edge 30. Preferably, the angle included between the edge 30 and the edge 33 is within the range 165° to 177°. Between the edge 30 and the arcuate edge 32, there is a similarly inclined edge 34. The inclined edges 33 and 34 have the same length, which is greater than the radius of curvature of the arcuate edge 31. Preferably, the length of the edge 33 is within the range 2 to 4 times the radius of curvature of the arcuate edge 31.

The recess in which the projection 29 is received has a size and shape complimenting that of the projection. Accordingly, the recess 30 adjacent to the projection 29 and which is formed at the same edge of the strip from which the tube is formed also has a size and shape complimentary to those of the projection 29. We have found that the tapered form of the projections facilitates movement of the projections along the roll-forming line and working of the strip by the rolls. In this respect, the shape of the projections illustrated in Figure 9 is an improvement on the shape of the projections shown in Figure 5.

In Figure 11, there is illustrated a tool for forming the projection 29 of Figure 9 at one edge of a strip. In Figure 11, surfaces of the tool corresponding to the inclined edges 33 and 34 shown in Figure 9 are not distinct from that surface of the tool which corresponds to the edge 30 of Figure 9. However, the tool does have mutually inclined edges corresponding to the edges 30, 33 and 34 formed on the strip.

The tool of Figure 11 is used as a punch to cut material from one edge of the strip metal stock. The tool has a central recess 35 which corresponds to the projection 29. At opposite ends of the recess 35, the tool has male portions 36 and 37. During the pressing or punching operation, the portions 36 and 37 are brought into engagement with marginal portions of the strip metal stock and are moved through the thickness of the stock to cut material away from the edge of the stock and form corresponding recesses. The tool may also cut material away from the edge of the projection 29 between these recesses.

At opposite ends of the tool shown in Figure 1, there are spaces 40 and 41 which are aligned with the male portions 36 and 37. The male portions and the recess 35 lie between the spaces 40 and 41. When the tool cut the recesses 38 and 39 in the edge of the strip stock, projections 42 and 43 formed on the stock occupy the spaces 40 and 41. The tool is then withdrawn from the stock and the stock is moved past the tool until the projection 43 on the edge of the stock is partly in registration with the space 40 in the tool. The degree of registration between the projection 43 and the space 40 is selected according to the required overall pitch of the formations along the stock. This pitch is selected to correspond to the required pitch of apertures along the stock. It will be understood that the registration between the space 40 and the projection 43 is varied only in a direction along the stock and not in a direction transverse to the length of the stock. Substantially complete registration produces the row of formations illustrated in the lower part of Figure 12. The recesses 44 and 45 are formed in the edge of the stock during the second application of the tool shown in Figure 11. The pitch of the projections is regular along the entire length of the stock. During operation of the tool shown in Figure 11, a further tool 46 (shown in Figure 13) forms at the opposite edge of the stock strip the row of formations illustrated in the upper part of Figure 12. It will be understood that the other tool has a form complimentary to that of the tool shown in Figure 11. Adjacent to opposite ends of the further tool, there are male portions 47, 48 corresponding to the spaces 40 and 41 and there is a further male portion 49 lying between but spaced from these end male portions.

In the lower part of Figure 14, there is illustrated a row of formations which results from operation of the tool shown in Figure 11 with substantially no registration between the space 41 and the projection 43 during the second application of the tool to the strip stock. Between the two applications of the tool, the stock is moved longitudinally a distance substantially equal to the length of the tool. Accordingly, a relatively long projection 43 is produced and the recess 44 is spaced relative far from the recess 39. Movement of the tools relative to each other in a direction along the stock is prevented so that the further tool 46 necessarily cut from the opposite edge of the stock a relatively long recess 45 which compliments the projection 43 exactly. One end potion of the recess 45 is cut from the stock during a first application of the further tool 46 and the remainder of the recess 45 is cut from the stock during the second application of the further tool.

The distance through which the stock is moved between successive operations of the tools can vary between the extreme values corresponding to Figures 12 and 14. This facilitates piercing of apertures in the stock at a variety of pitches within the corresponding range.

A shorter tool with fewer male formations may be substituted for the tool 46, the tool of Figure 11 being modified accordingly.

The invention may be applied to tubes having transverse cross-sectional shapes different from that shown in Figures 1 and 4. Other polygonal shapes may be used. Furthermore, the invention may be applied to a tube having a convex wall. The length of the tube is more than 10 times the largest transverse dimension of the tube.

The tube may be used as an upright in racking. Brackets for supporting shelves may be fitted into apertures provided in the side walls 11 and 12 of the tube.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

Claims

1. A method of forming a metal tube which has a row of apertures (20) which are spaced apart from each other along the length of the tube, the method including roll-forming strip metal stock to form the tube and being characterised in that there is formed at each of two opposite edges of the stock a respective row of formations (15, 16), each row comprising alternating projections and recesses, the projections of one row being complimentary to the projections of the other row, each of at least some of the recesses having a mouth (18) and an inner part (17) and the length of the mouth, measured along the row, being less than the length of the inner part, also measured along the row, forming apertures (20) of said row concurrently with the forming of formations (15, 16) of said rows and then roll-forming the stock to bring the edges of the stock into proximity with each other and with the projections of one row lying in the recesses of the other row.

2. A method according to Claim 1 wherein the stock is supported internally when the projections of one row are introduced into the recesses of the other row.

3. A method according to Claim 1 or Claim 2 wherein, after the projections of one row have been introduced into the recesses of the other row, the projections are squeezed between opposed surfaces (26, 28) one inside and the other outside the tube.

4. A method according to Claim 3 wherein the surface inside the tube has a rib (27) which forms a groove in the tube wall at the inside of the tube and wherein the outside of the tube remains flat.

5. A method according to any preceding claim wherein the stock is substantially flat when said projections, recesses and apertures are formed.

6. A method according to any preceding claim wherein a tool which forms the projections and recesses of at least one of said rows has a male portion which forms some or all of the recesses of the one row and wherein said male portion is moved into contact with and through the thickness of the stock to cut metal from an edge of the stock and form a recess, the male portion is withdrawn from the stock, the stock is moved along its length relative to the tool to bring one recess (45) partly into registration with the male portion and the male portion is then moved into contact with the stock and through the thickness of the stock to cut metal from the edge of the stock and extend said one recess further along the stock.

7. A tube having along one side of the tube a row of apertures and a joint along a further side of the tube, wherein the joint comprises two rows of formations, each row comprising alternating projections and recesses, the projections of one row lying in the recesses of the other row, the projections of one row complimenting the projections of the other row and each of at least some of the recesses having a mouth (18) and an inner part (17), wherein the length of the mouth, measured along the row, is less than the length of the inner part, also measured along the row.

8. A tube according to Claim 7 wherein the depth of each of at least some of the recesses (15) is considerably less than the length of the recess.

9. A method according to any one of Claims 1 to 6 or a tube according to either of Claims 7 and 8 wherein the mouth of each of at least some of the recesses is defined between convex marginal portions of adjacent projections.

10. A method according to any one of Claims 1 to 6 or Claim 9 or a tube according to any one of Claims 7, 8 and 9 wherein the tube has a polygonal transverse cross section and said rows of formations both lie at the same, substantially flat face of the tube.

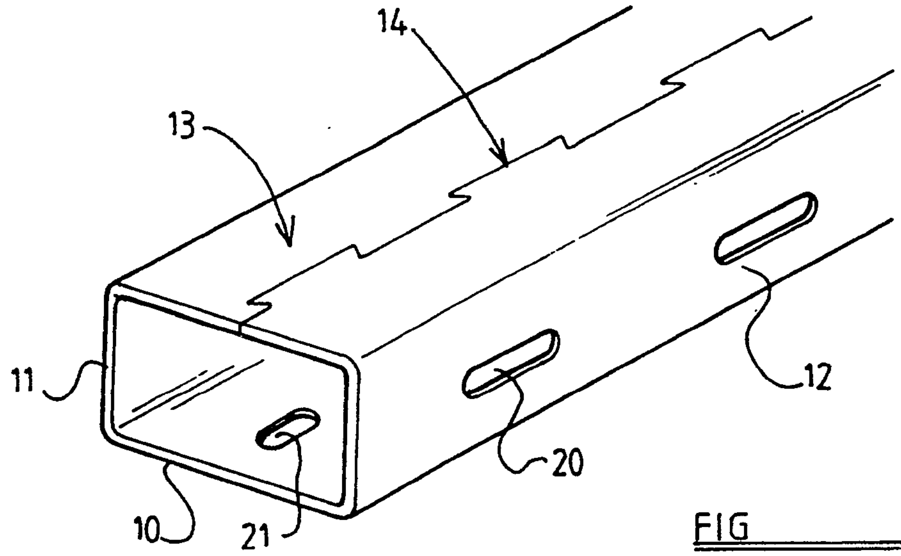


FIG 1

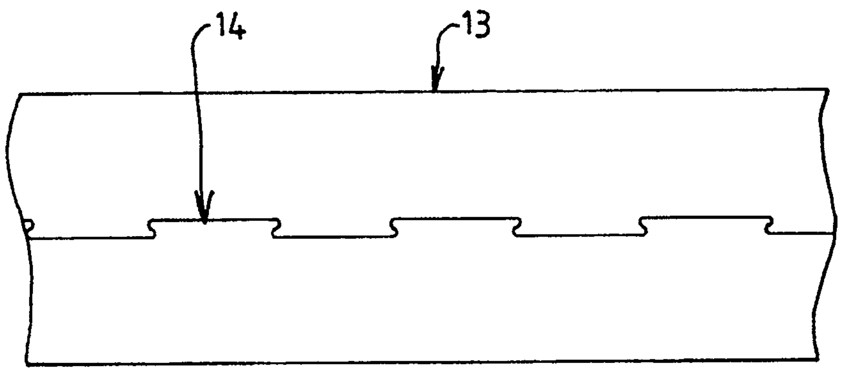


FIG 2

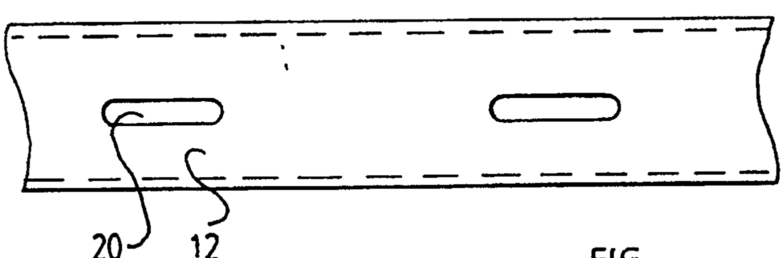


FIG 3

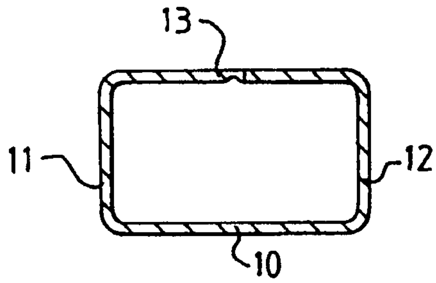


FIG 4

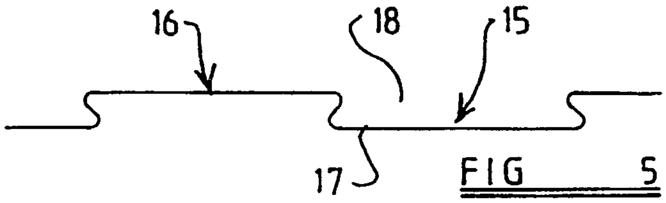


FIG 5

FIG 6

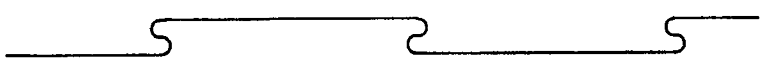


FIG 7

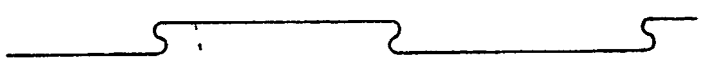


FIG 8

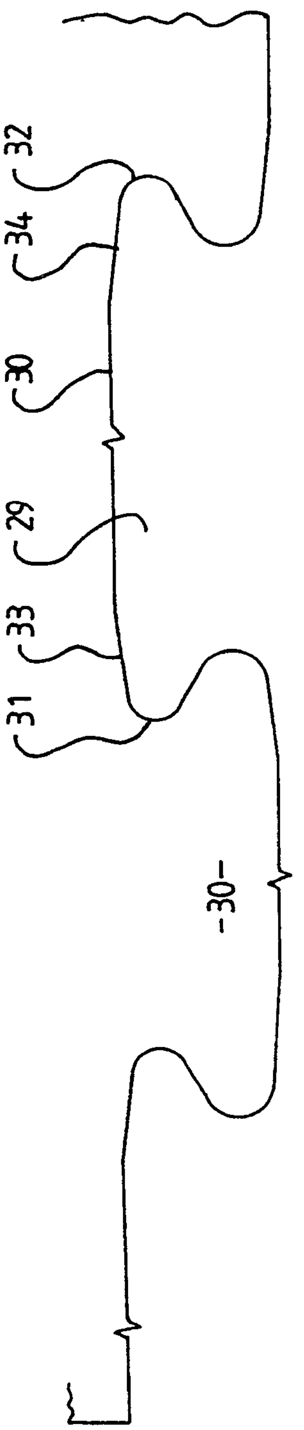


FIG 9

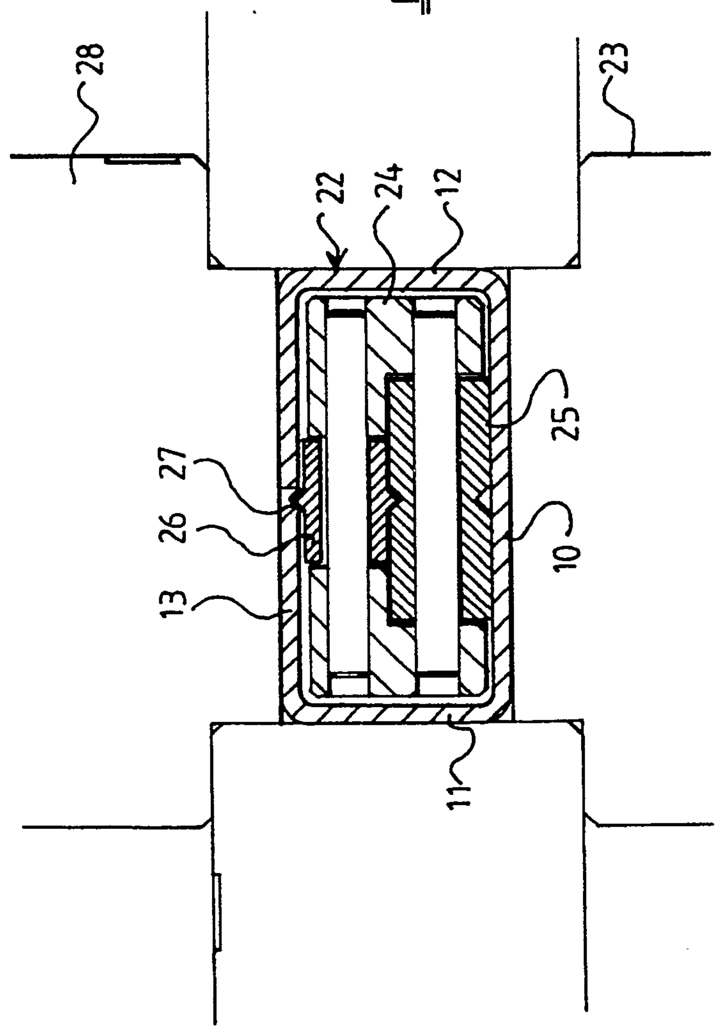


FIG 10

FIG 11

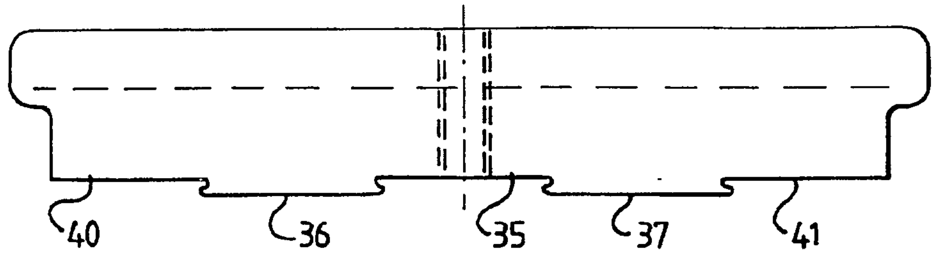
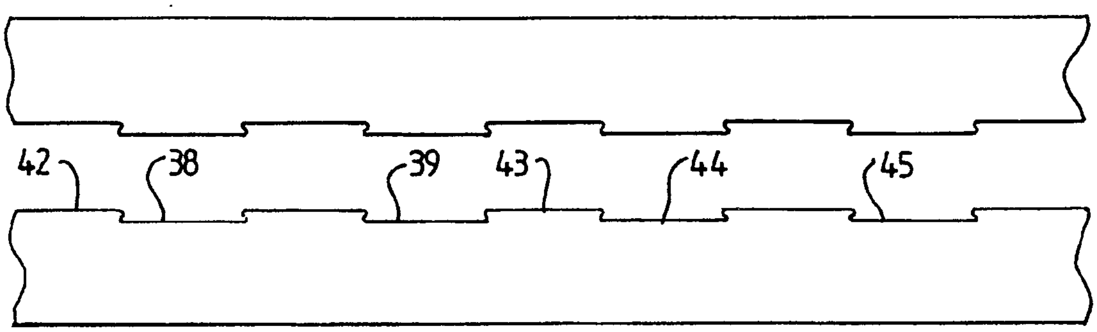


FIG 12



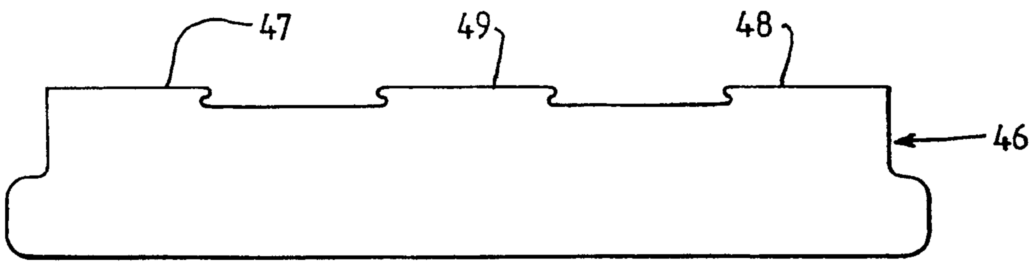


FIG 13

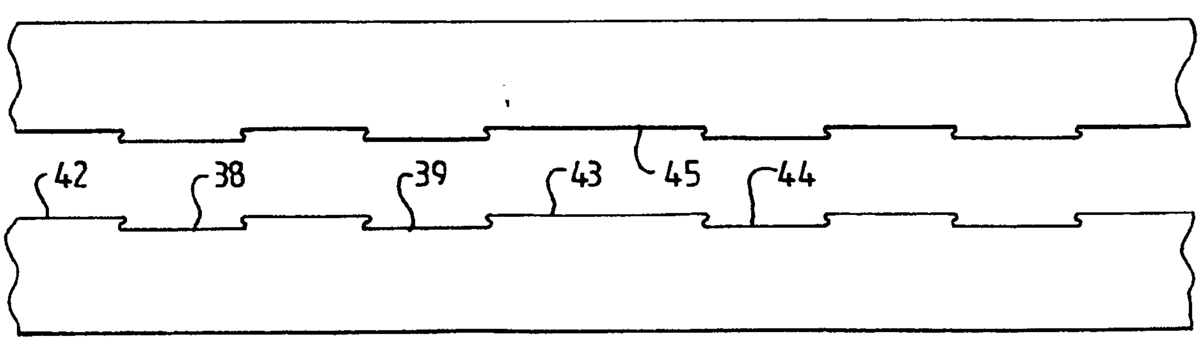


FIG 14