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APPARATUS FOR BENDING VITREOUS TUBING

Filed Nov. 18, 1937

2 Sheets-Sheet 1

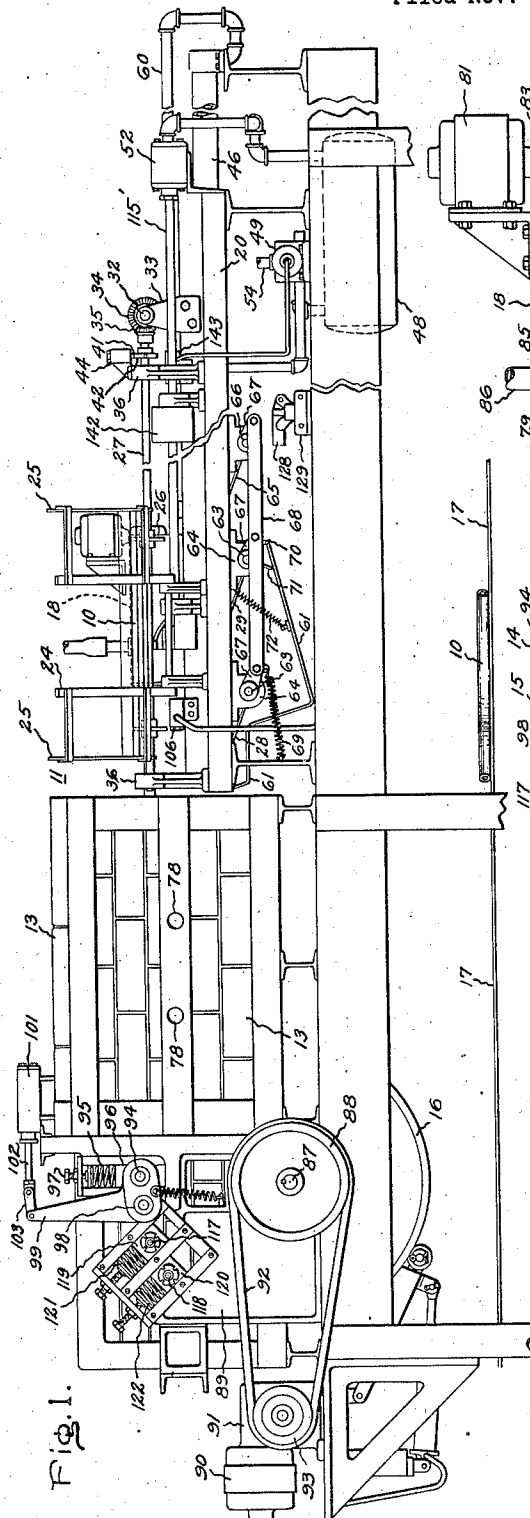


Fig. 1.

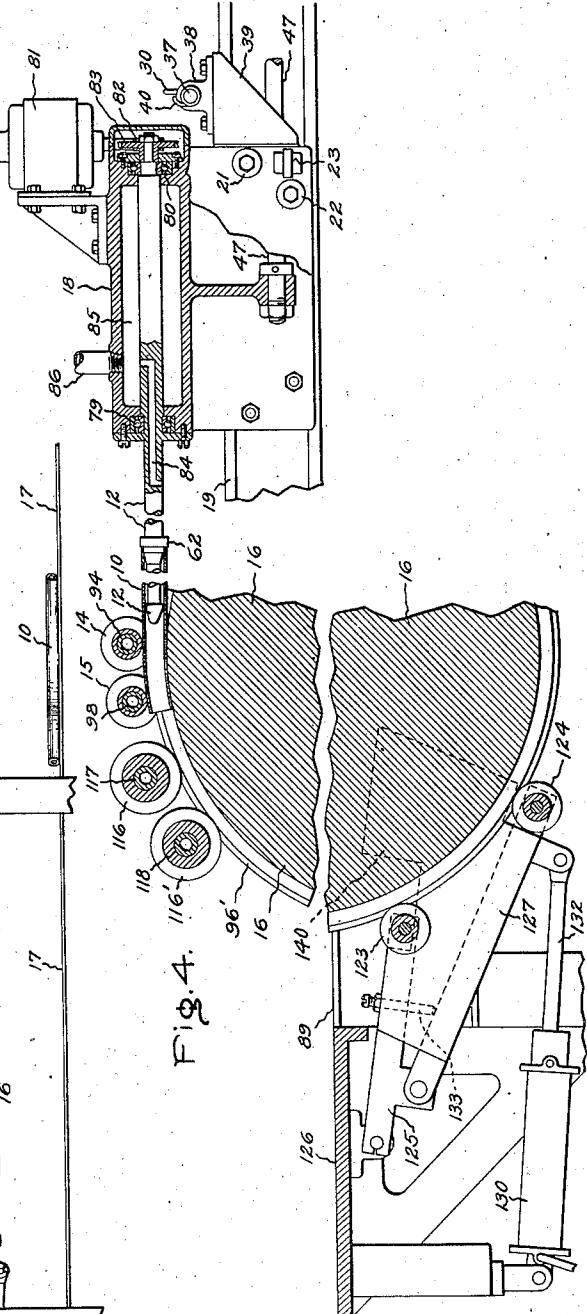


Fig. 4.

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2 Sheets-Sheet 2

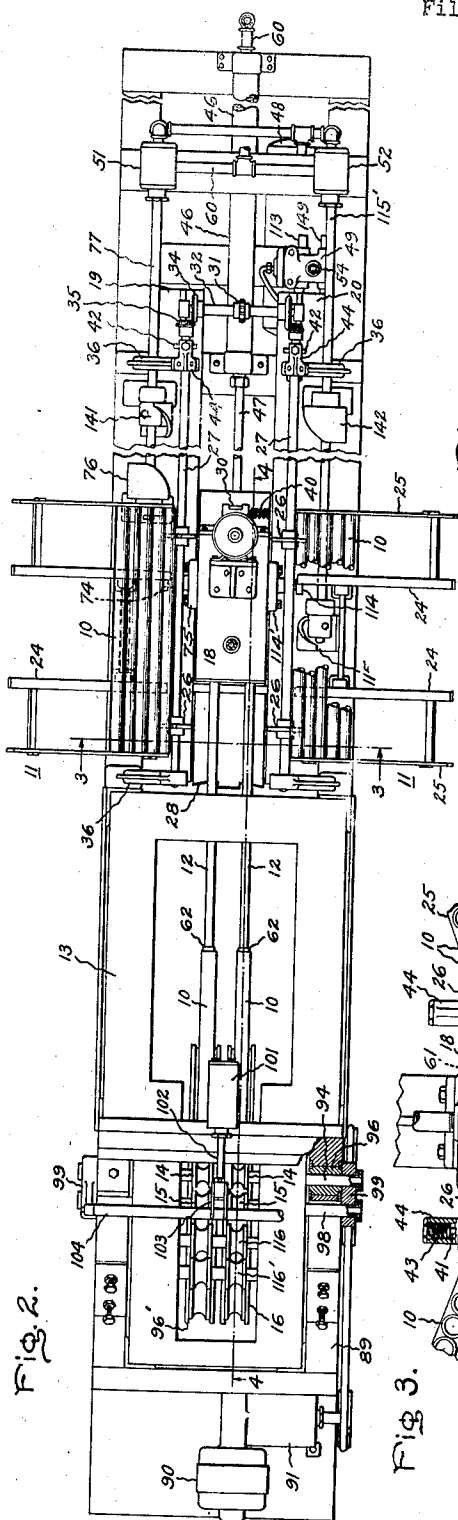


Fig. 2.

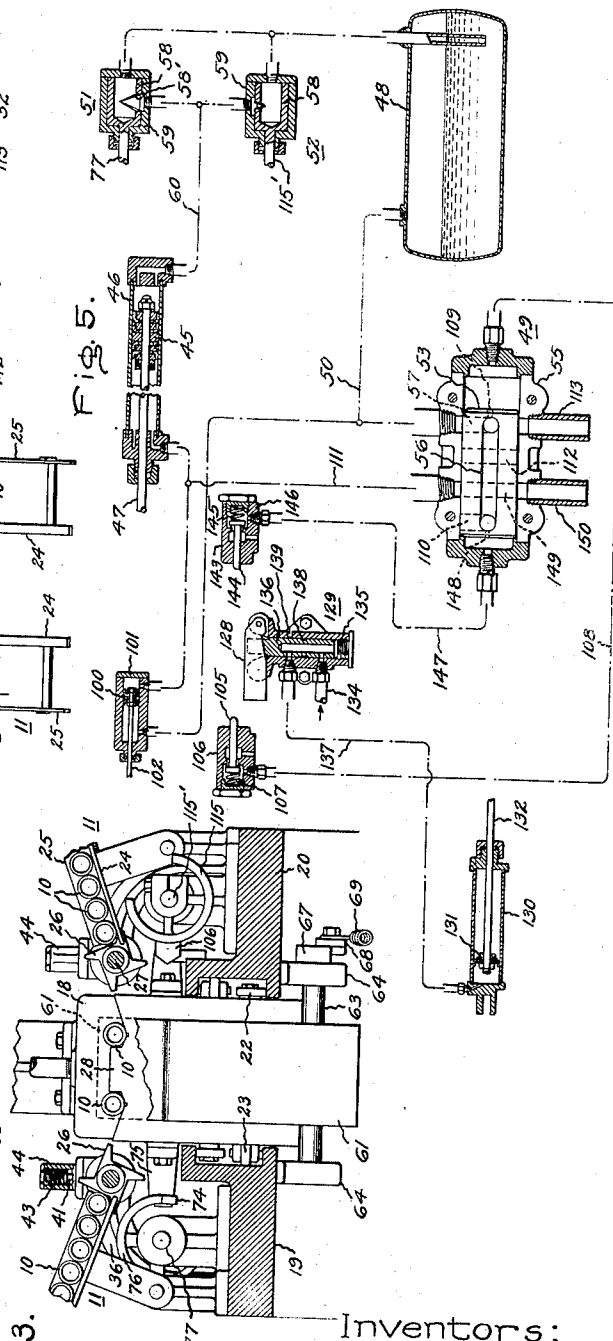


Fig. 3.

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UNITED STATES PATENT OFFICE

2,208,958

APPARATUS FOR BENDING VITREOUS TUBING

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Application November 18, 1937, Serial No. 175,196

10 Claims. (Cl. 49-7)

Our invention relates to apparatus for bending vitreous tubing or rods and more particularly to a machine for automatically bending short lengths of vitreous tubing or rods to a desired curvature.

Heretofore it has been the practice to bend vitreous tubing and rods manually with the assistance of tools which usually consisted of a form, means for heating the tubing and perhaps tools for bending the tubing around the form. A very high degree of skill was required by the worker and the operation was very slow and so costly as to prohibit the use of curved tubing for envelopes for incandescent lamps and most types of discharge lamps.

The principal object of our invention is to increase the speed and lower the cost of bending both vitreous rod and vitreous tubing by providing an entirely automatic machine for this purpose. Another object of our invention is to increase the uniformity of the bent rod or tubing. Other objects and advantages of our invention will appear from the following description of a tube or rod bending apparatus and from the drawings.

In the drawings, Fig. 1 is a side elevation of a tube bending machine comprising our invention with transverse sections removed therefrom to reduce the length of the drawing; Fig. 2 is a plan view thereof; Fig. 3 is a section along line 3-3 of Fig. 2 in the direction indicated; Fig. 4 is a vertical section along line 4-4 of Fig. 2 on an enlarged scale and with portions removed as indicated and the remaining parts moved nearer together; and Fig. 5 is a piping diagram with all apparatus therein shown in section.

The machine shown in the drawing simultaneously operates on two lengths of vitreous tubing 10 which are automatically fed from storage racks 11 at the middle and on opposite sides of the machine. A tube 10 is taken from each rack 11 at the same instant and is placed before the end of one of the spindles 12-12 which are at that instant located farther to the right than shown in Figs. 1 and 2. Each spindle 12 is moved to the left and passes into the interior of a tube 10 which is then released by its supporting means and is carried on said spindle 12 into the furnace or oven 13. The spindle 12 advances the tube 10 slowly through the furnace 13 so that the said tube is heated and softened before its end is inserted between the rollers 14-15 and the roll 16. The spindle 12 is then returned and the rotation of roll 16 carries the remainder of the tube 10 past the rollers 14-15 which bend it to the curvature of said roll. After an interval of time during which it cools down, the tube is carried to the dis-

charge conveyor belt 17 located below said roll 16 (Fig. 1). The machine is somewhat longer than shown and has sufficient structure to permit carriage 18 on which both spindles 12 are mounted to move the required distance. The movement of the carriage 18 controls the operations of the other portions of the machine which are controlled by means located along the path thereof and engaged by said carriage. The path of movement of the carriage 18 is along a track formed by the channeled bars 19 and 20 which are engaged by the rollers 21, 22 and 23 (Fig. 4) at each of the four corners of the carriage. The rollers 21 and 22 engage the top and bottoms of the channels in the bars 19 and 20 to hold the carriage 18 vertically in position and the rollers 23 engage the sides thereof to hold said carriage 18 in proper alignment.

In each instance, the tube 10 rests upon the inclined rails 24 of a rack 11 (Fig. 3) and is prevented from shifting longitudinally thereof by the end plates 25 attached thereto. The inclined position of the rails 24 causes one of the tubes 10 in the rack 11 to roll into corresponding notches of a pair of wheels 26 on a shaft 27 which feed a single tube 10 at intervals by a 90° rotation thereof. The teeth in the wheels 26 are only long enough to catch the particular tube 10 resting thereagainst and lift it up over the top of said wheels 26 where it rolls down the backs of the preceding teeth thereon and onto the upper edges of the vertically disposed plates 28 and 29 located adjacent the ends of rack 11. The said plates are shown in lowered position in Fig. 1. The wheels 26 are turned by the final movement of the carriage 18 in the preceding cycle of operation during which it travels to the right and carries the finger 30 (Figs. 2 and 4) against one of the teeth of the wheel 31 (Fig. 2). The finger 30 pushes the tooth engaged by it back, causing the wheel 31 and shaft 32 on which said wheel 31 is mounted to be turned slightly before the motion of carriage 18 is terminated. The shaft 32 is supported by a bracket 33 extending from each of the bars 19 and 20 and is provided with bevel gears 34 on opposite ends thereof which mesh with the bevel gears 35 on the ends of both shafts 27. The shafts 27 are supported by the brackets 36 attached to the bars 19 and 20. As shown in Figs. 2 and 4, the finger 30 is fastened to the pin 37 which is mounted in the bearing 38 on the bracket 39 extending from the carriage 18 and is prevented from turning in a counterclockwise direction by the portion of bearing 38 joining its ends. A torsion spring 40 has its ends

hooked in holes in the pin 37 and the bearing 38 and allows the finger 30 and pin 37 to be turned back by the teeth on wheel 31 when the carriage 18 moves in the opposite (forward) direction.

5 The rotation of the wheels 26 is limited to 90 degrees by a pin 41 (Figs. 1 and 3) which drops into notches in the rims of wheels 42 on shafts 27 and which is pressed thereagainst by the spring 43. The pin 41 is held in place by an arm 44 extending from one of the brackets 36 which provides a chamber in which the spring 43 is confined.

Immediately after the tubes 10 take positions before the spindles 12—12, the carriage 18 is moved to the left, carrying the spindles 12—12 into the interior of the said tubings 10. This movement of the carriage 18 is brought about by a corresponding movement of a piston 45 in a cylinder 46 (Figs. 1, 2 and 5) to which the carriage 18 is connected by rod 47, and results from the entrance of a liquid, preferably oil, into the right hand end of said cylinder 46. The liquid is forced into said cylinder 46 from a storage tank 48 by air introduced in said tank 48 through a piston valve 49 and pipe 50 and passes through valves 51 and 52 which control the rate of flow. At this time, a piston 53 (Fig. 5) in valve 49 is in the position shown and the compressed air is introduced therein from a source (not shown) through pipe 54 (Figs. 1 and 2) directly on top of the outer casing 55 thereof. From the pipe 54, the air passes into the longitudinal groove 56 in the top of the piston 53 which conducts it to the angular passage 57 therein in alignment with a hole in the casing 55 leading to pipe 50. The movement of the carriage 18 is fairly rapid at this time since the hollow cores 58 in valves 51 and 52 are turned so that the wider portion of the V slots 58' therein are opposite the openings in the bodies 59 which are both connected to the cylinder 46 through pipe 60.

During the first part of the movement of the spindles 12—12, the tubes 10—10 are held in position by the stop plate 61 (Figs. 1 and 3) which is then located in front of the left ends thereof as shown in Fig. 3, but after spindles 12—12 have passed into the tubes 10—10 so that the shoulders 62—62 thereon engage the ends of the tubes, the stop plate 61 and supporting plates 28 and 29 drop down to the positions shown in Fig. 1. Each of the supporting plates 28 and 29 is mounted on a shaft 63 which is supported from both ends by a bearing 64 fastened either to bar 19 or to bar 20 and is moved down by the movement of the carriage 18 against the plate 65 (only partially shown in Fig. 1) which pushes the plate 65 down to the position shown in Fig. 1. The plate 65 is mounted on a transverse shaft 66 which is connected to shafts 63 by three arms 67 and a rod 68 so that a movement of plate 65 causes corresponding movements of the supporting plates 28 and 29. The downward movement of the plates 28, 29 and 65 stretches the spring 69 which is connected to a stationary part of the machine and one of the arms 67. The stop plate 61 is pivoted at 70 on arms extending from one pair of bearings 64 and is moved down by the pressure of a plate 71, mounted on one of the shafts 63, thereagainst.

70 The downward movement of the stop plate 61 stretches the spring 72 located between posts therein and in supporting plate 29.

The rapid movement of the carriage 18 continues only until the tubes 10—10 are completely within the furnace 13, whereupon a roller 74 (Figs.

2 and 3) which is attached to the far side of the carriage 18 by means of a bracket 75 engages a cam 76. The cam 76 is connected to the core 58 of valve 51 through the shaft 77 and, when rotated by the roller 74, turns the core 58 so that flow of liquid through the valve 51 is lessened and the carriage is moved more slowly. The speed of movement of the carriage 18 is now such that the tubes 10—10 are retained, until properly heated, within the furnace 13 which is built of fire brick and has gas burners (not shown) on opposite sides to which the gas and air mixture is conducted through the holes 78 therein. The temperature of the furnace 13 is preferably controlled automatically by means (not shown) in order to assure the most efficient operation of the machine. To facilitate a thorough and uniform heating of each of the tubes 10—10, the said tubes are constantly rotated by the rotation of the spindles 12—12 which, as shown in Fig. 4, are each mounted on ball bearings 79 and 80 in the carriage 18 and are driven by an electric motor 81 mounted thereon. The connection between the motor 81 and the spindles 12—12 is made through a worm gear 82 mounted on the motor shaft which meshes with gears 83 on each of the spindles. Since excessive heat can be conducted back to the bearings in the carriage 18 in some instances, the spindles 12—12 are cooled by a flow of air in the passage 84 in each spindle which connects to the chamber 85 in the carriage 18 into which air is introduced through pipe 86.

By the time the forward end of each of the vitreous tubes 10—10 is heated sufficiently to permit bending, said end is carried between the rollers 14—15 and the form or roll 16 by the movements of the carriage 18. The rollers 14 and 15 and the roll 16 are preferably made of carbon so as not to stick to the tubes 10—10 and are provided with semi-circular grooves in the faces thereof which conform to the exterior shape of the tubes. Once a tube 10 passes between these rollers 14—15 and the roll 16, it is advanced by the rotation of the roll 16 which is mounted on a shaft 87 and is turned in a counter-clockwise direction by a pulley 88 mounted thereon. The shaft 87 is mounted in the frame 89 of the machine which also supports an electric motor 90 and speed reducer 91 which operates the pulley 88 through a belt 92 and pulley 93 on the shaft of the speed reducer 91.

The roll 16 has a fixed relation to the roller 14 which is mounted on a hollow shaft 94 and is pressed down against roll 16 by springs 95 located above slide blocks 96 on the opposite ends of shaft 94. The outer rims of the roller 14 ride in grooves 96' in the periphery of roll 16 at opposite sides of the semi-circular groove therein and does not distort the tube 10. The slide blocks 96 are located in ways in the frame 89 and engage one end of springs 95 which are retained in the required state of compression by bolts 97. At the time the end of the tube 10 passes under the roller 14, the roller 15 is held in a raised position and does not contact the tubing 10, but shortly thereafter said tube 10 passes below the roller 15 which is lowered so that the end of the tube is bent down into contact with roll 16. The roller 15 is mounted on a hollow shaft 98 which is supported by a lever 99 at each side of the machine and is caused to move down by a piston 100 in a cylinder 101 which is connected to said levers 99 through a rod 102, link 103 and rod 104. The

carriage 18 is directly responsible for the movement of the roller 15 since it reaches the limit of its movement at this time and strikes the control pin 105 of a valve 106 which causes the piston 53 within the valve 49 to shift and compressed air to pass into the cylinder 101 behind the piston 100. The carriage 18 moves the control pin 105 back into the valve 106 (Fig. 5) thereby compressing the spring 107 and opening said valve 106 so that air is bled from the space behind the piston 53 through the pipe 108 and said valve 106. In this way, the piston 53 is shifted since the inflow of air into the space referred to through the opening 109 in said piston 53 is not sufficient to prevent the air pressure behind the other end thereof from causing it to move. In the new location of the piston 53, the compressed air passing into the valve 49 through the pipe 54 is conducted by the groove 56 and an angular passage 110 in the piston 53 to the opening in the valve casing 55 leading to pipe 111. The pipe 111 conducts the compressed air to the cylinder 101, which lowers the roller 15 as described, and to the forward end of cylinder 46 which pushes the piston 45 and carriage 18 back.

In order that the piston 45 can be moved by the compressed air in the cylinder 46, the compressed air within the tank 48 is vented to the atmosphere through the valve 49 and the liquid within the cylinder 46 flows back into said tank 48 through valves 51 and 52. The venting takes place through transverse passage 112 in the piston 53 which now is located in alignment with openings in the casing 55 leading to pipe 50 and the pipe 113. The return movement of the carriage 18 is more rapid than the forward movement thereof as said carriage 18, at the end of its forward movement, carries a roller 114 (Fig. 2) attached to the side thereof by the bracket 114', against a cam 115. The cam 115 is connected by a rod 115' to the core 58 of the valve 52 which is turned so that the liquid in the cylinder 46 is permitted to return to the storage tank 48 more rapidly than it passed therefrom.

The tube 10 is now supported solely by the rollers 14—15 and the roll 16 and is advanced therebetween by the rotation of the roll 16 which also advances the bent or curved end under the rollers 116 and 116'. The rollers 116 and 116' each have a semi-circular groove therein that conforms to the shape of the tubing 10 and are pressed against the roll 16 so that the rims thereof ride in the grooves 96' in said roll 16 and the tubing 10 is held in place while cooling. The rollers 116 and 116' are supported by hollow shafts 117 and 118 respectively which are mounted in slide blocks 119 and 120 respectively in ways of the frame 89 at both sides of the machine and are pressed against the roll 16 by springs 121 and 122 located thereabove. During the rotation of the roll 16 the forward end of the tubing is carried farther around with the roll 16 and finally is engaged by the rollers 123 and 124 (Fig. 4) which hold it against roll 16 for an interval during which it is allowed to cool and is carried nearer to the discharge conveyor belt 17. The roller 123 is supported by an arm 125 which is pivoted on a bracket 126 extending from the frame 89 of the machine, whereas roller 124 is supported by an arm 127 pivotally attached to the arm 125. The rollers 123 and 124 are retained in this position only during the interval the tube 10 is advanced thereto since a following tube 10 is then being transferred onto the plates

28 and 29 (Fig. 1) and the bar 68 which moves them into position to receive said tubing 10 is against the control arm 128 of a valve 129. The valve 129 (Fig. 5) controls the flow of compressed air into the cylinder 130 behind the piston 131 which is connected to the arm 127 by rod 132 and which swings said arm 127 so that the rollers 123 and 124 are placed in the position shown. The arm 125 is carried up into position by the arm 127 which it engages through the bolt 133.

As shown in Fig. 5, the compressed air is introduced into the valve 129 through pipe 134 and is conducted through the passages in the valve body 135, the piston 136 and the pipe 137 to the cylinder 130. The control arm 128 of the valve 129 is pivoted in the valve body 135 and moves the piston 136 down against the lifting force of the compressed air within the passage in said piston 136. When the roll 16 turns so far that the tube 10 is located on the lower portion thereof the rollers 123 and 124 are swung down and back from said roll 16 so that the tube 10 is partially carried and partially rolls down onto the conveyor belt 17. This action results from the bleeding of the compressed air from the cylinder 130 through the valve 129 which permits the weight of the arms 125 and 127 to carry the rollers 123 and 124 down and is brought about by the downward movement of the plate 29 with the forward movement of the carriage 18 which raises the bar 68 from the control arm 128 of the valve 129. The compressed air within the piston 136 of the valve 129 raises it when the pressure is released from the control arm 128 so that a groove 138 around said piston 136 is brought into alignment with the passage in the valve body 135 leading to pipe 137 and the exhaust opening 139 in said body 135. In this way, the tube 10 is placed on the conveyor belt 17 so gently that all possibility of distortion is eliminated and the finished tube 10 is carried away from the machine by the conveyor 17. A partition 140 attached to the arm 127 prevents the tubes 10—10 from touching each other when they are unloaded. This partition 140 passes up into a space between the rolls 16—16 when the rollers 123 and 124 are in the raised position.

The return movement of the carriage 18 withdrawing the spindles 12—12 from the furnace 13 occurs at a uniform rate until nearly the end of the stroke is reached whereupon the rollers 14 and 114 on opposite sides thereof engage cams 141 and 142 respectively which adjust the valves 51 and 52. The cams 141 and 142 are mounted on the rods 77 and 115' which are connected to the cores 58—58 of the valves 51 and 52 and turn said cores 58—58 so that the flow of liquid through valve 51 is more rapid and through valve 52 is less rapid. This adjustment sets the speed of the forward movement of the carriage 18 which is now brought about by the striking of roller 114 thereon against valve 143. The valve 143 bleeds the compressed air from the left end (Fig. 5) of the piston 53 in valve 49 so that it shifts to the position shown and compressed air is permitted to flow through passage 57 to the tank 48 to actuate the carriage 18 as already described. The roller 114 engages the pin 144 of valve 143 which compresses the spring 145 and separates the flanged portion of the pin 144 from its seat on the valve body 146. The air allowed to escape through the valve 143 passes thereto through pipe 147 and flows more rapidly from the valve casing 55 than it is permitted to flow in through the hole 148 in the piston 53 so that the full air pres-

sure against the opposite end of the piston 53 causes it to shift. The air behind the left hand end of the piston 45 in cylinder 46 is exhausted through pipe 111, the transverse passage 149 in the piston 53 and the pipe 150 as succeeding repeat operations of the apparatus, which have been described, are brought about.

While we have shown and described certain novel features of the invention, it will be understood that various omissions, substitutions and changes in the form and details of the device illustrated and in its use and operation may be made by those skilled in the art without departing from the broad spirit and scope of the invention.

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

1. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for advancing the tubing into the oven to heat it to its softening temperature and for then advancing it into engagement with the form, means for pressing said tubing against said form, and means for rotating said form to carry the tubing thereon past said pressing means and to cause it to be bent to the shape of the form, the tube-engaging portions of said form and pressing means having opposed peripheral grooves of substantially the same cross sectional shape as the tubing to prevent distortion of its cross-sectional shape during the bending operation.

2. Apparatus for bending vitreous tubing comprising an oven, a roll the curvature of the periphery of which corresponds to the desired shape of the tubing rotatably mounted adjacent said oven, means for advancing the tubing into said oven to heat it to its softening temperature and for then advancing it into engagement with said roll, a plurality of rollers located adjacent the periphery of said roll for pressing said tubing against said roll, and means for rotating said roll to carry the tubing thereon past said rollers to cause it to be bent to the curvature of said roll, the tube-engaging portions of said roll and rollers having opposed peripheral grooves of substantially the same cross-sectional shape as the tubing to prevent distortion of its cross-sectional shape during the bending operation.

3. Apparatus for bending vitreous tubing comprising an oven, a roll the curvature of the periphery of which corresponds to the desired shape of the tubing rotatably mounted adjacent said oven, means for advancing the tubing into said oven to heat it to its softening temperature and for then advancing it into engagement with said roll, a plurality of rollers located adjacent the periphery of said roll for pressing said tubing against said roll, means for rotating said roll to carry the tubing thereon past said rollers to cause it to be bent to the curvature of said roll, and means for holding the tubing against said roll during further rotation thereof to allow said tubing to cool while it is still retained in the desired shape, the tube-engaging portions of said roll and rollers having opposed peripheral grooves of substantially the same cross-sectional shape as the tubing to prevent distortion of its cross-sectional shape during the bending operation.

4. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting the tubing adjacent said oven, a spindle adapted to

enter the tubing, means for carrying said spindle into the tubing and then further advancing it to carry said tubing into said oven to heat it to its softening temperature and then to carry an end of said tubing into engagement with said form, means for pressing said tubing into engagement with said form, and means for rotating said form to carry the tubing thereon past said pressing means and cause it to be bent to the shape of said form.

5. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting the tubing adjacent said oven, a spindle adapted to enter the tubing, a carriage for supporting said spindle, a track for said carriage located adjacent said tubing holding means and said oven, means for moving said carriage on its track to carry the said spindle into the tubing and then further advancing it to carry said tubing into said oven to heat it to its softening temperature and then to carry an end of said tubing into engagement with said form, means for pressing said tubing into engagement with said form, and means for rotating said form to carry the tubing thereon past said pressing means and cause it to be bent to the shape of the form.

6. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting the tubing adjacent said oven, a spindle adapted to enter the tubing, a carriage for supporting said spindle, a track for said carriage located adjacent said tubing holding means and said oven, means for moving said carriage on its track to carry the said spindle into the tubing and then further advancing it to carry said tubing into said oven to heat it to its softening temperature and then to carry an end of said tubing into engagement with said form, means carried by said carriage for rotating said spindle to cause the tubing thereon to be rotated while it is in the oven, means for pressing the tubing into engagement with said form, and means for rotating said form to carry the tubing thereon past said pressing means and cause it to be bent to the shape of said form.

7. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting the tubing adjacent said oven, a spindle adapted to enter the tubing, a carriage for supporting said spindle, a track for said carriage located adjacent said tubing holding means and said oven, means for moving said carriage on its track to carry said spindle into the tubing and then further advancing it to carry said tubing into said oven to heat it to its softening temperature and then to carry an end of said tubing into engagement with said form comprising a cylinder located adjacent said track and having a piston therein attached to said carriage for moving it, a tank connected to one end of said cylinder and containing a liquid, and means for supplying air pressure to said tank to force liquid therefrom into said cylinder and against one side of the piston therein to advance the carriage and for supplying air pressure to the other side of said piston to retract the carriage, means for pressing the tubing into engagement with said form, and means for rotating said form to carry the tubing

thereon past said pressing means and cause it to be bent to the shape of said form.

8. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting the tubing adjacent said oven, a spindle adapted to enter the tubing, a carriage for supporting said spindle, a track for said carriage located adjacent said tubing holding means and said oven, means for moving said carriage on its track to carry said spindle into the tubing and then further advance it to carry said tubing into said oven to heat it to its softening temperature and then to carry an end of said tubing into engagement with said form comprising a cylinder located adjacent said track and having a piston therein attached to said carriage for moving it, a tank connected to one end of said cylinder and containing a liquid, means for supplying air pressure to said tank to force the liquid therefrom into said cylinder and against one side of the piston therein to advance the carriage and for supplying air pressure to the other side of said piston to retract the carriage, a valve connected to said tank and to said cylinder for controlling the flow of liquid therebetween and means disposed along the path of movement of said carriage and engaged thereby for adjusting the position of said valve and varying the rate of movement of the said carriage, means for pressing the tubing into engagement with said form, and means for rotating said form to carry the tubing thereon past said pressing means and cause it to be bent to the shape of said form.

9. Apparatus for bending vitreous tubing comprising an oven, a form having a contour of the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting a plurality of tubings adjacent said oven, a plurality of spindles each adapted to enter one of said

tubings, a carriage for supporting said spindles, a track for said carriage located adjacent said tubing holding means and said oven, means for moving said carriage on its track to carry each of said spindles into one of said tubings and then further advance it to carry the tubing into said oven to heat it to its softening temperature and then to carry an end of the tubing into engagement with portions of said form, means for pressing tubings into engagement with said form, and means for rotating said form to carry the tubings thereon past said pressing means and cause said tubings to be bent to the shape of the form.

10. Apparatus for bending vitreous tubing comprising an oven, a plurality of rolls the curvature of the peripheries of which correspond to the desired shape of the tubing rotatably mounted adjacent said oven, means for supporting a plurality of tubings adjacent said oven, a plurality of spindles each adapted to enter one tubing, a carriage for supporting said spindles, a track for said carriage located adjacent said tubing holding means and said oven, means for moving said carriage on its track to carry each of said spindles into a tubing and then further advance it to carry the tubing into said oven to heat it to its softening temperature and then to carry an end of the tubing into engagement with the periphery of one of said rolls, means carried by said carriage for rotating said spindles to cause the tubings thereon to be rotated while in said oven, a plurality of rollers located adjacent the periphery of said rolls for pressing the tubings into engagement therewith, and means for rotating said rolls to carry the tubings thereon past said rollers and cause said tubings to be bent to the curvature of said roll.

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