July 4, 1961

J. L. CHANEY

2,990,648

THERMOMETER TUBE FORMING APPARATUS

Filed Nov. 7, 1956

5 Sheets-Sheet 1

FIG-1

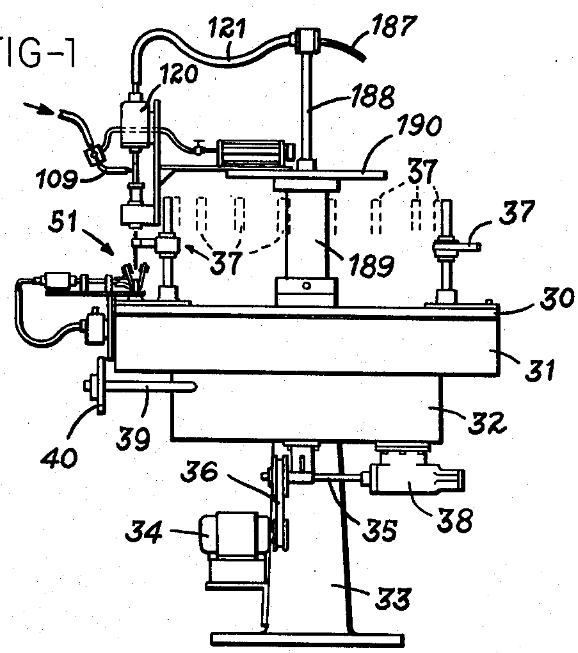

FIG-2

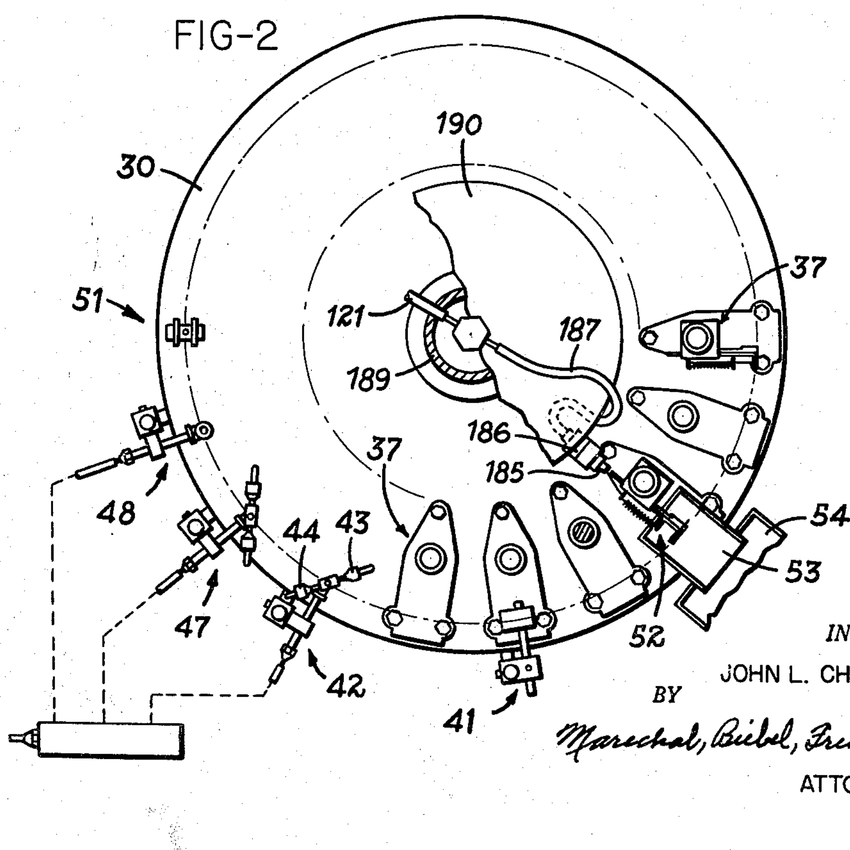

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FIG-3

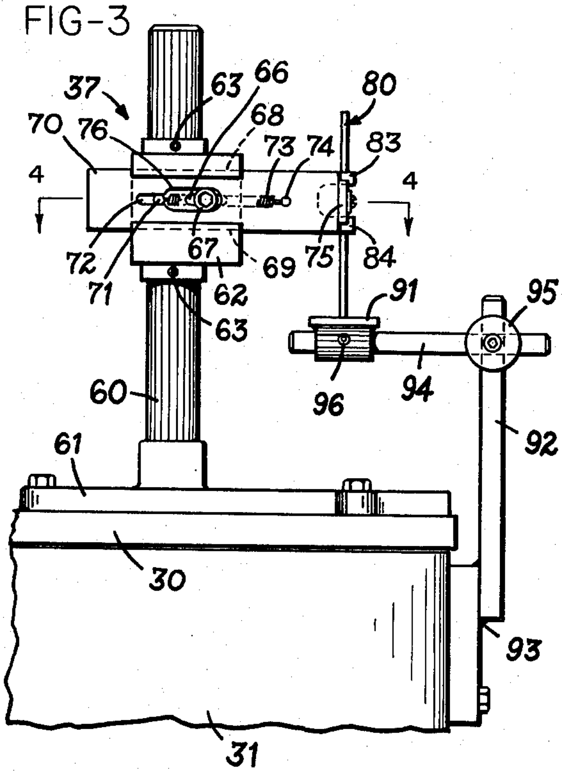

FIG-4

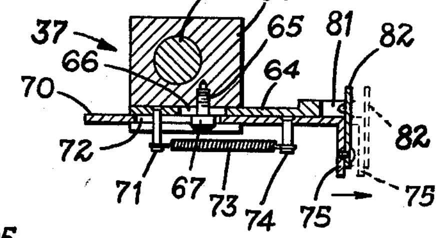

FIG-5

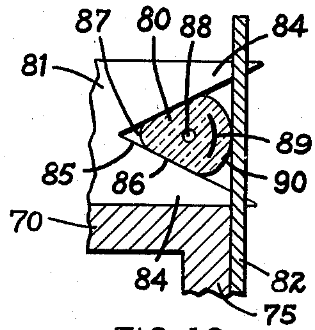

FIG-10

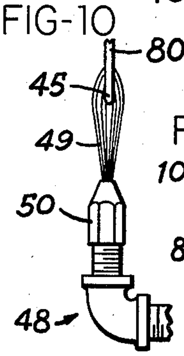

FIG-6

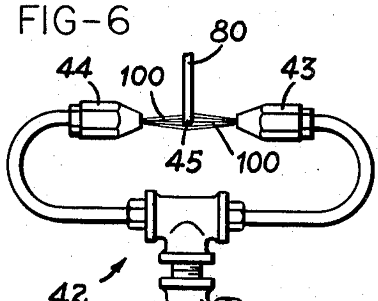

FIG-8

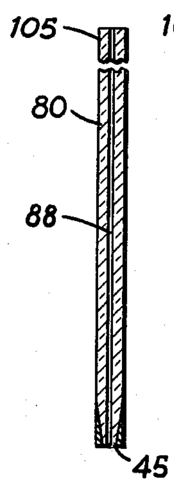

FIG-9

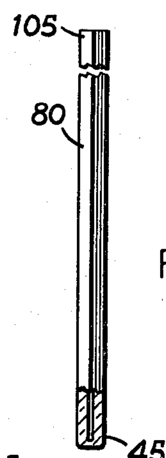

FIG-12

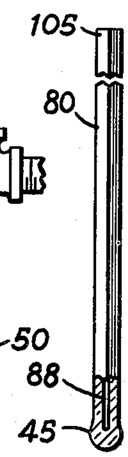

FIG-11

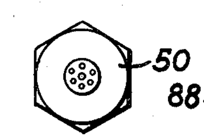

FIG-7

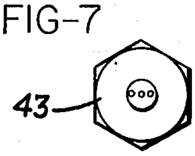

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FIG-13

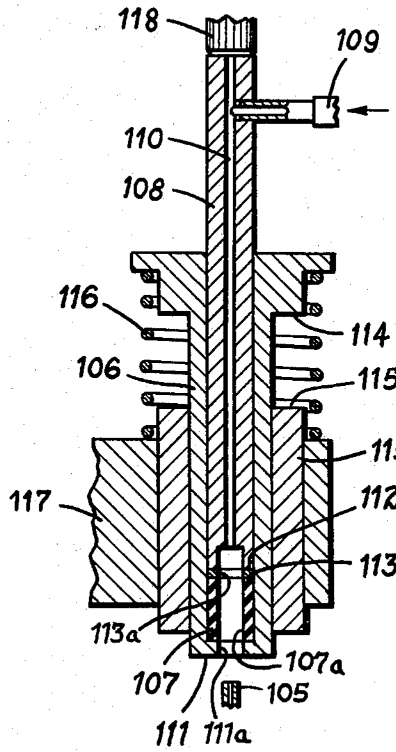

FIG-14

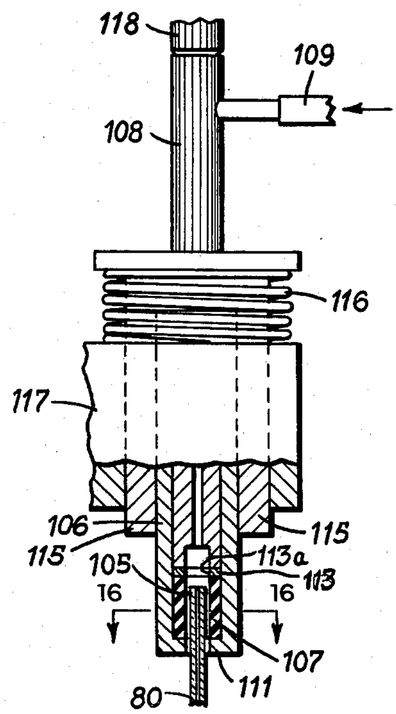

FIG-16

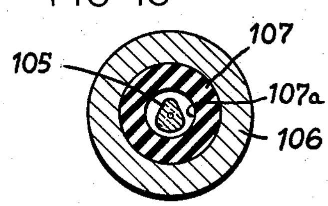

FIG-18

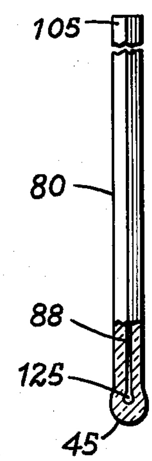

FIG-15

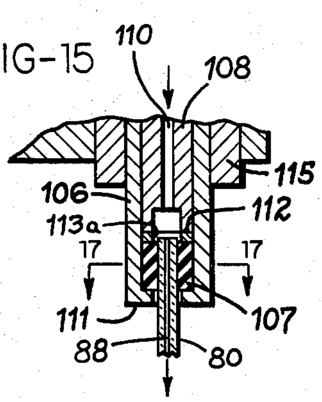

FIG-17

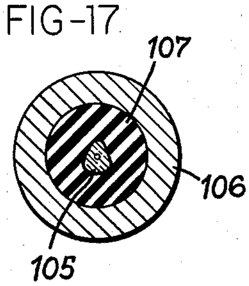

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FIG-19 FIG-20 FIG-21 FIG-25

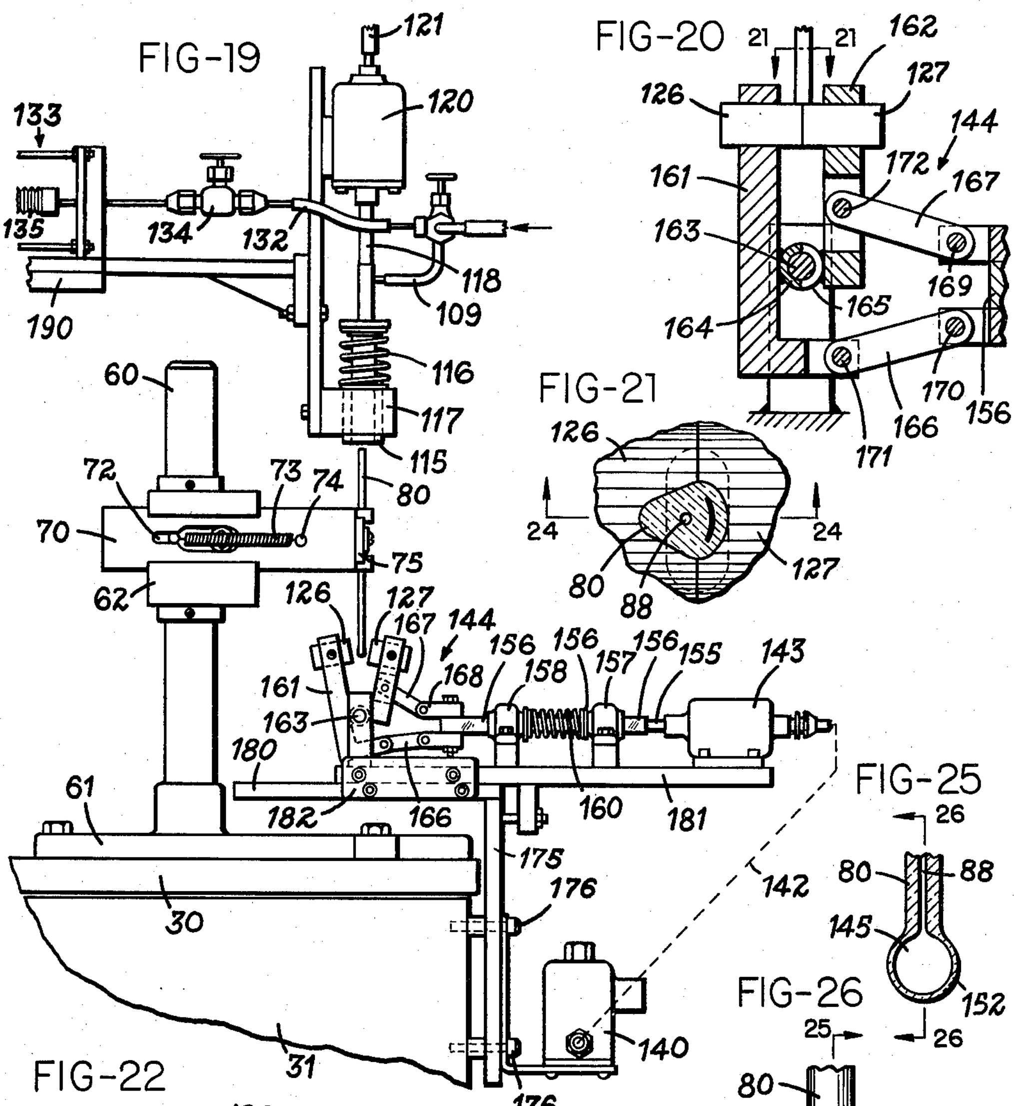

FIG-26

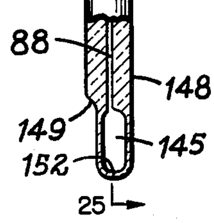

FIG-22

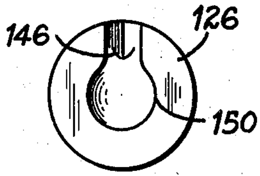

FIG-24

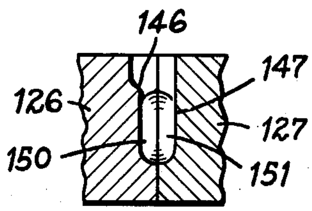

FIG-23

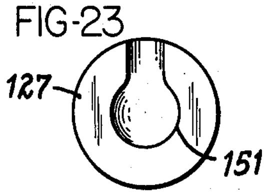

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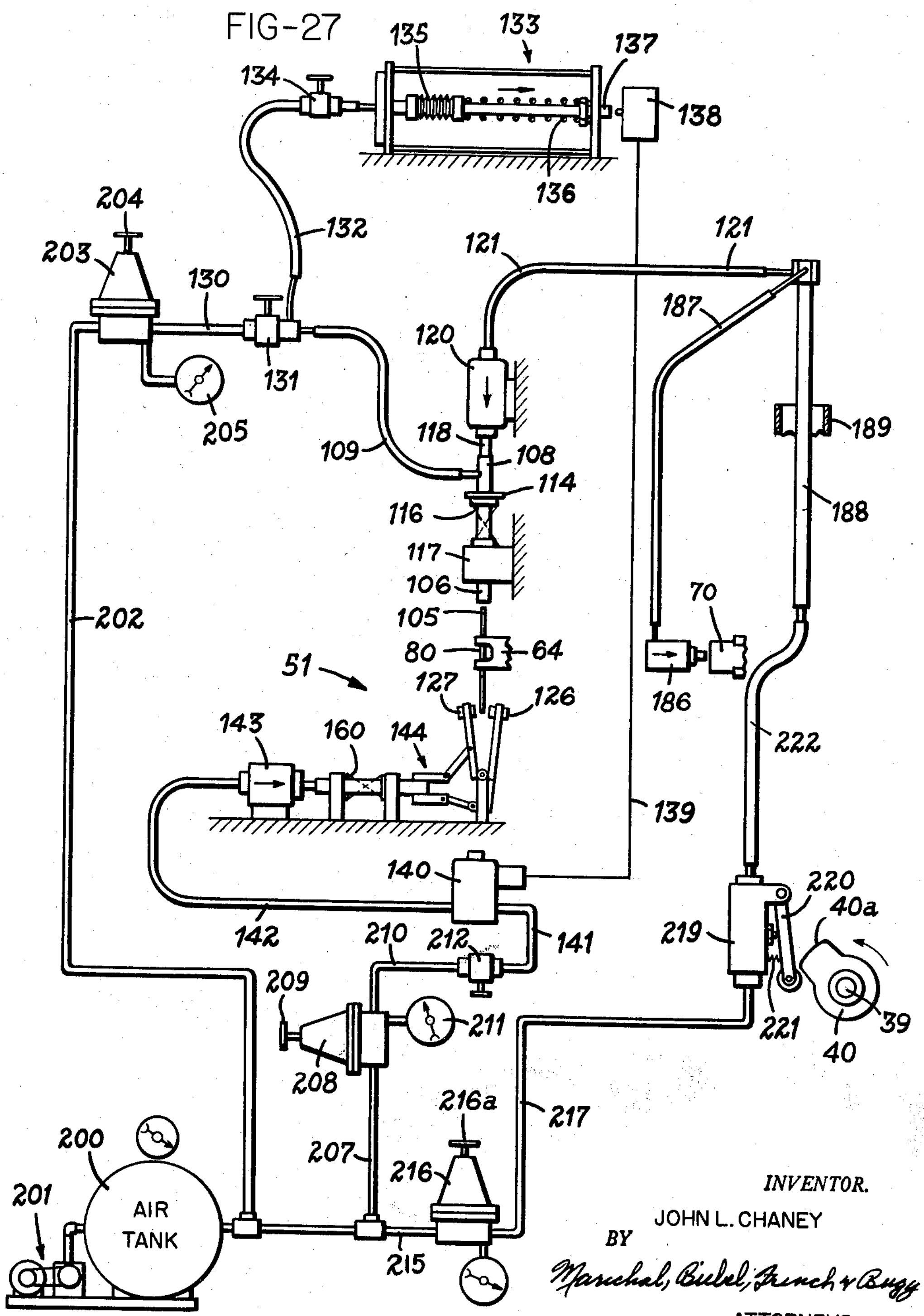
FIG-27



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THERMOMETER TUBE FORMING APPARATUS

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Filed Nov. 7, 1956, Ser. No. 620,837

5 Claims. (Cl. 49—7)

This invention relates to the manufacture of thermometer tubes or the like.

Thermometers as now manufactured and sold contain a temperature responsive and indicating liquid. This liquid is contained in an inner-temperature indicating passageway or bore of very small, hairlike, or capillary diameter. A liquid holding bulb is connected to this passageway at its bottom. The bulb holds approximately ten times as much liquid as the temperature indicating passageway, hence any small variation in the size of the bulb multiplies many fold its effect on the temperature indications. A tube ordinarily is shaped with a magnifying front to magnify the airlike column of liquid, and a reflecting face ordinarily is included to aid in reading the column. The tube ordinarily is placed against a flat scale which indicates the temperature in degrees. It is desirable to flatten the bulb and to locate it to one side of the tube axis to present a continuously straight face adjacent the flat scale. This is desirable so the tube and bulb can be secured closely adjacent the flat scale, to permit the temperature to be accurately and easily read. The previous methods used in the formation of the bulbs at the bottoms of the tubes have required considerable individual skill and such human equation has resulted in great irregularity in the formation of the bulbs. The present invention overcomes the disadvantages in previous manufacture by eliminating reliance on such individual skill and results in much greater uniformity of production, effectively reducing the previous high volume of scrap.

The previous methods resulted in the formation of many different sizes or groups of bulbs. Each one of these groups required a different scale to be placed behind the tube. This was necessary because any change in the volume of the bulb was magnified in the lineal travel of the thermostatic liquid in the hairlike temperature indicating passageway, since the volume of the bulb is approximately 10 times that of the passageway. These tubes are matched to the necessary scale by first cooling the thermometer, without the scale, in ice and water, to mark the 32° F. on the tube. Thereafter the tubes are heated to some other temperature such as 90° F. and a second mark is made. The distance between the marks establishes the class or group. With the previous methods, the variations were so great that approximately 20 different groups of tubes, and 20 different scales were required. The present invention results in much greater uniformity of bulb size, and has materially reduced the number of groups of tubes and scales, to approximately 6, with a resulting saving in time for sorting and selecting the tubes and scales and less wastage at the extremes.

Hence, an object of this invention is to provide an improved apparatus for sealing the ends of thermometer tubes and forming bulbs at the ends of such tubes with great rapidity and uniformity.

Another object of this invention is to provide apparatus in which a series of thermometer tubes are automatically sealed at their bulb forming end and bulbs are formed at such ends with great uniformity and rapidity.

Another object of this invention is to provide an apparatus in which a series of thermometer tubes are moved by an endless conveyor past a plurality of stations where the bulb ends of the tubes are sealed while being heated to a molten condition, and in which a gaseous medium under pressure is introduced into the open ends of the tubes while a mold is maintained at the bulb ends of the tubes to form and control the formation of the bulbs at these ends.

Further objects will become apparent as the description proceeds.

In the drawings:

FIG. 1 is a diagrammatic elevation of certain parts of a machine embodying this invention.

FIG. 2 is a top plan view, partly broken away, and enlarged, of the machine shown in FIG. 1.

FIG. 3 is an enlarged elevation of the elements adjacent the tube locating station of the machine.

FIG. 4 is a horizontal cross-section taken along the line **4—4** of FIG. 3.

FIG. 5 is an enlargement of a portion of FIG. 4.

FIG. 6 is a side elevation of some of the heating elements at one of the heating stations of the apparatus.

FIG. 7 is an enlarged end view of one of the burner elements shown in FIG. 6.

FIG. 8 is a cross-section of one of the tubes immediately after it has been subjected to the first heating operation.

FIG. 9 is a view, partly in elevation and partly in cross-section, showing the tube immediately after a further heating step which occurs at another station and during which the bulb end of the tube is initially sealed.

FIG. 10 is a side elevation of the tube and heating element in the final heating station.

FIG. 11 is an enlarged end view of the burner element of FIG. 10.

FIG. 12 is a view similar to FIG. 9, but showing a further sealing and melting action produced by the heating element of FIG. 10.

FIG. 13 shows the gaseous medium introducing elements of the apparatus at the bulb forming station and at the initial stage of operation.

FIG. 14 shows the elements shown in FIG. 13, but during a subsequent stage where the apparatus has surrounded the open end of the thermometer tube.

FIG. 15 shows a portion of the elements shown in FIG. 14 at a further subsequent stage of operation where the sealing sleeve has compressed and sealed itself around the end of the thermometer tube.

FIG. 16 is an enlarged cross-section taken along the line **16—16** of FIG. 14.

FIG. 17 is an enlarged cross-section taken along the line **17—17** of FIG. 15.

FIG. 18 shows the thermometer tube at the time when the initial enlargement has been formed at the molten bulb end of the tube.

FIG. 19 is an elevation of the elements at the bulb forming station of the apparatus.

FIG. 20 is an enlarged vertical cross-section of the mold actuating mechanism in closed position.

FIG. 21 is an enlarged cross-section taken along the line **21—21** of FIG. 20.

FIG. 22 is an enlarged elevation of the left hand element of the mold shown in FIG. 20.

FIG. 23 is a front elevation of the right hand element shown in FIG. 20.

FIG. 24 is a vertical cross-section taken along the line 24—24 of FIG. 21.

FIG. 25 is a vertical cross-section of the bulb end of the finished tube, taken along the line 25—25 of FIG. 26.

FIG. 26 is a cross-section taken along the line 26—26 of FIG. 25.

FIG. 27 is a diagram of the air flow connections in the apparatus to show how many of the elements in the apparatus are actuated.

Referring to the drawings which show a preferred embodiment of the invention and initially to FIGS. 1 and 2, an intermittently movable or rotatable endless conveyor, such as circular table **30**, is rotatably mounted on a stationary housing **31** and apron **32** which are supported on a pedestal **33**. Motor **34** rotates a shaft **35** through the medium of an adjustable speed belt drive **36**, and intermittently drives or rotates the table **30**, so the tube holders **37** are moved to, and pause at, each of a plurality of stations adjacent the conveyor **30**. For example, the shaft **35** drives the worm gear **38**, which in turn operates a Geneva drive, not shown, contained in the housing **31** which produces the intermittent rotation of the table **30**. Suitable gearing in the housing **31** automatically rotates the shaft **39** one revolution during each pause of the table **30**, but the shaft **39** preferably does not turn while the table **30** is moving. The shaft **39** carries a cam **40** for controlling certain operations which take place during the pauses of conveyor **30**, in a manner more fully to be described.

The holders **37** are equally spaced around the periphery of the table **30**, for example, at every 20°. The holders **37** serially stop at each of the stations adjacent the conveyor **30**, and certain operations take place at these stations which will be later described. Open ended straight tubes **80** are placed in the tube holders at station **41** preferably in vertical positions. The lower or bulb ends of the tubes are heated, melted and sealed at certain of the stations, by one or more heating means. For example, at station **42** a pair of burners **43** and **44** (FIG. 6) may heat the sides of the bulb end **45** of the tube to a temperature of about 500°, and the tube end becomes partially molten as indicated in FIG. 8. At station **47** a second set of opposed burners, similar to those shown in FIG. 6, are placed at a different angle from the burners of station **42**, and these burners further heat the bulb end of the tube to a temperature of about 800°, such as to cause the glass to soften and initially seal the end of the tube as indicated in FIG. 9. At station **48**, a vertical heater, as shown in FIG. 10, heats the bottom of the bulb end **45** by the upwardly directed flame **49**, from the burner **50**, and heats the bulb end of the tube to a still higher temperature of about 1500° to the proper molten condition, as indicated in FIG. 12. At station **51**, a gaseous medium under pressure is introduced into the unsealed ends **105** of the tube and a clamping mold at this station, later to be more fully described, controls the formation of the bulbs at the lower ends of the tubes to maintain them of uniform size and shape. The tubes then travel through several stations where the tubes gradually cool and harden until they reach station **52**. They are released at station **52**, and drop into the chutes **53** and slide into the bin **54**.

The tube loading operation which takes place at station **41** is more fully described by reference to FIGS. 3, 4 and 5. Each of the holders **37** includes a column **60**, carried by base **61** secured to the table **30**. A carriage **62** is secured to the column in a vertically adjustable manner by the screws **63**. The normally stationary clamp member **64** is horizontally adjustably secured to carriage **62** by means of screw **65** which passes through a narrow slot **66** in the clamp **64**. The slot **66** is narrow enough to permit the outer face of clamp **64** to be engaged by the head **67** of screw **65**. The clamp member **64** also slides in grooves **68** and **69**, formed in carriage **62**. The movable clamp member **70** is horizontally slidable with respect to the stationary clamp member **64**. To this end, the pin **71** is secured to the clamp member **64** and guides the narrow slot **72** in clamp member **70**. The pin **71** carries one end of spring **73**, the other end of which is secured to pin **74**, which is secured to the movable clamp member **70**. The clamp member **70** is provided with a right angled flange **75** behind which the operator may place his fingers to pull the clamp member **70** toward himself as indicated by the dotted lines in FIG. 4. The large slot **76** in clamp member **70** maintains the clamp member **70** in horizontal position, in cooperation with the head **67** of screw **65**. This is aided by the pin **71** and narrow slot **72** to maintain a straight-line movement of clamp **70**. When the clamp member **70** is pulled toward the operator a thermometer tube **80** is inserted between the jaw member **81** of stationary clamp **64** and the spring clip member **82** which is carried by the flange **75** of movable clamp **70**. The jaw member **81** includes the upper forked jaws **83** and the lower forked jaws **84** which have converging faces **85** which engage the converging surfaces **86** of the tube **80**. The faces **86** of the tube, in combination with the curved surface **87**, form a magnifying lens which enlarges the column or temperature indicating passageway **88** of the glass tube **80**. A reflecting surface **89** is formed within the tube **80** behind the column **88**, or it may be placed on the back face **90** in the form of a reflecting coat of paint.

The locking of the tubes **80** in the tube holders **37** is preferably a manual operation because of the irregular cross-section of the tubes **80**, as shown in FIG. 5.

Means are provided for longitudinally locating the tubes **80** in the holders **37**. Such means may take the form of normally stationary, but adjustably mounted table **91**, mounted at station **41**. For example, a vertical pin **92** is secured to the housing **31** by welds **93**. A horizontal pin **94** is vertically adjustably mounted on vertical pin **92** by a suitable clamp member **95**. Table **91** is horizontally adjustable on the pin **94**, being slidable thereon but being normally clamped by the screw **96**.

To place the tubes **80** in the holders **37**, the operator pulls the flange **75**, FIG. 4, to the dotted line position, inserts the tube **80** with the smaller side **87** toward the center of the machine, as shown in FIG. 5, and then releases the flange **75**, thereby to lock the tube **80** between the jaws **83**, **84** and the spring clip **82**. Before releasing the flange **75**, however, the operator allows the tube **80** to ride on top of the table **91**, so the tube **80** is properly longitudinally and vertically located before being clamped in the holder.

After leaving the loading station **41**, the tubes pass through the heating zone comprising one or more stations **42**, **47** and **48**. At station **42**, opposed burners **43** and **44**, as shown in FIG. 6, direct the flames **100** against the sides of bulb end **45**. The pause at this station is sufficient to raise the temperature of the tube end to about 500° F., which produces a partial melting of the end as indicated in FIG. 8. Thereafter the tube passes to station **47** where a second set of opposed burners, also as shown in FIG. 6, direct flames **100** from a different angle, completely to heat all sides of the tube end and raise the temperature to about 800° F., to produce an initial sealing thereof as shown in FIG. 9. The tube then progresses to station **48** where the vertical burner **50** of FIG. 10 directs flame **49** vertically up against the bottom of the tube end **45** and completely melts and seals the same in a slightly globular form, as shown at the bottom of FIG. 12.

The tubes then progress to station **51** where a combined blowing and molding operation forms the bulb at the bottom or bulb end of the tube as more fully described with respect to FIGS. 13 through 26.

Means in the form of a thermometer tube glass feeding device is provided at station **51** for feeding a gaseous medium under increasing pressure into the unsealed, open end **105** of the tube **80**. For example, the solid outer sleeve **106** is in alignment with the tube end **105** (FIG. 13) when such end pauses at station **51**. The outer sleeve **106** holds a flexible contractable inner sleeve **107** formed of a suitable elastomeric material such as rubber. The sleeve **107** has an axial opening **107*a*** of slightly greater diameter in an uncompressed condition than the greatest cross sectional dimension of the end **105** as shown in FIG. 16. The sleeves **106** and **107** are in their upper positions above tube end **105** as shown in FIG. 13. Sleeves **106** and **107** are then moved to their lower positions around tube end **105** as shown in FIGS. 14 and 15. In FIG. 14 the sleeves **106** and **107** have been placed around tube end **105**, but the sleeve **107** has not been contracted and sealed around the tube end **105**. In FIG. 15 the flexible sleeve **107** has been contracted and sealed about the end **105** by a downward movement of the end **112** of the solid inner sleeve **108**. The sleeve **108** forms a gas conduit **110** continuously connected to the hose **109**.

The gaseous medium or air coming from the hose **109** is at very low pressure when it reaches the conduit **110** of the inner sleeve **108**, since there is a free flow of air to the atmosphere at this time. However, after the sleeve **107** has been sealed around the tube end **105**, and the air continues to be forced into the tube **80**, the pressure in the hose **109** and the passageway **110** gradually rises sufficiently high to form the bulb at the bottom of the tube **80** and also to trip a mechanism for actuating the mold as hereinafter more fully to be described. The sleeve **107** constitutes a thermometer tube gripping portion arranged to receive the open end **105** of the tube for the application of gas pressure thereto from the hose **109**.

Further details of the contracting action of sleeve **107** are now described. The outer sleeve **106** has a flanged outer sleeve end **111** defining a thermometer stem inlet opening **111*a***. The inner sleeve **108** has an inner sleeve end **112** with a washer **113** with an opening **113*a***. The flexible sleeve **107** is longitudinally held between the ends **111** and **112**. The outer sleeve **106** has an upper flange **114** which is adapted to come in arresting engagement with the upper surface or abutment **115*a*** of the bushing **115**, when the sleeve **106** is in its lower position, as shown in FIGS. 14 and 15. A compression spring **116** is placed between the flange **114** and the bushing support **117**. The spring **116** is of sufficient strength to move the sleeve **106** to its upper position when the plunger **118** is not pushed downwardly. However, the strength of the spring **116** is not sufficient to cause any substantial contraction of the sleeve **107** while the plunger **118** is pushing the sleeve **108** down from the position shown in FIG. 13 to that shown in FIG. 14 and therefore the sleeve **107** is lowered over the end **105** without touching the tube **80**. The opening **113*a*** in the washer **113** and the opening **111*a*** in the flanged end **111** have substantially equal diameters one to the other as shown in FIGS. 13 and 14 in order that the compression of the sleeve **107** by the sleeve **108** does not result in the extrusion of the elastomeric material through the opening **111*a*** any more than through the opening **113*a***. By this means vertical displacement of the tube **80** is avoided. After the sleeve **106** reaches the position shown in FIG. 14 with the flange **114** against the bushing **115**, the plunger **118** and inner sleeve **108** continue their downward movement sufficiently to squeeze the flexible sleeve **107** longitudinally as shown in FIG. 15 and thus contract and seal it around the tube end **105**. The plunger **118** is pushed down and moved up by the pneumatic piston construction **120** shown in FIG. 1. The spring **116** aids in pushing the plunger **118** up. The plunger **118** is pushed down by air under pressure from the conduit or hose **121** under a control later to be described.

Referring to FIGS. 13 through 18, at the proper point in the cycle air or other gaseous medium is fed under pressure through the hose **109** and passageway **110** into the inner temperature indicating pasageway **88** of the glass tube **80**. Since there is no leakage of air to the atmosphere after the sealing action shown in FIG. 15 around the tube **80**, the air in pasageways **109**, **110** and column **88** gradually builds up in pressure, increasing to the point where a small enlargement **125**, FIG. 18, is formed within the molten end **45** of the tube **80**. This gradually increasing pressure of the air causes the limiting or clamping mold **126**, **127** (FIGS. 19–26) to surround and limit the bounds of the enlargement **125** at the bottom end of the tube and controls the formation of the bulb causing it to take the shape shown in FIGS. 25 and 26 in a manner more fully to be described.

The actuation of the mold **126**, **127** in response to the gradually increasing pressure in the passageways **109**, **110** is performed by the elements and connections shown in FIG. 27. The tube **109** receives air under pressure from the conduit **130** and the manually adjustable valve **131**. Conduit **130** has air under about 30 p.s.i. pressure, for example. However the valve **131** is turned to a throttling position to limit the rate of air flow which is fed to the pipe **109**, to produce the gradually increasing pressure heretofore described. Another pipe **132** is connected to the pipe **109** and is connected at its other end with the pressure responsive switch **133**. The air from the pipe **132** passes through the hand adjustable throttling valve **134** to bellows **135**, and gradually compresses spring **136**, and moves shaft **137** to close the normally open micro switch **138**, when a predetermined pressure is reached in the bellows **135** and pipes **109** and **132**. The closing of switch **138** closes the mold **126**, **127** as more fully hereafter described. When the pressure is relieved in the bellows **135**, the micro switch **138** opens and opens the mold **126**, **127**.

The electrical supply passing through the micro switch **138** is transmitted through the wire **139** to a solenoid valve **140** which opens upon receiving electric current and permits air under pressure to pass from the pipe **141** to the pipe **142**, to actuate the pneumatic air motor **143**. The air motor **143** actuates a mechanism **144** which causes the mold parts **126** and **127** to come together to the position shown in FIG. 20. When the valve **140** is de-energized, by the opening of switch **138**, the air in pipe **142** is allowed to escape at valve **140** providing for the retraction of the motor **143** through the spring **160** which returns the mold **126**, **127** to open position.

The closing of the mold **126**, **127** to the position shown in FIG. 20 takes place simultaneously or immediately after the formation of the small enlargement **125**, shown in FIG. 18. Thereafter the continued pressure of the air entering through the pipe **109** causes the small enlargement **125** of the FIG. 18 to form into the completed bulb **145** shown in FIGS. 25 and 26.

The mold half **126** has an offset **146** which cooperates with the straight face **147** of the mold half **127** to form the bulb **145** as shown in FIG. 26, in line with the passageway **88**, but out of line with the central axis of the tube **80**. This produces the straight face **148** on one side of the tube and produces the offset **149** on the other side of the tube. The straight face **148** of the tube permits it to be placed against the usual flat temperature indicating scale, not shown, without any danger of breakage or distortion. The mold halves **126**, **127** have circular cups **150** and **151** which form the circular rim **152** of bulb **145**, shown in FIG. 25.

Referring particularly to FIGS. 19 and 20, the operation of mechanism **144**, which actuates the mold halves **126**, **127**, will now be described in further detail. The pneumatic piston mechanism **143** has a plunger **155** which engages another plunger **156** mounted to move axially through the bearings **157** and **158**. A pin **159** receives one end of the compression return spring **160**, the other end of the spring **160** abutting the bearing **158**. The plunger **156** is moved to the left (in FIG. 19) by the plunger **155**, and it is returned by the spring **160** when the pressure is relieved from the pneumatic mechanism **143**.

The mold half **126** is carried by the pivoted lever **161**, while the mold half on **127** is carried by the pivoted lever **162**. The levers **161** and **162** are pivoted around the pin **163** by their respective axially offset hinge cylinders **164** and **165**. The levers **161** and **162** are connected by links **166** and **167** with the plunger **156** by any suitable construction **168** which permits the links **166** and **167** to pivot about the pins **169** and **170**. The links **166** and **167** are also pivoted at **171** and **172** to their respective levers **161** and **162**. When the plunger **156** is moved to the left, FIG. 19, the mold halves **126** and **127** are brought together, whereas when the plunger **156** is moved to the right, the halves **126** and **127** are separated.

The mold **126**, **127** is supported by any suitable mount. For example, a plate **175** is mounted on the housing **31** by means of the screws **176**, which also conveniently support valve **140**, as shown. The horizontal supports **180** and **181** are horizontally mounted and joined together by bolted construction **182**.

After the bulb forming action is completed at the station **51**, each tube **80** travels in a clockwise direction, as viewed in FIG. 2, through a plurality of other stations where the tubes pause and cool. Eventually they reach station **52** where the tubes are released to fall into the chute **53** and bin **54**. Tube releasing mechanism for moving the clamp **70** outwardly may be used. For example, plunger **185** is moved periodically outward and inwardly by the pneumatic piston construction **186**, which includes a return spring construction, not shown, for retracting the plunger **185** when the pneumatic pressure is released from the pipe **187** after the thermometer tubes are released.

The pipes **121** and **187** are fed by a vertical stationary pipe **188** (FIG. 1) which passes up through a hollow supporting column **189**, which also supports the horizontal central platform **190** for supporting tubes to be loaded at station **41** and for any other purpose which may be desired. The automatic actuation of the clamp **70** radially outward permits the tubes to fall from the holders **37** at station **52**.

The pneumatic system for operating the various parts of the machine is diagrammatically indicated in FIG. 27. For example, the air tank **200** has air maintained at any suitable pressure by means of the pumping mechanism **201** which has the usual presure responsive switch for automatically maintaining the pressure in the air tank **200** at 60 p.s.i., for example, as is readily understood. A conduit **202** leads to the automatic pressure reducing valve **203**, which may be manually adjustable to any desired pressure reduction by means of the knob **204**. The valve **203** reduces the air passing through it to a pressure of about 30 p.s.i., for example, when it enters the conduit **130**. This pressure is indicated by the gauge **205**. The manual throttling valves **131** and **134** may be adjusted to throttle the flow of air to reduce the pressure practically to atmospheric pressure when the end of passage **110** is open, as in FIG. 13, and to obtain the desired gradual pressure increase in pipe **109** when passage **110** is sealed to tube **80**, FIG. 15, as has been previously described. The valve **134** may be adjusted to increase or delay the responsiveness of the bellows **135** with respect to the rise in pressure in the pipes **109** and **132**.

Another pipe **207** receives air at 60 p.s.i. from the tank **200** and feeds it to the automatic pressure reducing valve **208**, which is manually adjusted at **209** and feeds air at 30 p.s.i., for example, to the pipe **210**, this pressure being indicated at the gauge **211**. The air from pipe **210** passes the manually adjustable throttling valve **212**, which feeds the air to the pipe **141**, solenoid valve **140**, pipe **142**, and piston actuator **143**. The throttling valve **212** may be used to regulate the responsiveness of the piston actuator **143** so that the closing action of mold **126**, **127** may be delayed more or less as desired. The valve **140** and the actuator **143** constitute mold operating means operable upon a signal to close the mold halves **126** and **127** about the sealed end of the tube.

Adjustable time delay means is provided by the adjustment of the relative time delays produced by the manual throttle valves **131**, **134** and **212**, and by the adjustable automatic valves **203**, **208** and **216**, to enable the operator to calibrate the machine to obtain the proper timing of the closing of the mold **126**, **127** in relation to the time of formation of the small enlargement **125** shown in FIG. 18. The valve **134**, the bellows **135** and the switch **138** constitute time delay means connected to apply an electric signal to the valve **140** of the mold operating means for closing the mold subsequent to the application of gas pressure to the thermometer tube through the conduit **110**. It is important to have the mold **126**, **127** out of contact with the bulb end until after the formation of enlargement **125**, to avoid any chilling effect on the bulb end by the mold prior to the formation of the enlargement **125**. Thereafter it is important to have the mold clamp around the bulb end before the enlargement has been blown to its maximum volume, since this permits the mold halves **126** and **127** to come completely together to present an identical volume limit to each expanding bulb. In this manner great uniformity of bulb size is obtained. The adjustment of air flow made possible by the manual adjustment of these valves enables the operator to obtain great accuracy in the relative timing of the initial bulb enlargement of FIG. 18 and the quick closing of the mold immediately thereafter and before the bulb has reached its correct maximum size.

Another pipe **215** receives air at 60 p.s.i. from the tank **200** and feeds it to an automatic pressure reducing valve **216** which is adjustable at **216***a* and which feeds air to the pipe **217** at 22 p.s.i., for example. This pressure may be indicated by the gauge **218**. The pipe **217** feeds air to the periodically actuated valve **219**, which opens when the lever **220** is moved to the left by the hill **40***a*, cam **40**, and which closes when the lever **220** is moved to the right by the spring **221** after the hill of the cam has passed. The valve **219** feeds the pipe **222** which is connected to the vertical pipe **188** heretofore described and which feeds the pipes **121** and **187**.

The operation, briefly summarized, is as follows: The endless conveyor, or circular table **30**, is intermittently rotated by a Geneva drive in a clockwise direction as viewed in FIG. 2. The table **30** carries a plurality of tube holding mechanisms **37** conveniently spaced every 20°, for example, around the table **30**. Straight lengths of unsealed glass thermometer tubes **80**, having a cross-section as shown in FIG. 5, are conveniently stacked on the stationary platform **190** adjacent the station **41**. The operator takes these tubes from the platform **190** and loads them individually on each holder **37** at station **41** in the manner indicated in FIGS. 3, 4, and 5. He places his fingers behind the flange **75** and pulls the clamp **70** toward himself, as indicated in FIG. 4, and places the tube length **80** between the spring clip **82** and the jaw members **83** and **84**. He then releases the flange **75** and the clamp **70** moves leftward and secures the tube **80** in proper position by means of the spring clip **82**, this tube having been vertically adjusted to the right height by engagement at its lower end with the platform **91**. Thereafter the tubes are carried in progressive movements and pauses past the various stations adjacent the rotating table **30**. Eventually the tubes pass the required heating means, such as one or more gas burners as at stations **42**, **47** and **48**. The burners at stations **42** and **47** are horizontally opposed to each other as indicated in FIG. 6 and have different directions as indicated in FIG. 2. The burner at station **48** is a vertical one as indicated in FIG. 10 and heats the bottom of the tube **45**. While at station **42**, the tubes **80** are heated to 500° F. at their lower ends **45** to produce an initial melting action, as indicated in FIG. 8. They are heated to 800° F. at station **47** and are slightly sealed at their lower ends, as indicated in FIG. 9. At station **48**, they are heated to

1500° F. and the bottom 45 of the tubes 80 become molten to the desired degree, as indicated in FIG. 12, and are in a condition to be blown at station 51.

At station 51, the operations indicated in FIGS. 13 through 26 are performed. First the hill 40*a* of cam 40 (FIG. 27) opens valve 219 and feeds air at 22 p.s.i. to the pipes 121 and 187. In the meantime, air under 30 lb. pressure has been continuously fed to the pipe 130 and past the throttling valve 131, so that air is allowed to leak slowly into the pipes 109 and 132. As long as the elements shown in FIG. 13 are in that position, the air from pipe 109 falls to practically atmospheric pressure, due to the fact that the lower end of passage 110 is open to the atmosphere as at FIG. 13. However, when the valve 219 of FIG. 27 is opened the plunger 118 is pushed down by the air pressure impulse in pipe 121 and this pushes the sleeves 108 and 106 to the positions of FIGS. 14 and 15 respectively. This causes the flexible sleeve 107 to be sealed around the open end 105 of the tube 80 and to permit the air under pressure to be fed from the pipe 109 into the bore or passageway 88 of the thermometer tubes 80. The air in pipe 109 gradually increases in pressure after the position of FIG. 15 has been reached, and increases the pressure in pipes 109 and 132 until the pressure responsive switch 133 closes the micro-switch 138 to energize the solenoid valve 140. The valve 140 opens when energized, and permits air under pressure to pass through the pipe 142 to the pneumatic plunger mechanism 143. When this occurs the plungers 155 and 156 are moved leftward as viewed in FIG. 19 (or rightward in FIG. 27), thus moving the mold elements 126 and 127 from the open position shown in FIGS. 19 and 27 to the closed position shown in FIG. 20. During these operations, the lower end 45 of the tube 80 has had a small enlargement 125 (FIG. 18) blown in it which is then further enlarged within the confines or bounds of the mold 126, 127 to form the bulb 145 (FIGS. 25 and 26) which has a circular cross-section as viewed in FIG. 25 and an offset construction as shown in FIG. 26. Hence, one face 148 (FIG. 26) of the tube is continuously straight, so that this face may be placed against the usual flat temperature indicating scale.

Subsequent to the opening of the elements 126 and 127 of the mold, the tubes leave station 51 and continue through a plurality of undesignated stations which permit the tubes to cool until they finally reach the unloading station 52 where they are released from the holder by the action of pneumatic plunger mechanism 186 which is temporarily energized when the hill 40*a* of cam 40 opens the valve 219 as previously described and sends a pressure impulse to plunger 186. The plunger of mechanism 186 is spring retracted when the valve 219 is closed. The tubes drop by gravity at station 52 into the chute 53 and slide into the bin 54.

This automatic procedure eliminates the many irregularities in bulb sizes caused by the human equations of previous methods, and produces bulb constructions of unusual regularity in size, and in large quantities, with a minimum labor requirement.

While the form of the embodiment of the invention as herein disclosed constitutes the form now preferred, it is to be understood that other forms may be adopted, which come within the scope of the claims which follow.

What is claimed is as follows:

1. In a machine for forming thermometer tubes, in combination, an intermittently movable conveyor, a tube holder on said conveyor serially movable to stations adjacent said conveyor and adapted to hold a tube with a molten bulb-forming end and with an open other end, an uninterrupted source of gas under pressure at one of said stations, means connecting said source to said open end of a tube at said station for introducing gas into said tube to form a small enlargement in said molten bulb-forming end free of chilling effect of a mold, a clamping mold having portions closeable about said enlargement to define the formed shape thereof, mold operating means operatively connected to said mold portions and operable upon a signal to close said portions about said enlargement, and time delay means connected to apply a signal to said mold operating means for closing said portions subsequent to the formation of said enlargement.

2. A tube blowing device comprising, a tube holder arranged to support a thermometer tube with an open end and with a molten sealed end, a thermometer tube gas feeding device including a gripping portion thereon arranged to receive the open end of said tube for the application of gas pressure thereto resulting in the formation of an initial small enlargement on said molten end free of chilling effect of a mold, a clamping mold including halves movable about said molten end to define the shape of a bulb formed thereon, mold operating means operatively connected to said mold halves and operable upon a signal to close said mold halves about said sealed end, and time delay means connected to apply a signal to said mold operating means for closing said halves subsequent to the application of said gas pressure through said feeding device.

3. In a thermometer tube blowing device for forming an enlarged bulb at a molten end of an unsealed thermometer tube, the combination comprising a source of gas under pressure, a gas conduit connected to said source, means applying said conduit to the unsealed end of said thermometer tube, a clamping mold operable when closed to define the limits of the bulb formed at said molten end by gas from said conduit, controllable mold operating means for closing said mold about the molten end of said tube, and pressure responsive means having a connection to said conduit and to said mold operating means for the actuation of said mold operating means at a predetermined point in the pressure build-up subsequent to the initial formation of the bulb by gas from said conduit.

4. In a thermometer tube blowing device for forming an enlarged bulb at a molten end of an unsealed thermometer tube, the combination comprising a source of gas under pressure, a gas conduit continuously connected to said source for the discharge of gas therefrom, means applying said conduit to the unsealed end of said thermometer tube, a clamping mold operable when closed to define the limits of the bulb formed at said molten end by gas from said conduit, a pneumatic mold motor operated by gas from said source for closing said mold about the molten end of said tube, and pressure responsive means having a connection to said conduit and to said source and arranged to apply gas therefrom to said motor for the actuation of said motor at a predetermined point in the pressure build-up subsequent to the initial formation of the bulb.

5. In a thermometer tube blowing device for forming an enlarged bulb at a molten end of an unsealed thermometer tube, the combination comprising a source of gas under pressure, a gas conduit connected to said source, means for applying said conduit to the unsealed end of said thermometer tube, a clamping mold for defining the limits of the bulb formed at said molten end by gas from said conduit, solenoid controlled mold operating means for clamping said mold about the molten end of said tube, and pressure responsive switch means responsive to the pressure in said conduit at said thermometer and having an operative electrical connection to said mold operating means for the delayed actuation of said mold operating means subsequent to the initial formation of the bulb by the gas from said conduit.

References Cited in the file of this patent

UNITED STATES PATENTS

635,392	Ruhe	Oct. 24, 1899
659,291	Colburn	Oct. 9, 1910

(Other references on following page)

UNITED STATES PATENTS

1,281,905	Brosehart	Oct. 15, 1918
1,294,319	Stewart	Feb. 11, 1919
1,330,707	Hoffstetter et al.	Feb. 10, 1920
1,334,007	White	Mar. 16, 1920
1,342,821	Leiman	June 8, 1920
1,532,077	Quackenbush et al.	Mar. 31, 1925
1,587,466	Brown et al.	June 1, 1926
1,635,771	Sunderlin	July 12, 1927
1,699,305	Meyer	Jan. 15, 1929
1,793,997	Chaney	Feb. 24, 1931
2,059,474	Meyer	Nov. 3, 1936
2,132,538	McGowan	Oct. 11, 1938
2,227,224	Kimble et al.	Dec. 31, 1940
2,306,995	Palmer et al.	Dec. 29, 1942

FOREIGN PATENTS

676,625	Germany	June 9, 1939
282,057	Great Britain	Mar. 2, 1928