Dec. 20, 1949 A. GREINER 2,491,857

METHOD AND APPARATUS FOR COILING ELONGATED VITREOUS STOCK

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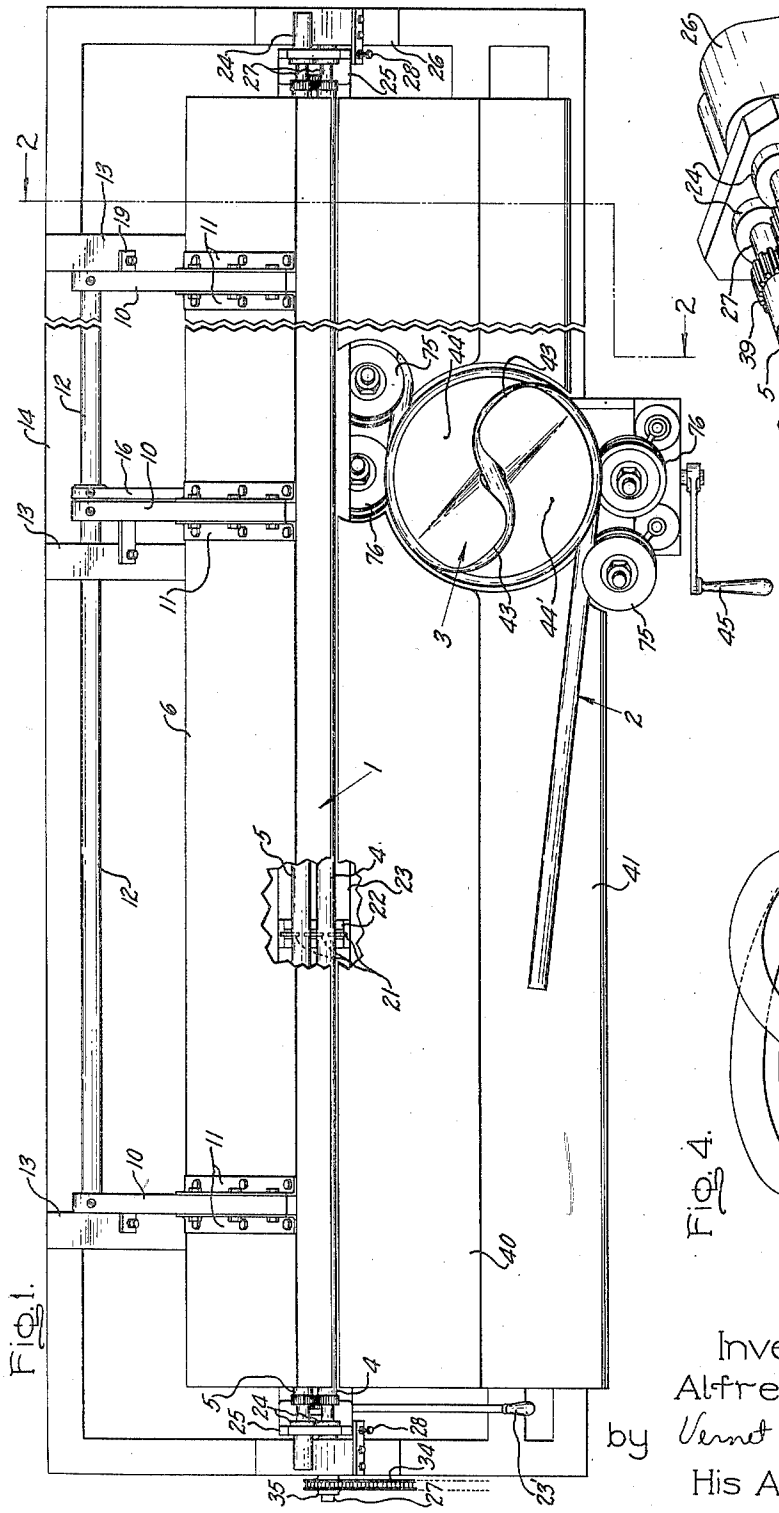


Fig. 1.

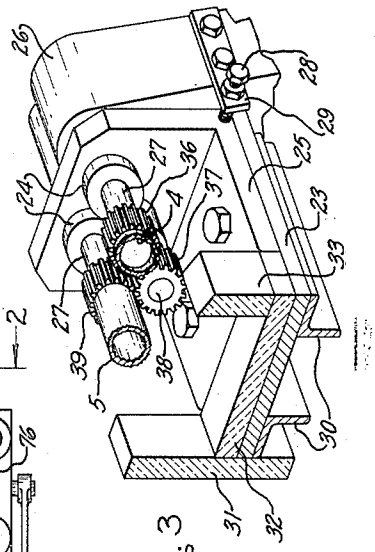


Fig. 3

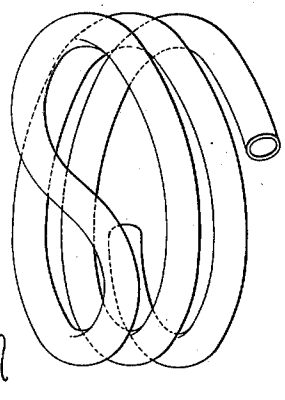


Fig. 4.

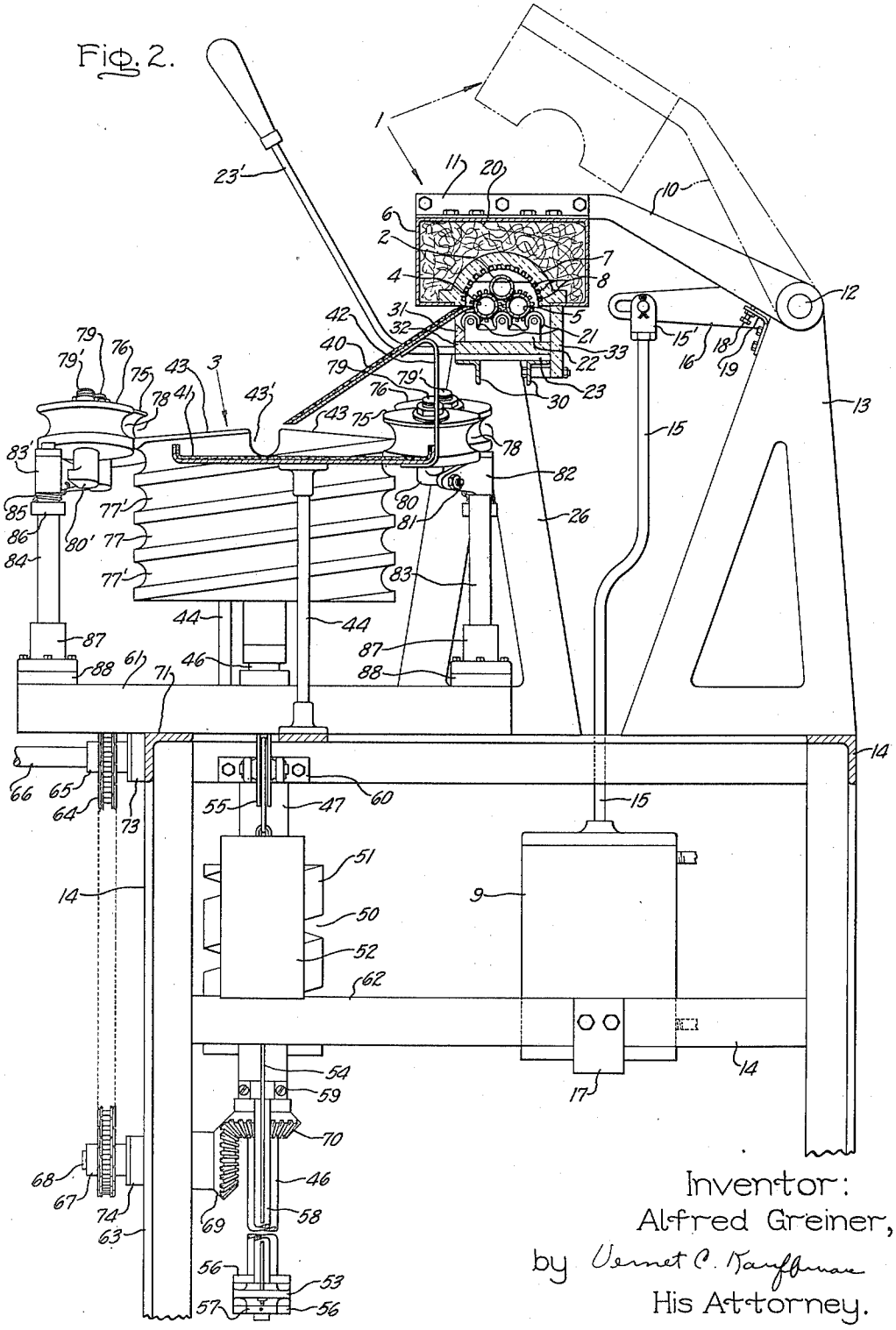
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METHOD AND APPARATUS FOR COILING ELONGATED VITREOUS STOCK

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Fig. 2.



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METHOD AND APPARATUS FOR COILING ELONGATED VITREOUS STOCK

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Fig. 8.

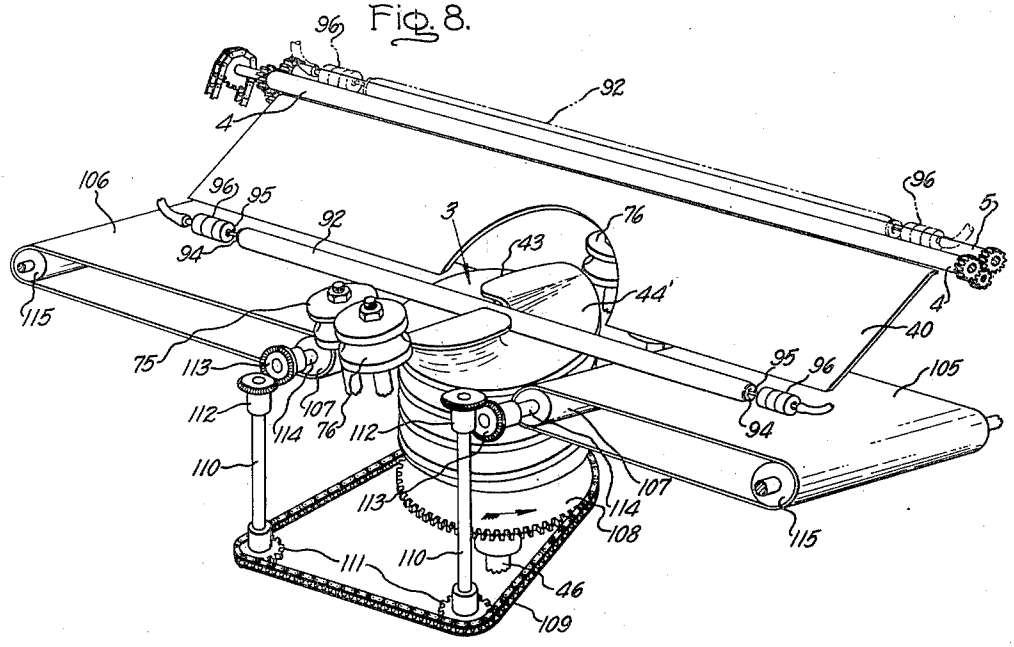


Fig. 9.

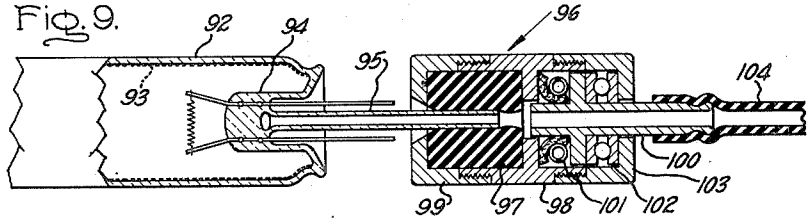
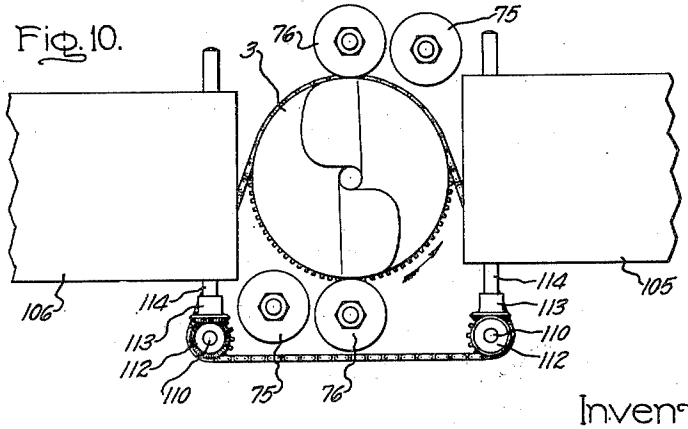


Fig. 10.



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Fig. 6.

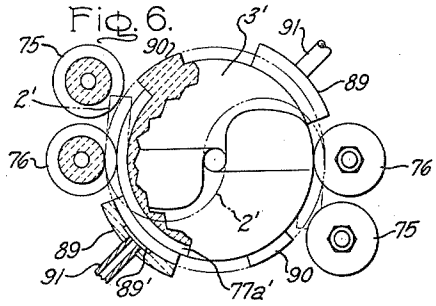


Fig. 7.

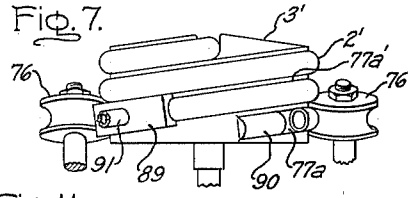


Fig. 5.

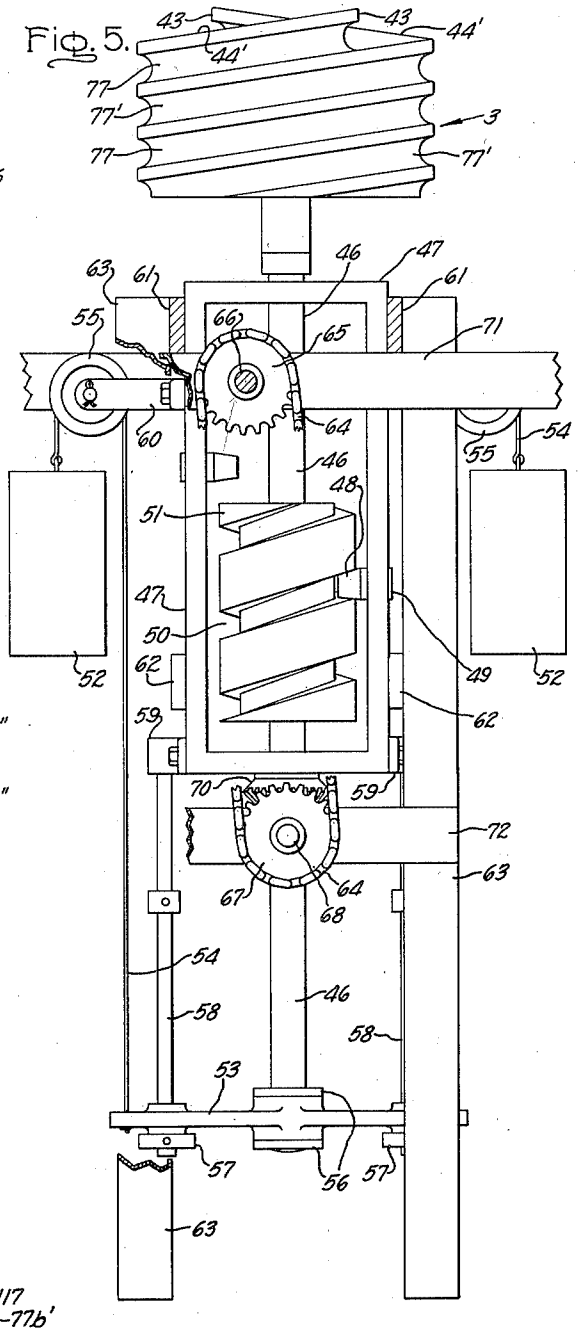


Fig. 11.

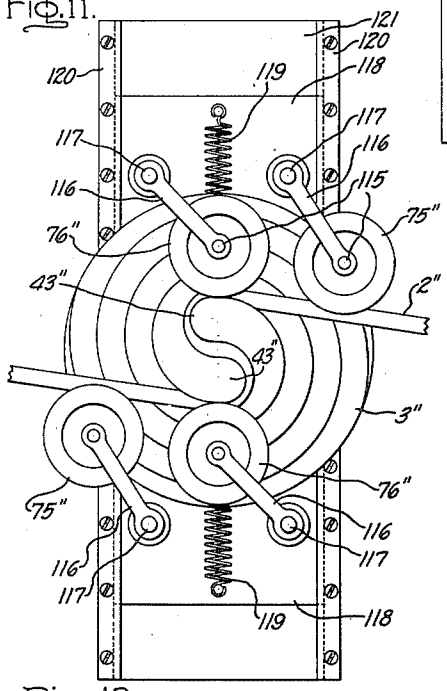
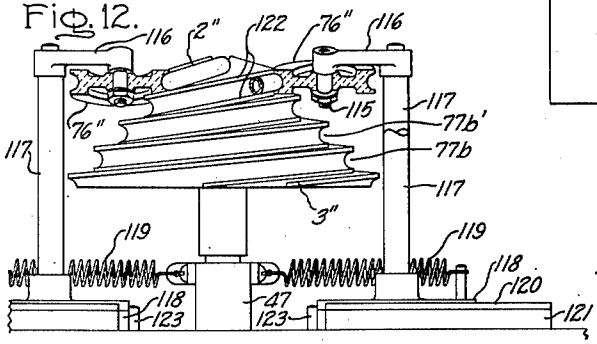


Fig. 12.



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UNITED STATES PATENT OFFICE

2,491,857

METHOD AND APPARATUS FOR COILING ELONGATED VITREOUS STOCK

Alfred Greiner, Cleveland Heights, Ohio, assignor to General Electric Company, a corporation of New York

Application November 25, 1947, Serial No. 787,948

23 Claims. (Cl. 49—7)

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My invention relates to methods and apparatus for bending an elongated vitreous body such as a length of tubing or rod into a spiral or helix, and more particularly to methods and apparatus for bending an elongated vitreous body of substantial length into a bifilarly coiled configuration or so-called double spiral or helix having the mid-point or bight of the tube length at one end of the helix and the intermediate portions thereof intercoiled and terminating at the opposite end of the helix. Such apparatus is also capable of bending elongated discharge lamps and the partially completed envelopes of such lamps to helical form to thereby facilitate the manufacture of a lamp of particularly desirable shape.

The principal objects of my invention are to materially reduce the skill and time required in the heating and bending of relatively long vitreous bodies into helical shape and to provide a ready and satisfactory apparatus for bending said vitreous bodies without distortion to a true shape. To this end apparatus is provided for heating the full length of the vitreous body to a workable state, which apparatus assures even distribution of the heat over the entire periphery of the vitreous body, and for manipulating said vitreous body to bend it rapidly into engagement with a form without otherwise changing the shape thereof.

Another object of my invention is to bend relatively long bodies such as discharge lamps, lamp envelopes and corresponding lengths of vitreous tubing or rod to a coiled concentrated form so that said bodies occupy much less space and are therefore better suited for convenient and satisfactory general application. To effect this object a form is provided having grooves of a shape defining the final form of the vitreous body and other means is provided for directing and pressing said vitreous body properly into the grooves of the form without distortion.

Another object of my invention is to provide for the rapid transfer of a highly heated and readily deformable elongated body from the heating means into proper relation to the bending apparatus in a manner avoiding appreciable cooling and deformation of the vitreous body.

Still another object of my invention is to provide a form about which the vitreous body is coiled to determine its shape and apparatus for manipulating said form and means for guiding and pressing said vitreous body into engagement with proper portions of the form to effect the bending of the said vitreous body. The form, in

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the preferred arrangement of my apparatus, is mounted in an opening in a tray or other supporting means which is adapted to hold the heated and bendable vitreous body, and other means are provided for rotating and raising said form in a manner to advance succeeding portions of said body adjacent the supporting surface of the platform as the coiling of the vitreous body onto the form progresses. Guide rolls are also provided to prevent the vitreous body from turning with the form and to direct it properly into confining grooves thereof, and other rolls are provided to press said vitreous body firmly against the form to cause it to conform thereto.

Another object of my invention is to provide in combination with apparatus for bending a hollow vitreous body into a groove in a form means cooperating with said form for introducing gas at pressure into the body to correct deficiencies in shape thereof developed during the bending operation. Such means is judged to be desirable when the vitreous body being bent has particularly thin walls of slight mass.

Still another object of my invention is to provide apparatus for causing a relative displacement of the vitreous body and the form toward each other during the bending operation to avoid, as much as possible, all longitudinal lengthening and deformation of said vitreous body. Still another object of my invention is to provide apparatus for introducing an inert gas into a hollow vitreous body during heating and after it is bent to shape to protect oxidizable materials in the hollow interior thereof and to permit the rounding out of the vitreous body and the obliteration of unavoidable deformations therein.

Still another object of my invention is to provide modified helix bending apparatus such that coils of different diameter can be formed. Modified apparatus of this type permits the vitreous body to be formed into irregular shapes, for instance, into a conical spiral or helix.

Still other objects and advantages of my invention will appear from the following detailed description of species thereof and from the drawing.

In the drawing, Fig. 1 is a plan view of heating and bending apparatus of my invention showing said apparatus midway through a cycle of operation and with an intermediate section of one end portion broken therefrom; Fig. 2 is an end elevation of said apparatus taken from a section therethrough along line 2—2 of Fig. 1 in the direction indicated and at the start of a cycle of

operation; Fig. 3 is a fragmentary perspective view of one end of the support rollers of the heating means and the mounting therefor; Fig. 4 is a perspective view of a length of vitreous tubing after being bent and reshaped by the apparatus; Fig. 5 is a side elevation of the bending form and the operating means thereof; Fig. 6 is a plan view partially broken away of the bending form and the associated means of modified apparatus which provides for the introduction of gas at pressure into the vitreous body after it is coiled about the form; Fig. 7 is a side elevation of bending form, bending rolls and gas introducing means of the aforesaid modified apparatus; Fig. 8 is a schematic perspective view of the essential elements of a modified heating and bending apparatus of my invention which provides further controls over the shape of the discharge lamp being bent and protection for the materials enclosed within the hollow interior thereof, the apparatus being shown part way through a cycle of operation and about to bend the discharge lamp which initially is heated in the position shown in dot-dash lines; Fig. 9 is a longitudinal section through the coupling of the last-mentioned modified apparatus and the end of the discharge lamp to which it is connected; Fig. 10 is a plan view of the form and the adjacent means of the last-mentioned modified apparatus for directing and bending the discharge lamp into engagement therewith; and Figs. 11 and 12 are plan and side elevations at right angles to each other of the form and other essential apparatus of a further modification for bending vitreous tubing into a conical double spiral.

The particular apparatus disclosed in Figs. 1 to 5 of the drawing is comprised of a long movable oven 1 for heating in a single operation the full length of the glass tubing 2 and means mounted adjacent thereto and incorporating the form 3 and associated means for bending said vitreous tubing 2 to a desired shape. The apparatus is under the control of an operator preferably stationed midway of the length thereof and opposite the form 3.

The cycle of operation is initiated by causing the oven 1 to raise from a position directly over the rollers 4 and 5 and then introducing the length of glass tubing 2 into said apparatus by resting said tubing 2 upon and between said rollers 4 and 5 in the position shown in Fig. 2. The movement of the oven 1 which is comprised of a metal enclosure 6 supporting refractory blocks 7 with electrical-resistance elements 8 about a semicircular hollow in the lower surface thereof over the rollers 4 and 5 is brought about indirectly by the manual manipulation of a valve (not shown) admitting compressed air into the cylinder 9 which cylinder 9 and associated means raises said oven 1 through the movement of three arms 10 attached by angle bars 11 to the top surface of said oven 1. The arms 10 are fastened to a lay shaft 12 journalled in brackets 13 mounted on the table-like frame 14 of the apparatus and are moved by rotation of said shaft 12 when the compressed air actuates a piston (not shown) within the cylinder 9 so that the operating rod 15 (which is connected to said piston), the connecting yoke 15' and the lever 16 move to turn the lay shaft 12. At the limit of movement, the oven 1 takes the position shown in dot-dash lines (Fig. 2). The cylinder 9 is fastened by means of a bracket 17 to the frame 14 and is disconnected from the compressed air supply and bled by further manual manipulation of the valve (not shown) when the glass tubing 2 has been placed on the rollers 4 and 5 and the oven 1 is again to be lowered into place thereabove. At the lowered limit of movement the arms 10 rest against the stop screws 18 extending from the ears 19 attached to the supporting brackets 13. The oven 1 is sufficiently long to completely cover the full length of the glass tubing 2 which in the present instance is eight feet in length and with the assistance of the filling 20 of insulation material restricts the escape of heat from the area around the resistance elements 8. As only the upper half of the glass tubing 2 is directly exposed to the radiations from the oven 1 proper distribution of the heat to the full periphery thereof depends on the rotation of said tubing 2 effected by corresponding rotation of the rollers 4 and 5.

The full length of the glass tubing 2 is supported by rollers 4 and 5 which are formed from lengths of heat resistant metal tubing having a smooth exterior surface and which extend beyond the ends of the oven 1. The rollers 4 and 5 are, in turn, supported intermediate of their length by groups of three rollers 21, like that shown in Figs. 1 and 2, held by a bracket 22 mounted on a plate 23 below the full length of said rollers 4 and 5 and at opposite ends, as shown in one instance in Fig. 3, by a pair of bushings 24, the bracket 25 and the support standard 26.

The entire assembly is formed into a unit by the attachment of the opposite ends of the plate 23 to the brackets 25 since said brackets 25 are the means of retaining the bushings 24 which surround the spindles 27 extending from the ends of the rollers 4 and 5. Only the bushings 24 about spindles 27 extending from the roller 4 are mounted in the support standards 26 and the unbalanced weight distribution of the unit assembly swings it thereabout to the position shown where the brackets 25 engage the stop screws 28 on the ears 29 of the support standards 26. Other portions of the assembly comprise the angle bars 30 on the lower surface of the plate 23 which bars 30 stiffen and hold said plate 23 in alignment and the asbestos blocks 31, 32 and 33 which assist in confining the heat of the oven 1 and the rollers 4 and 5 to the immediate region thereof. The heretofore mentioned rotative movement in the rollers 4 and 5 which turns the glass tubing 2 is introduced into roller 4 from a source (not shown) such as an electric motor and speed reducer through the chain 34 and sprocket 35, the latter of which is mounted on the spindle 27 at the left (Fig. 1) end thereof. The rotative motion of the roller 4 is transferred to roller 5 through a gear train at each end thereof comprised of gears 36 on the spindles 27 of roller 4, the intermediate gears 37 mounted on pins 38 held by brackets 25 and the gears 39 on the spindles 27 of roller 5.

The heating period allowed the glass tubing 2 is determined by the physical condition of said glass tubing 2 and is preferably such as to cause said tubing 2 to be heated to workable condition although not so hot as to cause it to collapse. The heating interval is determined by experiment and, when complete, is followed by the rapid transfer of the glass tubing 2 into operative relation to the bending form 3 and the rapid coiling thereof about said form 3 before said tubing 2 loses appreciable heat and workability. Before the glass tubing 2 is transferred, however, the oven 1 is raised by manual manipulation of the valve (not shown) controlling its movement

so that the rollers 4 and 5 and the supporting unit pivoted on the support standards 26 can be tilted to discharge said glass tubing 2 onto the inclined chute 40 which controls its further movement. The tilting of the rollers 4 and 5 and supporting unit is effected by downward pressure on the handle 23' which is attached to plate 23 and which, in moving downward, turns the assembly about the axis of the roller 4 thereby raising roller 5 so that it in effect lifts and pushes the glass tubing 2 over roller 4. There is sufficient inclination to the chute 40 to cause the glass tubing 2 to roll rapidly down the surface thereof and to drop off the lower edge to the desired position on the form 3 and tray 41 without interruption. Metal strips 42 at intervals along the length of the chute 40 provide the means of supporting said chute 40 from the stationary tray 41.

The glass tubing 2 drops from the edge of the chute 40 to a flat surface presented by the tray 41 and into a transverse groove 43' in the top of the form 3 which is located in a central opening in the tray. At such times the form 3 is so orientated and elevated that the mid-portion of glass tubing 2 falls on a flat transverse area of the upper end of the form 3 between the opposite raised lips 43—43 at the same elevation as the tray 41, and opposite end portions of said glass tubing 2 fall on the top surface of the tray 41. The form 3 and tray 41 which is mounted on a plurality of standards 44 extending upward from a cross-member of the frame 14 are so arranged that the tubing 2 is equally distributed on opposite sides of the center of the form 3. The bending operation is immediately brought about by the operator to avoid cooling of the glass tubing 2 by fairly rapidly rotating the crank 45 which causes a counter-clockwise rotation and gradual raising of the form 3.

As shown in Figs. 2 and 5, the form 3 is mounted on the upper end of a vertical spindle 46 which is both rotatable and slidable longitudinally in the carriage 47 and takes a vertical position determined by the engagement of a roller 48 on a pin 49 carried by the carriage 47 with the helical groove 50 in the cam 51 on a mid-portion of the spindle 46. The weight of the form and spindle assembly is born by the counter weights 52—52 on opposite sides thereof which are connected to a cross bar 53 on the lower end of spindle 46 by flexible cables 54—54 passing up and over the idler sheaves 55—55. The cross bar 53 does not effect the rotative position of the assembly as it is pivoted on the spindle 46 between the collars 56 attached thereto and determines the initial vertical position of the form 3 through its engagement with the fixed stop collars 57 on the corresponding guide rods 58 which are attached to opposite sides of the carriage 47 by brackets 59. Yokes 60 attached to the upper portion of the carriage 47 at opposite sides thereof provide a fixed support for the idler sheaves 55 of the counter balancing means whereas transverse bars 61 and 62 which are attached to upper and lower portions of the carriage 47 at opposite sides and which engage the legs 63—63 and various other portions of the frame 14 provide the fixed support for said carriage 47. The simultaneous rotation and raising of the form 3 which effects the bending of the glass tubing 2 is created therein by the transfer of the rotative movement of the crank 45 to the spindle 46 through the means of the chain 64 which engages the sprocket 65 on the shaft 66 supporting said crank 45 and which engages the sprocket 67 on the intermediate shaft 68, and through means of the intermeshing bevel gears 69 and 70 on the intermediate shaft 68 and spindle 46, respectively. Shafts 66 and 68 retain a fixed relation as they are mounted on respective longitudinal members 71 and 72 of the frame 14 by the bearings 73 and 74 respectively. The rotation of the spindle 46, however, causes it to be raised as the cam 51 turns therewith and advances the roller 48 into another portion of the helical groove 50 thereof. The vertical movement of the spindle 46 has no effect on the position of the bevel gear 70 since it drives through a key and a longitudinal keyway (not shown) therein and remains in position between bevel gear 69 and the carriage 47 as the spindle 46 slides upward therethrough.

Referring more particularly to the form 3, it consists of a drum having a pair of alternately spaced, or parallel, helical grooves 77 and 77' in its outside surface and is provided with a pair of oppositely positioned input lips 43 defining therebetween a transverse diametral groove 43' (Fig. 2) interconnecting the said pair of helical grooves 77, 77' at one end of the drum. It will also be noted that the lips 43 are joined to the transverse groove 43' by tapered surfaces 44' having the same direction of annular slope, to permit removal of the coiled tube upon reverse rotation of the drum. The drum form 3 may also be considered in the nature of a double helical worm provided with a transverse groove 43' across one end thereof, the bottom of said transverse groove 43' intersecting the trailing edges of the two spiral grooves 77, 77', said worm having the portions of its said end outwardly beyond the intersections of the transverse groove with the spiral grooves relieved at 44' at least to the extent that the surfaces 44' correspond to surfaces developed by the bottom of the transverse groove 43' when it is rotated along the pitch of the grooves 77, 77'.

In this particular instance, the rotational and upward movement of the form 3 carried the edges (Fig. 5) of the lips 43 over adjacent portions of the glass tubing 2 and the walls of the semi-circular grooved faces thereof against correspondingly shaped walls of the glass tubing 2. As the rotation of the form 3 progresses and the glass tubing 2 engages the walls of grooves in the lips 43, the opposite ends thereof move laterally across the surface of the tray 41 in opposite directions until they engage the guide rolls 75—75 which block further lateral movement. Still further rotation of the form 3 completes the wrapping of the glass tubing 2 into the semi-circularly curved grooves of the lips 43 and carries the immediately adjacent portions of said glass tubing 2 against the pressure rolls 76—76 which force it to the base of the grooves 77, 77' in the periphery of the form 3. The lips 43 and associated grooves slope outward and downward from the center of the form 3 at an angle corresponding to the pitch of the grooves 77, 77' in the periphery of the form 3. The rate of upward movement of the form 3 is such that the grooved portion of said form 3, into which the glass tubing 2 is drawn, is always in alignment with tray 41 and then moves up into alignment with the pressure rolls 76.

The guide rolls 75 and the pressure rolls 76 are

mounted above the surface of the tray 41 in alignment with the path taken by the glass tubing 2 as it is pulled therefrom to the grooves 77, 77' and are provided with peripheral grooves 78 substantially equal to one half the cross section of the glass tubing 2 so as to provide effective control over the path of movement and bending of said glass tubing 2. Each guide roll 75 is free to rotate about a support spindle 79, the head 80 of which is attached by means of a laterally extending stud 81 to an arm 82 mounted on the upper end of a standard 83 and is a fixed member. Each pressure roll 76, on the other hand, is similarly free to rotate about a support spindle 79', the head 80' of which is attached by means of a laterally extending stud (not shown) to an arm 83' pivoted on the upper end of a standard 84 and is pressed against the glass tubing 2 to an extent sufficient to cause said roll 76 to bear against the periphery of the form 3 by a torsion spring 85 engaging arm 83' and fixed collar 86 on the standard 84. The bases 87 for both standards 83 and 84 at opposite sides of the form 3 are mounted on the plates 88 resting on the transverse bars 61. Further rotation and upward movement of the form 3 continues, and finally the entire length of the glass tubing 2 passes beyond the guide and pressure rolls 75 and 76 and is coiled into grooves 77, 77' of the form. The entire bending operation is preferably brought about very rapidly to avoid loss of heat and improper bending of the glass tubing 2. Loss of heat from the tubing 2 to the apparatus is avoided as much as possible by providing woven asbestos coverings over the metal surfaces of the chute 40 and the tray 41. The form 3 and the guide and pressure rolls 75 and 76 are also made from a refractory, such as a molded magnesium oxide for instance, to avoid conduction of heat from the glass tubing 2 and a cooling shock thereto as the bending occurs.

After the glass tubing 2 has been completely coiled over the form 2 a short time interval is allowed to lapse to permit said tubing 2 to cool sufficiently to take a permanent set whereupon the operator unscrews the bent glass tubing, which now appears as in Fig. 4, from the form 3. The removal of the bent glass tubing 2 is usually performed by manually holding said tubing while the crank 45 is turned to return the form 3 to its starting position.

In certain applications of the bending apparatus as for instance when a length of very thin walled glass tubing is being shaped, it is desirable to modify the above apparatus to permit the glass tubing to be expanded by gas pressure after it has been bent about the form. The expansion of the glass tubing under such conditions removes any vertical or horizontal flattening of the tubing that may have occurred and assists in obliterating any wrinkles that may have formed in the more sharply bent inner wall of the helix.

To effect the introduction of a gas into the tubing, a modified bending form 3' and the shoes 89—89 shown in Figs. 6 and 7 are preferably used in combination with the apparatus just described. The use of the modified apparatus corresponds exactly to that of the previously described apparatus until the ends of the glass tubing 2' are finally pressed into the peripheral grooves 77*a* and 77*a'* of the form 3', at which time said ends lie in portions adjacent to protuberances 90—90 of said form 3' which block off the terminal ends of the grooves 77*a* and 77*a'*. The protruding portions 90—90 of the form 3' present an exterior contour like that of the glass tubing 2' within the grooves 77*a*, 77*a'* and therefore do not prevent further rotation of the form 3' which carries said portions 90—90 below the pressure rollers 76 and finally below the shoes 89—89. When the rotation of the form 3' progresses to a point where both ends of the glass tubing 2' and the protruding portions 90—90 are covered by the shoes 89—89, it is terminated and gas, usually air under pressure, is introduced into the confined open ends of the glass tubing 2' through passages 89' in the shoes 89—89. As the adjacent faces of the shoes 89, 89 conform to the periphery presented by the form 3' and the glass tubing 2' and are in close proximity thereto, the leakage therebetween is not sufficient to prevent the development of the desired pressure within the glass tubing 2' to expand it as desired. In certain instances, an air passage in only one of the shoes 89 is required to produce the necessary pressure within the glass tubing 2'. The pipes 91—91 and other means (not shown) are the means of furnishing support and conducting gas to the shoes 89—89 which are preferably retained at a fixed relation to form 3' and pressure rollers 76 at all times. After expansion of the glass tubing 2' has occurred an appropriate interval of time is allowed to lapse to permit said tubing 2 to cool and take a permanent set whereupon it is unscrewed and removed from the form 3'.

In still other instances, it is desirable to perform the glass tube shaping operation after said glass tube has been combined with other means, as for instance when said tubing is part of an almost completely assembled lamp. The bending operation can then be modified to advantage and be performed with the modified form of the bending apparatus shown in Figs. 8, 9 and 10 or with combinations thereof. Shown in said combination is a lamp 92 comprising a relatively long envelope having a coating of a fluorescent material 93 on the inner surface thereof and electrode assemblies 94 (as shown in Fig. 9), with exhaust tubes 95 extending therefrom, sealed into opposite ends of the envelope. In operating the modified apparatus, the operator first slips corresponding exhaust chucks 96 onto the ends of the exhaust tubes 95 so as to permit positive control of the interior atmosphere of the lamp 92 and then places said lamp 92 between the rollers 4 and 5 of heating means corresponding to that shown in detail in Figs. 1 and 2. The exhaust chucks 96 each contain a rubber gland 97 in the body 98 thereof having a central opening adapted to receive the end of the exhaust tube 95 and provides for the compression of said gland 97 to seal said exhaust tube 95 to the body 98 by means of the cap 99 which is manually screwed over the end of said body 98. A rotatable hollow spindle 100 which is held between the packing gland 101 and the ball bearing 102 behind the end cap 103 on said body 98, and the rubber hose 104 provide the means of making a gas tight connection thereto which permits independent rotation of the chuck 96. At the time the operator places the exhaust chuck 96 over the exhaust tube 95, the cap 99 thereof is unscrewed so as to allow said exhaust tube 95 to readily enter the opening of the rubber gland 97 and the operator merely screws said cap 99 tightly onto the body 98 of the exhaust chuck 96 to cause the rubber gland 97 to be expanded and seal said exhaust tube 95 to said body 98. The exterior of the exhaust chuck 96 is the same diameter as the lamp 92 and rests upon

and is rotated by the rollers 4 and 5 of the heating means in the same manner as the lamp 92 thereby relieving the exhaust tube 95 of all strain of support and rotation. The hollow spindle 100 and the rubber hose 104 are independent of the rotative motion of the other portions of the exhaust chuck 96 and are connected to separate stationary means (not shown) located adjacent opposite ends of the bending apparatus.

The lamp 92 is heated in the same manner as previously disclosed by an oven (not shown) lowered to proximity to the rollers 4 and 5. However, it is preferred that the oven be substantially the same length as the lamp envelope only, so as not to heat and thereby deleteriously affect the exhaust chuck 96. Jets of cool air directed against both chucks can assist in preventing said chucks from being heated undesirably. The presence of air within the lamp 92 in many cases is injurious to the various parts thereof, the fluorescent coating on the interior of the envelope for instance, at the high temperatures to which the lamp 92 is heated so that in such cases an inert atmosphere is supplied to replace the air. To effect the change in atmosphere within the lamp 92, a gas, such as nitrogen, is introduced into one end of said lamp 92 through the exhaust chuck 96 and the exhaust tube 95 and the displaced air therein is flushed out correspondingly through the other exhaust chuck 96 from the other end of said lamp 92. The entrance of the inert gas is preferably started immediately upon attachment of the exhaust chucks 96 to the lamp 92 and can continue at a moderate rate of flow thereafter and during the heating period of the lamp 92 so that the air is finally completely displaced by the time the lamp 92 attains a high temperature. The heating period of the apparatus is complete when the envelope of the lamp 92 increases in temperature sufficiently to allow it to be properly bent to shape in the subsequent operation of the bending apparatus and is terminated when the oven is raised and the rollers 4 and 5 are tilted to discharge the lamp 92 and the exhaust chucks 96 onto the chute 40 as a unit.

In the present modified apparatus the chute 40 discharges the lamp 92 over the center of the upper end of the form 3 as in the previous instance; however, the end portions thereof and the exhaust chucks 96 fall onto movable belts 105 and 106 at the same horizontal level as the end of the form 3. The bending of the lamp 92 about the form 3 is brought about immediately by causing the form 3 to be rotated and raised with the consequent opposite and lateral movements of the end portions of said lamp 92 across the belts 105 and 106 bringing said end portions into engagement with the guiding and pressing rolls 75 and 76 and the longitudinal movement of said end portions toward the form 3. The belts 105 and 106 are moved toward the form 3 during this interval at a rate designed to advance the end portions of the lamp 92 toward the form 3 as rapidly as it is wound thereabout so as to reduce the separate longitudinal movement of said end portions to a minimum and thereby reduce the possibility of any elongation of the lamp 92. The belts 105 and 106 also move the exhaust chucks 96 along with the end portions of the lamp 92 thereby reducing the strain on the exhaust tubes 95 by which they are connected to said lamp 92. Because the form 3 in the initial steps of the bending operation winds less of the end portions of the lamp 92 and causes said end portions to shift laterally there is some independent motion of said end portions on said belts 105 and 106.

The motion of the belts 105 and 106 originate in the rotative movement in the form 3 as said movement is transferred to the driving sheaves 107—107 supporting one end of said belts 105 and 106 through the large sprocket 108 on the supporting shaft 46 for said form 3, the chain 109, the counter shafts 110—110 which engage said chain 109 through sprockets 111—111 and the intermeshing bevel gears 112—112 and 113—113 which engage the counter shafts 110—110 and the supporting shafts 114—114 for the driving sheaves 107 respectively. The sheaves 115—115 at the opposite ends of the belts 105 and 106 idle and keep said belts taut.

After the lamp 92 is coiled about the form 3 and the motion of said form 3 is terminated, a further step in the bending operations of the apparatus is brought about by increasing the gas pressure within said lamp 92 by controls (not shown) connected to the exhaust chucks 96 so as to round-out slightly the envelope of said lamp 92 and remove any flattening and slight creases that may have been formed during the bending thereof. The gas pressure is created within the lamp 92 by blocking the escape of gas from one of the exhaust chucks 96 as need be to build up and then maintain said gas pressure for a sufficient interval to round-out the lamp 92 to the degree desired.

Following the above reshaping operation, a short interval is allowed to lapse to permit the lamp 92 to cool somewhat so that it becomes set and can be removed from the bending apparatus. The operator effects the removal of the lamp 92 in much the same manner as disclosed in connection with the previously described apparatus; however, the exhaust chucks 96 are preferably separated from the lamp 92 before said lamp 92 is unscrewed from the form 3. The operator releases the chucks 96 from the exhaust tubes 95 of the lamp 92 by unscrewing the caps 99 thereof sufficiently to relieve the pressure on the rubber glands 97 thereof and then pulls the exhaust chuck 96 off the end of the exhaust tube 95. The form 3 is then rotated in a clockwise direction while the lamp 92 is kept from movement so that said form 3 is actually unscrewed from the lamp 92 and returned to its starting position in one operation.

The successful bending of the glass tubing 2 or lamp 92 in the apparatus disclosed herein depends to a certain extent on the ability of the walls thereof to remain in shape and still be workable throughout the bending operation. It is therefore desirable to provide bending apparatus having other combinations of the described bending apparatus to adequately care for other glass bodies of different wall thickness and length and still other construction. For instance, the lamp being bent may not be injured by the use of air instead of inert gas so that air can be substituted therefor in all portions of the bending operation. The lamp can also be so short and of such small diameter that a single exhaust tube and cooperating exhaust chuck at one end thereof is sufficient for use in the manner described in modified apparatus. While in still other modifications of the bending apparatus the exhaust chucks can be moved toward the form during the bending operation by apparatus independent of the supporting means for the glass body and in still another, the exhaust chucks can engage the ends of the glass body only after it is bent about

the form in a manner corresponding to that shown in the first described modification.

The apparatus heretofore described can also be modified to form a helix of varying diameter without passing beyond the scope of my invention as, for instance, by substitution of the elements shown in Figs. 11 and 12 for corresponding elements therein. In the presently described modification a bending form 3'' is provided having a uniformly varying diameter such that the vitreous tubing 2'' is bent into a double helix having the shape of a conical double spiral. In combination with the form 3'' are provided movable means in the rolls 75'' and 76'' for guiding and pressing the vitreous tubing 2'' into the peripheral grooves therein and the previously described means of heating, transferring and holding the vitreous tubing 2'' in proper relation thereto. The vitreous tubing 2'' is initially placed between the raised lips 43''—43'' on the upper end of the form 3'' in a manner corresponding to the previous methods of operation and, as the form 3'' is rotated, and raised, is bent and drawn ino successive portions of the peripheral grooves 77*b*, 77*b*' by said form and rolls 75'' and 76'' which move to conform to the increase in diameter of the form. Each guide roll 75'' and the associated pressure roll 76'' are correspondingly mounted for rotation about spindles 115 extending from fixed arms 116 which are, in turn, mounted on standards 117 extending from a common slide 118 and are positioned by the engagement of the pressure roll 76'' with the form 3'' brought about by the biasing effect of a spring 119 engaging a post on the slide 118 and a connector on the side of the carriage 47. The slide 118 which is mounted below retaining plates 120—120 in ways of a bracket 121 attached to a portion of the frame (not shown in the present combination) supports the guide and pressure rolls 75'' and 76'' respectively at a fixed height causing them to engage that portion of the form 3'' into which the glass tubing 2'' is drawn as the bending operation progresses. The engagement of the periphery of the pressure rolls 76'' with the flat shoulder 122 above and below the grooves 77*b*, 77*b*' determines the position taken by said pressure rolls 76'' and accordingly effects the necessary outward movement of the pressure rolls 76'' when the pressure rolls 76'' are located opposite portions of the grooves 77*b*, 77*b*' and associated peripheral portions of the form 3'' of larger diameter. At the start of the bending cycle the grooves 77*b*, 77*b*' and the locating shoulders 122 of the form 3'' are located below, and therefore out of engagement with, the pressure rolls 76'' and the limits of movement of said pressure rolls 76'' are established by the engagement of slides 118 with stop posts 123. After the vitreous tubing 2'' is bent to conform to the form 3'' and then allowed to cool it can be removed therefrom by being unscrewed and then lifted from the form 3''. The above guide and pressure rolls 75'' and 76'' are capable of operation with other bending forms of differently varying shape; however, such different forms must have at least one flat surface adjacent the groove therein to provide an engagement surface against which the pressure rolls 76'' can bear.

The conical double spiral made on the apparatus shown in Figs. 11 and 12 may be changed to a flat spiral, when desired, by reheating the conical spiral and compressing it axially so that its turns then lie in a single plane with both its free ends at the outside of the spiral.

No claims are made herein to the lamps embodying the double helical tubes as described herein, that being the subject matter of my copending application Serial No. 787,949, filed of even date herewith.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The method of coiling tubes of vitreous material which comprises heating a tube to a workable temperature, engaging the tube at its mid-section and then helically coiling both ends of the tube in the same direction about a common axis to form a double helix.

2. The method of coiling tubes of vitreous material which comprises heating a tube to a workable temperature, engaging the tube at its mid-section and then helically coiling both ends of the tube simultaneously and in the same direction about a common axis to form a double helix.

3. A forming drum for elongated stock and having a pair of alternately spaced helical grooves on the outside surface thereof and provided with oppositely positioned input lips at one end thereof.

4. A forming drum for elongated stock and having a pair of alternately spaced helical grooves on the outside surface thereof and provided with a pair of oppositely positioned input lips defining therebetween a transverse groove interconnecting the said pair of spaced helical grooves at one end of the drum.

5. A forming drum for elongated stock and having a pair of alternately spaced helical grooves on the outside surface thereof and provided with a pair of oppositely positioned input lips defining therebetween a transverse groove interconnecting the said pair of spaced helical grooves at one end of the drum, said lips being joined to said transverse groove by tapered surfaces having the same direction of annular slope to permit removal of the stock from the drum by a reverse relative rotation between the drum and the stock.

6. Apparatus for bending a heated elongated vitreous body into a double helix comprising the combination of a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at one end thereof, means providing support surfaces transverse to the drum axis and on opposite sides thereof and in alignment with said one end of the drum for supporting the vitreous body with its mid-section across said drum, and means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum.

7. Apparatus for bending a heated elongated vitreous body into a double helix comprising the combination of a vertically disposed forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at its upper end, means providing a horizontal support surface on opposite sides of said drum and in alignment with its upper end for supporting the vitreous body with its mid-section overlying said drum, and means for simultaneously rotating said drum and moving it upwardly to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum.

8. Apparatus for bending a heated elongated vitreous body into a double helix comprising the combination of a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips

at one end thereof, means providing support surfaces transverse to the drum axis and on opposite sides thereof and in alignment with said one end of the drum for supporting the vitreous body with its mid-section across said drum, means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, and means located at fixed positions adjacent the surface of the drum for directing successive portions of the vitreous body into the drum grooves during movement of said drum.

9. Apparatus as set forth in claim 8 wherein the last-mentioned means comprise guide rolls on opposite sides of the drum and having their axes substantially normal to the pitch of the drum grooves, each guide roll having a peripheral groove therein opposite a respective groove in said drum.

10. Apparatus for bending a heated elongated vitreous body into a double helix comprising the combination of a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at one end thereof, means providing support surfaces transverse to the drum axis and on opposite sides thereof and in alignment with said one end of the drum for supporting the vitreous body with its mid-section across said drum, means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, and pressure rolls engaging the outside surface of said drum opposite portions of the respective helical grooves therein to progressively press the vitreous body into said grooves during the rotation of said drum.

11. Apparatus for bending a heated elongated vitreous body into a double helix comprising the combination of a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at one end thereof, means providing support surfaces transverse to the drum axis and on opposite sides thereof and in alignment with said one end of the drum for supporting the vitreous body with its mid-section across said drum, and means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, guide rolls located at fixed positions adjacent the surface of the drum and on opposite sides thereof on axes substantially normal to the pitch of the drum grooves, each said guide roll having a peripheral groove therein opposite a respective drum groove, and pressure rolls engaging the outside surface of said drum opposite portions of the respective grooves therein to progressively press the vitreous body into said grooves during the rotation of the drum.

12. In apparatus of the class described, the combination of means for supporting an elongated vitreous body, means adjacent said support means for heating said vitreous body to workable condition, a horizontal tray mounted adjacent said heating means and having an opening intermediate its length, means to effect transfer of the heated vitreous body from said supporting means to said tray with the mid-portion of said vitreous body lying across said opening, a vertically disposed forming drum having its upper end located in the opening in said tray, said drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at its upper end, and means for simultaneously rotating said drum and moving it upward to cause the vitreous body to be coiled around said lips and into the respective grooves in said drum.

13. Apparatus as set forth in claim 12 wherein the said means to effect transfer of the heated vitreous body includes an inclined chute extending from a position adjacent the said supporting means to a position over the said tray.

14. Apparatus as set forth in claim 12 wherein the said means to effect transfer of the heated vitreous body includes an inclined chute extending from a position adjacent the said supporting means to a position over the said tray, and wherein said supporting means comprises a pair of parallel rollers between which the vitreous body is supported, means to rotate said rollers to revolve the vitreous body thereon during heating thereof, and means for displacing one of said rollers with respect to the other to cause the vitreous body to fall onto the said chute for delivery to said tray.

15. Apparatus for bending a heated elongated tubular vitreous body into a double helix comprising the combination of a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at one end thereof, means providing support surfaces transverse to the drum axis and on opposite sides thereof and in alignment with said one end of the drum for supporting the vitreous body with its mid-section across said drum, means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, and means movable into operative relation with said drum and into engagement with an end of the tubular vitreous body for introducing therein a compressed gaseous medium to round out the surfaces thereof.

16. Apparatus of the class described comprising means for supporting an elongated tubular vitreous body having on its interior a coating which is sensitive to oxidation at elevated temperatures, means adjacent said support means for heating said vitreous body to a workable condition, a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at one end thereof, means providing a second support surface transverse to the drum axis and on opposite sides thereof and in alignment with said one end of the drum, means to transfer the vitreous body from said first supporting means to said second support surface with the mid-section of said vitreous body across the said one end of the drum, means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, and mean for introducing and maintaining non-oxidizing gas into said tubular vitreous body during the heating and coiling thereof.

17. Apparatus of the class described comprising means for supporting an elongated tubular vitreous body having on its interior a coating which is sensitive to oxidation at elevated temperatures, means adjacent said support means for heating said vitreous body to a workable condition, a forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at one end thereof, means providing a second support surface transverse to the drum axis and on op-

posite sides thereof and in alignment with said one end of the drum, means to transfer the vitreous body from said first supporting means to said second support surface with the mid-section of said vitreous body across the said one end of the drum, means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, and means to connect an end of said tubular vitreous body with a supply of non-oxidizing gas effective to introduce and maintain a gas in said tubular vitreous body during the heating and coiling thereof and to increase the pressure of the gas at the end of the coiling operation.

18. Apparatus for coiling a heated elongated vitreous body into helical form comprising the combination of a forming drum having its outer surface helically grooved and provided with a lip at one end, movable support means extending transversely to the drum axis and in alignment with said one end of the drum for holding a vitreous body with a portion thereof overlying said one end of the drum, means for rotating the drum and moving it axially to cause the vitreous body to be coiled around said lip and into the groove in said drum, and means for advancing the said movable support means toward said drum during rotation of the drum.

19. Apparatus as set forth in claim 6 wherein said support surfaces are movable, and including means mounting said support surfaces for movement toward the said drum.

20. In apparatus of the class described comprising a rotatable and axially movable forming drum having a helically grooved outer surface to receive a tubular vitreous body, means in close proximity to the surface of said drum arranged to cover the end of the said tubular body upon termination of the rotational and axial movement of the drum, and means for conducting compressed gas through said last-mentioned means into the said tubular body.

21. In apparatus of the class described comprising a rotatable and axially movable forming drum having a helically grooved outer surface to receive a tubular vitreous body, the terminal end of said groove having therein a protuberance which blocks the said end of the groove at a point closely adjacent to the end of a tubular vitreous body coiled around said groove, means in close proximity to the surface of said drum arranged to cover the end of the said tubular body and said protuberance upon termination of the rotational and axial movement of the drum, and means for conducting compressed gas through said last-mentioned means into the said tubular body.

22. In apparatus of the class described for coiling elongated stock, a conical forming drum having a pair of alternately spaced spiral grooves on the outside surface thereof and provided with oppositely positioned input lips at the smaller end thereof, means mounting said drum for simultaneous rotation and axial movement, pressure members located opposite portions of said drum grooves for pressing said stock into said grooves, and means mounting said pressure members for movement laterally of the drum axis in conformity with the surface of said drum during its axial movement.

23. Apparatus for bending a heated elongated vitreous body into a conical double spiral comprising the combination of a conical forming drum having a pair of parallel helical grooves on its outside surface and provided with oppositely positioned input lips at the smaller end thereof, means providing support surfaces transverse to the drum axis and on opposite sides thereof and in alignment with said smaller end of the drum for supporting the vitreous body with its mid-section across said drum, and means for simultaneously rotating said drum and moving it axially to cause the vitreous body to be coiled around said lips and into the respective grooves in the drum, guide rolls located at fixed positions adjacent the surface of the drum and on opposite sides thereof, and pressure rolls engaging the outside surface of said drum opposite portions of the respective grooves therein to progressively press the vitreous body into said grooves during the rotation of the drum, and means mounting said guide rolls and pressure rolls for movement laterally of the drum axis in conformity with the surface of said drum during its axial movement.

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The following references are of record in the file of this patent:

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