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COMPLETE SPECIFICATION

Improvements in or relating to the Production of Tubular Bodies

I, WILHELM ECKHARDT, of Czechoslovakian nationality, of Rue Arcade 7, Paris VIII, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for shaping flat strips of material into tubular bodies, especially for producing tubes, pipes, boilers, and the like.

According to the prior art, it is already known to produce tubular bodies such as tubes, pipes, and the like from flat strips of material of a certain width by feeding such a strip to a shaping tool which consists of a slotted hollow cylinder with a mandrel disposed therein, the outer diameter of which corresponds substantially to the inner diameter of the hollow body to be produced, while the inner diameter of the slotted cylinder substantially corresponds to the outer diameter of the tubular body. This method of production has the disadvantages that it entails very great frictional forces and therefore requires considerable power to carry it out.

According to another known method of production the shaping tools are made in the form of several rollers, two or more of which act upon the wide outer side of the strip to be bent and another roller which acts upon the wide inner side of the strip. However, because of the provision either of a mandrel or of an inner roller within the hollow cylinder, these two mentioned methods do not permit the production of tubular bodies of a relatively small diameter. Also, since the mandrel or the inner roller can only be mounted at one end, it is impossible to produce tubular bodies of a comparatively great wall thickness.

In both of these known methods it is

necessary to feed the strip to the respective shaping tools at a specific angle relative to the main axis of the shaping tools which depends upon the width of the strip and the diameter of the hollow body to be produced. If this angle is correctly adjusted, the edges of the curving strip will abut against each other so that they can then be properly welded together. If the strip is of an exactly uniform width at all points transverse to its length, there will theoretically be no difficulties. In actual practice, however, it will be found that the width of even the most accurate strip of material varies by 1% in either direction so that despite the most accurate adjustment of the feeding angle the edges to be welded together will be in actual contact with each other at very few points so that it will be quite difficult to weld the edges properly to each other by an automatic welding operation. In order to insure that the width of the strip will be constant throughout its length, it is necessary in these methods that the edges of the strip be worked upon before it may be fed toward the shaping tool or tools. Furthermore, the smaller the angle is made between the feeding direction of the strip and the main axis of the shaping tool, the greater will be the danger that the strip might also become deformed in a direction transverse to the direction to its movement so that the width of the slit between the edge of the part of the strip which is being fed to the tool and the edge which has already been curved will vary, with the result that the two edges will not properly abut against each other or at least be sufficiently close to each other to be securely welded together.

It is the principal object of the present invention to provide a method and apparatus which will overcome the above-mentioned



disadvantage

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difficulties and disadvantages of the known methods and apparatus.

According to the invention therefore there is provided a method of producing tubular elements comprising the steps of continuously feeding a flat strip of material to the inner curved surface of a hollow shaping tool of substantially semicircular cross section from the open side thereof and at an angle thereto, helically coiling said strip solely by its moving engagement with said inner curved surface so that the curved edges of adjacent portions of said strip substantially engage each other, and welding said adjacent edges together from the inside of said coiled portions accessible from said open side of said shaping tool so as to form an internally closed helical seam of a tubular element.

Preferably the said helical seam is also welded on the outside. I may if desired feed the said strip into the tool at an angle to its open side which is smaller than the angle which would be required to produce a roller having an outer peripheral surface engaging the entire inner curved surface of the tool.

According to another feature of the invention there is provided an apparatus for producing tubular elements comprising a shaping tool consisting of an elongated hollow member having an inner curved surface of substantially semicircular cross section, means for feeding at least one flat strip of material toward and into said shaping tool from the open side thereof and at an angle to the axis thereof so as to engage with at least a part of said curved inner surface and, by its own movement along said surface, coil into a helical tubular element, and means for welding the edges of adjacent coil portions to each other from the inside of said tubular element accessible from the open side of said shaping tool so as to form an internally closed helical seam on said tubular element.

The strip can be fed into the tool by means of rollers, at least one of which is driven, and guiding means which are designed to prevent the strip from bending or buckling. The apparatus preferably includes a slide rest or the like which is mounted at a point behind the shaping tool and serves to guide the finished hollow body from the apparatus. The latter is also designed so as to permit an adjustment of the angle between one longitudinal edge of the strip which is being fed to the shaping tool and the main axis of the latter, and to permit the curved portions of the strip to be welded together while still within the area of the shaping tool.

The shaping tool and the slide rest with a support or backrest thereon are preferably mounted on separate turntables, and the turntable of the slide rest is preferably mounted

on a stationary frame so as to be slidable thereon. In order to reduce the pivoting of the shaping tool and the slide rest with the support as much as possible during the operation, it is advisable to guide the strip during its feeding movement by means of rollers, the axes of which extend vertically to the plane of the strip, to mount these rollers in pairs along both edges of the strip, and to provide at least those rollers which are mounted near the shaping tool at a distance from each other which corresponds to the smallest width of the strip which is admissible for a proper shaping and welding operation. In order to facilitate a pivotal movement of the shaping tool and the slide rest carrying the support about a vertical axis, it is advisable to secure a table or the like on the slide rest on which a carriage is slidable in a direction transverse to the direction of the adjusting movement of the slide rest, and to mount a cutting mechanism on this carriage. The cutting mechanism is movable in a direction transverse to the direction of movement of the carriage to permit the finished tubular body to be cut into sections of any desired length. The carriage supporting the cutting mechanism may be held in engagement with the finished tube, for example, by means of a roller, so as to follow the movement of the tube from the shaping tool to permit the tubular sections to be cut off while the shaping operation progresses.

It is a further object of the invention to overcome another disadvantage which may occur during the shaping operation, namely, that the edges of the strip which are to be welded to each other might shift relative to each other so that the inner or outer generatrices of the finished tube will no longer extend along a straight line. This may occur, for example, if by a pivotal movement of the finished part of the tube relative to the shaping tool the pressure will become too high at the point at which two edges of the strip are to be welded together.

In order to prevent the occurrence of this disadvantage, suitable means may be provided at least on one edge of the spirally curved strip for guiding the adjacent edge which is to be connected and welded thereto when the tube is being formed. These edge guiding or connecting means may be of different designs. Thus, for example, the cross-sectional shape of one edge portion of the strip may be deformed, for example, by an upsetting operation, so as to provide this edge with a groove of a width which corresponds to the thickness of the strip. Instead of deforming the edge portion of the strip itself, it is also possible to provide a striplike guiding or connecting member which is fitted upon or secured to one edge of the strip which is to be shaped into a tube,

and has a lateral groove therein of a width corresponding to the thickness of the strip. A still more practical embodiment of such a guiding or connecting member consists in making it of a substantially I-shaped cross section with a pair of grooves extending in opposite directions within the same plane. One of these grooved sides of the connecting member is then fitted over one edge portion of the strip while the same is being fed toward the shaping tool, while the other grooved side receives the other edge of the strip after the latter has been spirally curved. For increasing the strength not only of the weld but also of the entire tubular body, it is further advisable to provide the I-shaped connecting member with a riblike projection on at least one side which extends in a direction transverse to the common plane of the grooves therein.

A further very simple method of providing the guiding or connecting means consists in forming a groove within one edge of the strip itself and a projection or tongue on the other edge which is to be connected thereto. Such tongue or the like should then at least partly fill out the groove. The tongue and groove are preferably both made of a V-shaped cross section since they may be easily produced during the operation of feeding the strip toward the shaping tool and will easily fit into each other.

The guiding means may, however, also be attained by superimposing at least two strips of material upon each other in a staggered relation to each other in the lateral direction. In order to reduce the frictional forces occurring during the bending operation, it is advisable to preheat one of the strips before both strips together are inserted into the shaping tool. If more than two strips are superimposed upon each other, it is advisable to preheat each strip to a temperature different from that of the others. It has been found that such preheating will not only result in a better bending of the strip within the shaping tool, but that it will also result in an initial tension of the strips since those strips which have been preheated will again shrink after their edges have been welded to each other. A very simple manner of welding a strip which consists, for example, of three layers of material, may be attained by staggering these layers so that during the feeding operation the edges of the two outer layers will extend within the same plane vertical to the plane of the strips.

If one of the edges of a strip is to be provided with a tongue and the other edge with a groove, each of the lateral guide rollers which insure that the strip has the proper width may be associated with a pair of rings which are rotatable about a common axis. One of these two rings is preferably

acted upon by at least one spring of adjustable tension which presses this ring against the strip. These rings are provided for removing any scale which might still adhere to the edge portions of the strip.

It is a surprising fact that if the butt joints of the strip are connected to each other by a weld of a thickness which is greater than the thickness required in order to attain a welding coefficient of 1 it will be possible to attain a tubular body, for example, a pipe or a boiler, which has a strength greater than that of the wall thickness of the material of the respective body itself. In other words, a tubular body with a welded seam according to the invention has a greater strength, and can withstand a greater internal pressure than a similar seamless body. Such an increase in the strength of the tubular body made according to the invention will be attained especially if the weld is made in the form of a bead or rib.

According to the known methods and apparatus as previously described, the presence of the mandrel or of the roller which supported the curving strip at the inside of the shaping tool did not permit the strip edges to be welded together at their points of engagement unless the strip was fed to the shaping tool in such a manner that the strip portion which was already curved would approach the flat, still unbent strip portion from below. Consequently, the welding operation could only be carried out from the outside. However, after the strip edges have thus once been welded together, it is ordinarily no longer possible to weld the seam also from the inside of the tubular body since the welding tool cannot be inserted therein. A really secure weld which should be applied from both sides could therefore previously not be attained.

It is therefore another very important object of the present invention to devise a method and apparatus which permits the adjacent edges of the tubularly curved strip to be welded together not only from the outside, but also from the inside. Another object of the invention is to carry out such double welding operation in a very simple and inexpensive manner. These objects may be attained by devising a shaping tool which does not require any mandrel or roller at the inside of the tubularly curving strip and which is open at one side as previously described. It will then be possible to have an easy access from one lateral side to the inside of the tubularly curved portion while the bending operation progresses, and thus to weld the strip edges together at first from the inside. If it should then be desired to weld the tubular body also from the outside in order to attain a perfect, absolutely tight seam, such external welding may be easily

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carried out at any point subsequent to that where the internal weld was previously applied, since through such internal welding the strip edges are secured to each other and the seam can no longer be ripped apart. If the known methods and apparatus as previously described were first used to make tubular bodies of a certain diameter, and other bodies of a larger or smaller diameter were then to be made, it was necessary to replace the shaping tool previously used by one which had either a larger or smaller diameter, and, provided that the strip to be used had the same width as that used for making the previous bodies, to change the angle at which the strip of material was fed to the shaping tool. If the strip to be used had a different width to that used in the previous operation for making tubular bodies of a different diameter, it was sometimes possible to maintain the feed angle of the strip relative to the shaping tool. Therefore, if the width of the strip material remained the same and the shaping tool was mounted in a stationary position, it was necessary not only to replace the shaping tool for one of a different dimension, but also to pivot the extremely heavy feeding mechanism so as to adapt the angle between the feeding mechanism and the main axis of the shaping tool, that is, for example, the central axis of three rollers which formed the shaping tool, to the radius of curvature of the tube to be produced. In these prior methods, the diameter of the finished tubular body, for example, a pipe, boiler, or the like, depended upon the position of the rollers relative to each other. This relative position was, in turn, dependent upon a specific feed angle of the strip material. Since this feed angle was not changed during the operation of the apparatus, and since the slot between the strip edges which were to be welded together therefore varied in width because of small changes in the width of the strip material, it was also necessary to vary the width of the weld. Furthermore, if the slit between the strip edges became too wide, there was a considerable danger that the weld was not secure. It was therefore necessary to check the finished tubular body carefully for tightness and solidity of the welded seam and to seal weak or leaky points by additional welding.

The present invention is based upon the new finding that, after the apparatus has once been set for making a tubular body of one diameter, an adjustment of the feed angle of the strip material relative to the shaping tool can result in a tubular body of a different diameter if the shaping tool has a curved surface which acts upon only one of the side surfaces of the strip. It has further been found according to the invention that it will be fully adequate to use a half-

open tool which has a radius of curvature approximately equal to the radius of the largest tubular body which is intended to be made on the apparatus. Since the same shaping tool may thus be used to make tubular bodies of any diameter smaller than twice the radius of the tool, the expense previously required for making separate tools for each different tube diameter is now considerably reduced, and the time previously required to change the tools is also saved. Furthermore, since the shaping tool is completely open at one side, it is possible closely to observe the shaping process and to check that it proceeds properly. Contrary to the general previous assumption of any person familiar with the art of producing closed tubular bodies from flat strips of material, it has therefore been found that it is very well possible to produce such bodies of different diameters merely by changing the feed angle of the strip material relative to the axis of the shaping tool. Furthermore, it has been found that, if the feed angle is constantly changed while the strip material is being fed to the shaping tool, it is also possible to use the same tool in order to make conical tubes, even though the generating surface of the shaping tool forms a part of a cylinder.

While in accordance with the above description it is necessary to insure that the strip will always be fed to the shaping tool at an angle of such an inclination that the curved part of the strip will be engaged against the part which is still straight, it is possible to limit the adjustment of the feed angle to a minimum by the provision of a plurality of rollers at both sides of the feed path of the straight strip, and of suitable means for adjusting the distance between the corresponding rollers on both sides so that at least the rollers of the closest pair in front of the shaping tool will be spaced from each other at a distance which corresponds to the smallest admissible width of the strip. If the width of the strip is, for example, 600 mm and varies 0.5% in either direction, it would be necessary to adjust the rollers of at least the closest pair to a distance of 597 mm. However, since the width of the strip varies between 597 mm and 603 mm, the strip will be upset along its edges and be formed with a bead or bulge thereon, and the width of the strip will thus remain constant. If the width of the strip deviates only very little from the admissible minimum of 597 mm, no bead will be formed but the edges of the strip which by nature are slightly rounded will be upset to become rectangular in cross section. The small bead on the strip edges produced by such upsetting operation will, when passing to the welding point, increase the solidity of the finished tubular body and also facilitate the welding operation since

sufficient material will then be available on which the weld may be formed.

During the bending operation in the shaping tool, the cross-sectional shape and thus the width of the strip will also change, although only at a slight extent, so that the distance between the strip edges which are to be welded together will not remain perfectly constant. A constant distance between the edges to be welded together is, however, very desirable, and for arc welding it should preferably amount to 0.3 to 0.5 mm and for induction welding to zero or even be negative in order to produce an upsetting pressure. In order to attain such a constant distance between the strip edges to be welded, it is necessary to provide suitable means which permit the feed angle at which the strip is inserted into the shaping tool to be quickly adjusted within small limits during the shaping of the strip, that is, for example, at an angle of 15 seconds within a period of one second. If the width of the strip decreases by the shaping operation, the feed angle must be enlarged, and if it should slightly decrease, the feed angle must accordingly be reduced in order to attain a constant diameter of the finished tube. For obvious reasons, it is, however, impossible to carry out such a rapid adjustment of the feed angle, that is, of the angle between the feeding mechanism and the main axis of the shaping tool, if for this purpose, the heavy feed mechanism, which often weighs several tons, has to be pivoted relative to the shaping tool. The present invention therefore provides suitable means which produce such a quick adjustment of the feed angle during the shaping process by pivoting the much lighter shaping tool relative to the feeding mechanism.

As long as a tubular body of a relatively small wall thickness is to be made of a relatively small diameter, for example, 4 inches at a wall thickness of 2 to 3 mm or about $\frac{1}{16}$ ", it will be sufficient if the supporting member carrying the finished tubular body, for example, a slide rest, be pivoted together with the shaping tool. If, however, the tubular body is to be made of a relatively great diameter of, for example, more than 10 inches, or of a relatively great wall thickness of, for example, more than 5 mm or about $\frac{3}{16}$ ", it may become rather difficult to carry out the required quick pivotal movement because of the heavy weight of the finished body. If, however, the finished tubular body is then supported by a lunette or other suitable backrest which, in turn, is supported by a slide rest or the like, and the lunette is capable of pivoting relative to the shaping tool, the greater leverage attained if the force necessary for pivoting the tubular body together with the shaping tool is applied to the lunette or the slide rest,

will not only permit a proper pivoting movement of the tubular body and the shaping tool but it may also be used to exert a constant pressure upon the strip edges at the first point where they are to be welded together. Consequently, the finished tubular body will be given a certain initial tension which will increase the solidity of the weld and of the entire body.

Further objects, features, and advantages of the present invention will be apparent from the following detailed description thereof, particularly when read with reference to the accompanying diagrammatic drawings, in which:—

Fig. 1 shows a cross section of a shaping tool according to the invention taken along line I—I in Fig. 2, with a strip of material being fed to such tool to be shaped into the form of a tube;

Fig. 2 shows a cross section of the shaping tool according to Fig. 1, to which a strip of material is being fed at such an angle that the radius of curvature of the tube to be made substantially corresponds to the radius of curvature of the shaping tool;

Fig. 3 shows a cross section taken along line III—III of Fig. 4, of another shaping tool according to the invention, likewise with a strip of material being fed thereto;

Fig. 4 shows a cross section of the shaping tool according to Fig. 3, to which a strip of material is being fed at such an angle that the radius of curvature of the tube to be made is smaller than the radius of curvature of the shaping tool;

Fig. 5 shows a partial plan view of the apparatus according to the invention;

Fig. 6 shows a side view of the rollers which feed the flat strip of material to the shaping tool;

Fig. 7 shows a cross section of a strip of material which is to be used for making a tubular body with a welded helical seam, wherein one edge of the strip is upset to form a groove;

Fig. 8 shows a cross section of a strip of material, one edge of which is provided with a guiding or connecting member of I-shaped cross section having a thickness only slightly greater than the thickness of the strip;

Fig. 9 shows a cross section of a strip of material which is provided with a connecting member of a thickness considerably greater than the thickness of the strip;

Fig. 10 shows a cross section of a connecting member similar to that illustrated in Fig. 9;

Fig. 11 shows a cross section of a strip of material which is provided with a V-shaped groove along one edge thereof and with a corresponding projection or tongue along the other edge;

Fig. 12 shows a cross section of two superimposed strips of material which are staggered

relative to each other in a direction transverse to the length of the strip;

Fig. 13 shows a cross section of the area adjacent to the welded edges of a tubular body made of two superimposed strips of material;

Fig. 14 shows a cross section of the area adjacent to the welded edges of a tubular body made of three superimposed strips of material;

Fig. 15 shows a cross section of the area adjacent to the welded seam of a hollow body made of one strip of material;

Fig. 16 shows a cross section of one of the left rollers of the group of rollers and rings which are disposed at both sides of the strip of material for removing the scale therefrom at the area of the edges thereof, for insuring that the strip has the desired width, for forming a tongue along its edge, and for guiding the strip; while

Fig. 17 shows a cross section of the corresponding roller and rings at the right side of the strip.

Referring to the drawings, Figs. 1 to 4 illustrate the method according to the invention of shaping tubular bodies such as pipes, tubes, boilers, and the like. The shaping tool 2 is made in the form of a half shell with a semicylindrical inner surface. A straight strip 1 of material is fed to the shaping tool 2 at an angle α which is made of a size so that the radius of curvature of the tube or pipe 3 to be produced is slightly smaller than the radius of curvature r of shaping tool 2. If the angle α as shown in Fig. 1 were made slightly larger, the strip of material in being fed into tool 2 would wedge or jam in the tool. After the front end 4 of strip 1 has been shaped in tool 2 and strip 1 continues moving into the tool at the same angle α , this curved end 4 will abut at the point 5 against the right edge 6 of strip 1 and will remain in engagement with the edge even after the same is also bent into a curved shape. If the two edges 6 and 7 are then secured together by internal welding in the direction as shown by arrow 8 for which purpose a tack-weld would actually be sufficient, it will be possible to maintain the shape of the tube thus produced, and the seam then forming behind the welded point 5 may then be adequately sealed at one or more subsequent points, preferably by welding from the outside. The shaping operation as above described can, however, be carried out properly only if strip 1 is firmly guided, for example, by a guide member 9, up to a point closely in front of shaping tool 2.

If strip 1 is fed toward shaping tool 2 at an angle α' , as illustrated in Fig. 3, which is smaller than angle α in Fig. 1, the diameter of tube 3' would be smaller than the diameter of tube 3. The final diameter of

the tube to be produced therefore depends solely upon the angle α or α' at which strip 1 is fed toward and into the shaping tool 2. That this is true has been proved by many tests which have actually been carried out. The only change occurring if the material is fed at a smaller angle so as to produce a tube of a smaller diameter is in the location of the point where the straight edge 6 abuts against the curved edge 7. As illustrated in Fig. 3, this contact point 5' will then lie within the space which is surrounded by the shaping tool 2 rather than in front of the latter as shown in Fig. 1.

Fig. 5 shows a partial view of a machine which is designed to produce a tube from a straight strip of material in accordance with the present invention. Strip 1 is preferably fed by means of a plurality of rollers, not shown, at least one of which is driven, toward a feeding and guiding mechanism which essentially consists of one or more pairs of rollers 10 which are disposed above each other and a plurality of lateral rollers 11 and 12 which are disposed in pairs at opposite sides of strip 1 and parallel to each other. Rollers 10 are spaced from each other at a distance which corresponds to the thickness of strip 1, while rollers 11 and 12 are spaced at different distances from each other, namely, at those points which are relatively remote from shaping tool 2 at a distance which equals the greatest permissible width of the strip, and at those points which are closest to shaping tool 2 at a distance which equals the smallest permissible width of the strip. The distance between the intermediate pairs of rollers 11 and 12 between the remotest and closest pairs gradually reduces from such maximum distance to such minimum distance. While in Fig. 5 only one pair of superimposed rollers 10 has been illustrated, it is advisable to provide a plurality of such pairs at certain distances from each other in the longitudinal direction of strip 1. In the particular embodiment of the invention as illustrated in Fig. 5 it is assumed that the feed movement of strip 1 toward the machine is produced by means of two superimposed rollers 15 and 15', as shown more particularly in Fig. 6. The lower feed roller 15' which is rotatably mounted in a fixed position is driven by a motor 14 through a set of gears 13 and a shaft 13', while the upper feed roller 15 is rotatably mounted within a supporting frame 16, 16' which is adjustable in a vertical direction as indicated by the arrow 15'' and loaded by a weight member 16''. Intermediate the feed rollers 15, 15' and the shaping tool 2, guide means 9 are mounted which extend to a point shortly in front of shaping tool 2 as indicated by the line 17, and which are preferably reinforced by ribs 18.

Shaping tool 2 is secured to the upper surface of a turntable 19 by means of a supporting bracket 20. Turntable 19 is rotatably mounted on a table, frame, or the like 21 which forms the supporting base of the machine. After the flat strip of material 1 has been passed between the upper and lower rollers 10, the lateral rollers 11 and 12 and feed rollers 15 and 15', it engages at point 22 upon shaping tool 2, the cross-sectional shape of which corresponds to that illustrated in Figs. 1 to 4. Through the gradual forward movement of strip 1 produced by feed rollers 15 and 15', the strip is then helically coiled to form a tube 3, 3'. Since the edges of the strip abutting against each other to form a helical seam are connected to each other at least by tack-welding, the tubular part emerging from shaping tool 2 will form a rigid element. This tubular part is guided by resting upon two balls 23 which form a support or backrest. Each of these balls 23 is rotatably mounted in a bearing 24 which, in turn, is adjustably mounted on a slide rest 25. The two bearings may, for example, be adjustable relative to each other by means of a spindle 26 which is provided with right-hand and left-hand threads. Slide rest 25 is mounted on a turntable 27 which can be moved back and forth in the direction indicated in Fig. 5 by the arrow 29 by means of a motor 28. If slide rest 25 is moved in one or the other direction, turntable 27 will also turn at a corresponding amount.

As long as the tubular part 3, 3' does not as yet rest on balls 23 of the backrest, slide rest 25 may be adjusted relative to a frame 30 so that the position of balls 23 corresponds to the angle at which strip 1 is fed toward shaping tool 2. Frame 30 is secured in a stationary position by means of bolts 31 or the like. Slide rest 25 has rigidly secured thereto a table or the like 32 on which a carriage 33 is slidably mounted. One or more rollers 34 are rotatably mounted on carriage 33 and may be pressed against the tubular part 3, 3' by means of an eccentric, not shown, which may be operated by a hand lever 35. If the roller or rollers 34 are moved into engagement with the outer surface of tube 3, 3', and the tube while being made moves in the direction indicated by arrow 36, carriage 33 will shift likewise in the same direction and at the same speed along table 32. Since carriage 33 also supports a cutting tool, for example, a rotary saw 37 which is driven by a motor 38, this saw may be moved simultaneously with rollers 34 in the direction toward tube 3, 3' and the latter may be cut into sections of any desired length. If the cutting mechanism is mounted and arranged as illustrated in Fig. 5, the tubular section will not be cut off completely and drop off until it has passed

beyond slide rest 25. Rollers 34 are preferably made of rubber or provided with a rubber surface in order to increase their adhesion on tube 3, 3'. If a section of a certain length is to be cut off tube 3, 3', it is merely necessary to operate lever 35 to move one of rollers 34 into engagement with the outer surface of tube 3, 3' whereby the adjusted tube length will be cut off automatically within a plane which extends vertically to the axis of tube 3, 3' since the tube moves not only in the direction of arrow 36 but also rotates about its own axis.

In order to press the edges of the strip which are to be welded together against each other under a certain pressure, it is advisable during the tube-shaping operation to pivot slide rest 25 through a small angle in the direction indicated by arrow 39. This small movement may be controlled, for example, by microswitches which operate motor 28 and effect such movement in accordance with the width of strip 1 shortly before it enters into shaping tool 2. In place of such a control of microswitches, it is also possible to subject slide rest 25 to the action of one or more springs which tend to pivot slide rest 25 in the direction of arrow 39. Such pivoting movement produces an initial tension in tube 3, 3' while it is being made. Consequently, when the finished tube is subjected to an internal pressure, such pressure must first overcome the initial tension before it will act upon the strength of the material itself.

For securing the edges of the strip to each other so as to attain a firmly sealing seam, different means may be provided. Thus, for example, as illustrated in Fig. 7, the right edge of strip 40 may be provided with a groove 43 between two short side arms 41 and 42. This may be attained, for example, by a simple upsetting operation during the feeding movement. The width of groove 43 corresponds to the thickness of strip 40, while its depth depends upon the desired amount of interengagement or overlap of the two edges. However, groove 43 is preferably made of a depth which substantially corresponds to one-half of the thickness of strip 40. In order to facilitate the insertion of the other edge of the helically shaped strip into groove 43, it is advisable to round off the edges 44 of arms 41 and 42. Groove 43 may, for example, be produced by making rollers 12, which guide the strip of material toward shaping tool 2, of such a shape that during the movement of the strip along the rollers the same will increasingly press upon the right edge of the strip and gradually mold or upset the edge to form groove 43 and side arms 41 and 42, as illustrated in Fig. 7.

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right edge of the strip itself, it is also possible, as shown in Fig. 8, to provide the straight rectangular strip 45 with a guiding or connecting member 46 of substantially I-shaped cross section which has two grooves 47 and 48 disposed within the same plane. This connecting member 46 only needs to be slightly thicker than strip 45. To permit an easier insertion of the edges of strip 45 into groove 47 and 48, the outer edges of the arms forming the grooves are preferably likewise rounded off as shown in Fig. 7. These edges and member 46 will then be welded in a manner similar to that described with reference to Fig. 9.

A more preferable shape of the connecting member 46' is illustrated in Fig. 9, in which the central web thereof is extended toward one side so as to form a rib 49 which extends transverse to grooves 47' and 48'. This connecting member 46' is applied to strip 45 so that rib 49 will project from the outer surface of the tubular body and thus extend in a helical line along the same. Connecting member 46' may then be secured to the edge portions of the spirally curved strip 45 by a weld 50.

Connecting member 46'' may also be given a cross-sectional shape as illustrated in Fig. 10. It has two grooves 47'' and 48'' and two ribs 49' and 49'' projecting in opposite directions and transverse to the plane of the grooves. If this connecting member is applied to the edge portions of strip 45, it will be advisable to provide a weld at both sides of each rib 49' and 49''. Rib 49' is preferably made of a height which is equal to twice the thickness of strip 45, while the height of rib 49'' may be considerably lower and, for example, amount to the thickness of the strip or to one much less than such thickness. Rib 49'' may, for example, serve for the purpose of giving a fluid contained in or passing through the tube a twisting motion during its movement along its inner wall whereby the friction of the fluid along such inner wall will be reduced.

The desired interconnection of the edges of the helically curved strip may also be attained in a more simple manner than previously described by providing one edge of the strip with a suitable projection and the other edge with a corresponding groove. Thus, for example, as illustrated in Fig. 11, strip 51 may be provided with a V-shaped groove 52 along one edge and a corresponding V-shaped tongue 53 along the other edge. This tongue 53 should be designed so that it will at least partly fill out groove 52 when the strip is curved into its helical tubular shape and the two edges are engaged into each other. The outer edges 52' of groove 52 may also be rounded off as previously described to facilitate the insertion of tongue 53 into groove 52. Groove

52 and tongue 53 may also be formed on the two edges of strip 51 in a manner similarly as described with respect to Fig. 7 and as will be more specifically described with reference to Fig. 16.

The strips of material which are commonly available in commerce usually have a thickness of 1 to 8 mm, although strips of a thickness of 10 mm may also be obtained. Thus, if a hollow body is to be made according to the invention with a wall thickness of, for example, 12 mm, it may be advisable to superimpose two strips of an equal thickness of 6 mm upon each other. If two such superimposed strips 54 and 55 are staggered relative to each other transversely to their length, as illustrated in Fig. 12, no special connecting means such as shown in Figs. 7 to 11 will be required since the steplike overlap of the edges of one layer relative to those of the other layer may serve as a tongue-and-groove connection. It is then merely necessary to provide suitably shaped guide and pressure rollers which insure the proper width of the superimposed strips and prevents them from shifting transversely to each other while being fed to the shaping tool. When the two strips 54 and 55 are then bent by the shaping tool, edges 56 and 57 of strip 54 and edges 58 and 59 of strip 55 will approach each other until they are in engagement with each other, whereupon they may be welded to each other, as illustrated in Fig. 13. Within the area of the abutting edges 56 and 57, the two edge portions of strip 54 are preferably secured to each other from the inside by a weld 60, the root 61 of which is disposed within the solid part of strip 55, while within the area of the abutting edges 58 and 59 the two portions of strip 55 are similarly welded to each other and to one edge portion of strip 54 since the root 62 of weld 63 lies within the solid part of this portion of strip 54.

If three strips of material 64, 65 and 66 are to be superimposed, as illustrated in Fig. 14, they are preferably staggered relative to each other so that edge 67 and 68 of strips 64 and 66 extend within the same plane and vertically to the plane of the strips themselves. The abutting edges 69 of strip 65 extends parallel to the common plane of edges 67 and 68 and either at one side thereof or the other. The edge portions of all three strips together thus form a single connecting means. Similarly as described with reference to Fig. 7, some of the edges of strips 64 and 66 are preferably rounded off to facilitate the interengagement of the strip portion 65 at the right side with the groove formed between strips 64 and 66. This may also be attained by the pressure exerted upon the edges of guide rollers 11 and 12 which should have a stepped shape to insure the

proper position of the three strips 64, 65, and 66 relative to each other during the feeding movement.

The three strips are combined with each other in a similar manner as described with reference to Fig. 13 by means of an inner weld 70 and an outer weld 71, the roots of which lie within the opposite outer and inner strips 64 and 66. However, instead of being staggered relative to each other as shown in Fig. 13, the two welds 70 and 71 according to Fig. 14 lie within the same vertical plane and intersect each other in the manner shown.

The method in which strip portions which are shaped as shown in Fig. 11 may be welded to each other is indicated in Fig. 15. The two abutting edge portions 51 have a tongue and groove along their respective edges interengaging with each other. The outer weld 72 preferably has a thickness greater than the inner weld 73. This may likewise be applied to the other embodiments and particularly to those shown in Figs. 13 and 14.

Figs. 16 and 17 finally illustrate the method of providing the two lateral edges of each strip of material with connecting means, for example, those as illustrated in Fig. 11, by means of the guide or pressure rollers which insure that the strip has the proper width so that in the subsequent bending operation it will form into a proper tube. A frame 74 which is mounted in a stationary position on a base, not shown, contains and guides a slide member 75 which is adjustable by means of a threaded spindle 76. The front end of spindle 76 has a flange 77 carrying a ball 78 which abuts against a V-shaped recess 79 of slide member 75. An extension 81 is welded to slide member 75 and carries a plate 80 which engages behind flange 77 so that, when spindle 76 is turned in one direction or the other, slide member 75 may be moved back and forth.

Slide member 75 carries a stepped shaft 82 which is secured thereto, for example, by bolts 83. Two annular members 85 and 86 are rotatably mounted on shaft 82 by means of a ball bearing 84. The upper caplike member 86 is acted upon by one or more springs 87 which are supported by an adjustable nut 88 which is screwed upon the threaded end of shaft 82. The lower member 85 carries a ring 89 and partly within this ring, a roller 90 which is partly surrounded by a ring 91 which is mounted on cap 86. Ring 91 may move upwardly and downwardly in the direction indicated by arrow 92 in accordance with the thickness of the strip of material 51 to be shaped and under the pressure of springs 87 which may be adjusted by nut 88. Ball bearing 84 is prevented from sliding in the axial direc-

tion by a ring 93 and a spring ring 94. The chamber in which ball bearing 84 is mounted is sealed toward the outside by washers 95 and 95' or the like.

While roller 90 of the group of rollers which is disposed at the left side of strip 51 has a V-shaped groove 96, as shown in Fig. 16, the corresponding roller 90' of the group of rollers at the right side of strip 51, as shown in Fig. 17, is provided with a corresponding V-shaped tongue 97, similarly as illustrated in Fig. 11. The other parts of the roller mounting at the right side of strip 51, according to Fig. 17, correspond to those at the left side as shown in Fig. 16, except for the fact that the right group of rollers is not adjustable relative to the stationary frame 74, although such adjustability may also be provided for these rollers. While rollers 90 and 90' are intended to mold the V-shaped tongue and groove 52 and 53 into or upon the two edges of the strip during the feeding movement of the strip, to limit the width of the strip and if necessary to reduce the same slightly by an upsetting pressure upon the edges, and to guide the strip during its feeding movement, rings 89 and 91 at both sides of the strip serve to remove any scale which might adhere to the edge portions. For this purpose, rings 89 and 91 are preferably made of a suitable abrasive material.

If the rollers 90 and 90' and rings 89 and 91 according to Figs. 16 and 17 are also intended for guiding a plurality of superimposed strips, and for maintaining them in their proper position relative to each other during their passage toward the shaping tool, these rollers may be designed so that several rings and rollers 89, 90, 91 of suitable shapes will be arranged relative to each other in accordance with the desired relative position of the superimposed and staggered strips. If desired, the edges of one or more of such superimposed strips may also be provided with tongues and grooves as previously described. Insofar as this may be possible the various features of the different embodiments of the invention may also be combined with each other. Thus, for example, as already indicated, blunt edge portions which abut against each other may be secured to each other by a weld bead which is thicker than the weld bead previously applied for connecting two strips, sheets, or the like in order to be able to take up pressure which are higher than those admissible by the thickness of the material itself.

Although my invention has been illustrated and described with reference to the preferred embodiments thereof, I wish to have it understood that it is in no way limited to the details of such embodiments,

but is capable of numerous modifications within the scope of the appended claims.

WHAT I CLAIM IS:—

1. A method of producing tubular elements comprising the steps of continuously feeding a flat strip of material to the inner curved surface of a hollow shaping tool of substantially semicircular cross section from the open side thereof and at an angle thereto, helically coiling said strip solely by its moving engagement with said inner curved surface so that the curved edges of adjacent portions of said strip substantially engage each other, and welding said adjacent edges together from the inside of said coiled portions accessible from said open side of said shaping tool so as to form an internally closed helical seam of a tubular element.

2. A method as claimed in Claim 1 in which said helical seam is welded also on the outside.

3. A method as claimed in Claim 2 in which said strip is fed to said tool at an angle to its open side which is smaller than the angle which would be required for producing a roller having an outer peripheral surface engaging with the entire inner curved surface of said shaping tool.

4. A method as claimed in Claim 3 including the steps of guiding said strip during said feeding movement up to a point closely adjacent to said shaping tool, and adjusting the angular position of said shaping tool relative to the position of said feeding strip while the shaping operation progresses.

5. A method as claimed in Claim 4, further comprising the step of supporting the welded tubular element at a certain distance from said shaping tool, and adjusting the angular position of the supporting means and thereby also of the shaping tool relative to the position of said feeding strip while the shaping operation progresses.

6. A method as claimed in any of the preceding claims including the step of providing at least one of the lateral edges of said strip while it is being fed toward said shaping tool with means for guiding the adjacent edges of said strip into proper alignment with each other during the subsequent shaping operation for thereafter attaining a proper weld.

7. A method as claimed in any of the preceding claims, further comprising the step of shaping at least one of the lateral edges of said strip while it is being fed toward said shaping tool so as to enable it to guide the adjacent edge to be welded thereto during the subsequent shaping operation so that both edges will be in proper alignment with each other for the subsequent welding operation.

8. A method as claimed in any of the preceding claims, including the step of rolling the lateral edges of said strip while being

fed toward said shaping tool so as to form a groove in one edge and a substantially corresponding tongue along the other edge, said tongue and groove being adapted to engage with each other during the subsequent shaping operation to place said edges in proper alignment with each other for the subsequent welding operation.

9. A method as claimed in any of Claims 1 to 7, including the step of impressing and upsetting a substantially U-shaped groove with a pair of arms defining the same on one edge of said strip while said strip is being fed toward said shaping tool, said groove having a width substantially equal to the thickness of the material of said strip, said arms being adapted to guide the other edge into said groove during the subsequent shaping operation.

10. A method as claimed in any of Claims 1 to 7, including the step of upsetting any part on one edge of said strip which exceeds a certain width of said strip while said strip is being fed toward said shaping tool.

11. A method as claimed in Claim 6 in which a strip like member of generally I-shaped cross section is provided to serve as a guide for said adjacent edges.

12. A method as claimed in Claim 11 in which said strip like member has a rib like projection on at least one of the outer surfaces thereof.

13. A method as claimed in any of the preceding claims, including the steps of supporting the welded tubular element at a certain distance from said shaping tool, and cutting off sections of said tubular element while the shaping operation continues and said element thereby moves forwardly.

14. A method as claimed in any of the preceding claims, including the steps of gradually and continuously changing the angular position of said shaping tool relative to the position of said feeding strip while the shaping operation progresses so as to form a tubular element of a conical shape.

15. A method as claimed in any of Claims 1 to 5, including the steps of continuously feeding a plurality of superimposed strips of material to the inner curved surface of said hollow shaping tool, guiding said strips during said feeding movement up to a point closely adjacent to said shaping tool so that they will be uniformly offset relative to each other so that each strip projects at one edge laterally beyond the other strip, helically curving said strips solely by the moving engagement of one of said strips with said inner curved surface so that the projecting edge portion of one strip substantially engages with the corresponding recessed portion of an adjacent portion of said strip, welding said adjacent edge portions together from the inside of the curved portion accessible from said open side of said shaping tool so

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but is capable of numerous modifications within the scope of the appended claims.

WHAT I CLAIM IS:—

1. A method of producing tubular elements comprising the steps of continuously feeding a flat strip of material to the inner curved surface of a hollow shaping tool of substantially semicircular cross section from the open side thereof and at an angle thereto, helically coiling said strip solely by its moving engagement with said inner curved surface so that the curved edges of adjacent portions of said strip substantially engage each other, and welding said adjacent edges together from the inside of said coiled portions accessible from said open side of said shaping tool so as to form an internally closed helical seam of a tubular element.

2. A method as claimed in Claim 1 in which said helical seam is welded also on the outside.

3. A method as claimed in Claim 2 in which said strip is fed to said tool at an angle to its open side which is smaller than the angle which would be required for producing a roller having an outer peripheral surface engaging with the entire inner curved surface of said shaping tool.

4. A method as claimed in Claim 3 including the steps of guiding said strip during said feeding movement up to a point closely adjacent to said shaping tool, and adjusting the angular position of said shaping tool relative to the position of said feeding strip while the shaping operation progresses.

5. A method as claimed in Claim 4, further comprising the step of supporting the welded tubular element at a certain distance from said shaping tool, and adjusting the angular position of the supporting means and thereby also of the shaping tool relative to the position of said feeding strip while the shaping operation progresses.

6. A method as claimed in any of the preceding claims including the step of providing at least one of the lateral edges of said strip while it is being fed toward said shaping tool with means for guiding the adjacent edges of said strip into proper alignment with each other during the subsequent shaping operation for thereafter attaining a proper weld.

7. A method as claimed in any of the preceding claims, further comprising the step of shaping at least one of the lateral edges of said strip while it is being fed toward said shaping tool so as to enable it to guide the adjacent edge to be welded thereto during the subsequent shaping operation so that both edges will be in proper alignment with each other for the subsequent welding operation.

8. A method as claimed in any of the preceding claims, including the step of rolling the lateral edges of said strip while being

fed toward said shaping tool so as to form a groove in one edge and a substantially corresponding tongue along the other edge, said tongue and groove being adapted to engage with each other during the subsequent shaping operation to place said edges in proper alignment with each other for the subsequent welding operation.

9. A method as claimed in any of Claims 1 to 7, including the step of impressing and upsetting a substantially U-shaped groove with a pair of arms defining the same on one edge of said strip while said strip is being fed toward said shaping tool, said groove having a width substantially equal to the thickness of the material of said strip, said arms being adapted to guide the other edge into said groove during the subsequent shaping operation.

10. A method as claimed in any of Claims 1 to 7, including the step of upsetting any part on one edge of said strip which exceeds a certain width of said strip while said strip is being fed toward said shaping tool.

11. A method as claimed in Claim 6 in which a strip like member of generally I-shaped cross section is provided to serve as a guide for said adjacent edges.

12. A method as claimed in Claim 11 in which said strip like member has a rib like projection on at least one of the outer surfaces thereof.

13. A method as claimed in any of the preceding claims, including the steps of supporting the welded tubular element at a certain distance from said shaping tool, and cutting off sections of said tubular element while the shaping operation continues and said element thereby moves forwardly.

14. A method as claimed in any of the preceding claims, including the steps of gradually and continuously changing the angular position of said shaping tool relative to the position of said feeding strip while the shaping operation progresses so as to form a tubular element of a conical shape.

15. A method as claimed in any of Claims 1 to 5, including the steps of continuously feeding a plurality of superimposed strips of material to the inner curved surface of said hollow shaping tool, guiding said strips during said feeding movement up to a point closely adjacent to said shaping tool so that they will be uniformly offset relative to each other so that each strip projects at one edge laterally beyond the other strip, helically curving said strips solely by the moving engagement of one of said strips with said inner curved surface so that the projecting edge portion of one strip substantially engages with the corresponding recessed portion of an adjacent portion of said strip, welding said adjacent edge portions together from the inside of the curved portion accessible from said open side of said shaping tool so



as to form an internally closed helical seam of a tubular element, and subsequently welding said seam also at the outside.

16. A method as claimed in Claim 15, further comprising the step of preheating at least one of said strips before it is inserted into said shaping tool.

17. A method as claimed in Claim 15 or 16, further comprising the step of preheating said superimposed strips to different temperatures before they are inserted into said shaping tool.

18. A method as claimed in any of Claims 15 to 17, in which said superimposed strips are guided relative to each other toward said shaping tool so that the edges of two strips which are separated by a third strip are disposed within the same plane extending vertical to the plane of said strips and are laterally offset relative to said third strip.

19. A method as claimed in any of the preceding claims, in which the internal weld is made so as to project toward the inside of said tubular element.

20. A method as claimed in any of Claims 2 to 19 in which both the internal and outside welds are made so as to form a riblike projection on said tubular element.

21. A method as claimed in Claim 20, in which said outside weld is made of a greater height than said internal weld.

22. A method as claimed in any of the preceding claims, in which said weld has a thickness and strength greater than that of the material of said strip.

23. An apparatus for producing tubular elements comprising a shaping tool consisting of an elongated hollow member having an inner curved surface of substantially semi-circular cross section, means for feeding at least one flat strip of material toward and into said shaping tool from the open side thereof and at an angle to the axis thereof so as to engage with at least a part of said curved inner surface and, by its own movement along said surface, coil into a helical tubular element, and means for welding the edges of adjacent coil portions to each other from the inside of said tubular element accessible from the open side of said shaping tool so as to form an internally closed helical seam on said tubular element.

24. An apparatus as defined in Claim 23, further comprising means for guiding said strip at all sides during said feeding movement and up to a point closely adjacent to said shaping tool.

25. An apparatus as claimed in Claim 23 or 24, further comprising means for also welding said helical seam at the outside.

26. An apparatus as claimed in any of Claims 23 to 25, wherein said feeding means are disposed so as to feed said strip into said shaping tool at an angle smaller than the angle which would be required to produce

a roller having an outer peripheral surface in full engagement with the entire inner surface of said shaping tool.

27. An apparatus as claimed in any of Claims 23 to 26, further comprising means for adjusting the position of said shaping tool so as to vary the angle between said shaping tool and said feeding means.

28. An apparatus as claimed in any of Claims 23 to 27, further comprising means for adjusting the position of said shaping tool while the shaping operation continues so as to vary the angle between said shaping tool and said feeding means.

29. An apparatus as claimed in any of Claims 23 to 28, further comprising means spaced from said shaping tool for supporting the finished tubular element during its continued movement while the shaping operation progresses.

30. An apparatus as claimed in Claim 29, including means for adjusting the position of said supporting means relative to the position of said shaping tool so as slightly to bend the finished part of said tubular element relative to the unwelded part within said shaping tool.

31. An apparatus as claimed in Claim 30, in which said adjustably mounted supporting means serve, through the intermediary of said tubular element connecting said shaping tool with said supporting means, also for the adjustment of the position of said shaping tool relative to said feeding means.

32. An apparatus as claimed in any of Claims 23 to 31, including means for cutting off sections of said finished tubular element, and means for transmitting the continuous forward movement of said tubular member to said cutting means so that the latter may cut off said sections while said forward movement continues.

33. An apparatus as claimed in Claim 31, including a support mounted on said supporting means and extending along said finished tubular member and spaced from said shaping tool, a carriage movable along said support, cutting means mounted on said carriage, means for moving said cutting means in a direction transverse to the direction of movement of said finished tubular member, and means adapted to be placed at any desired point into engagement with said tubular member for transmitting the continuous forward movement of said member to said carriage to permit said cutting means to sever said tubular member into sections while said forward movement continues.

34. An apparatus as claimed in Claim 33, wherein said transmitting means comprise at least one friction roller mounted on said carriage and adapted to engage upon said tubular member.

35. An apparatus as claimed in Claim 31, including a turntable, said shaping tool



being mounted on said turntable, and a stationary base, a second turntable mounted on said base for sliding movement along the same, said supporting means being mounted on said second turntable.

36. An apparatus as claimed in Claim 24, wherein said guiding means comprise a plurality of rollers arranged in pairs opposite to each other at both side edges of said strip and each being rotatable about an axis extending vertically to the plane of said strip, said rollers at least of the pair disposed most closely adjacent to said shaping tool being spaced from each other at a distance corresponding to the smallest admissible width of said strip.

37. An apparatus as claimed in Claim 36, wherein said guiding means further comprise a pair of rings associated with each of said rollers, rotatable about the axis of the respective roller, and adapted to guide the upper and lower edge portions of said strip.

38. An apparatus as claimed in Claim 37, further comprising resilient means acting upon one of said rings to press the same upon said strip, and means for adjusting the strength of said spring.

39. An apparatus as claimed in Claim 38, wherein said rings substantially consist of an abrasive material.

40. An apparatus as claimed in any of Claims 36 to 39, including means for adjusting the rollers at one side of said strip relative to those at the other side.

41. An apparatus as claimed in any of Claims 36 to 40, in which at least one of said rollers at one side of said strip is

adapted to upset said edge to a width greater than the thickness of said strip and to impress a substantially U-shaped groove into said upset edge, said groove having a width substantially equal to the thickness of said strip, said groove and the narrow webs defining the same being adapted to serve as means for guiding the two adjacent curved edges relative to each other during the shaping operation so as to be in proper alignment for being welded to each other.

42. An apparatus as claimed in any of Claims 36 to 40, in which at least one pair of said rollers at opposite sides of said strip are shaped so as to roll a groove into one edge and a substantially corresponding tongue upon the other edge, said tongue and groove being adapted to serve as means for guiding the curved edges relative to each other during the shaping operation so as to be in proper alignment for being welded to each other.

43. An apparatus as claimed in Claim 42, wherein said tongue and groove are of substantially V-shaped cross section.

44. Methods of producing tubular elements substantially as described with reference to the accompanying drawings.

45. Apparatus for producing tubular elements substantially as described with reference to the accompanying drawings.

For the Applicant,
FRANK B. DEHN & CO.,
Chartered Patent Agents,
Kingsway House,
103, Kingsway,
London, W.C.2.

T.E.



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