United States Patent [19]

Roth

[11] **3,786,662**

[45] **Jan. 22, 1974**

[54] **ELECTROPNEUMATIC OR ELECTROHYDRAULIC CUTOFF, FLANGING AND RE-FORMING OF TUBING**

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[22] Filed: **Aug. 31, 1970**

[21] Appl. No.: **68,505**

Related U.S. Application Data

[63] Continuation of Ser. No. 441,017, March 19, 1965, abandoned.

[52] **U.S. Cl.** **72/55**

[51] **Int. Cl.** **B21d 28/18**

[58] **Field of Search** ..... 72/56, 55; 29/421 E; 113/120 R, 120 AA

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Primary Examiner—Richard J. Herbst

Attorney, Agent, or Firm—Diller, Brown, Ramik & Holt

[57] **ABSTRACT**

Disclosed herein is apparatus and method for the electropneumatic or electrohydraulic severing, flanging, re-forming and the like of members such as, for examples, container bodies and the like. The force generated for performing these operations is created through the application of electrical energy to a pair of electrodes positioned within a chamber to provide an electrical discharge within such chamber. The electrical discharge creates a plasma bubble between the electrodes and such bubble continues to grow as continued power is supplied to the electrodes. The force so created drives the wall of the member or workpiece against an adjacent die to perform the desired operation or operations.

10 Claims, 11 Drawing Figures

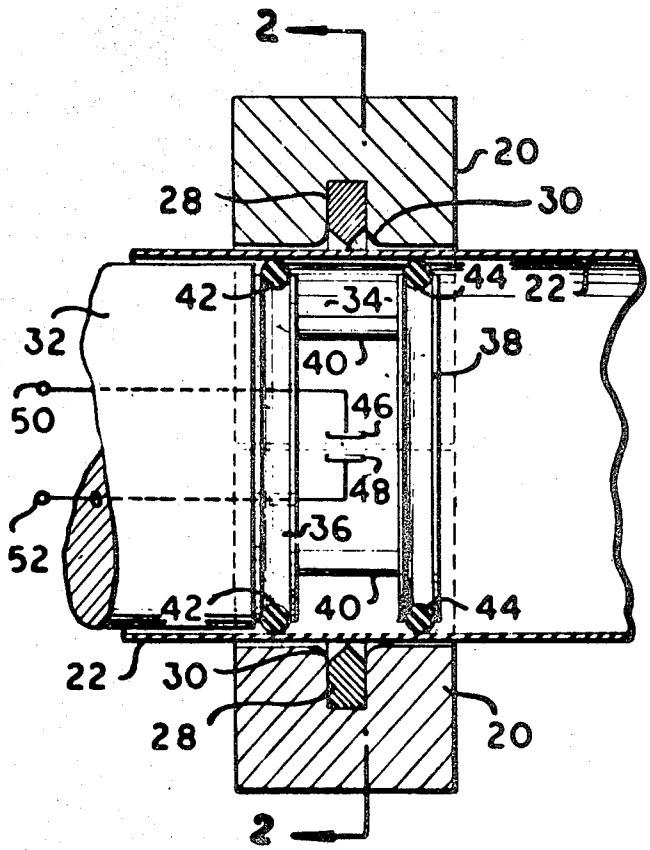


FIG. 1

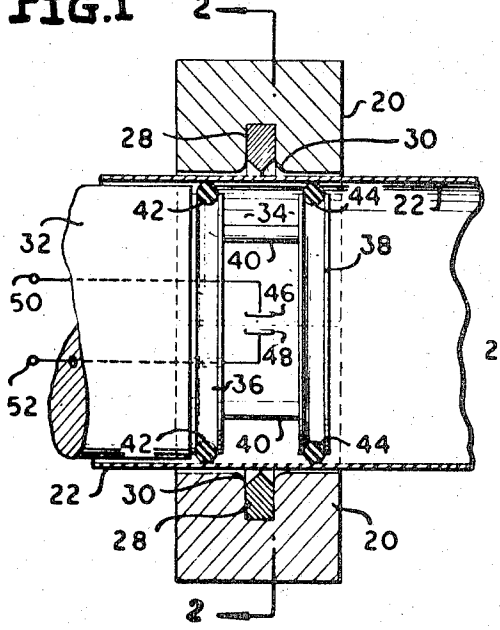
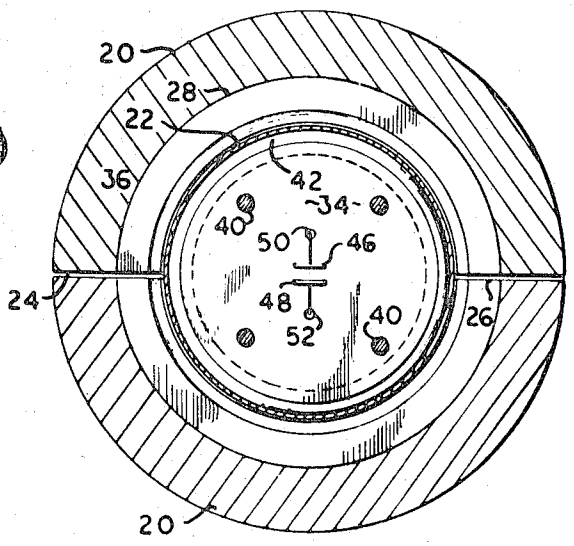


FIG. 2



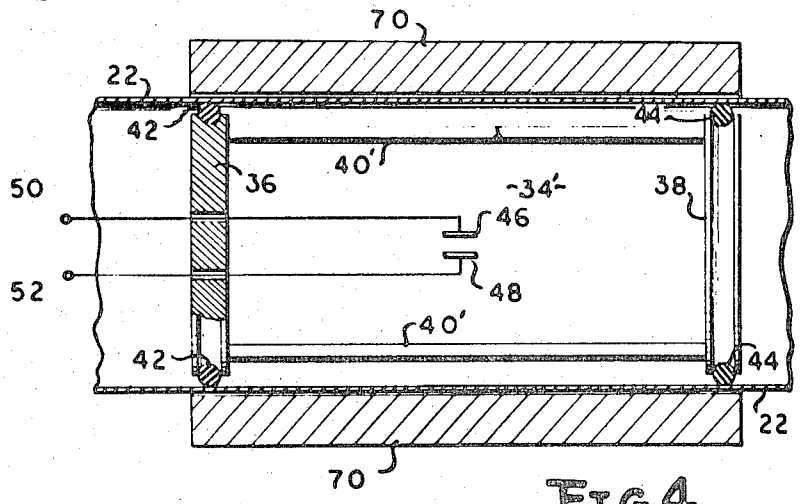


FIG. 3

FIG. 4

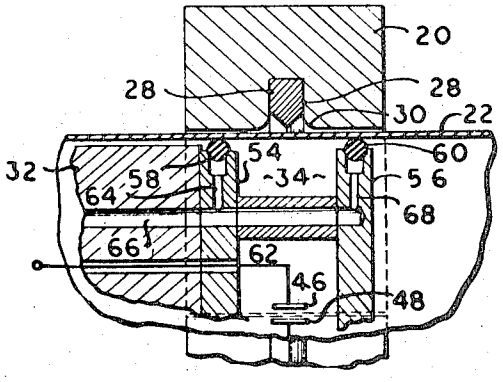


FIG. 5

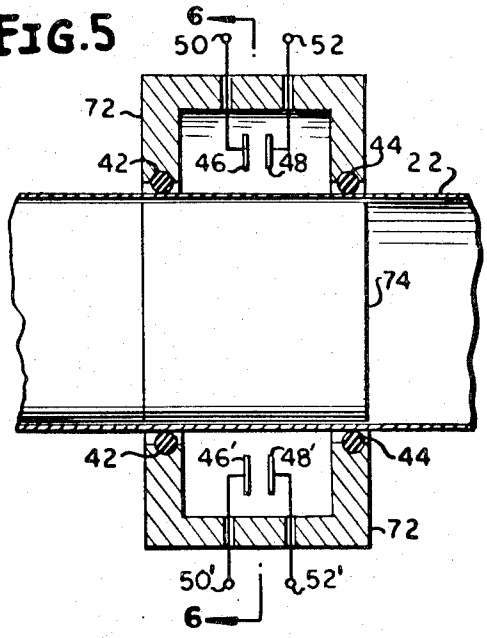
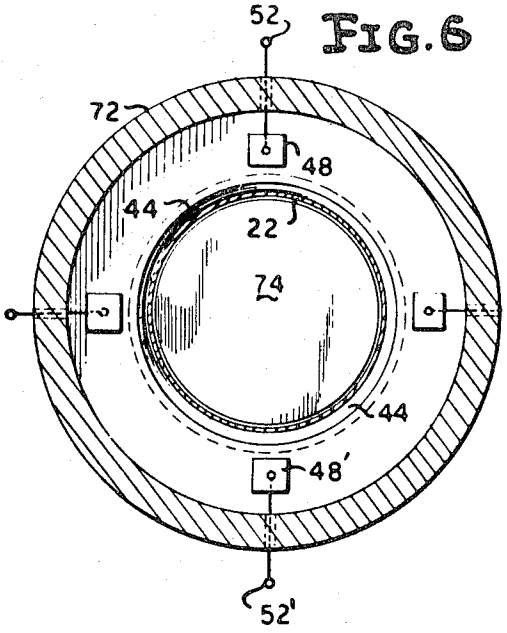


FIG. 6



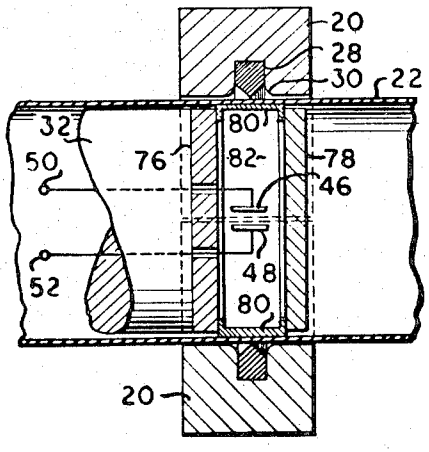


FIG. 7

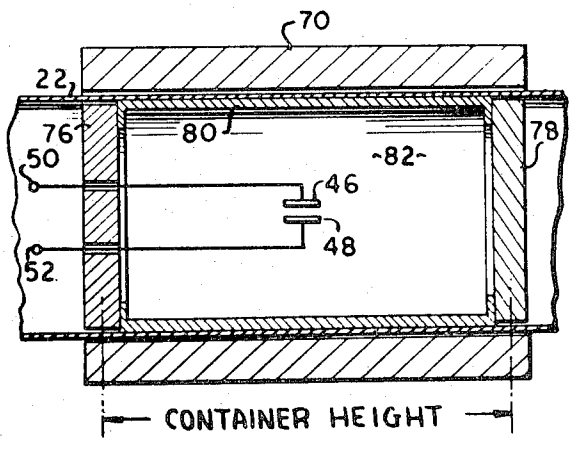


FIG. 9

FIG. 8

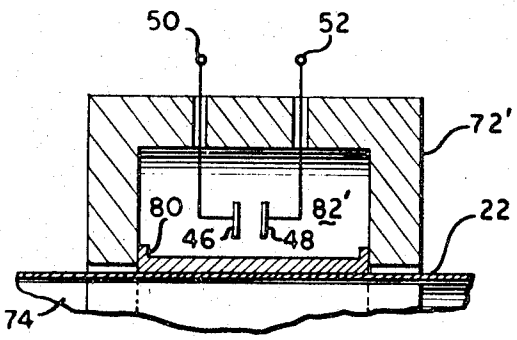


FIG. 10

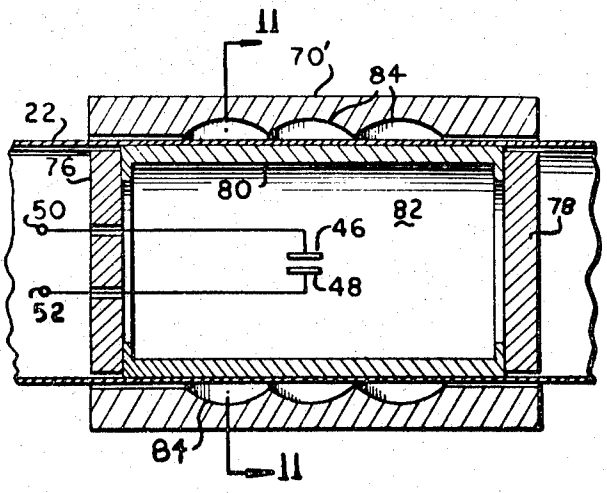
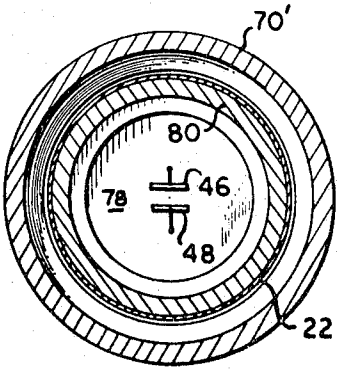


FIG. 11



ELECTROPNEUMATIC OR ELECTROHYDRAULIC CUTOFF, FLANGING AND RE-FORMING OF TUBING

This application is a continuation of Ser. No. 441,017, filed Mar. 19, 1965, now abandoned.

This invention relates to severing, flanging, and re-forming means and more specifically to apparatus and methods for performing these operations by the employment of an arc discharge in an electropneumatic or electrohydraulic medium.

Heretofore, in operations relating to the fabrication of containers possessing thin walls, the initial step in the fabrication of the container is to sever a portion from stock material. This portion, known as a blank, is then advanced to means which form the blank in the desired configuration. The operations of cutting or severing, flanging, reshaping and/or re-forming were accomplished at relatively slow speeds and each operation was performed individually. If the fabrication of containers, whether they be of metal, plastic, paper or any combination of these materials, is to be truly successful, then the operation must be performed at high speed, with economies of operation, and the fabrication must be easily controlled.

The present invention contemplates that rather than severing a blank from a roll of stock material and then proceeding with the subsequent fabrication operations, the stock material would be formed in the desired configuration directly and then severed after the configuration of the container has been accomplished. In addition, it is envisioned by the practice of the present invention that a pluraltiy of operations performed in the heretofore manner, would be accomplished in a single operation.

At the present time, there is no known truly successful manner for severing a cylindrical container after the container has been formed into a cylindrical body. A die may be employed in a usual manner to sever the container; however, the usual severing operation results in a distortion of the container to such a degree that re-forming is either mandatory or is impossible.

In addition to the severing capabilities of the invention, the flanging of the container body would be accomplished at the same time as the severing operation. Accordingly, it will be intuitively clear that a great savings in time and material will be effected by combining the previous steps of severing and flanging into a single operation.

The principles of the invention may also be applied to the operation of re-forming or reshaping a container body. It will be understood that throughout the specification reshaping and re-forming are synonymous and will be used interchangeably. The re-forming operation could be performed before or after the severing and flanging operation as previously outlined. If it is desired, the re-forming operation could be performed by a continuous operation without the necessity of halting the containers while traveling through the fabrication process.

Accordingly, it is the principal object of the present invention to improve container severing techniques.

It is a further object of the present invention to improve container severing techniques employing the force created by the discharge of a spark across a pair of electrodes.

It is a further object of the present invention to improve container re-forming or reshaping techniques by the force created through the discharge of a spark across a pair of electrodes.

It is a further object of the present invention to provide a system capable of simultaneously performing a severing and flanging operation on container bodies.

It is a still further object of the present invention to provide a means for performing operations on container bodies by causing a spark discharge in a fluid medium to displace the body according to a predetermined configuration.

Although a number of operations are shown and described which may be performed on container bodies, the principle of the invention relates to, in one embodiment, positioning a length of cylindrically formed material within a restraining means and severing a portion of the material, which severing takes place radially and completely about the periphery of the container. The container edge may also be flanged simultaneously with the severing operation. The container body is positioned within a circular die and supported about the inside periphery of the die is a cutting or severing knife. Within the die, a chamber is formed which houses a pair of electrodes. The chamber may house any one of a number of fluids, such as air, water or oil of high dielectric constant, etc. When a power supply capable of causing a discharge to take place between the electrodes is applied to connecting leads, the force created by the discharge is transmitted through the fluid to the inside wall of the container. At the point where the cutting knife meets the container, a severing operation will result. The cutting knife is beveled which permits the rapidly moving severed container edge to continue on into the beveled area (a void between the side of the severing knife and the die) to then result in a flanging operation. Due to the elasticity of the material, a certain amount of flanging may take place just prior to the complete severing of the cylindrical wall of the container. The energies which force the wall of the container against the severing-flanging die are created by the discharging of the high current spark across the spark gap. A plasma bubble is formed in the spark gap and continues to grow as continued power is supplied to the electrodes. This expansion, in one embodiment, forces the elastomeric material out very rapidly against the tubing, causing the desired operation on the tubing. This force occurs within microseconds so that a very rapid severing and flanging rate may be maintained.

In addition to the severing and flanging operation, a re-forming operation may be performed. In the re-forming operation, the severing knife die is replaced with a re-forming die in which the spark discharge causes the container wall to be violently forced against the re-forming die to result in a forming or re-forming operation.

Various modifications are anticipated, one of which would be the positioning of the severing knife within the container, with the severing operation to be accomplished by driving the container wall inwardly. In addition, various combinations of severing, re-forming, or flanging may be accomplished by positioning the elements of the invention in the desired manner.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to

the following specification taken in conjunction with the accompanying drawings in which:

FIG. 1 is a cross-sectional side elevation view showing a cylindrical member in position for severing and flanging;

FIG. 2 is a sectional view taken on the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary view of a modification of the form of the invention illustrated in the FIG. 1;

FIG. 4 is a cross-sectional view showing one form of the re-former and a cylindrical body in position for re-forming;

FIG. 5 is a cross-sectional side elevation view similar to the view of the FIG. 1 and illustrating a modified form of the invention wherein the electrodes are disposed about the container body;

FIG. 6 is a sectional view taken on the line 6—6 of FIG. 5;

FIG. 7 is a sectional side elevation view similar to the view of the FIG. 1 and illustrating a modified form of the invention.

FIG. 8 is a fragmentary view of a modified form of the invention shown in the FIG. 1;

FIG. 9 is a sectional view similar to the view of the FIG. 4 and illustrating a modified form of the container re-former or reshaper and a container body in position to be re-formed or reshaped;

FIG. 10 is a sectional view similar to the view of the FIG. 9 but illustrating a type of embossing die wherein undulations are formed in the container wall to result in a reshaping or re-forming of the tube or container body; and

FIG. 11 is a sectional view taken on the line 11—11 of the FIG. 10.

It may be noted at this point, that the apparatus shown in the FIGS. 1 through 6 is best suited for performing operations with the spark discharge being in an atmosphere of air or other gas. These embodiments may be termed electropneumatic. The apparatus shown in the FIGS. 7 through 11 are best suited for operations wherein the chamber enclosing the spark discharge area contains a liquid. These embodiments may be termed electrohydraulic. However, it will be understood that either a gas or liquid may be employed in any of the apparatus illustrated in the figures.

With reference to the FIGS. 1 and 2, a cylindrical die 20 surrounds a cylindrical tube or container body 22. The die 20 is split at 24 and 26 to facilitate the removal of a severed and flanged container body by separating the die 20, which separation means are not shown.

Supported within the die 20 and directed inwardly is a severing knife 28 having its severing surface substantially perpendicular to the container body 22. The container body 22 fills substantially all the area within the inside of the die 20 and may or may not lightly engage the die 20 in the absence of a severing operation. It will be noted that the severing surface or point of the severing knife 28 extends to a point substantially in line with the inside periphery of the die 20. Formed next to the severing knife 28 and on the die 20 is a flanging radius 30 which controls the shape of the flange formed on the edge of the container body 22 when the container body 22 is driven against the severing knife 28 and severed. By varying the flanging radius 30, on the die 20, a great variety of shapes and sizes of flanges may be derived. By reducing the flanging radius 30 to substantially zero, then little or at best a very small radius would be formed on the container body 22. It will be intuitively clear that a certain area must be provided next to the severing knife 28 to permit the knife 28 to completely penetrate the wall of the container body 22, if such is desired.

In the FIGS. 1 and 2, a horn extension 32, of slightly lesser diameter than the container body 22, supports the means within the die 20 to cause the severing and flanging operation. A gas chamber 34 is formed between a sealing plate 36, which is rigidly connected to the horn extension 32 and a second sealing plate 38 which is held in place by a plurality of spacers 40. Thus, the chamber 34 is formed in the area between the sealing plates 36 and 38. The chamber 34 is substantially sealed between the sealing plates 36 and 38 and the container body 22 by a pair of low friction seals (such as the familiar O-ring) 42 and 44, respectively. The horn extension 32 would be movable and would normally place the chamber 34 in a position within the area toward which the severing knife 28 is directed.

Supported by any suitable means, not shown, are a pair of electrodes 46 and 48 which are coupled to a power supply, not shown, by the conductors 50 and 52, respectively. The force which does the mechanical work of severing and/or flanging a container body 22 is created by discharging a high power spark across the electrodes 46 and 48. A plasma bubble is fomred in the spark gap between the electrodes 46 and 48 and continues to grow as additional power is applied to the electrodes by the power supply, not shown. The spark discharge causes heating and vaporization of some of the fluid and expansion of this vapor along with gases entrapped within the fluid. The bubble thus generated displaces the fluid which in turn provides the force for subsequent operation. Thus, a cylindrical body such as a container body 22 would be thrown outwardly and against the severing knife 28 and into and about the flanging radius 30. The die 20 would then be opened by any conventional means, and the severed portion of the cylindrical body 22 would be removed and the remaining portion of the cylindrical body 22 would be advanced to the point where another severing and/or flanging operation is desired.

Spark discharges between a pair of electrodes, such as the electrodes 46 and 48 in the FIG. 1, are well known in the art and do not need to be explained in detail with reference to the invention.

The FIG. 3 shows a modification of the chamber sealing means of the FIG. 1. As the FIG. 1 employs a pair of O-rings 42 and 44, the apparatus of the FIG. 3 employs inflatable members. The chamber 34 is formed by the sealing plates 54 and 56. About their peripheries and engaging the inner circumference of a container body 22 are the inflatable tubes or members 58 and 60, positioned respectively upon the sealing plates 54 and 56. The sealing plate 54 is connected to the horn extension 32 (in a manner similar to that shown in the FIG. 1) and the second sealing plate 56 is supported by a spacer 62 which is rigidly coupled to the sealing plate 54. Communicating with and within the sealing plate 54, is a passage 64 which connects with a source of pressure within a tube such as the air supply tube 66. The tube 60 communicates with the air supply tube 66 through a passage 68. The electrodes 46 and 48 are substantially identical to those shown in the FIG. 1.

In the embodiment of the FIG. 3, the tubes 58 and 60 would be deflated during positioning of a container

body or cylindrical tube 22 and upon the container body 22 reaching the point at which it is desired to sever and/or flange the body 22, a source of pressure would be applied to the air supply tube 66 which would inflate the tubes 58 and 60 and engage the inside circumference of the container body 22 to effect a seal formed within the chamber area 34 defined by the sealing plates 54 and 56 and the inner circumference of the container body 22. When an appropriate source of potential is applied to cause a discharge between the electrodes 46 and 48, the container body 22 would be abruptly driven against the severing knife 28 and the flanging radius 30 to result in a complete severing and flanging of the container body 22.

During certain operations, the container body or cylindrical tube 22, whether metal, plastic, paper or any combination of these materials, may become distorted and require a re-forming or re-shaping of the cylindrical body. Accordingly, such a means is provided by the embodiment of the FIG. 4 wherein like elements are designated in a manner similar to those of the FIG. 1. The sealing plates 36 and 38 are positioned a greater distance apart than those of the FIG. 1 as shown by the designation 40'. The sealing members 42 and 44 are positioned entirely about the sealing plates 36 and 38, respectively, and form a chamber 34' within the area enclosed by the sealing plates 36 and 38, the seals 42 and 44, and the inside circumference of a container body or cylindrical tube 22.

As shown in the FIG. 4, a re-forming or re-shaping die 70, of cylindrical shape, completely surrounds the container body 22 and in proximity thereto. When a discharge is effected between the electrodes 46 and 48, the gas within the chamber 34' would be heated and the confined air, would produce a very high gas pressure due to its thermal expansion. This energy, would force the container body 22 against the re-forming die 70 to result in a re-shaping or re-forming of the body.

In the FIG. 4, it will be noted that the re-forming die 70 is positioned externally to the member to be shaped. In the embodiment shown in the FIGS. 5 and 6, the re-forming die is positioned within the body and the discharge is caused between pairs of electrodes within a chamber formed about the body.

The apparatus of the FIGS. 5 and 6, will perform a re-forming or re-shaping operation by directing the re-shaping energy inwardly toward the center of the container body 22. A U-shaped channel 72 is cylindrical with the open portion of the "U" directed inwardly toward similar configurations of the channel. A re-forming die 74 is positioned within the cylindrical U-shaped channel 72 but is of slightly lesser diameter than the diameter of the area within the body 72. A container body 22 is positioned between the outer extremities of the reforming die 74 and the inner circumference of the U-shaped channel 72. A pair of sealing members 42 and 44 are positioned within the notches of the projecting members of the U-shaped channel 72 and are in engagement with the outer circumference of the container body 22. The seals or O-rings 42 and 44 are of a low friction material to permit sliding engagement between the container body 22 and the seals 42 and 44.

A plurality of pairs of electrodes 46 and 48, having electrical leads 50 and 52 coupled, respectively, thereto, are positioned about the chamber formed within the U-shaped member 72 and in the particular embodiment shown and described, four such pairs of electrodes are shown; however; it will be understood that any number of pairs of electrodes may be provided according to the requirements of the operation to be performed.

Thus, with a container body or cylindrical tube 22 in the position shown in the FIG. 5, a substantially sealed and closed chamber is formed within the U-shaped member 72 and the container body 22. Upon the application of a suitable power source to the conductors 50 and 52, a discharge will be caused to occur between the electrodes 46 and 48 and its resulting thermal expansion of the gases within the chamber, will force the walls of the container body 22 inwardly against the re-forming die 74 to result in a re-forming or reshaping operation.

Whereas the FIGS. 1 through 6 disclose embodiments of the invention wherein the chamber would contain an atmosphere such as air, the embodiments shown in the FIGS. 7 through 11 are known as electro-hydraulic forming means and would employ a fluid within the chamber such as water, and oil of high electric constant, or other suitable material. The fluid is contained within the chamber by an elastomeric material to be hereinafter described.

One form of this embodiment is shown in the FIG. 7. The die 20 and the severing knife 28 surround the container body 22 as in the FIG. 1. The horn extension 32 supports a first sealing plate 76 to the left of the severing knife 28 and a second sealing plate 78 to the right of the severing knife 28. It is not necessary that the knife 28 be centered between the sealing plates 76 and 78 but may be anywhere in line with a chamber 82 and about an elastomeric material 80. The elastomeric material 80 of circular configuration is hollow and joins the sealing plates 76 and 78. The outside circumference of the elastomeric material 80 may or may not loosely engage the container body 22 and may be secured to the sealing plates 76 and 78 in any suitable manner. A fluid chamber 82 is now formed within the confines of the elastomeric material 80. A pair of electrodes 46 and 48 are positioned within the fluid chamber 82 and have connecting electrical leads 50 and 52 coupled respectively, thereto. The force which performs the mechanical work to cause severing and/or flanging of a container body 22 in the FIG. 7, is created by discharging a high voltage spark across the electrodes 46 and 48. A plasma body or bubble is formed in the spark gap between the electrodes and continues to grow as continued power is applied to the electrodes 46 and 48. This forces the elastomeric material 80 out very rapidly against the body or tubing 22, causing the tubing 22 to expand against the die to result in a severing and flanging operation.

In the FIG. 8, a re-forming apparatus is shown which employs a fluid chamber 82' which completely surrounds the container body 22 to be re-formed. Whereas the embodiment in the FIG. 5 discloses the electropneumatic arrangement, the electrohydraulic arrangement is shown in the FIG. 8. A U-shaped channel 72' is of circular configuration and completely surrounds the container body 22 and the re-forming die 74. The elastomeric material 80 provides a seal to contain the fluid within the chamber 82'. Upon the application of a suitable voltage to the conductors 50 and 52, the resulting discharge between electrodes 46 and 48 will force the elastomeric material 80 against the

container body 22 to result in a re-forming or reshaping operation.

In the FIG. 9, a re-forming or reshaping apparatus is shown which directs its forces outwardly, unlike the embodiment of the FIG. 8 which directs its reshaping forces inwardly. The sealing plates 76 and 78 are positioned a greater distance apart than that in the FIG. 7 so that reshaping may take place over a greater distance, which expanse is not required in a severing operation to which the apparatus of the FIG. 7 is directed. The elastomeric material 80 joins the sealing plates 76 and 78 and may be in intimate contact, loose contact or not in contact at all with the container body 22. Arranged circumferentially about the cohntainer body 22 is a re-forming die 70, similar to that shown in the FIG. 4. Upon the application of a suitable voltage, the spark discharge between the electrodes 46 and 48 will cause the material 80 to be driven outwardly and force the container body 22 against the inner wall of the re-forming die 70, to result in a reshaping of the container body 22.

The elastomeric material 80 may be of any suitable construction such as rubber, plastic, etc., and need be deformable by pressure within the chambers 82 and 82'. It is sufficiently resilient and yielding to transmit any pressure waves caused by the spark discharge between the electrodes 46 and 48 to the container body 22. The amplitude and duration of the electrical supply coupled to the conductors 50 and 52 may be controlled by any suitable control means. In addition, capacitors may be utilized to assure the correct energy charge applied to the electrodes 46 and 48. The control then, will include suitable means for applying the appropriate voltage to the capacitor, suitable impedance means in the capacitor and spark gap circuit to vary the time constant of the circuit, and thereby control the discharge rate. In addition, suitable means would be provided to control the time intervals between successive energizations of the electrodes.

The FIGS. 10 and 11 illustrate reshaping or re-forming means and are similar to the illustration of the FIG. 9 except that instead of a smooth die 70, the die 70' of the FIG. 10 has formed about its inner wall a plurality of undulations 84. When a spark discharge appears across the spark gap formed by the electrodes 46 and 48, the resulting outward movement of the elastomeric material 80 drives the container body 22 into the undulations 84 which result in rings or beads about the circumference of the container 22, which beads provide added strength and esthetic appeal. It will be understood that any number of undulations 84 may be provided and that the undulations 84 may be of any suitable geometric shape in which it is possible to form the container wall 22 without a severing or parting of the material. Further, it will be readily understood that reshaping may take many different forms and that the dies 70' may be conical, square, triangular, etc., or any combination of these geometric figures. As the container material 22 or tube is advanced through or about the dies so formed, excitation of the electrical energy will cause the elastomeric membrane 80 to drive the container body 22 into engagement with the conforming die.

Thus, there has been described a means for severing, flanging, reshaping or re-forming cylindrical containers by the use of the electrical energy created through a spark discharge across a pair of electrodes. In a first embodiment, either of the operations may be performed within a chamber containing a gas such as air. In other embodiments, the chamber may, as well as a gas, contain water or an oil which will transfer the force resulting from the electrical discharge between the electrodes 46 and 48 to cause the desired operation to the container wall. It will be understood that severing and/or flanging and/or re-forming may be performed either simultaneously, separately, or in any useful combination, as desired. For example, a re-forming operation may precede or follow a severing operation and severing and flanging may be performed substantially simultaneously. It may be an advantage to do all the operations simultaneously.

Thus, the present invention may be embodied in other specific forms without departing from the spirit and the essential characteristics of the invention. The present embodiment is, therefore, to be considered in all respects as illustrative and the scope of the invention being indicated by the appended claims rather than the foregoing dsscription, and all changes which come within the meaning and range of the equivalency of the claims are, therefore, intended to be embraced therein.

I claim:

1. Tubular body forming means comprising an annular die having a circular portion removed about its inner periphery, flanging radiuses formed at the junction of the removed portion and the inner surface of said die, a severing knife positioned within the removed portion of said die, means defining a chamber within the die but permitting the positioning of a body between the severing knife and the chamber means, and means for developing an electrical discharge within said chamber to produce severing and flanging of a body at a predetermined point by causing the portion of a body juxtaposed the severing knife to be advanced toward the severing knife and against the flanging radius.

2. Tubular body forming means comprising annular severing means, a first sealing plate, a second sealing plate spaced apart from and supported by said first sealing plate, the area between said first and said second sealing plates defining a chamber, means for supporting said sealing plates within the severing means but permitting the positioning of a body between the severing means and the chamber defined by said sealing plates, and means for developing an electrical discharge within said chamber to produce a severing of a body at a predetermined point by causing the portion of a body juxtaposed the severing means to be advanced toward the severing means.

3. The combination as defined in claim 2 including resilient means positioned upon each of said sealing plates to effect a seal between its respective sealing plate and a body to be formed.

4. The combination as defined in claim 3 wherein said resilient means are O-rings of low frictional material.

5. A cylindrical body forming means comprising an expandable annular die, a groove formed about the inside of said die, flanging radiuses formed at the junction of the groove and the inside of said die, severing means positioned within said groove and directed inwardly, a first circular plate member, a second circular plate member positioned apart from and supported by said first plate member, the area between said first and said second plate members defining a chamber having a gas-

eous atmosphere, a horn extension for supporting the circular plate members within the die but permitting the positioning of a body between the severing means and the plate members, resilient means positioned upon each of said plate members to effect a seal of the chamber to the body to be formed, and a pair of electrodes positioned within the chamber and between said first and said second plate members for developing an electrical discharge within said chamber and causing an expansion of the gaseous atmosphere to produce severing and flanging of a body at a predetermined point of the body by driving the portion of a body juxtaposed the severing means and flanging radius to be advanced toward the severing means and the flanging radius.

6. Cylindrical body forming means comprising an expandable annular die, a severing knife positioned within said die and directed inwardly, a horn extension, a pair of circular plates supported by said horn extension and defining a chamber within the die but permitting the positioning of a body between the severing knife and the circular plates, inflatable means positioned about the periphery of each of said circular means to effect a seal between its respective circular means and the body to be formed, and means for developing an electrical discharge within said chamber between said circular plates to produce a severing of a body at a predetermined point by causing the portion of a body juxtaposed the severing knife to be advanced toward the severing knife.

7. The combination as defined in claim **6** including a passageway communicating with each of said resilient means positioned upon said circular plates for expanding said resilient means.

8. Cylindrical body forming means comprising annular severing means, a first circular plate, a second circular plate spaced apart from said first circular plate, resilient means joining the peripheries of said first and said second circular plates, the area within said first plate, said second plate and said resilient means defining a chamber, means for supporting said means defining a chamber within the severing means but permitting the positioning of a body between the severing means and the resilient means, and means for developing an electrical discharge within said chamber to produce a severing of a body at a predetermined point by causing the portion of a body juxtaposed the severing means to be advanced toward the severing means.

9. Cylindrical body forming means comprising annular severing means, a first circular plate, a second circular plate spaced apart from said first circular plate, cylindrical resilient means joining the peripheries of said first and said second circular plates, the area within said first circular plate, said second circular plate and said resilient means forming a chamber for confining a fluid, means for supporting said fluid chamber within the severing means but permitting the positioning of a body between the severing means and the fluid chamber, and means for developing an electrical discharge within said chamber to cause the severing of a body at a predetermined point by causing the portion of a body juxtaposed the severing means to be advanced toward the severing means.

10. The combination as defined in claim **9** comprising flanging radiuses formed adjacent to said annular severing means for flanging said severed cylindrical body at substantially the same time as the severing operation.

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