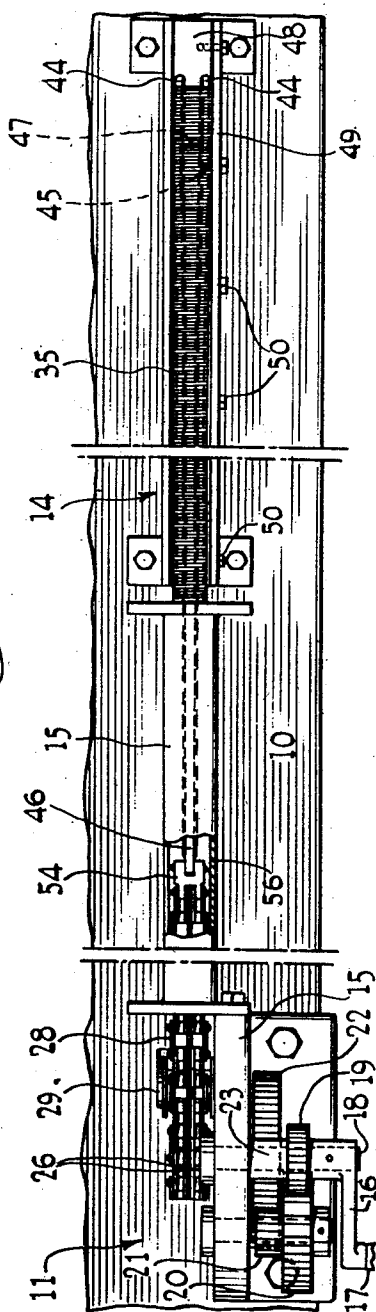


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2,452,125



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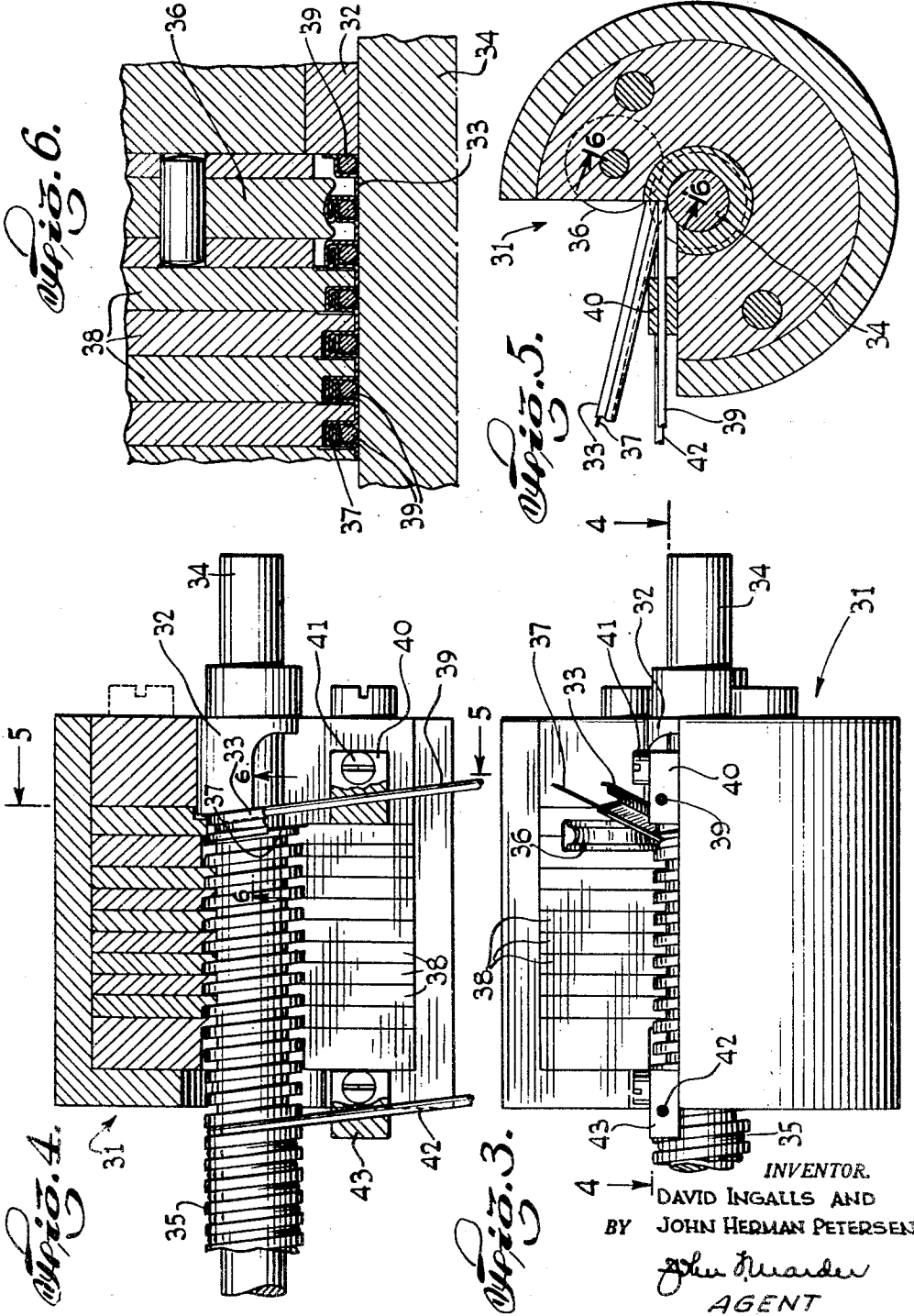
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D. INGALLS ET AL
METHOD OF FORMING AND CHANGING THE CROSS
SECTION OF CONVOLUTED METAL TUBING

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Filed June 12, 1945

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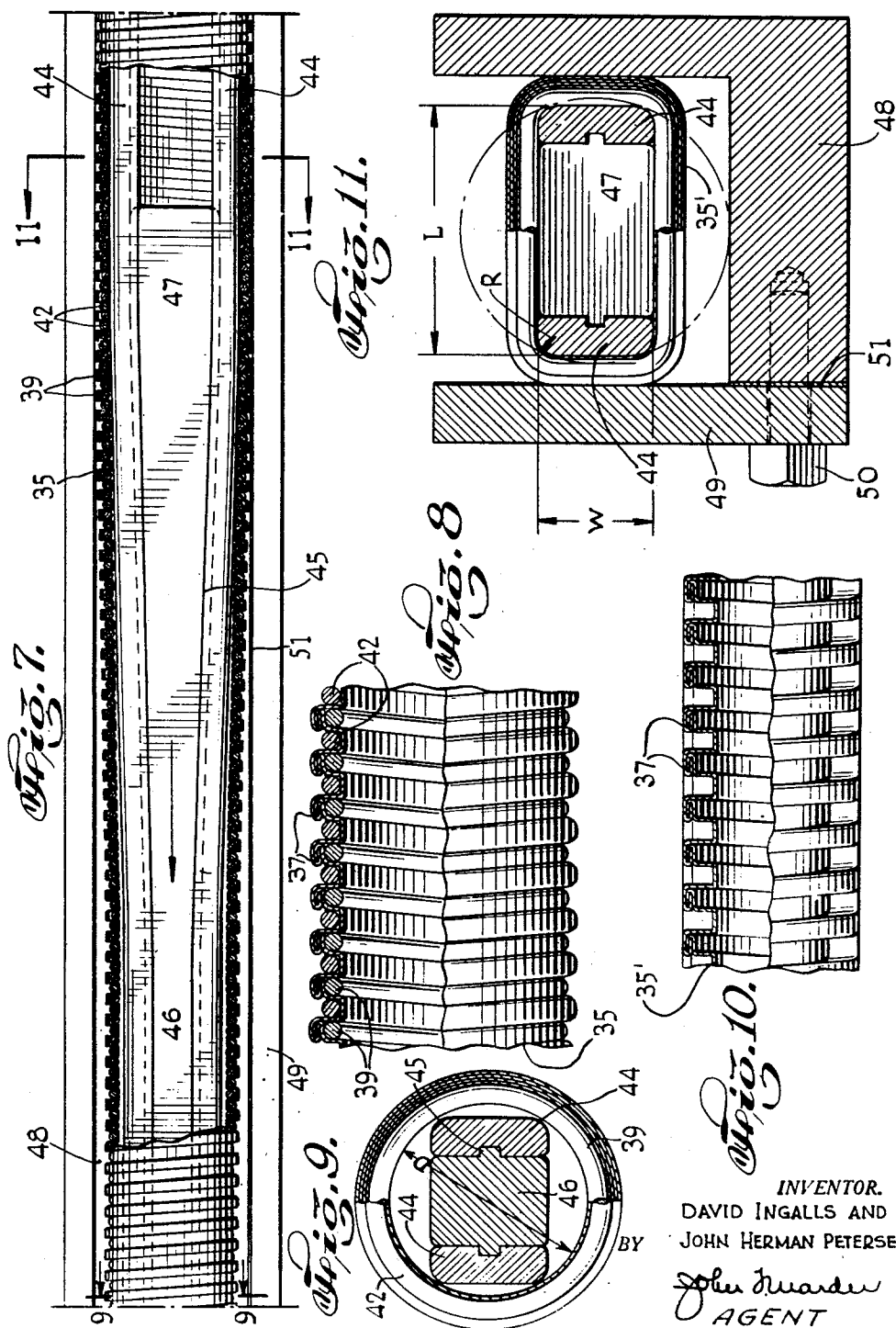
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METHOD OF FORMING AND CHANGING THE CROSS
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4 Sheets-Sheet 3



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METHOD OF FORMING AND CHANGING THE CROSS
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Fig. 12.

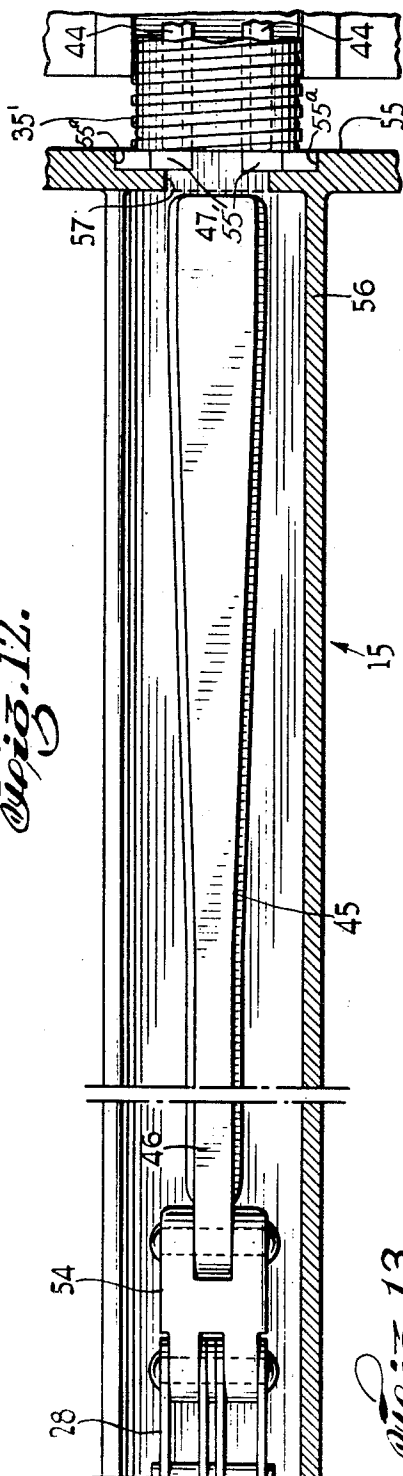


Fig. 14.

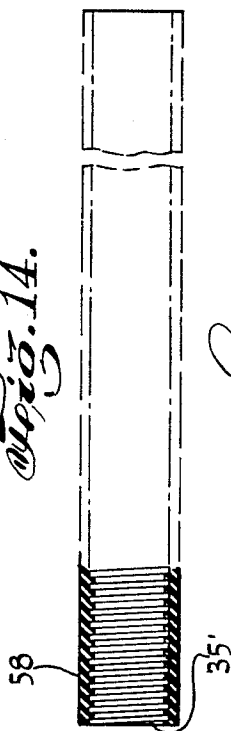


Fig. 15.

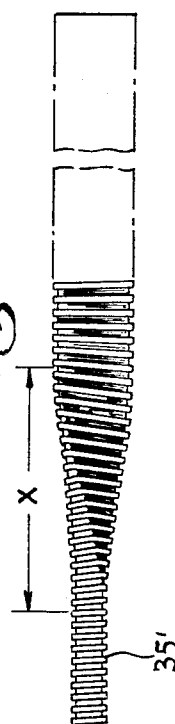
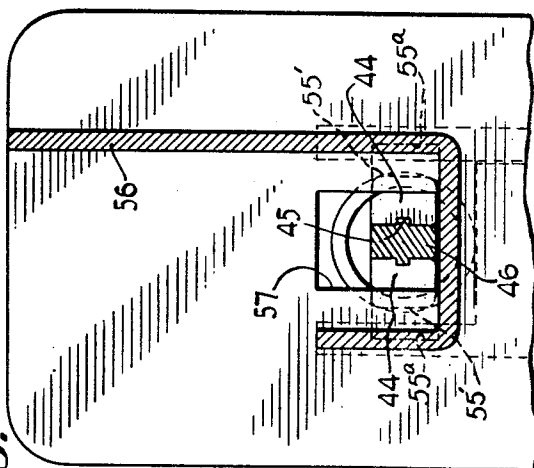


Fig. 13.



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2,452,125

METHOD OF FORMING AND CHANGING THE CROSS SECTION OF CONVOLUTED METAL TUBING

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Application June 12, 1945, Serial No. 599,088

12 Claims. (Cl. 153—2)

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This invention relates to flexible metallic tubing and particularly to the type of tubing which has walls of corrugated longitudinal sectional configuration as that shown in U. S. Patent No. 1,198,392 to L. H. Brinkman. In particular, the invention relates to a means for and a method of forming tubing of this description in transverse shapes other than circular such as rectangular, hexagonal, or elliptical.

In the interest of utilizing conventional dies and methods for making circular convoluted tubing when making rectangular tubes or other tube shapes, it is desirable in some instances to proceed first to make a circular tube and to re-form this shape. While the usual metal pipes and tubes, within limits of size and ductility of material, may be formed from circular transverse section to other transverse sections by cold drawing a tool of a desired shape through the interior of the tube bearing directly against the tube wall, whereby the metal flows to the shape of the tool, in the case of a flexible tube having a corrugated wall, however, this procedure can not be followed because a forming tool drawn through the inside would tend to collapse relatively fragile corrugated sides and to destroy the flexibility of the tube.

It is a primary object of this invention to provide a method of cold working a convoluted tube to change the cross sectional configuration from circular to another desired shape without destroying the tube convolution form. A further purpose of the invention is to provide equipment for forming a corrugated or convoluted tube of a desired shape from a circular tube with a minimum of mechanical effort. Another object of the invention is to provide a convoluted flexible metallic tube which will sustain interior and exterior forming operations thereto without destroying the convolution. A still further object of the invention is to provide a tube forming device for relatively fragile tubing which does not create deleterious stresses on the tube during forming.

The objects of the invention are attained in part by the use of a circular convoluted tube having a removable deformable material wound in a particular manner on the interior of the tube for the purpose of filling and supporting the tube convolutions during forming operations. A corresponding material may be wrapped around the outside of the tube to substantially fill and further support the convolutions of the tube to prevent stresses which would otherwise result during forming operations.

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The invention consists in the new and improved methods, construction, and devices to be hereinafter described and claimed for carrying out the above stated objects and such other intentional objects as will be adverted to in the following description of the preferred embodiment of the invention shown in the accompanying drawings.

In the drawings:

Figure 1 is a side elevation view of the equipment used to form a rectangular tube employing this invention, partly broken away and sectioned for clarity;

Figure 2 is a top plan view of the equipment of Figure 1;

Figure 3 is a side elevation view of a die used to form a helically convoluted tube employed with this invention;

Figure 4 is a section view of the die taken along the lines 4—4 of Figure 3;

Figure 5 is a section view taken along the lines 5—5 of Figure 4;

Figure 6 is an enlarged section view of a fragmentary portion of the die of Figures 3, 4, and 5 taken along the lines 6—6 of Figure 5;

Figure 7 is a top plan view partly in section of a length of tubing being formed from circular to rectangular section;

Figure 8 is an enlarged view half in section and half in elevation of a length of circular tubing constructed in accordance with this invention;

Figure 9 is a section view taken along the lines 9—9 of Figure 7;

Figure 10 is an enlarged view half in section and half in elevation of a length of formed rectangular tubing made according to this invention;

Figure 11 is a view taken along the lines 11—11 of Figure 7;

Figure 12 is a fragment of the top plan view of Figure 2 with the forming devices shown in the position which they would occupy directly after the formation of a length of rectangular tubing;

Figure 13 is a cross section view taken on the lines 13—13 of Figure 1;

Figure 14 is a longitudinal elevation view of a length of rectangular tubing produced with the equipment of this invention and having a special molded covering; and

Figure 15 is an elevation view of a length of tubing having a particular configuration produced subsequent to rectangular forming.

Referring now to the drawings, in Figures 1 and 2 a base or bench 10 supports the various structures employed with this invention and including a gear reduction unit 11 cooperating with a chain pull device to be later described used to

re-form a circular tube to another shape. This forming mechanism is constructed generally of conventional parts associated and arranged for the purpose of cold working a circular tube with certain improvements to adapt the equipment to tubing having convoluted wall section. The gear unit 11 is secured in place on the bench 10 with suitable fastening devices. Projecting horizontally from the frame 15 of the gear unit and rigidly attached thereto is an auxiliary frame 18 which is used as a guide and an abutment for the special tools employed with the work supporting and forming devices generally grouped at 14.

In the gear unit 11 a crank arm 16 having an operating handle 17 is fixed to shaft 18 journaled in frame 15 and is used to actuate the chain drive through the train of gears 19, 20, 21, and 22 to the chain sprocket 26, all suitably mounted on frame 15. Depending upon the ratio of diameters of the gearing in the train and the leverage of the crank arm 16, a considerable mechanical advantage is possible at the end of the gear train to increase the power applied manually on the handle of crank 16 and to transmit the power to the chain sprocket 26. A mechanical advantage of 40-1 has been employed in practice with satisfactory results in a device of this kind resulting in approximately 2000 pounds pull on the link chain 28 with a 50 pound pressure exerted on the handle. The link chain is, in turn, fastened to a wedge or draw bar 45 which is pulled through the tubing 35 as will be hereinafter described. In order to provide for a substantial wrap on the chain 28 around the sprocket and to permit the chain to drop vertically as the wedge is drawn through the tube, an idler sprocket 29 is rotatably mounted on side frame 15 over which idler the chain is trained.

Referring now to Figures 3 and 4, the preferred type of tubing employed with this invention is of flexible corrugated metallic construction being fabricated from a narrow thin strip which has been pre-formed by the use of rollers or other suitable devices, and is subsequently helically wound about a driven arbor with adjacent edges interlocked as they are wound. It is customary to use relatively ductile metal for tubing of this description inasmuch as a certain amount of stretching is required in the wrapping and seam locking procedures.

A die generally indicated at 31 of multiple piece construction similar to that described in the U. S. patent to Stone, No. 1,905,762, is employed in the formation of the circular section tubing. A back section piece 32 guides the pre-formed strip 33 into the die at the correct helix angle so that one edge will become associated with the opposite edge of the first adjacent turn of the strip wound on the driven arbor 34. Satisfactory arrangements for the assembly and support of the die 31 and the power drive to the arbor 34 may be made as in the aforesaid patent to Stone. As the strip reaches the die it is engaged by the die roller 36 suitably mounted for rotation in the die which serves to interfold the hook shaped edge of the incoming strip with the upstanding edge of the portion of the strip which has been previously wound around the arbor, thereby forming a seam on the outside of the convolution as shown in the section view in Figure 6. Concurrently with the feeding-in of a strip of pre-formed metal, a thread or wire 37 of fluxed solder is fed therewith in a manner by which it will become wrapped inside of the interlocked seam so that upon subsequent heating the solder will fuse and the interlocked

joint will be completely sealed. During the formation of the tube it is continuously stripped from the arbor 34 by the die sections 38.

No attempt has been made herein to describe in complete detail the convoluted tube formation since description of these operations and the equipment used therewith may be found in patents referred to elsewhere in this specification. It is intended to indicate principally the functions, operations, and features having a bearing on the specialized application of this invention wherein differences are evident from conventional corrugated spirally wound tube making practice.

At the same time that the pre-formed strip 33 is being fed to the die and at the same rate of feed as is used with the strip, a continuous deformable wire or rod 39 is also fed to the die from a suitable supply to become associated with the finished tube on the inner side of the convolutions thereof. A copper wire of circular cross section is preferable for this purpose although any suitable type or shape of material may be employed which is deformable and removable, and which will support the convolutions during operations to be described. In cases where the length and width of the inner tube convolution are not equal, it may be desirable to employ deformable wire having a rectangular cross section.

As shown particularly in Figures 4 and 6, this wire enters the die between the back die section 32 and the edge of a formed strip, the diameter of the wire being approximately equal to the length and the width of the convolution form. The wire is guided during its entrance into the die by a block 40 which is rigidly fixed to the die by the screw 41 and is carried into the die by "wrap" around the mandrel or arbor 34. The back section 32 guides the wire 39 around the arbor in much the same manner as the strip 33 is guided at the correct helix angle for the tube to be formed and, after the first revolution on the arbor 34, the wire comes directly under the forming roller 36 at the point of interlocking of the outside seam on the tube. Inasmuch as the wire extends diametrically from the surface of the arbor 34 to the under side of the top of the convolution form, it will serve to support the convolution as the interlocked seam is rolled under the influence of roller 36 and also since the wire is of ductile material it will take the circular form of the arbor and will substantially fill the inside convolution during tube formation. A second wire 42 may also be employed to substantially fill the outside convolution as shown in Figure 4 by wrapping it over the tube guided by block 43 at the exit of the tube from the die 31.

Referring now to the finished tube as it comes from the die and before re-forming, Figure 8 shows a fragmentary length of this tube 35 having a wire 39 wound in its inner convolutions and a wire 42 included within the outside convolutions. This tube is ready for further operations of tube forming as will be described. Inasmuch as the wire 39 is included in the inner convolutions, any forming operations performed employing various pressure exerting tools used against the inside tube wall will react with the reinforced convoluted tube in much the same manner as if the tube were of solid wall section. Since forming tools to be applied against the inner tube wall may be placed directly against the wire, there will be a tendency to resist stresses which would otherwise be directed entirely against the fragile convolutions. Reinforcement is further enhanced by the winding of wire within the outer convolu-

tion which will help to distribute inside forming stress although this outside wire will have no direct contact with inside forming devices. After re-forming the tube from the inside as will be described, the supporting wires may be stripped from the tube so that the convolutions will be open to permit flexing and give bending in the side walls as is customary with flexible tubing of this description.

Referring now to Figure 7 which shows an enlarged view of some of the tube forming devices, a pair of grooved rectangular metal forming bars 44 used in operations performed on the circular convoluted tube 35 and a wedge 45 having tongues mating with the forming bar grooves is drawn therebetween tending to spread the tube and to change its sectional configuration. The purpose of the forming bars 44 is to prevent longitudinal stress on the inside surface of the tube and to avoid sliding frictional contact which would be experienced when using a wedge drawn through the tube and contacting the tube walls. As will be noted at the left hand side of this view and also in Figure 9, where the convoluted tube is of circular cross section, the inside area of the circular tube accommodates forming bars 44 together with the shank 46 of wedge 45. On the right hand side of Figure 7 and in the center of Figure 11 the enlarged end 47 of wedge 45 has been drawn through the tube 35 and has reformed the cross section shape from circular to rectangular by bending the material of the tube.

In order that a rectangle of a given size may be formed in such an operation, it is necessary to use a tube having a circular shape with approximately the same inside circumference as the inside perimeter of the desired rectangle. In other words, to create a rectangular section having inside dimensions L and W, Figure 11, it would be necessary to employ a circular section tube of inside diameter D, Figure 9, where $\pi D = 2(L + W)$. Certain correction is necessary to allow for the corner radius R where a radius at the corner is necessary or desirable. In some cases, it has been found advantageous to employ a circular section tube slightly smaller than the theoretical equivalent in a rectangular tube to produce a certain amount of stretch during re-forming and to thereby give uniformly flat sides to the rectangular tube.

When the distance between corner bends of the rectangular shape is relatively short as in the case of the W dimension of Figure 11 and where the tubing is not of a material which is readily deformable, it has been found desirable to use exterior guides in the forming operations, such as the channel section in the drawings, comprising an L-shaped member 48, Figure 11, and a detachable side 49 held together by cap screw 50. Side piece 49 is detachable in order to permit the removal of a rectangular tube from the channel after the forming operation during which it may become wedged therein. Lateral adjustment of the side piece 49 may be made if desired for different rectangular tubing sizes by inserting shims 51 between the lower leg of the L member 48 and the side piece 49. In cases where the tubing employed in re-forming has good working qualities it may be possible to omit the channel sides relying on the base support only with no exterior forming means.

Referring again to Figures 1 and 2, the work supporting channel is mounted on the bench or base 10 by means of support brackets 52 secured to the bench through spacers 53 provided for ver-

tical adjustment. Alignment is necessary so that the center line of the circular tube to be reformed is substantially tangent to the pitch circle of the sprocket 26 of the gear reduction unit 11. This positioning is maintained by one size of a series of spacing blocks 53 used for various tube diameters. Position of the channel is also maintained transversely of the machine so that the channel support and sprocket are in alignment. A direct pull results when drawing the wedge 45 between the forming bars 44 by means of the gear unit which is interconnected with the wedge by means of a bifurcated link 54 on chain 28.

Sufficient distance is provided between the sprocket 26 in gear unit 11 and the end of tube 35 so that the wedge 45 with its shank 46 and enlarged portion 47 may be completely drawn through the tube as shown in Figure 12 before the end of the wedge shank 46 reaches the chain sprocket. The face 55 of abutment frame 15' serves to hold the forming bars 44 against being moved toward the gear unit by the friction force exerted by the wedge during tube forming operations, and yet the aperture 57 of frame 15' is sufficiently large to permit the enlarged portion 47 of wedge 45 to pass therethrough and to completely traverse the tube 35'. Lugs 55' at the ends of the forming bars 44 make the end faces of the forming bars wide enough to bear against the face 55 on opposite sides of the aperture 57. The portions of the face 55 with which the ends of the bars 44 come in contact are recessed to prevent the lugs 55' from distorting the sides of the tube. These recesses in the face 55 are designated by the reference characters 55a. Figure 13 additionally shows this aperture 57 in the frame 15' and also shows the J section 56 extending between the abutment face 55 and the flange by which auxiliary frame 15' is fastened to frame 15. This J section serves as a guide for the chain and the wedge between the gear unit and the work support 14.

Figure 8 shows the corrugated tube 35 with wires 39 and 42 substantially filling the inside and outside corrugations before re-forming and Figure 10 shows the tube 35' after re-forming, with the supporting wires stripped therefrom, the solder thread 37 in the locked seam not being fused. While the solder remains unfused it is possible to twist the tube on itself, whereupon there will be relative displacement in the seams and in the case of a rectangular tube, as in Figure 15, the axes of the rectangular section may be rotated so that the long dimension at one end may take any desired angular relationship with the long dimension at the other end. The tube would, after twisting, be heated to the proper temperature for a period of time to fuse the solder in the seam and create a stable and pressure-tight rectangular tube with a pre-determined angular relationship of the cross section axes. In general, however, angularity of this sort is not required in the use of rectangular tubing and solder fusing may take place continuously during tube formation, as with the use of a gas burner suitably located adjacent the exit of the formed circular tube from the die 31, Figure 4.

It may be desirable after formation of the rectangular tube to mold a layer of rubber or other plastic material on the outside of the tube in order to resist abrasion or to increase the life of the rectangular tube in flexing. Figure 14 shows such an article, the molded covering 58 having been added subsequent to rectangular tube forming but before removing the inside wire 39. The out-

side wire 42 may or may not be removed depending upon the desired qualities of the finished assembly. The purpose of retaining the wire in the inner corrugations of rectangular tube during molding operations is to give added strength to the tube during the molding pressure and to prevent any bending of the side walls of the tube, yet this wire may be later removed to give the light weight and flexibility of the tubing alone.

In producing rectangular tubing with this invention, lengths of circular section convoluted metal tube 35' are prepared having wire wound on the inside and outside according to the above description. To avoid unravelling, these wires may preferably be soldered to the tube on the inside and outside after the tubing has been cut to a desired length. A pair of forming bars 44 of suitable size are inserted within the circular tube and the tube is placed on the work supporting channel as shown in Figure 1 with the rectangular forming bars in abutting relationship with the frame 15'. The link chain 28 is so arranged as to be resting in the J section of the frame with a free end in the proximity of the tube to be formed.

Thereafter, wedge 45 may be inserted through the tube so that its shank fits between the forming bars 44 and so that the wedge end projects outside of the end away from the gear unit. A pin connection is made between the wedge shank and chain 28 and a lubricant applied to surfaces having frictional contact. As the crank handle is rotated counterclockwise the wedge is drawn between the forming bars to re-form the tube from circular to rectangular cross section.

Continued rotation of the crank carries the wedge completely through the tube until it rests entirely on the J section of frame 15' where it may be removed for a repeated tube forming operation. Inasmuch as the forming bars 44 are confined during tube re-forming by the tube walls, it is necessary that a certain amount of bending of these bars take place as the wedge is drawn therethrough. This bending is provided for by making the bars relatively thin. Tube re-formation takes place progressively over a relatively short length of tubing and therefore the force required is not excessive. Figure 1 shows the approximate shape of the tube, part of which is circular section and part of which has been re-formed to rectangular, and intermediate between the two there is a length of tube which is partially re-formed. With the wire support in the convolutions it is not possible for the tube convolutions to be distorted during this cold working, and the finished rectangular tube will have approximately the same form of convolution as has the circular tube.

While the invention has been illustrated with manually operated devices using a particular style of tubing and re-forming the tubing to a rectangular cross-sectional configuration, it will be understood that various types of power supply mechanisms such as hydraulic and electric motor driven may be substituted for manual operation, and that other types of tubing will be applicable to the procedure and equipment described. It will also be understood that other shapes than rectangular may be produced such as hexagonal and elliptical, without departing from the spirit of the invention or from the scope of the claims. Having thus described our invention, what we claim is:

1. In the art of re-forming flexible corrugated metal tube that has a helically corrugated wall, the improvement which consists in filling with a

deformable pressure resisting material those corrugations that open toward the inside of the tube, changing the cross section shape of the tube by pressure applied internally thereof, and removing the corrugation filling material while said material is in a solid state.

2. In the art of re-forming flexible corrugated metal tube that has a helically corrugated wall the improvement which consists in filling with a continuous length of deformable pressure resisting material those corrugations that open toward the inside of the tube, changing the cross section shape of the tube by pressure applied internally thereof, and then removing the continuous length of pressure resisting material from the internal corrugations while said material is in a solid state.

3. In the art of re-forming flexible helically wound metal tube that has a corrugated wall, the improvement which consists in filling with a deformable pressure resisting material those corrugations that open toward the inside of the tube, filling the other corrugations with a deformable material outside of the tubing, changing the cross section shape of the tube by pressure applied internally thereof, and then removing the deformable material from both the internal and external tube corrugations while said material is in a solid state.

4. In the art of re-forming flexible helically wound metal tube the improvement which consists in filling the internal corrugation with a continuous length of metal wire, changing the cross section shape of the tube by pressure applied internally thereof, and removing the wire from the internal tube corrugation.

5. In the art of reforming flexible helically wound metal tube the improvement which comprises filling the internal corrugation with a continuous length of a metal wire, filling the outer corrugation with a deformable material, changing the cross section shape of the tube by pressure applied internally thereof while both the inner and outer corrugations of the tube are filled, and after reforming the tube, removing the wire from the internal tube corrugation and also removing the material from the outer tube corrugation.

6. The improvement in the art of making flexible metal tubing that has a corrugated wall, which improvement consists in forming a metal tube of circular cross section and with a helical corrugation, substantially filling with a deformable pressure resisting material those corrugation convolutions that open toward the inside of the tube, re-forming the cross section shape of the tube by applying pressure internally thereof and removing the corrugation filling material while said material is in a solid state.

7. The improvement in the art of making flexible metal tubing that has a corrugated wall, which improvement consists in forming a corrugated metal tube of circular cross section with a helical seam, substantially filling with a continuous length of deformable metal wire those corrugations that open toward the inside of the tube, wrapping a continuous length of deformable metal wire in the external tube corrugation, re-forming the cross section shape of the tube by applying pressure internally thereof and removing the wires from the corrugations after the reforming operation.

8. In the art of making rectangular convoluted metal tubing, the improvement which consists in forming a circular section helically wound convoluted tube having a continuous length of de-

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formable metal wire substantially filling the internal helical corrugation, re-forming the cross section shape of the tube by applying pressure internally thereof, and removing the wire from the internal helical corrugation after reforming.

9. In the art of making rectangular convoluted metal tubing the improvement which consists in forming a circular section helically wound convoluted tube having a continuous length of deformable wire substantially filling the helical internal corrugation and having a continuous length of deformable metal wire included in the helical external corrugation, re-forming the cross section shape of the tube by applying pressure internally thereof and removing the wire from the internal helical corrugation after reforming.

10. In the art of making rectangular convoluted metal tubing, the improvement which consists in forming a circular section helically wound convoluted tube having a continuous length of deformable metal wire substantially filling the internal helical corrugation, re-forming the cross section shape of the tube by applying pressure internally thereof while resisting the internally applied pressure by external pressure resisting members and removing the wire from the internal helical corrugation after reforming.

11. The method of making flexible tubing having a corrugated wall, which method comprises winding a longitudinally corrugated metal strip into a helix to form a tube of circular cross section, joining contiguous edges of the strip along the helical seam of the tube, feeding a continuous length of metal wire into the tube as the strip is formed into a helix and in such relation to the strip that the metal wire is located in the corrugations that open toward the inside of the tube, reforming the tube to a different shape of cross section by applying pressure internally thereof, and removing the wire from the internal corrugations after reforming.

12. The method of making flexible tubing having a corrugated wall, which method comprises winding a longitudinally corrugated metal strip into a helix to form a tube of circular cross section, joining contiguous edges of the strip along the

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helical seam of the tube, feeding a continuous length of metal wire into the tube as the strip is formed into a helix and in such relation to the strip that the metal wire is located in the corrugations that open toward the inside of the tube, laying wire in the corrugations that open toward the outside of the tube, and with the wires in both the inner and outer corrugations, reforming the tube to a different shape by applying mechanical pressure to the inside wire and to the portions of the tube wall under the outside wire to bend the tube to a different shape of cross section, and then removing both the inside and outside wires after the tube has been reformed.

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