April 21, 1953 D. W. FENTRESS 2,635,330

METHOD OF MAKING TUBING STRUCTURES

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Fig. 1.

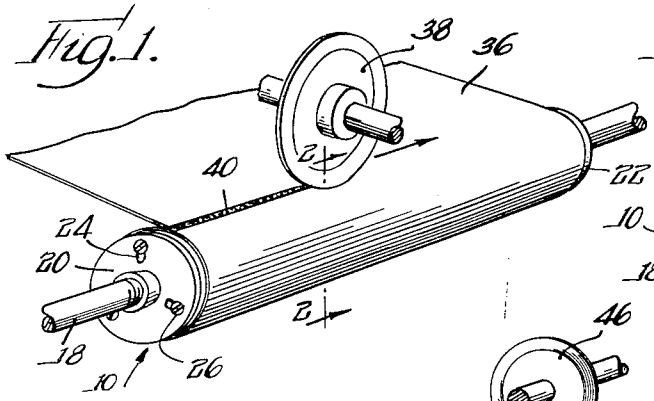


Fig. 2.

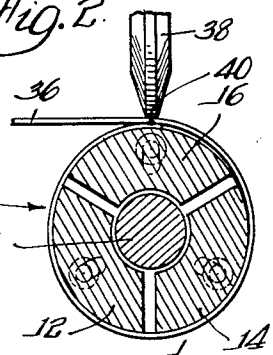


Fig. 3.

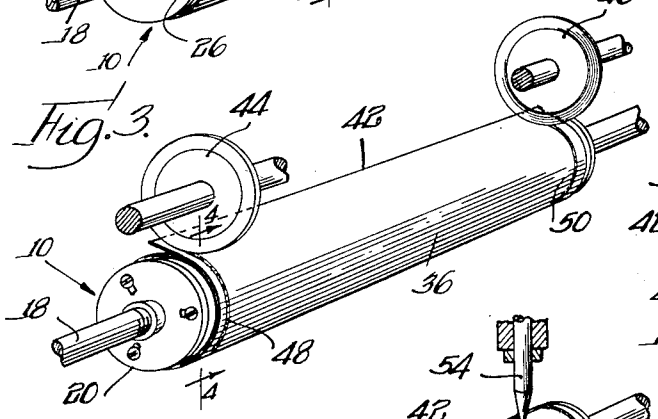


Fig. 4

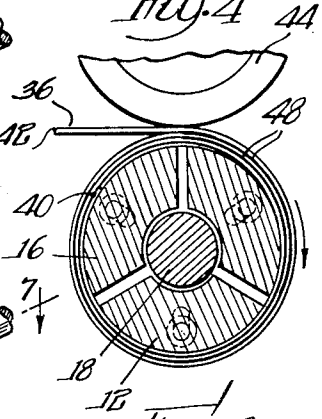


Fig. 5.

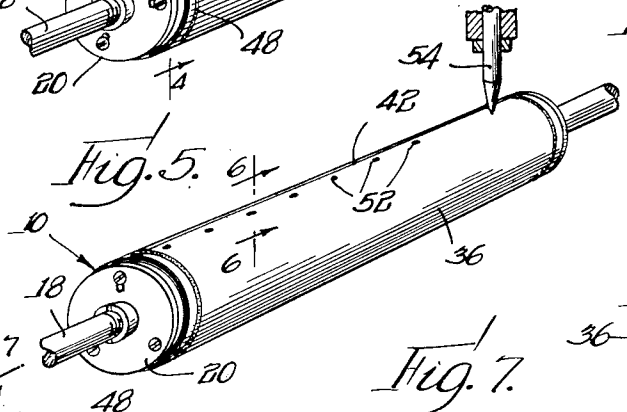


Fig. 6.

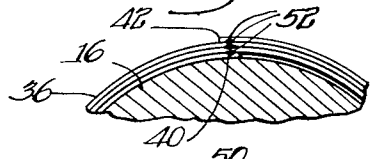
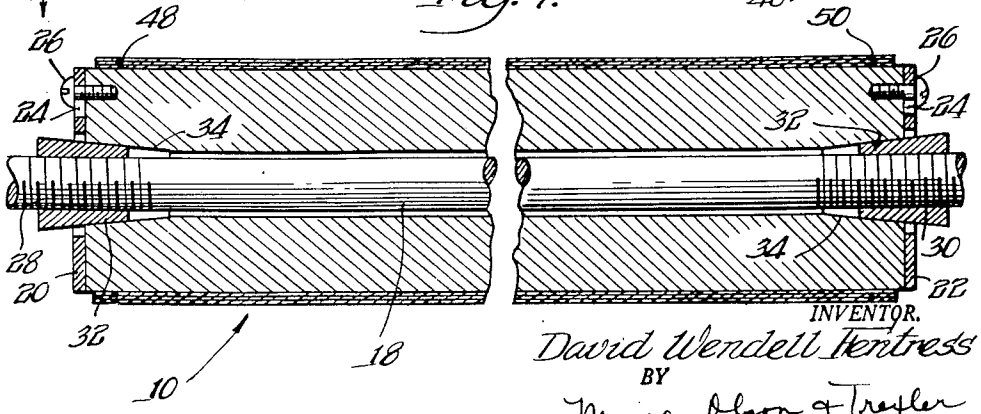


Fig. 7.



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Fig. 8.

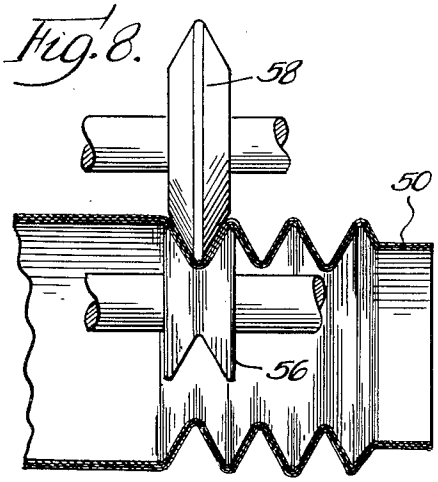


Fig. 9.

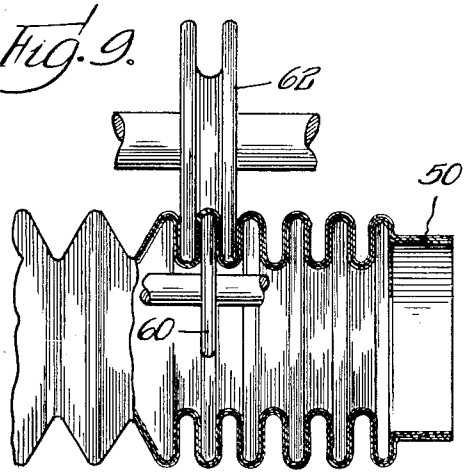


Fig. 10.

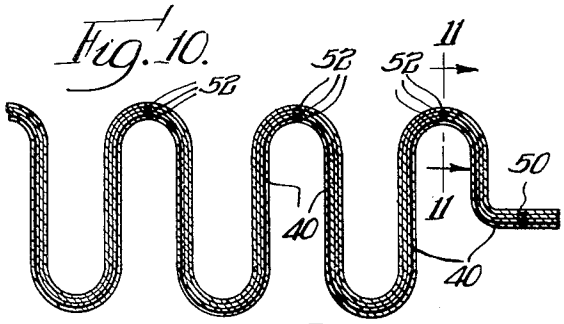


Fig. 11.

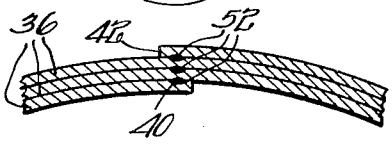


Fig. 14.

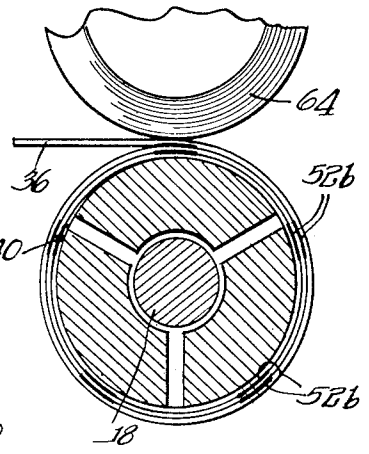


Fig. 12.

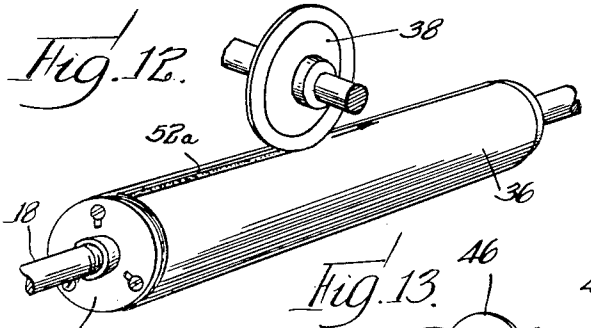
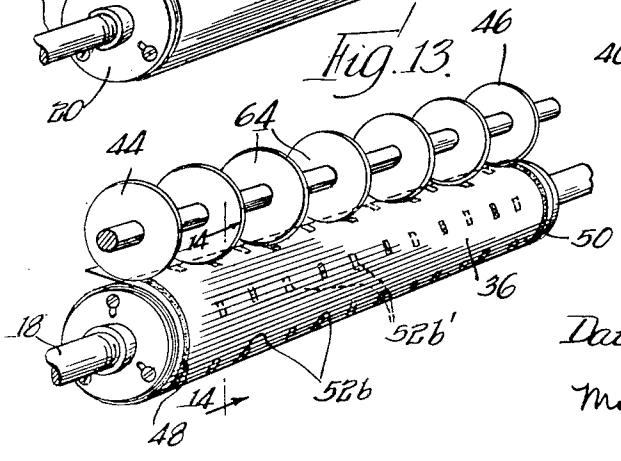


Fig. 13.



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Fig. 15.

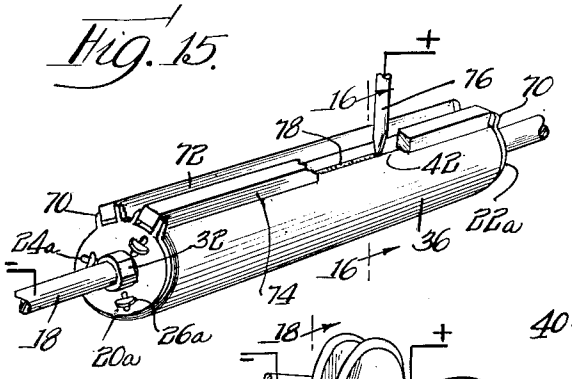


Fig. 16.

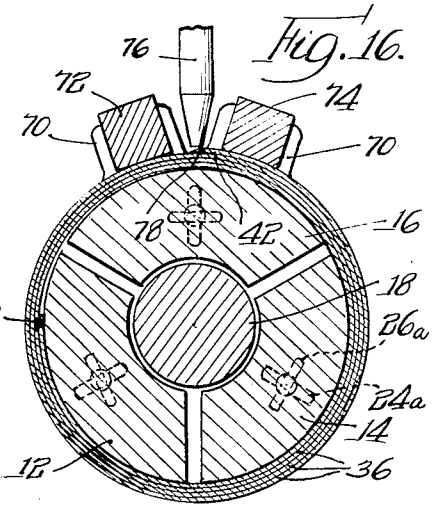


Fig. 17.

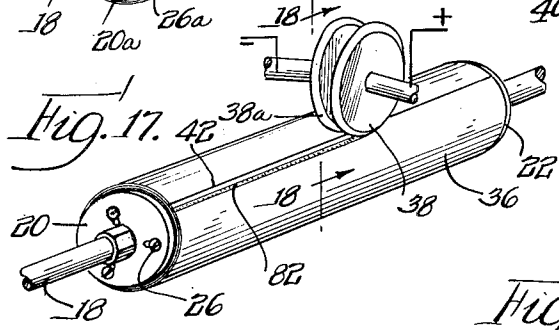


Fig. 18.

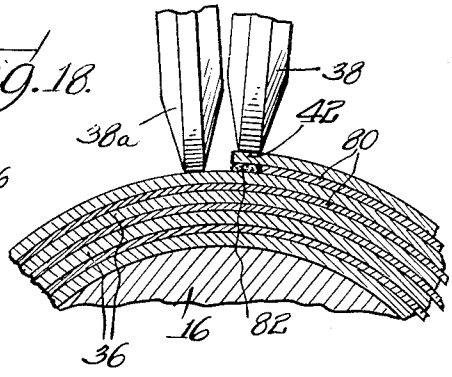


Fig. 19.

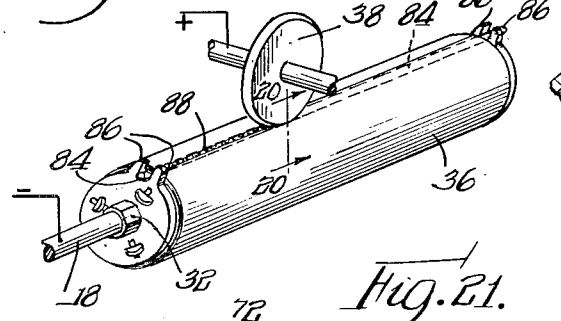


Fig. 21.

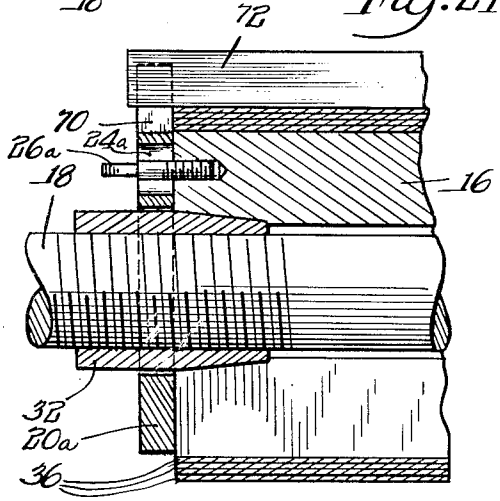
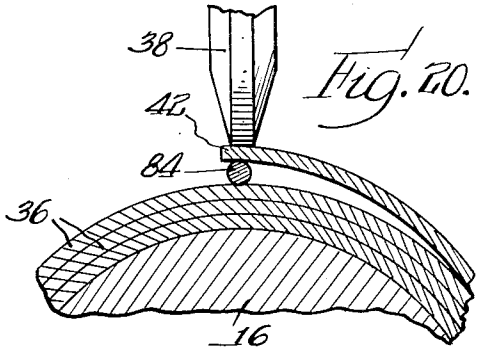


Fig. 20.



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METHOD OF MAKING TUBING STRUCTURES

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Fig. 22.

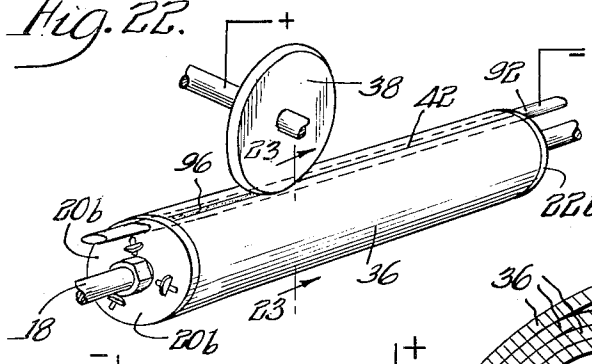
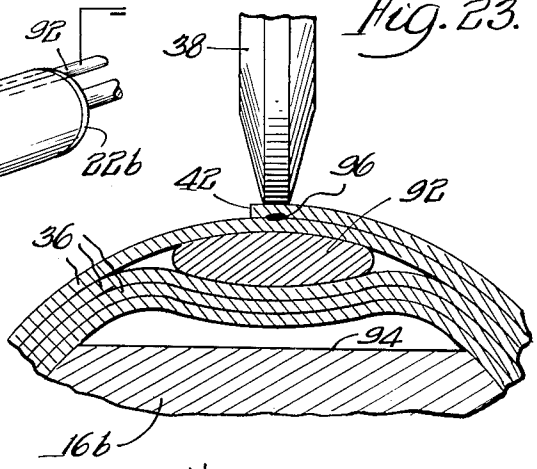


Fig. 23.



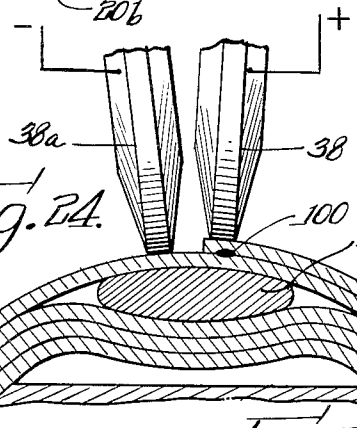


Fig. 24.

Fig. 27.

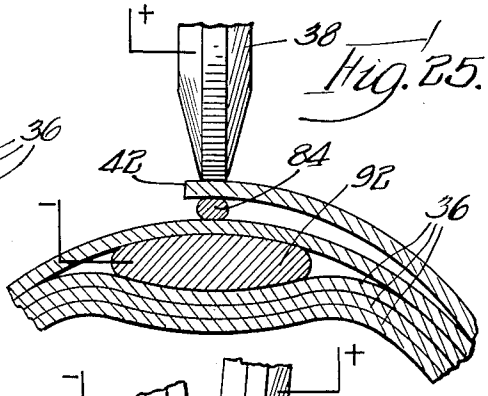


Fig. 25.

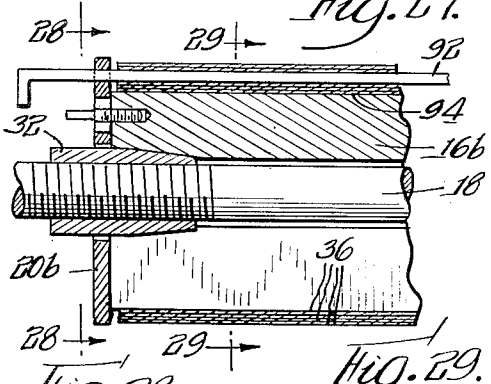


Fig. 28.

Fig. 29.

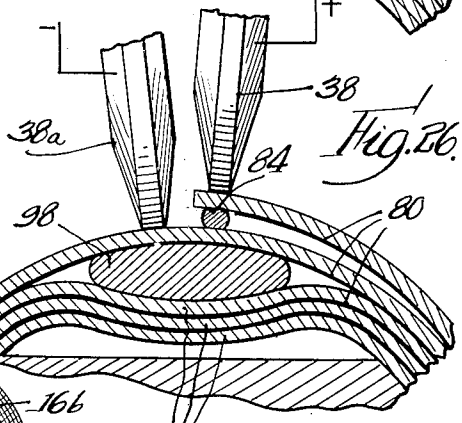
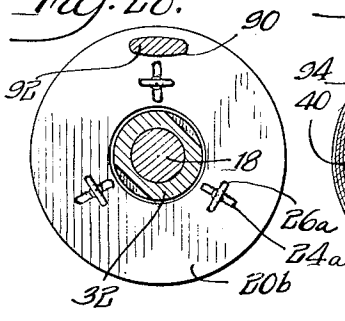
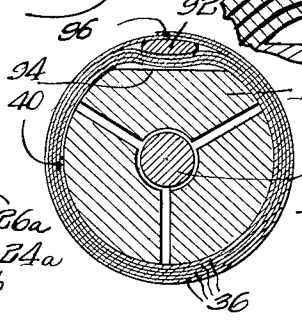


Fig. 26.





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Patented Apr. 21, 1953

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UNITED STATES PATENT OFFICE

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METHOD OF MAKING TUBING STRUCTURES

David Wendell Fentress, Barrington, Ill., assignor to Chicago Metal Hose Corporation, Maywood, Ill., a corporation of Illinois

Application November 17, 1947, Serial No. 786,407

4 Claims. (Cl. 29—148.2)

1

This invention relates to tubing structures, and to means and methods for effecting the fabrication thereof, and concerns particularly tubing of the flexible or corrugated type.

It is an object of the invention to provide a flexible or corrugated tubing structure of improved construction and improved operating characteristics, and to provide improved and readily operable means and methods for effecting the tubing fabrication.

More specifically stated, it is an object of the invention to provide an improved corrugated tubing of spiral laminated construction, having a high degree of flexibility in relation to its strength and resistance to fluid bursting pressures.

Further objects of the invention are to provide an improved corrugated tubing structure of the foregoing type, which will have requisite fluid tightness; and which is so reinforced that it will be durable in service, and may be corrugated or convoluted without undue distortion of the wall surfaces, while still retaining a high degree of flexibility.

Various other objects, advantages and features of the invention will be apparent from the following specification when taken in connection with the accompanying drawings, wherein certain preferred embodiments of the invention are set forth for purposes of illustration.

In the drawings, wherein like reference numerals refer to like parts throughout:

Fig. 1 is a perspective view, somewhat diagrammatic in form, illustrating means and methods for effecting the initial fabricating step in the construction of tubing in accordance with the present invention, and in accordance with one preferred embodiment thereof;

Fig. 2 is an enlarged transverse sectional view through the welding support arbor and associated parts, as illustrated in Fig. 1, and taken as indicated by the line 2—2 thereof;

Fig. 3 is a view similar to Fig. 1, but illustrating a further step in the fabrication of the tubing;

Fig. 4 is an enlarged transverse sectional view through the arbor and associated parts, taken as indicated by the line 4—4 of Fig. 3;

Fig. 5 is a view, similar to Figs. 1 and 3, but illustrating a still further step in the fabrication of the tubing;

Fig. 6 is an enlarged partial section through the structure of Fig. 5, taken as indicated by the line 6—6 thereof;

Fig. 7 is a longitudinal sectional view through

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the welding arbor, showing the tubing in the condition of Fig. 5, and taken as indicated by the line 7—7 thereof;

Figs. 8 and 9 are views illustrating successive steps in effecting the corrugation of the tubing, in accordance with the embodiment selected for illustration;

Fig. 10 is an enlarged longitudinal sectional view through the tubing wall, illustrating the manner of welding and securing the several wall thicknesses;

Fig. 11 is a transverse sectional view through the tubing wall on a further enlarged scale, and taken as indicated by the line 11—11 of Fig. 10;

Fig. 12 is a view similar to Figs. 1, 3 and 5, but illustrating a modified embodiment;

Fig. 13 is a view, also similar to Figs. 1, 3 and 5, but illustrating a still further modified embodiment or structure;

Fig. 14 is an enlarged transverse sectional view through the welding arbor and associated parts showing the structure of Fig. 13, and taken as indicated by the line 14—14 thereof;

Figs. 15–29 are views illustrating further modified embodiments of the invention, incorporating means and methods for effecting localized welding of the outermost lamination to secure fluid-tightness with retained flexibility; Fig. 15 being a view similar to Fig. 5 showing the welding of the outermost lamination by electric arc welding;

Fig. 16 is an enlarged sectional view of the structure of Fig. 15 on the line 16—16 thereof;

Fig. 17 is a view, similar to Fig. 5, illustrating the application of dual electrode rollers for effecting the welding of the outermost laminations by electro-resistance welding;

Fig. 18 is an enlarged partial sectional view of the structure of Fig. 17, on the line 18—18 thereof;

Fig. 19 is a view also similar to Fig. 5 illustrating the welding of the outermost laminations in accordance with the general principles of projection welding;

Fig. 20 is an enlarged sectional detail view of the structure of Fig. 19 on the line 20—20 thereof;

Fig. 21 is an enlarged detail sectional view of the mandrel structure of Fig. 15;

Fig. 22 is a view, also similar to Fig. 5, illustrating the welding of the outermost laminations by the use of an inserted electrode bar;

Fig. 23 is an enlarged sectional detail view of the structure of Fig. 22 on the line 23—23 thereof;

Fig. 24 is a view similar to Fig. 23 illustrating the welding of the outermost laminations by

dual electrode rollers in conjection with an inserted bar shunt conductor:

Figs. 25 and 26 are views similar to Figs. 23 and 24, respectively, but incorporating also the use of a projection welding wire; and

Figs. 27, 28 and 29 are longitudinal and transverse detail sectional views of the mandrel structure of Fig. 22; Figs. 28 and 29 being taken as indicated by the lines 28—28 and 29—29, respectively, of Fig. 27.

This application is a continuation-in-part of my copending application, Serial No. 711,351, filed November 21, 1946 and entitled "Tubing Structure and Method of Manufacture."

In certain instances tubing structures are required having a high degree of flexibility in respect to their strength and resistance to bursting pressures. In such instances the use of tubing having a laminated wall structure is indicated; the laminated wall having a strength or resistance to bursting pressures which is roughly proportional to the over-all thickness of the composite wall, whereas the rigidity or resistance to flexibility of the tubing is likewise only a first power multiple of the rigidity of each lamination. If the tubing is constructed of a single wall of increased thickness, the rigidity varies, roughly as the cube of the wall thickness so that in the case of tubing having a relatively thick wall a structure deficient in the necessary flexibility may result.

While the use of laminated tubing is thus desirable in many instances, difficulty has been encountered in the production of satisfactory flexible laminated tubing, particularly in connection with the fabrication and corrugation thereof. In accordance with the present invention satisfactory and readily operable means and methods are provided for fabricating the laminated tube wall, and for effecting the reinforcement and securing thereof without unduly impairing flexibility, and in such manner that the tubing may be satisfactorily corrugated with such type of convolution as may be desired, without distortion or rupture of the tube wall surfaces.

Referring more specifically to the drawings, and first to the embodiment illustrated in Figs. 1–11, in Fig. 1 there is illustrated a support and welding mandrel 10, the detailed construction of which is best shown in Figs. 2 and 7. As shown, the mandrel or arbor is composed of three expansible sections 12, 14 and 16 mounted upon a central shaft 18 which may be supported and rotatably driven in any desired manner by means not shown. A pair of end plates 20 and 22 is provided at the ends of the mandrel, these end plates being provided with radial slots 24 adapted to receive screws 26 carried by the several mandrel sections. The screws are sufficiently loose so that radial shifting of the mandrel sections in respect to the end plates is thus permitted, the outward movement of the sections being limited by the engagement of the screw shanks against the ends of the plate slots.

The shaft 18 is provided with right and left-hand threaded portions 28 and 30, which portions are cooperable with a pair of threaded cone members 32 adapted to slide against conical surfaces 34 suitably formed in the opposite ends of the bores of the mandrel sections.

It will be seen that upon relative rotation of shaft 18 in respect to the mandrel, the several sections thereof will be radially expanded to a predetermined size determined by the length of the slots 24, or permitted to collapse to a smaller size to facilitate the removal of a completed cylinder work piece from the mandrel. Normally and during the operations presently to be described, the shaft 18 and the several mandrel sections move as a unit, if and as the mandrel is rotated.

Referring further to Figs. 1 and 2, in fabricating the tubing a sheet 36 is first drawn from a suitable supply source onto and around the expanded mandrel 10 by the rotation thereof. The sheet 36 is formed of suitable material, such as metal, of which the tubing is to be fabricated, and has a length transversely of the mandrel axis determined by the diameter of the tubing to be formed and the number of laminations desired, and a length axially of the mandrel determined by the length of the tubing desired. The length of the mandrel 10 is likewise determined by the length of the tubing to be formed, and the expanded diameter thereof determines the normal or mean diameter of the tubing prior to the corrugating operations. Tubing structures of various lengths may be fabricated in accordance with the invention to provide either relatively long conduits or relatively short bellows, as may be desired; and it is to be understood that the term "tubing" as herein used denotes any desired length including relatively short structures sometimes referred to as bellows.

After slightly in excess of one complete convolution of the metal sheet has been drawn onto the mandrel, as shown in Fig. 2, a welding roller 38 is engaged against the overlapped seam, the welding roller having been previously withdrawn from the mandrel during the initial winding operation of the metal sheet, as will be understood. As the welding roller is shifted longitudinally of the mandrel, as indicated by the arrow in Fig. 1, and welding current applied, a longitudinal seam weld will be provided extending lengthwise of the tubing, as indicated by the reference number 40. Suitable means may be provided for mounting the welding roller, and for shifting the roller longitudinally of the mandrel, or for shifting the mandrel longitudinally in respect to the roller, and for applying the welding current to the roller and to the mandrel, in accordance with standard welding practice.

After the longitudinal weld 40 has been formed, the welding roller 38 is withdrawn and rotation of the mandrel structure resumed so as to further wind the sheet 36 upon the mandrel into several superimposed spiral laminations, as many as desired. The length of the sheet 36 is such that the end 42 thereof will slightly overlap the welded seam 40 in the finished tubing (see Fig. 11). During the final revolution of the mandrel, a pair of welding rollers 44 and 46 is engaged against the sheet at the opposite ends of the mandrel and welding current applied so as to form circular seam-resistance welds 48 and 50 between the sheets at the opposite ends of the tubing. The rollers 44 and 46 may be continuously engaged against the sheet both during the initial winding as shown in Fig. 1, and during the subsequent winding, if desired, and if the rollers are power driven they will aid in winding the sheet upon the mandrel. For economy it is desirable that the welding current only be applied during the final revolution of the mandrel to form one complete circular seam-resistance weld at each tubing end.

To further seal the tubing sheet and retain it in position during the subsequent corrugating operations the trailing sheet edge 42 may next

be spot welded into position as indicated at 52 in Figs. 5 and 6. This spot welding may conveniently be effected by means of a welding electrode 54 engaged sequentially along the length of the mandrel at spaced intervals, and the welding current applied. The spot welds 52 are preferably spaced apart a distance corresponding to the pitch of the tubing corrugations to be formed, so that each spot weld will be at a predetermined position in the convolution, as will subsequently appear. After the welding operations the tubing may be removed from the welding and support mandrel, by effecting the collapse thereof as previously described.

The corrugations, either helical or annular, may be formed in any desired manner. As illustrated in Figs. 8 and 9 the corrugations in the particular embodiment shown are annularly formed by a plurality of sequential rolling operations between suitably formed shaping rollers. As shown, the tubing is first subjected at spaced intervals to the action of a pair of complementary forming rollers 56 and 58 disposed internally and externally of the tubing whereby to form sequentially, a plurality of annular corrugations or convolutions in the tubing. To effect the further shaping of the convolutions into the desired form, they may be subjected to the action of further forming rollers 60 and 62, as shown in Fig. 9, whereby to form the convolutions into the desired final shape. As previously indicated, the means for forming the convolutions may take various specific forms, for example as shown in Dreyer Patent 1,879,663, dated September 27, 1932, or as shown in Fentress Patent 2,306,018, dated December 22, 1942.

The details of the completed tubing wall are illustrated in Figs. 10 and 11. It will be seen that a corrugated tubing wall having a plurality of spiral laminations is provided, the corrugations being annular and a triple ply wall structure being formed in the particular embodiment illustrated. The longitudinal seam weld 40 extends lengthwise of the entire tubing and forms a fluid seal extending lengthwise of the entire tube so that the spiral wall structure is positively sealed against fluid leakage. However, it will be seen that this weld is formed only between the two innermost wall thicknesses or laminations whereby the weld imparts only a minimum of rigidity to the structure. The remaining laminations except for the innermost two are free to slide relative to each other during the formation of convolutions, thus eliminating built up stress and resistance to formation which would result in a similar thickness composed of one piece. Also, the laminations are free to slide relative to each other during the flexing of the tube in service, permitting a high factor of flexibility and fatigue life.

The spot welds 52 extend through all laminations, but these are selectively positioned at the crests of the convolutions where flexing is a minimum during use of the tubing, so that these welds likewise reduce the flexibility of the tubing only a minimum amount.

The circular seam-resistance welds 48 and 50 likewise pass through all laminations and provide a secure holding means for anchoring the tubing walls together at the tubing ends. These welds are beyond the zone of flexing and hence do not interfere with the shifting of the tube walls during the flexing movements.

The several welds, as heretofore discussed, provide a sufficient and firm anchorage for the tubing walls so that no misalignment or unwanted distortion thereof takes place during corrugating operations, regardless of the specific type of corrugating means which may be employed. By this means a tubing structure is produced of maximum strength, maximum flexibility, and with accurately formed corrugations or convolutions, to provide a resulting finished product of maximum efficiency which will maintain itself in alignment and flex freely in use.

In certain instances, wherein the very highest degree of flexibility is not required, it may be desirable to provide additional anchorage for the tubing laminations prior to the corrugating operations. In such instances, as shown in Fig. 12, the spot welds 52 may be replaced by a second longitudinal seam-resistance weld as indicated at 52*a*. This weld may be formed by causing the welding roller 36 to be projected longitudinally of the tubing a second time, after the final winding of the strip, so as to replace the spot welding 52 by a longitudinal seam weld 52*a*. In other words, as indicated in Fig. 12, a longitudinal seam-resistance weld is first applied between the innermost laminations of the tube, as in Fig. 1, and a second longitudinal resistance weld 52*a* superimposed thereon after the final winding operations.

In Figs. 13 and 14 a still further modified embodiment is illustrated. In this instance after the longitudinal seam weld 40 has been formed, as previously described in reference to Fig. 1, and as the final convolutions are being wound upon the mandrel, a plurality of welding rollers 64 is engaged with the sheet along with the welding rollers 44 and 46 and welding current applied to form welds as indicated at 52*b* simultaneously with the formation of the circular seam-resistance welds 48 and 50. The welds 52*b* may be complete circular seam-resistance welds, or spaced spot welds as indicated in Figs. 13 and 14, or only a single spot weld, if desired, depending upon the time of application of the welding current. The welding rollers 64 are so positioned that the welds 52*b* are formed at those portions of the tubing which will form the tubing crests after the corrugating operations. One welding roller 64 may be provided for each tubing crest, or only for spaced tubing crests, as indicated in Fig. 13. By shifting the rollers 64 additional tubing crests may be welded as indicated by the dotted welds 52*b*', after the formation of the welds 52*b*.

In Figs. 15–29 means and methods are illustrated for effecting the seam welding of the outermost tubing laminations, after the spiral wrapping operations, by means of a weld which penetrates only the outermost laminated walls. By this means a seam weld for the outer laminations is provided, for insured fluid-tightness and maximum stability of the tubing, while at the same time retaining the high flexibility provided by freely slidable laminated walls.

Referring first to Figs. 15, 16 and 21, the mandrel is in this instance composed of a plurality of radially shiftable sections 12, 14 and 16 mounted upon a central shaft 18 as previously described; but the end plates 20*a* and 22*a*, corresponding to the mandrel end plates 20 and 22 previously described, are in this instance provided with radially projecting ears or lugs 70 defining slots for the reception of a pair of longitudinally extending chill bars 72 and 74 engageable with the formed tubing on the opposite sides of the tubing end 42 to be welded.

A welding electrode 76 is provided, said elec-

trode having means for shifting it longitudinally of the tubing, or there being means for shifting the mandrel longitudinally beneath the electrode as desired. Upon the application of the welding current to the electrode and to the mandrel, as diagrammatically indicated in Fig. 15, a longitudinal seam weld 78 will be formed extending longitudinally of the sheet end 42 to effect the securing of the two outermost laminations. Due to the presence of the chill bars, and by controlling the speed and current density applied to the welding electrode, the weld 78 may be prevented from penetrating beyond the outermost laminations, whereby to retain freedom of movement between the remaining tubing laminated walls 36 for maximum flexibility. The welding electrode 76 may either be of the arc welding type, wherein the metal of the electrode is deposited in molten form into the weld; or it may be the heliarc type wherein the electrode has associated therewith means for projecting an inert gas around the weld during the application of the welding current, and wherein the metal of the electrode remains intact and an autogenous weld is formed of the parent metal of the tube sheet. As illustrated in Fig. 16, the outer weld 17 may preferably be disposed at a point displaced substantially 90° from the inner seam weld 40, whereby to distribute the rigidifying effects of the two welded seams substantially uniformly on the tubing in reference to lateral and vertical bending. To facilitate removal of the end plate 20*a*, for removal of the finished tubing, the screws 26*a* are in this instance provided with T-shaped heads for selective alignment with the plate slots 24*a*.

In Figs. 17 and 18 an arrangement is disclosed for effecting the selective welding of only the outermost tubing laminations by means of dual cooperative electrodes, preferably coupled with the use of means for localizing the welding operations to the desired work areas.

As shown in Figs. 17 and 18, a pair of roller electrodes 38 and 38*a* is in this instance preferably employed, the mandrel being insulated and the roller electrodes being connected, respectively, to the opposite poles of the welding transformer, as diagrammatically indicated in Fig. 17. Also, as shown in Fig. 18, a layer 80 of insulating material is disposed between the various laminations 36 of the tube sheet, the layer 80 preferably forming a complete covering or barrier wall between the tube sheet laminations except immediately adjacent the sheet end 42. The layer 80 may comprise a separate sheet of insulating material superposed in respect to the tube sheet and spirally wrapped therewith, or it may comprise an insulating coating painted or otherwise physically or chemically applied to the sheet except adjacent the immediate sheet end 42.

As the welding rollers 38 and 38*a* are moved longitudinally of the sheet end, and the welding current applied, a weld as indicated at 82 will be formed longitudinally between the outermost sheet laminations, the close juxtaposition of the electrodes and the insulating material 80 cooperating to localize the weld between the outermost laminations, leaving the remaining tube laminations free for flexing in accordance with the principles heretofore discussed.

In Figs. 19 and 20 an arrangement is shown for accomplishing the selective welding of the outermost laminations into a longitudinal seam weld utilizing principles analogous to those employed in projection welding. In this instance a wire 84 is laid beneath the final lamination closely juxtaposed to the strip end 42, the wire preferably being positioned by means of suitable lugs 86 formed on the mandrel end plates, similar to the lugs 70 previously described.

As the welding roller 38 is moved longitudinally over the wire 84, and welding pressure and current applied, the high resistance contact between the wire and the tube sheet will produce heating resulting in the softening of the wire which under the pressure of the electrode will become formed into a longitudinal seam-resistance weld 88 between the outermost tube laminations, the weld, however, being localized to the outermost laminations directly contacted by the wire.

As in the case of the insulation 80, previously described, the wire 84 is shown in the drawings in exaggerated size for illustrative purposes. As will be understood, the purpose of the wire is not to add metal but to localize the heating area between the wall laminations. The wire may in certain instances be very small, and after the completion of the weld 88 becomes substantially indistinguishable, and a part of the metal sheet material as in the case, for example, of the welds 40 and 52 previously described.

Referring to Figs. 22, 23 and 27–29, an arrangement is shown for effecting the selective welding of the outermost tubing laminations by means of an inserted bar electrode extending longitudinally of the tubing beneath the outermost laminations.

As best shown in Figs. 27 and 28, the mandrel end plates 20*b* and 22*b* are in this instance provided with a slot or opening 90 into which there is inserted an electrode bar 92 extending longitudinally of the tube. This bar is inserted into position just prior to the winding of the final tube laminations, the mandrel section 16*b* being cut away as indicated at 94, Fig. 29, to receive the deformation of the inner tube laminations. The bar electrode 92 may be on the order of ten times the stock thickness, the latter being for example only two or three thousandths inches in the instance of thin walled tubing, and thicker in the instance of heavier wall sections. Preferably the thickness of the electrode bar is maintained as small as possible so as to minimize the inward deflections of the inner tube laminations to a negligible amount, such deflection being shown in an exaggerated degree in the drawings for illustrative purposes.

The mandrel is in this instance insulated and the poles of the welding transformer are connected, respectively, to the electrode bar and the welding roller. As the roller is moved longitudinally of the sheet end 42, a longitudinal seam-resistance weld will be formed as indicated at 96 selectively between the outermost tube laminations. After the formation of the weld the electrode bar 92 may be removed longitudinally, and if desired the circular end resistance welds 48 and 50 then formed or completed.

In Fig. 24 an arrangement is illustrated employing a pair of juxtaposed electrodes and an inserted shunt conductor or third conducting electrode for effecting the selective welding of the outermost tube laminations.

In this instance a pair of roller electrodes 38 and 38*a* is employed, similar to the arrangement of Fig. 17, the electrodes being selectively connected to the opposite poles of the welding transformer. A shunt conductor bar 98 mounted in position similar to the electrode bar 92 previously described is employed to aid in transmitting the current between the electrode rollers, whereby to localize and produce a single longitudinal seam-resistance weld 100 selectively be-

tween the outermost tubing laminations as the electrode rollers are moved longitudinally of the sheet end and the welding current applied. After the formation of the weld the shunt conductor bar **98** may be removed, in a manner similar to the electrode bar **92** previously described.

Various of the means heretofore described for producing the selective welding of the outermost tubing laminations may be used in conjunction. Thus, in Fig. 25 an arrangement is illustrated combining the wire **84** of Fig. 20 with the electrode bar **92** of Fig. 23. In Fig. 26 an arrangement is shown combining the use of the wire **84** with the double electrodes **38** and **38***a* and the shunt conductor **98** of Fig. 24, and including also the insulating coating **89** as heretofore discussed in reference to Fig. 18.

It is obvious that various changes may be made in the specific embodiments set forth, and in the method steps stated, without departing from the spirit of the invention. The invention is accordingly not to be limited to the specific structures and methods shown and described, but only as indicated in the following claims.

The invention is hereby claimed as follows:

1. The method of making a flexible tubing structure which comprises wrapping a tube sheet about a mandrel to size the tubing and provide portions thereof in overlapped relation, welding a longitudinal seam along said overlapped portions my means of a roller electrode while using the mandrel as a cooperative electrode and also as a support for the wrapped sheet, wrapping the sheet in further convolutions about said mandrel which has a cut-away surface in the periphery thereof, engaging a roller electrode against the outer surface of the tube sheet adjacent the margin thereof to provide a second seam weld extending longitudinally of the tubing structure, forcing inner tube windings inwardly into the cut-away surface of the mandrel with the outermost laminations remaining in substantially tubular form and localizing the welding current within the outermost laminations by means of an electrode bar within the cut-away surface of the mandrel and between the tube windings forced inwardly thereof and the outermost laminations, and with the outer surface of the bar positioned to effect conformation of the inner surface of the outermost laminations with the outer surface of the inner laminations when in tubing form.

2. The method of making a flexible tubing structure as claimed in claim 1, including the step of convoluting the tubing along a predetermined portion of its length to provide a convoluted and spirally laminated tubing wall.

3. The method of making a flexible tubing structure as claimed in claim 1, which includes the step of inserting a filament of welding material between outermost laminations exteriorly of the inserted elongated bar electrode for localizing the welding current to the tubing in the vicinity of the filament to effect the second or outermost seam weld.

4. The method of making a flexible tubing structure as claimed in claim 1, wherein the welding current is localized and restricted within the outermost laminations by interposing insulation selectively between the laminations.

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