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(71) Applicant: **WEST (IPSWICH) LIMITED**
Unit L1, Foundry Road, Nacton Road
Ipswich, Suffolk(GB)

(72) Inventor: **Van den Burgh, Jack Malcolm Bruce**
41 Cordys Lane, Trimley
Felixstowe, Suffolk, IP10 0JD(GB)
Inventor: **Hall, Peter**
2 Broomhill Road
Ipswich, Suffolk(GB)

(74) Representative: **Dummett, Thomas Ian Peter**
et al
Dummett Copp & Co. 14 The Square
Martlesham Heath Ipswich Suffolk, IP5
7SL(GB)

(54) Method and apparatus for forming ducting.

(57) The present invention provides a method for forming polygonal ducting from an intially circular cross-section duct by radially expanding a mandrel within the duct so as to cause radial deformation of the duct into the desired shape. The invention also provides a mandrel for use in the method of the invention.

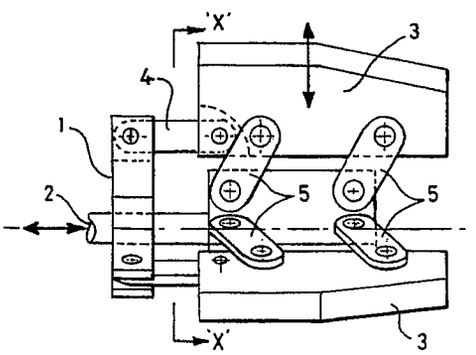

Fig.1

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METHOD AND APPARATUS FOR FORMING DUCTING

The present invention relates to a method and apparatus for forming ducting, notably to a method for forming ducting of a polygonal cross-section.

BACKGROUND TO THE INVENTION:

Polygonal ducting has hitherto been made by axially joining sheets of a suitable wall material along their edges by flanges or the like. However, this is cumbersome and difficult where the cross-section is to be other than a simple triangular, square or rectangular shape Furthermore, problems are often encountered in sealing the axial joints in such a construction. Where a circular cross-section duct is required, this can be made by winding a strip of the wall material outside or inside a suitable former to form a spirally wound duct with the turns of the spiral overlapping or crimped together to form the joint along the adjacent edges of the material.

It has been proposed to form a polygonal duct by spirally winding a strip of the wall material and forming the duct by bending the strip at each apex of the cross-section of the duct. However, such a method suffers from problems in ensuring accurate register of the bends with each other and the duct produced often has twists in it which are unacceptable. In order to reduce this problem, it has been proposed to increase the radius of the bends so that the duct has a more rounded appearance. However, this is not wholly successful and gives rise to problems in using the duct.

We have devised a method and apparatus which reduces the above problems and which produces a polygonal duct having sharp bends at its apexes which assist use of the formed duct.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides a method for forming a duct having a polygonal cross-section with at least three apexes thereto, which method comprises subjecting a generally circular cross-section duct to radial stretching along the line of the intended apexes of the desired cross-section to be formed whereby the duct is deformed in at least three directions to adopt the desired cross-section.

Preferably, the initial duct is a generally circular cross-section duct which has been formed by any suitable process, for example by forming a sheet of wall material into a circular cross-section duct by drawing the sheet over a suitable mandrel or through a suitable die or other forming tool and welding the axial butt or overlap joint in the duct so produced. However, it is preferred that the initial duct be a spirally wound duct fabricated using conventional spiral winding techniques. Furthermore, the invention can be applied as the last stages of the duct forming process so that the initial circular cross-section duct is produced only as a transient intermediate in an overall process. For convenience, the invention will be described hereinafter in terms of a separate process for converting a length of a spirally wound circular cross-section duct to the desired polygonal cross-section.

The intial duct will usually have a substantially circular cross-section. However, for some shapes of duct, notably for large diameter ducts, it may be preferred to subject the initial duct to some pre-forming to reduce the extent of shaping of the duct. Thus, the intial duct may be subject to initial shaping into an oval cross-section duct by applying external pressure to squeeze the duct along one diameter, or partial forming of the duct into a polygonal shape may be carried out by drawing the duct through an external former, for example to produce a generally triangular cross-section with rounded apexes which are to be finished using the method of the invention. For convenience, the invention will be described hereinafter in terms of the forming of a duct which has not been subjected to such pre-forming.

In the method of the invention, the duct wall is stretched from within the duct to adopt the desired configuration. The stretching causes the curved wall of the duct to deform into a series of generally planar surfaces and the overall circumference of the duct is increased, typically by from 0.5 to 5%, during this operation so as to reach or slightly exceed the yield point of the wall material so that the stretch is permanently induced.

The stretching can be achieved by a wide range of devices and can be carried out progressively both radially and axially. However, we prefer that the duct stretching mechanism act against opposed internal faces of the duct simultaneously so that the wall of the duct itself acts as the plattern against which the mechanism acts and the desired increase in circumference is achieved. Thus, the stretching is preferably achieved by means of a radially expanding mandrel carrying axially extending former bars which are radially extended to bear against the wall of the duct and simultaneously deform the sections of the duct at the apexes of the desired cross-section. Such a mandrel can extend the full length of the duct to be stretched so that the desired cross-section is

achieved in a single operation. However, we prefer that the mandrel extend for only part of the axial length of the duct and that the stretching is carried out progressivly along the length of the duct as the mandrel moves axially within the duct. If desired, the mandrel can act progressively radially as well as axially, for example as when the leading portion of the mandrel does not extend to the full radial extent of the desired cross-section to be formed.

Thus, a suitable stretching mechanism for present use comprises a series of axial bars each having a radially outward face conforming to the internal shape of the apex to be achieved and carried on a radially expansible central traveller. The free ends of the bars are inserted through the duct and are supported both axially and radially in an end plate having radial tracks which allow the ends of the bars to move radially outward to the desired position of the apexes in the cross-section of the stretched duct. The traveller is intially located at the other end of the bars and is set to have a radial size which, with the radial depth of the bars, corresponds to the desired shape of the duct. The traveller is then drawn or pushed through the duct, for example by an hydraulic ram, and causes the bars to move radially outwardly to stretch the walls of the duct.

In a preferred form of the stretching mechanism, a mandrel carrying a series of radially extensible short axial former bars substantially parallel to one another and to the wall of the duct is moved progressivly along the duct to form the desired shape of the duct in a series of stages. The mandrel comprises a central axial support having the axial former bars attached thereto at the desired positions circumferentially by radially expansible means. The expansible means may be, for example, radially acting hydraulic rams or screw mechanisms. However, a preferred expansible means comprisies a series of radial arms pivotting about transverse axes which are pivotted from a position at which they lie adjacent the axis of the mandrel to one in which they adopt a more radial orientation. The arms carry at or adjacent their radially outward ends the axial former bars. Axial movement of an operating rod or rotation of a cammed rod or the like causes the former bars to be moved radially and thus stretch the wall of the duct. Preferably, the former bars have an axially tapered configuration whereby the forward portion of the mandrel has a smaller extended radius that the rearward portion of the mandrel, thus aiding forward motion of the mandrel into un-stretched sections of the duct. Furthermore, the forward portion can be configured so that only partial stretching of the wall of the duct is carried out by this portion of the mandrel, thus achieving a measure of preforming of the duct before complete forming of the duct is achieved by the rearward portion of the former bars.

The invention provides a simple method and apparatus whereby polygonal cross-section ducts can be formed having any desired configuration and with sharp radius apexes. The configuration of the mandrel for use in the method of the invention can readily be adjusted so that it can be used on a wide range of sizes of duct. Furthermore, by appropriate design of the mandrel, for example by having one of the former bars fixed, it is possible to use the method of the invention to form asymmetric ducts and not solely ducts which are radially symmetrical. If desired, the apexes can be formed with large radii of curvature to give a duct with rounded corners.

DESCRIPTION OF THE DRAWINGS:

The mandrel of the invention will now be described with respect to a preferred form thereof as shown in the accompanying drawings in which Figure 1 in an axial view of the mandrel in the radially collpased configuration; Figure 2 is a transverse cross-section along the line X-X through the mandrel of Figure 1; Figure 3 is an axial view of an alternative form of the mandrel of Figure 1 in the radially extended configuration; Figure 4 is a transverse section through an alternative form of mandrel; Figure 5 is an axial view of a further alternative form of mandrel; and Figure 6 shows typical cross-sections of the ducts which can be formed using the method of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The mandrel of Figure 1 comprises a central support shaft 1, which can be of any suitable size and shape, having journalled within it for axial movement an operating rod 2. At the end of shaft 1 are mounted three axial former bars 3, connected to the end of the shaft by pivot linkages 4 which allow the bars 3 to move radially with respect to the longitudinal axis of shaft 1. The operating rod extends beyond the end of the shaft 1 to lie substantially centrally between the three formed bars. The bars are connected to the operating rod by pivotted radial arms 5. When operating rod 2 is moved axially rearwardly, the arms 5 pivot to lie adjacent the rod 2, thus moving the former bars 3 radially inwardly. When rod 2 is moved axially forward, the arms 5 pivot to move the bars 3 radially outward to bear against the wall of a duct within which the mandrel has been inserted.

As shown in Figure 1, the leading portion of the

former bars can be tapered to aid insertion of the mandrel into the duct and forward maovement of the mandrel within the duct.

In place of the multiple fishplate linkage used in the mandrel of Figure 1, the former bars 3 can be directly pivotted on the end of shaft 1 and a single pivotted fishplate linkage 6 used to expand or contract the mandrel radially may be used as shown in Figure 3.

In place of the push/pull action of the operating rod 2 shown in Figures 1 to 3, the former bars 3 can be mounted on radially acting hydraulic rams 10 housed within an operating head at the end of shaft 1 which are fed with hydraulic fluid by, for example a bore 11 within shaft 1.

Alternatively, as shown in Figure 5, the radial movement of the former bars 35 can be achieved by axial movement of a tapered plug 20 carried by operating rod 2; or the plug shown in Figure 5 could have a cammed profile so that rotation of the plug causes the bars 3 to move radially in radial support channels in an operating head similar to that shown in Figure 4.

As stated above, the above forms of mandrel can be used to form symmetric triangular ducts as shown in Figure 6d. Where the mandrel carries four or six former bars, it can be used to form the square or hexagonal cross-section ducts shown in Figures 6c and 6a. In all these cross-sections, the former bars have acted symmetrically and radially outwardly from the longitudinal axis of the mendrel. In the case of rectangular cross-section ducts, the former arms may either act along radii which are not symmetrically directed about the axis of the mandrel (as shown dotted in the bottom section of Figure 6b) or may act from points removed from the axis of the mandrel (as shown dotted in the upper section of Figure 6b) and the optimum design of the mandrel may vary having regard to the size of the duct to be deformed using the mandrel.

With the asymmetric triangular section duct shown in Figure 6e, the lower former bar 3 has remained stationary, for example because it is fixed within the operating head or because no radial drive thrust has been applied to it, whereas the upper two former bars have been moved radially to stretch the wall of the duct.

By varying the movement, the location and direction of thrust of the former bars in the mandrel, it is possible to produce a wide variety of cross-sections in the formed ducts.

Accordingly, the present invention provides a radially acting mandrel adapted for axial travel within a duct, which mandrel comprises axially orientated former bars having a radially outward surface conforming to at least part of the desired internal shape of the duct, at least some of which former bars are adapted to be urged radially outwardly by a drive mechanism so as to contact and deform the walls of the duct in at least three directions to shape and stretch the walls of the duct to form a polygonal cross-section duct.

Claims

1. A method for forming a duct having a polygonal cross-section with at least three apexes thereto, which method is characterised in that it comprises subjecting a generally circular cross-section duct to radial stretching along the line of the intended apexes of the desired cross-section to be formed whereby the duct is deformed in at least three directions to adopt the desired cross-section.

2. A method as claimed in claim 1, characterised in that the initial duct is a generally circular cross-section duct which is radially deformed by drawing a radially expanding mandrel through the duct.

3. A method as claimed in either of claims 1 or 2, characterised in that the radial deformation of the duct is achieved by means of a mandrel which extends for only part of the length of the duct and is moved axially so that radial deformation of the duct is carried out progressively as the mandrel is moved axially with respect to the duct.

4. A method as claimed in any one of the preceding claims, characterised in that the duct is subjected to an initial radial deforming stage before being deformed fully to its desired radial configuration.

5. A method as claimed in any one of the preceding claims, characterised in that a mandrel within the duct carries radially extensible axial arms which are caused to extend radially to bear against opposed areas of the wall of the duct simultaneously.

6. A method as claimed in any one of the preceding claims, characterised in that the circumferential dimension of the wall of the duct is increased during the radial deformation of the duct wall so as to reach or exceed the yield point of the wall material.

7. A method as claimed in any one of the preceding claims, characterised in that the circumferential dimension of the duct wall is increased by from 0.5 to 5% during the radial deformation of the duct wall.

8. A radially acting mandrel adapted for axial travel within a duct and for use in the method of claim 1, which mandrel comprises axially orientated former bars 3 having a radially outward surface conforming to at least part of the desired internal shape of the duct, at least some of which former bars 3 are adapted to be urged radially outwardly by a drive mechanism 2 so as to contact and deform the walls of the duct in at least three directions to shape and stretch the walls of the duct to form a polygonal

cross-section duct.

9. A mandrel as claimed in claim 8, characterised in that the leading portion of the mandrel does not extend to the full radial extent of the desired cross-section to be formed.

10. A mandrel as claimed in either of claims 8 or 9, characterised in that at least some of the axial former bars 3 are carried by a pivot mechanism 4, 5, 6 upon an axially extending support member 1 whereby the pivot mechanism 4, 5, 6 causes the former bars 3 to move radially with respect to the support member 1; and in that it carries a mechanism 2 for urging the former bars 3 radially with respect to the support member 1.

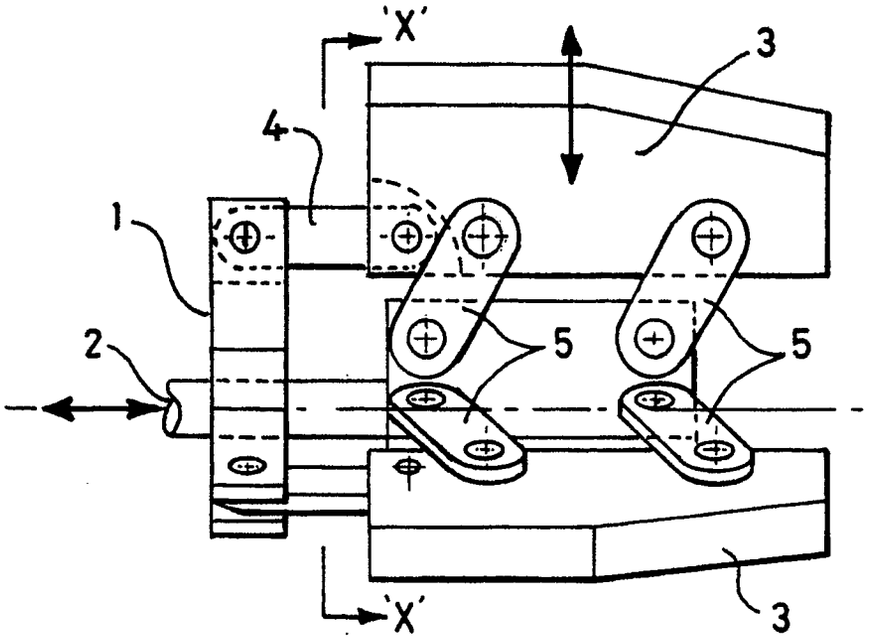


Fig. 1

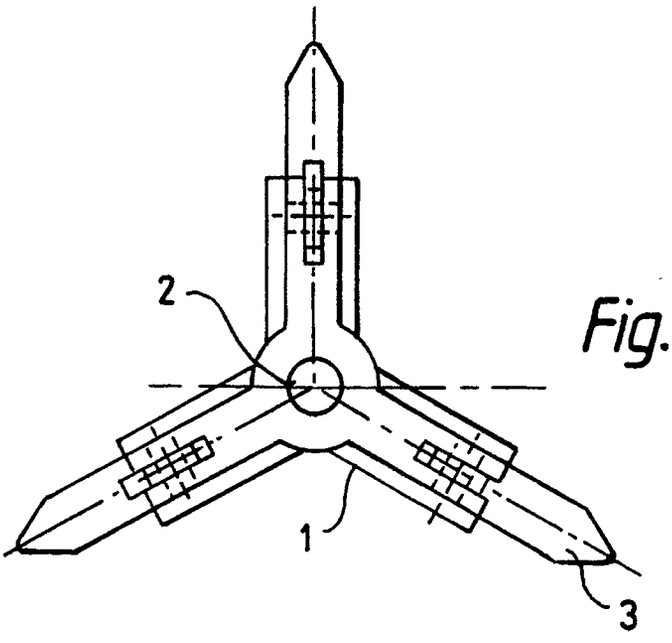


Fig. 2

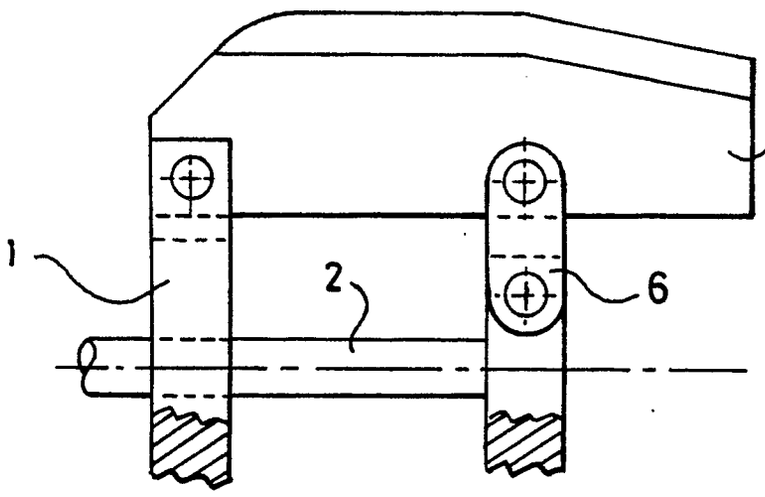


Fig. 3

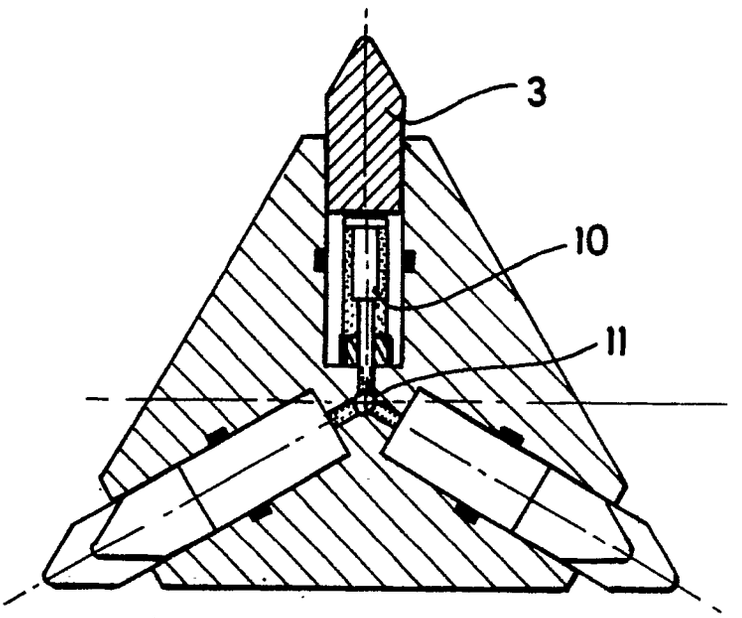


Fig. 4

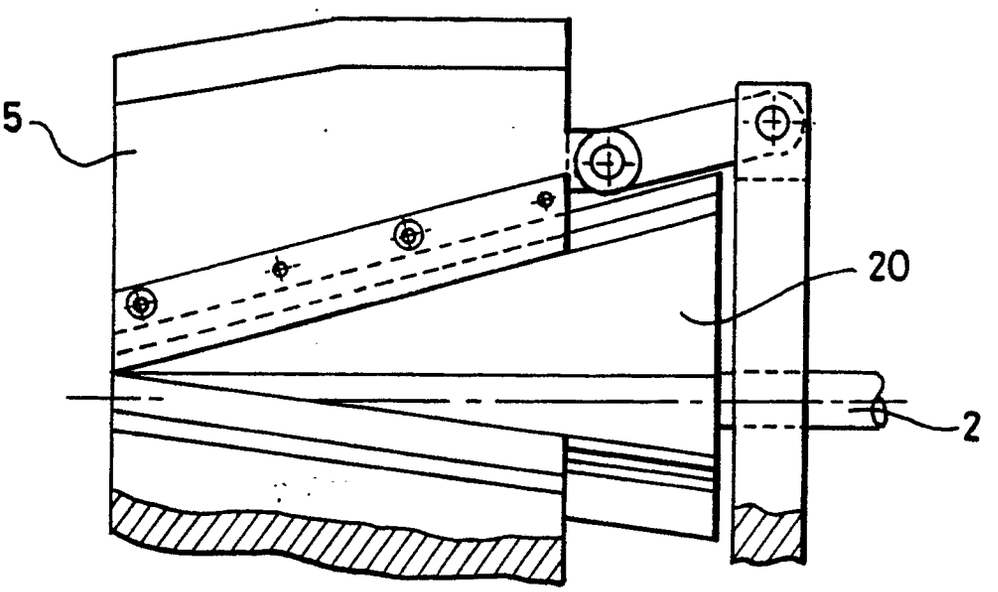
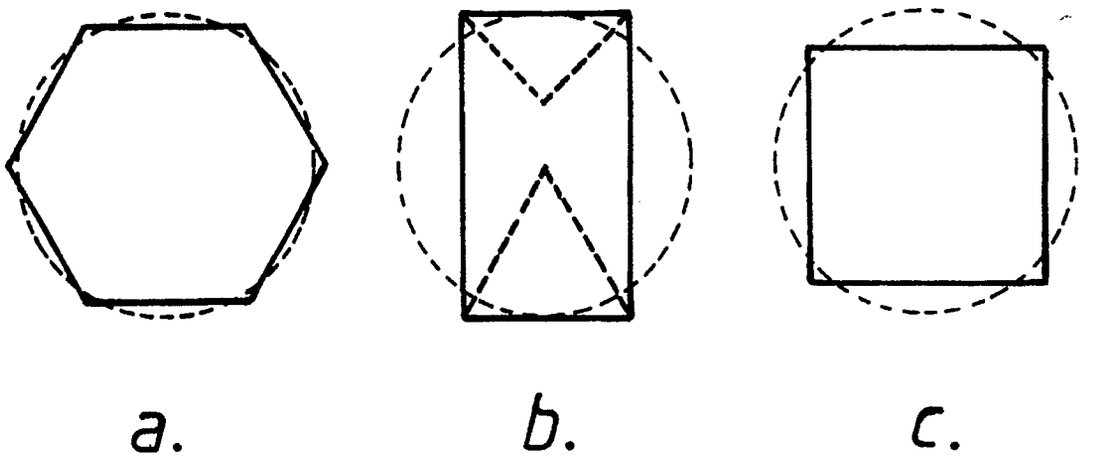


Fig. 5



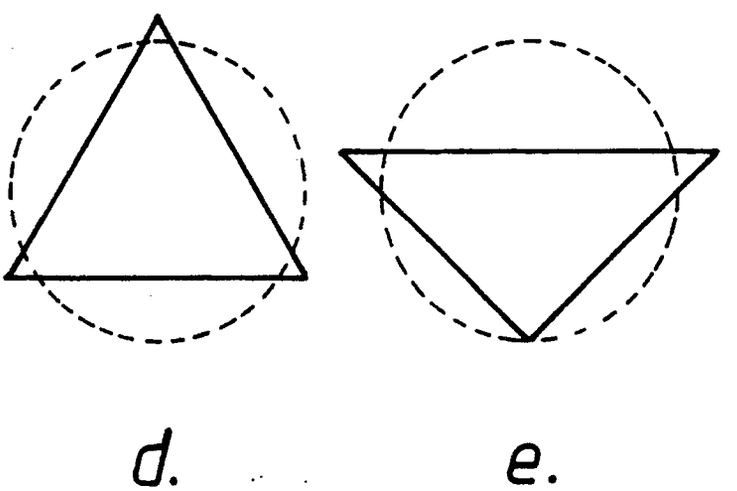


Fig. 6