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1,880,184

APPARATUS FOR PRODUCTION OF BELLOWS TUBING

Original Filed Aug. 13, 1928. 4 Sheets-Sheet 1

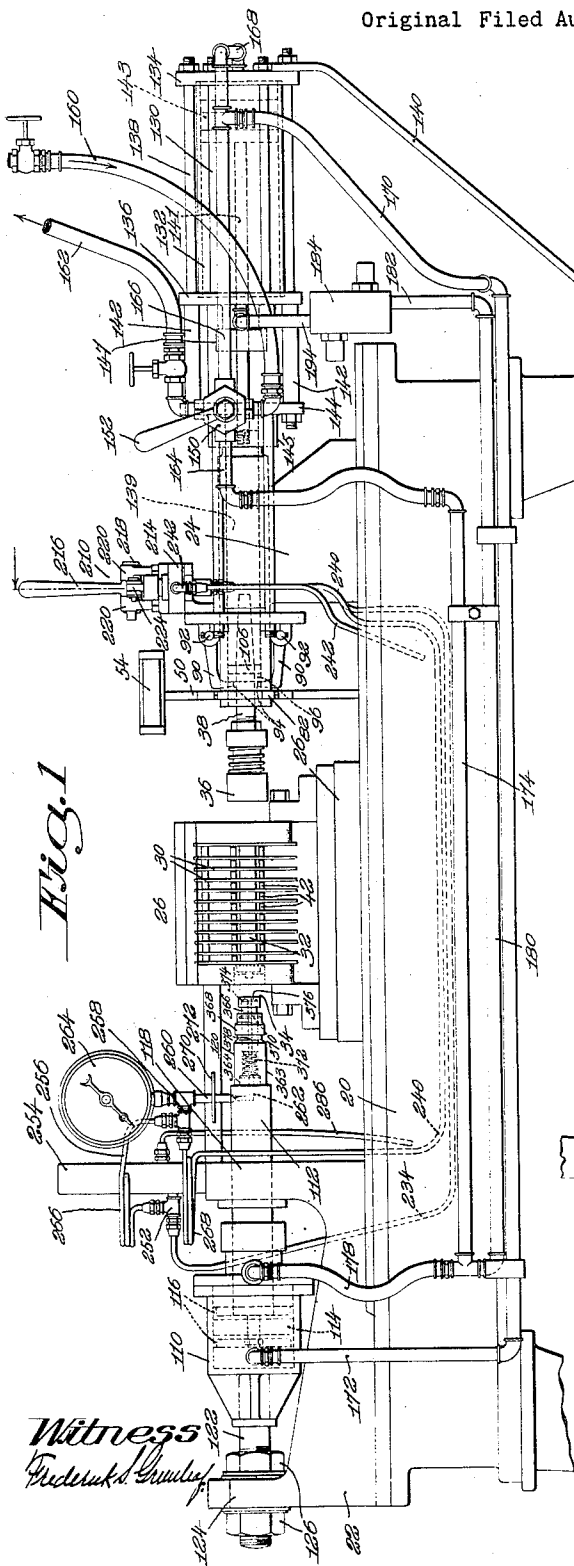


Fig. 1

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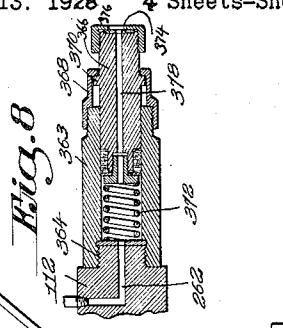


Fig. 8

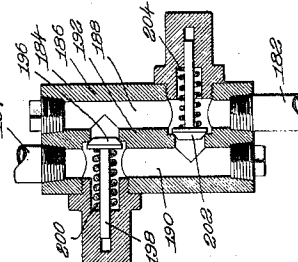


Fig. 7

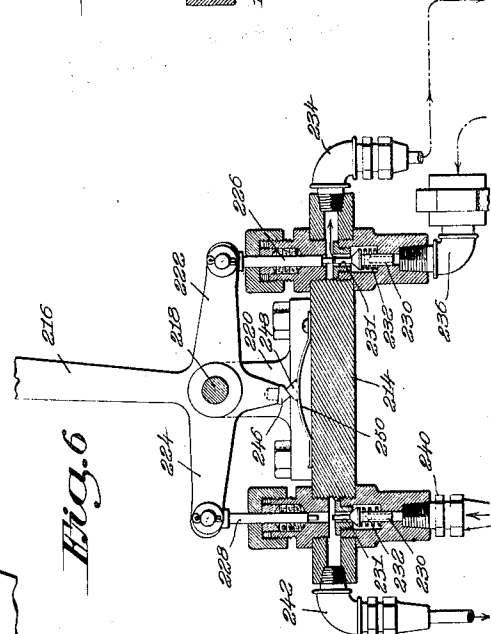


Fig. 6

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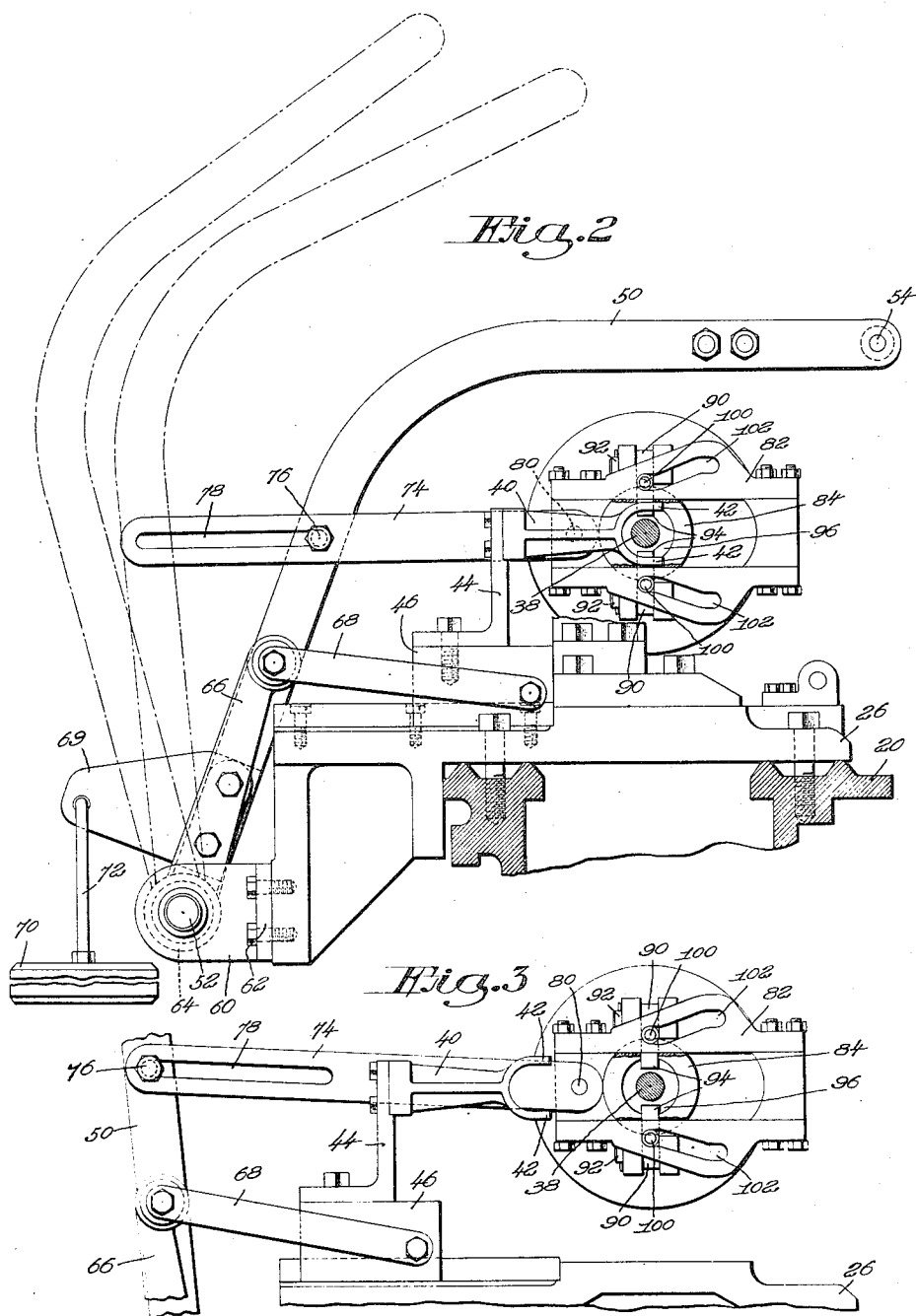
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APPARATUS FOR PRODUCTION OF BELLOWS TUBING

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Sept. 27, 1932.

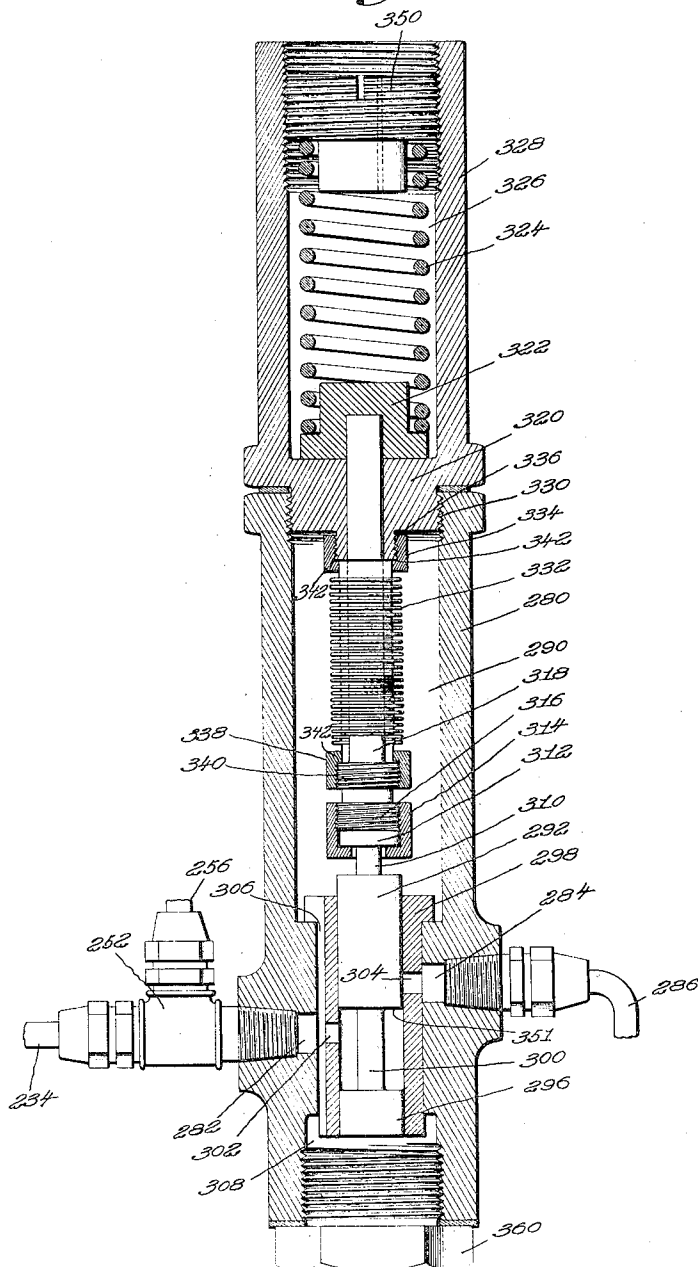
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APPARATUS FOR PRODUCTION OF BELLOWS TUBING

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Fig. 9



Witness

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UNITED STATES PATENT OFFICE

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APPARATUS FOR PRODUCTION OF BELLOWS TUBING

Application filed August 13, 1928, Serial No. 299,164. Renewed January 28, 1932.

The present invention relates to improvements in apparatus for the formation of bellows folds in tubing, and more particularly to apparatus of the type disclosed in my application, Serial No. 99,418, filed April 2, 1926, patented October 30, 1928, as No. 1,689,620.

In this type of apparatus, the tube is first inserted within the partible die members which are individually locked thereabout in spaced relationship. Thereafter the fluid pressure head is manually advanced into sealing engagement with the fluid passage formed in one end of the tube, and the contracting ram is manually advanced to engage with the opposite end of the tube projecting from the die assembly either directly or through the interposition of an end fitting, if one is employed. With the parts in assembled relation and the tube firmly engaged at opposite ends, fluid pressure is introduced into the interior of the tube through the pressure head and the spacer members withdrawn from between the die plates. Subsequently, the contracting ram is manually advanced lengthwise of the tube to contract the tube and simultaneously collapse the die plates, the portions of the tube between the die plates meanwhile rolling outwardly to form a series of bellows folds due to the internal fluid pressure. At the completion of the operation, the contracting ram is withdrawn, the die plates are opened, and the completed bellows removed. Thereafter the die plates are allowed to return to initial position, and the cycle of operation repeated.

The object of the present invention is to improve the construction and operation of this type of machine, with a particular view to markedly increasing the speed of formation of the finished article, and in addition to insure uniformity of the resulting product.

With this and other objects in view, the various features of the invention consist in certain novel features of construction, combinations and arrangements of parts, the advantage of which will be obvious to those skilled in the art from the accompanying description.

In the drawings illustrating the preferred form of the invention,

Fig. 1 is a side elevation of the improved machine;

Fig. 2 is a detail partly in section illustrating the mechanism for removing the spacer members to inoperative position and releasing the contracting ram;

Figs. 3 and 4 are details illustrating respectively views of the releasing mechanism after the withdrawal of the spacer fingers and before release of the ram, and at completion of the releasing movement of the ram;

Fig. 5 is a detail illustrating a side view of the mechanism shown in Figs. 2 to 4, inclusive;

Fig. 6 is a detail illustrating an elevation partly in section of the double-acting valve mechanism for connecting the fluid-pressure head alternately to the high-pressure source and to a suitable drainage outlet;

Fig. 7 is a detail illustrating a section of the automatic valve mechanism for insuring proper coordination between the movements of the fluid-pressure head and the contracting ram;

Fig. 8 is a detail illustrating a view of the spring compensator embodied in the fluid-pressure head for forming a fluid pressure seal; and

Fig. 9 is a detail illustrating a section in elevation of the valve for automatically regulating the fluid pressure within the bellows tube during the formative operation.

The apparatus shown in the illustrated embodiment of the invention comprises a partible die assembly similar in arrangement and mode of operation to that previously described in my aforesaid patent. This die assembly is removably mounted upon the frame of the apparatus between oppositely disposed members, constituting respectively a pressure head and contracting ram. Cooperating with the die assembly are a series of spacing fingers designed to engage between the successive partible dies and cause a uniform separation of the latter. These spacer fingers are mounted for movement transversely of the dies, and are designed to be withdrawn or moved from operative position prior to the contraction of the tube during the formative

operation. Cooperating with the opposite ends of a tube located within the die assembly, as previously stated, are a fluid pressure head and contracting ram. Both of these members are preferably actuated hydraulically, and are designed to be moved into operative and contracting relation at opposite ends of the tube by the actuation of a single control. This is accomplished through the employment of a ram connected to each member, both rams being connected with a source of pressure controlled by a single valve in such a manner that actuation of the valve causes simultaneous or concurrent movement of the pressure ram and contracting ram toward or from the tube as the case may be. In actual practice, the fluid pressure ram is advanced into sealing engagement with a suitable fitting mounted upon the end of the tube, and the contracting ram is advanced until positively limited by a releasing mechanism interconnected with the spacer fingers in such a manner that continued movement of the ram in a direction to contract the tube is prevented until withdrawal of the spacer fingers, whereupon the stop is removed to permit axial contracting movement of the ram under the influence of the constantly acting fluid pressure. Fluid pressure within the tube is initially introduced, and thereafter maintained from a suitable source of supply controlled by a single instrumentality. During the formation of the bellows folds and the contraction of the tube, this pressure is automatically maintained in an initially predetermined amount by an automatic regulating valve. Upon completion of the operation, the fluid pressure within the tube is instantly exhausted and the fluid pressure and contracting ram simultaneously withdrawn to permit opening of the partible dies and removal of the finished product.

The apparatus shown in the illustrated embodiment of the invention comprises generally a bed or frame 20 of conventional form, having mounted at opposite ends, respectively, heads 22 and 24, for the reception of the fluid pressure mechanism and the contracting mechanism. Mounted upon the bed between these heads is a removable die assembly, indicated generally at 26. The removable die assembly, as indicated more particularly in Fig. 1, comprises a series of partible die members 30 which are individually locked about a tube, indicated generally at 32, and are capable of a collapsing movement during the formation of the bellows, all as described in the application referred to. Cooperating with the tube at one end is a fluid pressure fitting 34, and at the opposite end a fitting 36 mounted upon the outer end of the contracting ram 38 for engagement with the closed end of the tube. The partible die members are initially spaced apart by a series of spacer bars 40 having bifurcated or forked ends ter-

minating in spacer fingers 42, which extend between adjacent die members and embrace the tube, as indicated in Fig. 2. The spacer bars 40 are secured to an angle bracket 44, which is in turn mounted upon a transverse slide 46 adapted to carry the spacer members into and out of operative relation between the dies. The transverse movement of the spacer members is accomplished by an operating lever 50 which projects upwardly from a rock shaft 52 at the rear of the machine, and thence across the machine at one end of the die assembly, terminating in an operating handle 54 at the front of the machine in convenient relation to the operator. The rock shaft 52, as indicated more particularly in Fig. 5, is mounted in bearings 60 formed in brackets 62 secured to the bed of the machine, and is rigidly connected with the hub 64 of a rocker arm 66 which is connected at its upper end with the slide 46 through a link 68. With this construction, transverse movements of the operating lever are imparted directly to the spacer members. In order to counterbalance the weight of the moving parts and facilitate movement of the spacer members into inoperative position, the operating lever adjacent the fulcrum is provided with a rearwardly extending bracket 69 which has a counterbalance weight 70 depending from its free end through a link 72. The operating lever 50 also serves to release the contracting ram and permit continued axial movement of the ram upon withdrawal of the separator fingers from between the die members. To this end the operating lever is loosely connected with a slide arm 74 through a stud 76 and slot 78 formed in the arm. This arm in turn is connected at its inner end through the pin 80 with a sliding head 82, which as shown more particularly in Figs. 2 to 5, inclusive, is designed for sliding movements transversely of a stationary sleeve 84 within which the contracting ram moves. The sleeve is provided with oppositely disposed slots to form a bearing for the movement transversely of the sliding head, and the latter is operatively connected with the movable arm through locking fingers 90 pivoted at 92, and having inwardly extending free ends 94 which in locking position engage with a collar 96 adjustably mounted upon the ram 38 in a manner to prevent continued movement of the ram in the direction of contraction after such engagement. Each locking finger is provided with an outwardly extending knob or stud 100, these knobs riding in supplementary slots 102 formed in the sliding head, the slots being so designed that transverse movement of the head in one direction spreads the locking fingers sufficiently to release the ram and in the opposite direction drops the locking fingers into position in front of the collar. As will be evident from an inspection of the drawings, more particularly Figs. 3 and 4,

the initial advancing movement of the ram causes the collar 96 to engage with the ends of the locking fingers, and thereafter prevents further movement in this direction. Upon withdrawal of the separator members, however, through operation of the control lever 50, the parts are first caused to assume the position shown in Fig. 3 in which the separator members are completely removed from between the partible die plates, the control lever has reached a position in which the stud 76 engages with the free end of the slot 78, and in which further movement actuates the slide head 82. In this position, the studs 100 are located at the inner ends of the inclined slots 102. Continued movement of the control lever in the position shown in Fig. 4 imparts further movement to the separator members, and in addition transverse movement of the slide head sufficient to cause the studs 100 to traverse the inclined slots to the position shown in Fig. 4 and separate the locking fingers sufficiently to permit contractual movement of the ram under the influence of the pressure head. In this connection it will be noted that the collar 96 is adjustably mounted on a threaded portion 104 of the ram, and cooperates with a locking collar or nut 106 engaging therewith. By suitably adjusting the position of the collar lengthwise of the ram, the locking fingers can be caused to arrest movement of the ram at the exact point when the head 36 contacts with the closed end of the bellows or the end fitting thereon to sustain the tube against the thrust due to introduction of fluid pressure within the tube. This is important as otherwise the axial thrust on the interior of the tube, due to the fluid pressure, might bulge or stretch the tube axially, especially when no end fitting is employed. With the ram in engagement with the end of the tube or the fitting applied thereto, the latter is sustained against such a thrust.

In the illustrated embodiment of the invention, the movements of the fluid pressure head and the contracting ram are accomplished hydraulically. This provides an exceedingly simple and efficient method of securing the required movements, although it is obvious that other equivalent mechanisms might be employed for this purpose if so desired. Referring more particularly to Fig. 1 of the drawings, it will be observed that a cylinder 110 is mounted within the supporting head 22, and has extending therefrom a piston rod 112 connected interiorly to a plunger 114 provided with cup packings 116. The piston rod 112 is slidably received in an end member 118 of the head 22, and carries at its free end the pressure compensating assembly, indicated at 120, to be presently described. The hydraulic cylinder 110 is provided at the end opposite the piston with a stem 122 which extends through a flange 124 and is rigidly

secured thereto by oppositely disposed locking nuts 126 threaded upon the stem 122. By adjusting the locking nuts upon the stem, the cylinder 110 may be bodily displaced longitudinally of the apparatus and accordingly vary the limits of travel of the fluid pressure head. This is desirable as it permits adjustment of the limits of movement of the fluid pressure head in this manner. The tube contracting ram 38 is slidably mounted in a head 24 at the opposite end of the bed, and is connected with a hydraulic cylinder 130, consisting essentially of a cylindrical tube 132 clamped between end plates 134 and 136 by tie rods 138. The assembly is supported at its outer end by an inclined strut 140 extending downwardly to the base of the machine. The tie rods 138 extend beyond the end plate 136, and are provided with spacer sleeves 142 interposed between the plate 136 and the plate 144. The ram 38 is removably mounted in the end of an elongated piston rod 139 which slides within the head 24 clearly indicated, this piston rod being threadedly connected at its rear end with a second rod 141 forming the plunger rod connected with the hydraulic plunger 143. The plate 144 is provided with a box 145 rigidly joined to the end of the head 24 to provide a rigid connection for the hydraulic cylinder and distance rods. With this construction, the ram 38 and connected piston rod 139 have an elongated bearing in the head 24. In a like manner, the operating plunger rod 141 has a bearing adjacent its outer end in the extended portion 147 of the plate 136.

The pressure head and contracting ram are moved simultaneously in opposite directions through actuation of the hydraulically operated pistons. This is accomplished from a centralized control 150 which in cooperation with a series of liquid conduits delivers pressure to the interior of the cylinders 110 and 130. A centralized control may be a conventional form of four-way cock valve having an operating handle 152. Entering the casing of this valve, at the bottom is the main liquid supply conduit 160 connected with the source of liquid or fluid pressure, and communicating with the casing at the top is the exhaust conduit 162 which preferably communicates with the liquid supply tank. Communicating with the control valve casing at the left is a conduit 164, and at the right is a conduit 166. The conduit 166 extends lengthwise of the cylinder 130, and communicates with the end of the cylinder through a connection 168. This conduit is also provided with a branch 170 which extends lengthwise of the machine and through a branch 172 communicates with the outer end of the fluid pressure cylinder 110. In one position of the control valve 150 the inlet conduit 160 is connected with the conduit 166 by virtue of which the outer ends of the two

cylinders are simultaneously connected to the source of pressure causing the respective plungers to move inwardly toward the die assembly. Simultaneously, the conduit 164 is connected with the discharge conduit 162, causing the opposite or inner ends of the cylinders to be connected to the exhaust. Upon movement of the control handle 152 to the other extreme operating position, the connections are reversed and the conduit 164 is then connected with the inlet 160 and the conduit 166 is connected with the exhaust 162. As indicated more particularly in Fig. 1, the conduit 164 extends across the front of the machine at 174, and thence upwardly at 178 to the inner end of the fluid pressure cylinder 110. Adjacent this end the conduit is provided with a branch 180 which extends back lengthwise of the machine and upwardly at 182 connected with the inner end of the ram cylinder 130. When the control handle is positioned substantially midway between the two extremes of movement, the conduits 164 and 166 are closed to both inlet and exhaust conduits 160 and 162, so that pressures upon opposite sides of the plungers are balanced and the latter maintained in any desired intermediate position.

It will be evident that with this construction, initial movement of the control valve to apply pressure behind the plungers moves the fluid pressure head into engagement with the end of the tube and the contracting ram into engagement with the stop mechanism, and that upon movement of the control to the second extreme position the inner ends of the cylinders are connected to pressure and the outer ends to exhaust, causing the separation of the fluid pressure head and contracting ram. In order to expedite the removal of the finished product from within the die assembly, it is important that the fluid pressure head be instantly withdrawn from its position in sealing engagement with the end of the tube without waiting for the complete withdrawal of the contracting ram which may take place at a slower rate. To this end mechanism is provided for insuring such a movement of the fluid pressure head instantly upon actuation of the control valve. Referring to Figs. 1 and 7, it will be observed that inserted in the branch conduit 182 leading to the inner end of the ram cylinder 130 is a ram-retarding mechanism or fluid pressure head accelerating mechanism, indicated generally at 184. The purpose of this mechanism is to insure that upon connection of the conduit 164 to the source of supply 160, the fluid pressure head shall be instantly actuated through the full force of the fluid pressure exerted thereon. To this end, referring to the specific embodiment of the device shown in Fig. 7, it will be observed that a casing 186 is provided with two separate chambers 188 and 190, divided by a partition 192. The

first chamber 188 is connected directly at its lower end with the branch conduit 182, and the second chamber 190 is connected at its upper end with a short conduit 194 leaving directly to the end of the ram cylinder. With this construction it will be evident that pressure transmitted to the inner end of the ram cylinder must be exerted through the retarding mechanism 184. Communication between the two chambers from the pressure side is controlled by a valve 196 having a stem 198 surrounded by a relatively heavy spring 200. The valve normally prevents communication between the chambers until the pressure within the chamber 188 is sufficient to compress the spring and remove the valve from its seat. The strength of the spring is such that upon initial movement of the control valve 150 to connect the conduits 160 and 164, the valve 196 remains closed, causing the full force of the fluid pressure in the conduit 160 to be directed into the fluid pressure cylinder 110 to initially withdraw the fluid pressure head from engagement with the tube. When this comparatively short movement of withdrawal has been accomplished, the full force of the pressure is thereafter exerted in the chamber 188, and is sufficient to lift the valve 196 from its seat and withdraw the ram to the limit of its movement. When the control valve is moved in the opposite direction to connect the conduit 194 to exhaust, then communication between the chamber 190 and the chamber 188 is controlled by a second valve 202, which is provided with a comparatively light spring 204 and which readily yields to permit communication between the two chambers and the conduit 182 to permit the contracting ram to move toward the die assembly simultaneously with the fluid pressure head. Although this retarding or accelerating mechanism, as it may be termed, actually serves to accelerate the withdrawal of the fluid pressure head at completion of the product, it will nevertheless be understood that by a proper location and connections it may readily serve for controlling the relative movements of the two members in any desired manner from a single centralized control.

It will be evident that after the movements of the fluid pressure head and contracting ram into engagement with opposite ends of a tube, fluid pressure is introduced into the interior of the tube for forming and sustaining the tube during its contraction. This fluid pressure is materially higher than that employed for the movements of the rams, and is preferably derived from a separate source of supply. The control of the sustaining fluid pressure, as it may be termed as contrasted with the plunger operating pressure, is accomplished by a control valve 210 located in proximity to the valve 150

and the release lever 50. This valve, as indicated more particularly in Figs. 1 and 6, is mounted above the contracting ram on a base 214, and is provided with an operating handle 216 fulcrumed at 218 upon a support 220. The operating handle is provided with oppositely-disposed arms 222 and 224, each of which is connected at its outer end with an operating plunger 226 and 228. These operating plungers are designed to engage and release small slide valves 230 each normally closing a passage 231 by a spring 232. The valves 230 are on the order of needle valves, and are intended to suitably operate under the relative high pressures employed and to close the passages against such pressures when not in operation. The arm 222 and the plunger 226 can close communication between a conduit 234 leading from the control valve to the fluid pressure head, and a supply conduit 236 connecting the passage directly with the high pressure source. The opposed arm 224 and connected plunger 228 controls a second conduit 240 communicating with the fluid pressure head, and a conduit 242 forming an atmospheric drain. When the high pressure control is located in one of two predetermined positions, therefore, the fluid pressure head and interior of the tube is connected directly to the high pressure source. When the valve is moved to the second of two predetermined positions, the interior of the tube is cut off from the high pressure source, and is connected directly to an atmospheric drain or vent, as will be evident. The two operating positions of the control lever are preferably determined by the employment of a detent 246 projecting downwardly from the control adjacent the fulcrum engaging with a complementary projection 248, mounted upon a bowed spring 250 to maintain the lever in either one of two operative positions, as will be evident to those skilled in the art. Referring more particularly to Fig. 1, the main conduit 234 communicating in one position of the valve with the high pressure source, is tapped into a fitting 252 which communicates with an automatic pressure regulating mechanism, indicated at 254, and with the conduit 256 tapped into a second fitting 258, communicating directly through a short conduit 260 with the passages 262 formed in the fluid pressure head. Mounted above the fitting 258 may be a pressure gage 264 to indicate at all times the pressure existing immediately at the fluid pressure head and within the interior of the bellows. It will be evident that the pressure gage, together with the connected fitting and conduit, are mounted upon the movable plunger 112, and the fluid pressure head accordingly moves with this portion of the head into and out of sealing engagement. To permit this relative movement, the portion 256 of the high pressure conduit, together with the adjacent por-

tion of the discharge conduit 240, are provided with coils 266 and 268 to permit this relative movement without necessity for providing sliding connections or similar devices. Furthermore, the conduit 260 is provided with a disk 270 which rotarily engages with a distance bar or track 272 rigidly connected at opposite ends to the die assembly and flange 118, and serving not only to brace the die assembly but in addition to provide a guide for the pressure gage and connected parts during the movement of the fluid pressure head. From the foregoing description, it will be evident that when the high-pressure control is moved to operative position, the conduit 234 is connected to the high-pressure source and at the same time the automatic pressure regulator 254, the pressure gage 264, and the interior of the tube are likewise connected to the high pressure source. Upon movement of the control valve to the second or exhaust position, the conduit 234 with the connected parts is cut off from the high-pressure source and the interior of the fluid pressure head, and the connected tube communicates with the atmospheric drain or vent 242.

In forming bellows folds in tubing through the employment of an internal fluid pressure, it is important that during the formative operation the pressure shall be accurately controlled, irrespective of the rate at which the tube is contracted through the ram. This regulation of the pressure presents no particular problem if the contraction of the tube takes place slowly or through manual operation in such a fashion that contraction can be instantly arrested if undue variation of pressure is observed. On the other hand, if after initial introduction of fluid pressure and removal of the spacer members from between the die plates, the tube is thereafter to be contracted at a rapid rate, control of the high pressures employed presents a serious problem. This is due in part to the fact that during the first portion of the contracting movement, the cubical capacity of the tube, due to the enlargement or bulging between the collapsing die plates, constantly increases. During the last part of the movement, however, when the die plates are finally collapsed upon one another, the movement represents primarily a closing of the opposite walls of the bellows folds toward one another with a reduction in cubical capacity. During this period of the movement, it is important that the pressure shall not exceed the previously predetermined amounts. During the first part of the movement, on the other hand, it is equally important that the pressure shall be maintained in sufficient amount to prevent initial collapse of the walls with consequent folding or crimping of the folds. The present invention embodies a unique and highly efficient form of regulation which serves to

maintain the pressure within the tube itself at the desired limits, irrespective of the rate of contraction of the tube under the action of the ram. To accomplish this purpose, an automatic regulator, indicated generally at 5 254, is inserted in the high pressure line, as previously stated, immediately adjacent the connection of this line with the fluid pressure passage or head. This regulator comprises, 10 generally speaking, a casing 280 supported directly upon the frame 118 and having a port 282 connected directly with the fitting 252, and a second port 284 connected with an atmospheric drainage conduit 286, as indicated more particularly in Figs. 1 and 9. 15 Slidingly supported within a chamber 290 formed in the casing is a balanced valve 292 having portions 294 and 296 slidingly received within a guide sleeve 298, and separated by a reduced portion 300. The guide sleeve is provided with ports 302 and 304 in constant registration with the ports 282 and 284, and is locked in place within the casing 280 in any desired manner. This guide 20 sleeve is provided with a longitudinal recess 306 to permit the high pressure side to be transmitted freely to the chamber 290 above the valve and the chamber 308 below the valve, thus balancing out the pressure on opposite ends of the valve. The upper end of the valve is provided with a stem 310 having an enlarged collar 312 which loosely floats within a fitting 314 threadedly connected with the lower end 316 of a rod 318. The operating rod 318 extends upwardly through a 25 partition head 320, and is surmounted at its upper end by a thrust block 322 engaged by a spring 324 located in a spring chamber 326 formed in a second sleeve 328 threadedly connected with the casing 280 at 330. The rod 318 slides freely through the partition head 320, and communication between the pressure chamber 290 and the spring chamber 326 is prevented by a bellows 332 which hermetically seals the passage between the two chambers. This bellows, as indicated, is provided with a fitting 334 at the upper end threaded at 336 to a neck depending from the partition head 320, and at its lower end with a fitting 338 threaded to an enlarged boss 340 on the 30 rod 318. The opposite ends of the bellows are flanged outwardly at 342, providing a portion which is firmly clamped between the fitting and the adjacent part in each case. This construction provides means for hermetically sealing communication between the two chambers while permitting the necessary sliding movements of the rod 318 through expansion and contraction of the bellows unit. 35 The spring chamber is provided at its upper end with a threaded cap or block 350 which engages the upper end of the thrust spring and by adjustment within the sleeve 328 may vary the pressure exerted by the spring on the block 322. The member 350 is

preferably provided with a vent opening to insure maintenance of the spring chamber at atmospheric pressure. With this construction it will be evident that the exterior of the bellows 332 is subjected to the pressure within the chamber 290, whereas the interior of the bellows is subjected to pressure within the spring chamber, owing to the free movement of the rod in the partition head 320. Inasmuch as pressures upon the piston valve 70 292 are substantially balanced out, the unbalanced pressure tending to move the valve is the unbalanced pressure upon the bellows seal, due to the excess of pressure exerted externally of the bellows. In actual practice, 80 if the operating pressure be introduced within the tube to be formed is 600 pounds, the thrust spring 324 is adjusted until at this pressure the lower face 350 of the slide valve is positioned just below the exhaust port 304, 85 cutting off communication therewith. In this position of the mechanism, the thrust block 322 is elevated by the rod 318 and the connected parts are maintained in a condition of balance with no pressure venting from the 90 port 284. If the pressure within the chamber 290, however, exceeds this predetermined amount, the parts are immediately unbalanced, due to the greater pressure within the chamber, and the piston valve 292 is elevated the slight distance necessary to uncover the port and vent pressure. Inasmuch as this pressure is customarily secured with liquid, such as water, it will be evident that venting of a slight amount of water instantly 100 relieves the pressure, and that further venting must be arrested. Upon dropping of the pressure, the balance is immediately restored, and the vent is closed, equilibrium having been reestablished. On the other hand, if 105 excess of pressure continues, the valve is opened wider and increased venting occurs. In actual practice, it is found that desired regulation is accomplished with no chattering of the valve or undue fluctuation of pressure, and this irrespective of the rate at which changes in cubical capacity of the tube occurs. It will be evident that, owing to the proximity of the regulating mechanism, the pressure within the regulating mechanism is at all 110 times substantially the pressure within the head, and that no lag is introduced due to fluctuations within the pressure line.

The casing 280 is sealed beneath the valve by a cap nut 360 which is threadedly connected into the lower end of the casing, as indicated in Fig. 9. 115

The fluid pressure head is provided with a compensating device which insures sealing engagement of the head throughout the formation of the bellows. To this end, the end of the ram 112 is provided with a tubular head 363 threadedly connected at 364 to a reduced neck formed on the end of the ram. This sleeve provides a bearing for a sliding 120 125 130

head 366 in the outer end thereof, the movement of the sliding head being limited by a second sleeve 368 which engages with an annular flange 370 formed on the head. The head is normally maintained in outer position by a strong spring 372. The outer end of the head is provided with a yielding gasket 374 held in place by a cap 376. As indicated, the head is provided with a pressure passage 378 extending therethrough and in constant communication with a supply passage 262. With the foregoing construction, as the fluid pressure head is advanced into sealing engagement with the fitting on the end of the tube, the sealing ring first engages with the fitting and clamps it against the end die. Thereafter continued movement of the head causes the spring to partially yield, in which position the head is maintained during the formation of the bellows, the sealing pressure being exerted directly by the spring 372. With this construction, the seal is maintained irrespective of fluctuations in pressure or slight jarring or movement of the connected parts during the formative operation.

It will be evident to those skilled in the art that the source of high fluid pressure may conveniently be any conventional form of high pressure liquid pump provided with an accumulator to insure not only a constant pressure, but the necessary volume to initially fill the tube and to thereafter maintain the tube filled during contraction in length and bulging between the collapsible dies. In the usual method of operation, this source of high pressure maintains a pressure in the line somewhat higher than the desired pressure to be maintained within the tube during formation of the bellows. The pressure regulator, on the other hand, is adjusted to maintain the desired lower pressure head within the tube and to accomplish this maintenance of a lower pressure by a substantially constant and variable venting of fluid or liquid from within the pressure conduit adjacent to the pressure head during contraction of the tube and formation of the bellows.

What is claimed is:—

1. Apparatus for producing bellows tubing comprising a die assembly, movable members designed to engage opposite ends of a tube within the assembly, means for simultaneously moving the members toward one another into operative position in engagement with the tube, means for introducing fluid pressure to the interior of the tube through one of the members, and means for thereafter imparting a continued movement of approach to one of the members to contract the tube while subjected to the internal fluid pressure.

2. Apparatus for producing bellows tubing comprising a die assembly, a fluid pressure head mounted at one end of the assembly, a contracting ram mounted at the op-

posite end of the assembly, means for moving the contracting ram toward the assembly, a stop for limiting the movement of approach of the ram when substantially in contact with the end of the tube mounted in the assembly, and means for releasing the ram to permit a continued movement of approach lengthwise of the tube.

3. Apparatus for producing bellows tubing comprising a die assembly, a fluid pressure head engaging one end of a tube within the die assembly, a series of spacer members cooperating with the die assembly, a contracting member, a stop for limiting the initial movement of the contracting member toward the die assembly, a releasing control, and operative connections between the control, spacer members, and stop, to withdraw the spacer members and stop and permit continued movement of the contracting member toward the fluid pressure head.

4. Apparatus for producing bellows tubing comprising a series of partible dies adapted to enclose a tube, a fluid pressure head mounted at one end of the dies, a contracting member mounted at the opposite end of the dies, means for moving the contracting member toward the dies in alignment with the tube supported therein, means for arresting the movement of approach when the contracting member is in substantial contact with the end of the tube, means for introducing fluid pressure into the interior of the tube, and means for thereafter releasing the contracting member to permit a continued movement of approach and thus to contract the tube.

5. Apparatus for producing bellows tubing comprising a series of partible dies adapted to enclose a tube, a fluid pressure head mounted at one end of the dies, a contracting member mounted at the opposite end of the dies, means for moving the contracting member toward the dies in alignment with the tube supported therein, means for initially maintaining the dies in spaced relationship, means for arresting the movement of the contracting member when in substantial contact with the end of the tube, means for introducing fluid pressure into the interior of the tube, and means for thereafter removing the spacing means and releasing the contracting member to permit a continued movement of approach.

6. Apparatus for producing bellows tubing comprising a series of partible dies, a fluid pressure head at one end of the dies, a contracting member at the opposite end of the dies, means for moving the head and contracting member toward the dies, a series of spacer members cooperating with the dies, means for arresting the movement of the contracting member toward the dies, and a single control means designed to preliminarily render the spacer members inoperative and

to thereafter release the contracting member to permit a continued movement of approach after removal of the spacer members.

7. Apparatus for producing bellows tubing comprising a series of partible dies, a fluid pressure head at one end of the dies, a contracting member at the opposite end of the dies, means for moving the head and contracting member toward the dies, a series of spacer members cooperating with the dies, means for arresting the movement of the contracting member toward the dies, a control lever conveniently accessible to the operator, connections between the control lever and spacer members for removing the spacer members into inoperative position upon initial movement of the control lever, connections between the lever, and arresting means for releasing the contracting member upon complete removal of the spacer members into inoperative position.

8. Apparatus for producing bellows tubing comprising a series of partible dies, a contracting member movable lengthwise of a tube supported in the dies, a locking member movable into and out of operative position with respect to the contracting member in the plane of movement of the contracting member, an actuating member operatively connected with the locking member and movable transversely of the plane of movement of the contracting member, and a control member connected therewith.

9. Apparatus for producing bellows tubing comprising a contracting member movable lengthwise of the machine, a control lever movable transversely thereof, a control slide, connections between the slide and control lever, a locking finger designed to arrest the movement of the contracting member in one position of the locking finger, and connections between the locking finger and slide for moving the locking finger into and out of operative position upon transverse movement of the slide.

10. Apparatus for producing bellows tubing comprising a series of partible dies, a contracting ram, means for moving the ram toward the partible dies, a removable stop designed to arrest the movement of the ram toward the dies, and an adjustable abutment cooperating with the stop to limit the position of the ram in which the movement of approach is arrested.

11. Apparatus for producing bellows tubing comprising a series of partible dies, spacer members cooperating with the dies, a contracting ram, means for moving the ram toward the dies, a removable stop for arresting the movement of the ram toward the dies, a control member, direct connections between the control member and spacer members for moving the latter upon initial movement of the control, and lost-motion connections between the control member and

stop removing the latter after movement of the spacer members has been initiated.

12. Apparatus for producing bellows tubing comprising a collapsible die assembly, a pressure head operatively engaged with a tube supported in the assembly, a contracting ram, means for imparting a comparatively rapid movement to the ram to contract the tube within the assembly, means for introducing fluid pressure into the tube, and means for maintaining the fluid pressure within the tube substantially constant independent of abrupt variations in the volumetric capacity of the tube due to the rapid contraction in length.

13. Apparatus for producing bellows tubing comprising a collapsible die assembly, a fluid pressure head, a contracting ram, means for introducing fluid pressure into the tube through the head, means for moving the ram in a direction to contract the tube with fluid pressure therein, pressure regulating mechanism connected with the fluid pressure line in proximity to the head and designed to automatically maintain a constant pressure within the tube both as the volumetric capacity of the tube increases and diminishes during contraction.

14. Apparatus for producing bellows tubing comprising a series of collapsible dies, a fluid pressure head at one end of the die assembly, a contracting member at the opposite end of the die assembly, means for supplying liquid at a substantially constant high pressure and in varying volumes as needed to the fluid pressure head, and pressure regulating mechanism positioned adjacent the head in communication with the fluid pressure source and designed to maintain a substantially constant and somewhat lower pressure head and to vent liquid in variable amounts for this purpose during the contraction of the tube.

15. Apparatus for producing bellows tubing comprising a series of partible die members, a fluid pressure head connected with a tube supported within the die members, a pressure conduit communicating with the head designed to introduce fluid on a substantially high pressure into the tube sealed by the head, means for contracting the tube, a metallic bellows subjected on one side to the pressure within the conduit and on the opposite side to a substantially lower and constant pressure independent of the pressure within the conduit, a balance valve operated by variation in differential pressure upon the bellows, and a vent opening controlled by the position of the balance valve to automatically regulate the pressure within the tube.

16. Apparatus for producing bellows tubing comprising a die assembly, a fluid pressure head and contracting ram positioned at opposite sides of the die assembly, means

for moving the two members toward one another into operative relation with a tube held within the assembly, and means acting automatically to first initiate withdrawal of the pressure head from engagement with the tube and thereafter complete removal of the pressure head and contracting ram.

17. Apparatus for producing bellows tubing comprising a pressure head and contracting ram positioned at opposite sides of the die assembly, an operating plunger connected to each member, fluid pressure connections at opposite sides of each plunger, and a single control designed in one position to introduce fluid pressure behind the outer ends of the plungers to concurrently move the pressure head and ram toward one another and in a second position to introduce fluid pressure behind the inner ends of the plungers to separate the members.

18. Apparatus for producing bellows tubing comprising a die assembly, a pressure head and contracting ram at opposite ends of the die assembly, fluid pressure and exhaust lines, a single control, operating plungers connected with the pressure head and contracting ram respectively, and operative connections designed to concurrently connect the outer ends of the plungers to the source of fluid pressure and the inner ends of the plungers to exhaust in one position of the valve and to reverse the connections in a second position of the valve to cause concurrent movements in opposite directions of the two members upon movement of the valve from one position to another.

19. Apparatus for producing bellows tubing comprising a die assembly, a fluid pressure head designed to seal the end of a tube within the assembly, a high pressure fluid supply, a control mechanism connected therewith, connections between the control and the fluid pressure head supplying pressure thereto, a return from the fluid pressure head to the control for exhausting pressure therefrom, means for operating the control to connect the fluid pressure head to the high pressure source in one position and to the exhaust in the second position, and means for automatically regulating the pressure when the head is connected to the high pressure source.

20. Apparatus for producing bellows tubing comprising a frame, a die assembly mounted on the frame adapted to receive a tube in substantially horizontal position, a fluid pressure head and contracting ram positioned at opposite ends of the die assembly, fluid pressure connections for moving the head and ram into operative relation with the tube within the assembly, means for conducting high pressure fluid to the head for introduction into a tube sealed thereby, means conveniently accessible to the operator for controlling the admission of high

pressure fluid to the head, and means adjacent thereto for controlling the movement of the fluid pressure head and contracting ram under the influence of fluid pressure.

21. Apparatus for producing bellows tubing comprising a die assembly, a movable pressure head for sealing the end of the tube within the assembly, a high pressure line, an automatic pressure regulator connected with the line, a pressure gage movable with the head, and flexible pressure connections between the high pressure line and movable head.

22. Apparatus for producing bellows tubing comprising a collapsible die assembly, a fluid pressure head, a fluid operated plunger connected with the head, a cylinder within which the plunger operates designed to limit the range of movement of the plunger and fluid pressure head, and means for bodily adjusting the cylinder to shift the range of movement of the head.

23. Apparatus for producing bellows tubing comprising a stationary die assembly provided with a series of partible dies collapsible toward and from one another, oppositely disposed members movable toward and from one another axially of a tube supported within the die assembly, fluid operated mechanism for imparting movement of the members toward and from one another, and means under the control of the operator for governing the operation of the mechanism.

24. Apparatus for producing bellows tubing comprising a collapsible die assembly, a head movable toward and from the die assembly, a sliding member carried within the head, a spring for normally maintaining the sliding member in advanced position, and connections between the sliding member and head for determining the advanced position of the sliding member with relation thereto, the sliding member being designed to engage with the tube within the die assembly and to be withdrawn from advanced position and retained yieldingly in engagement with the tube by the spring.

25. Apparatus for producing bellows tubing comprising a collapsible die assembly, fluid operated members movable toward one another into contracting relation with opposite ends of a tube held within the assembly, means for introducing internal fluid pressure into the tube while thus supported, and means for thereafter permitting a further relative movement of approach of the fluid operated members to contract the tube and simultaneously collapse the die assembly.

26. Apparatus for producing bellows tubing comprising a die assembly, movable members positioned at opposite ends of a tube within the assembly, manually controlled means for causing automatic movement of both members toward one another into contracting relation with the tube, means for

introducing fluid pressure to the interior of the tube, and means for thereafter imparting a continued movement of approach to one of the members to contract the tube while
5 subjected to internal fluid pressure.

27. Apparatus for producing bellows tubing comprising a die assembly, a pressure head supported at one end of the assembly, a contracting member supported at the opposite end of the assembly, means for moving
10 the contracting member toward the assembly, means for limiting the movement of approach of the contracting member at a predetermined point when the member has
15 reached an operative position from which tube contraction is initiated, and manually controlled means for thereafter causing the contracting member to approach the pressure member and contract the tube in a lengthwise
20 direction.

28. Apparatus for producing bellows tubing comprising a die assembly, a pressure head supported at one end of the assembly, a series of spacer members cooperating with
25 the die assembly for insuring a predetermined spacing of the dies supported therein, a contracting member, means for limiting the initial movement of the contracting member toward the die assembly at a predetermined
30 point, a releasing control, and operative connections for first rendering the spacer members inoperative and for thereafter causing a continued movement of approach to be imparted to the contracting member length-
35 wise of the tube.

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