July 4, 1950 L. R. O'NEILL 2,513,739

METHOD AND APPARATUS FOR FORMING METALLIC BODIES

Filed March 15, 1949 2 Sheets-Sheet 1

FIG. 1.

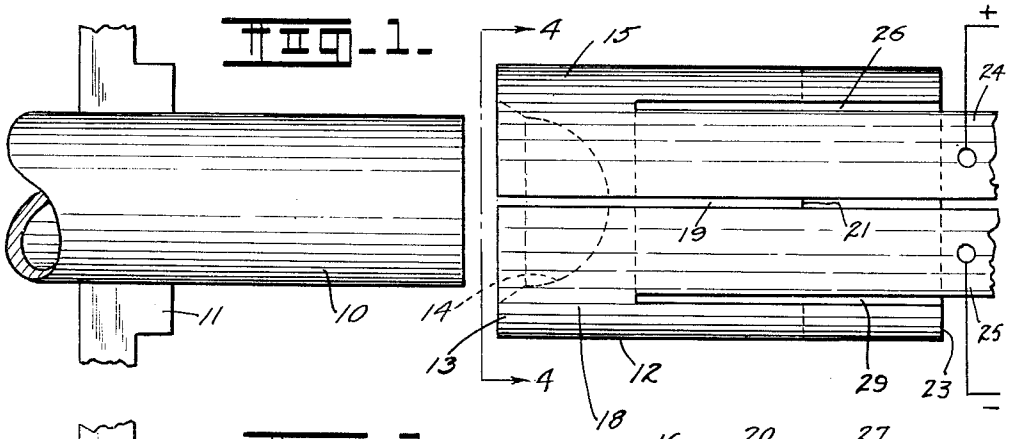


FIG. 2.

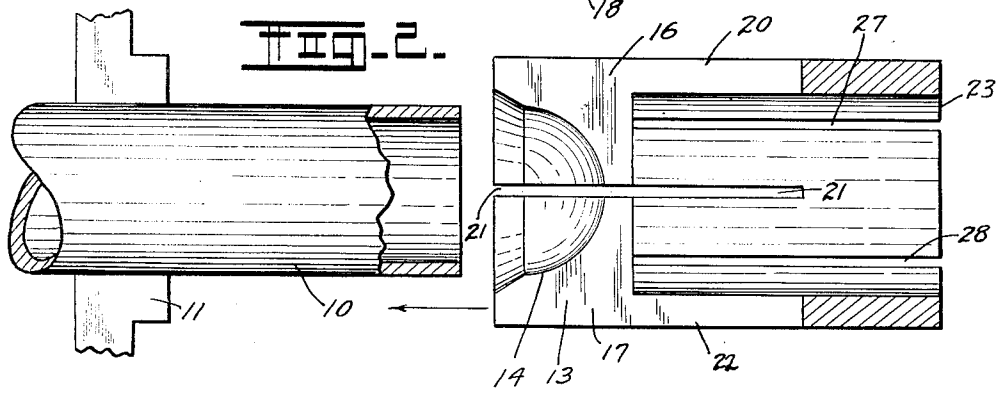


FIG. 3.

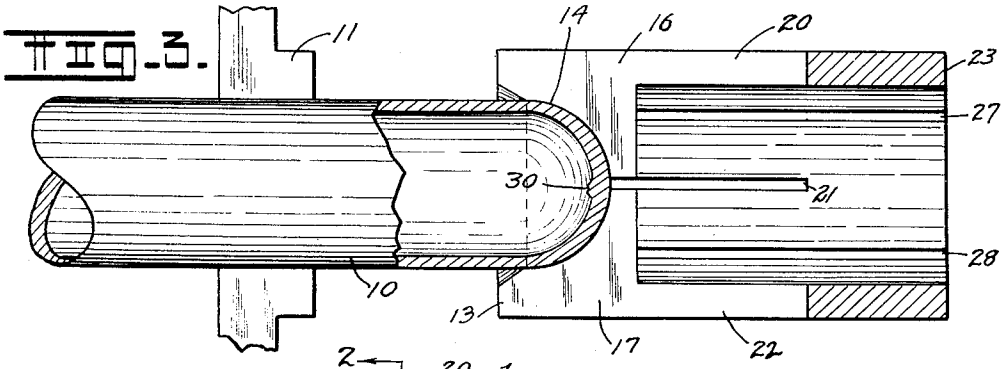
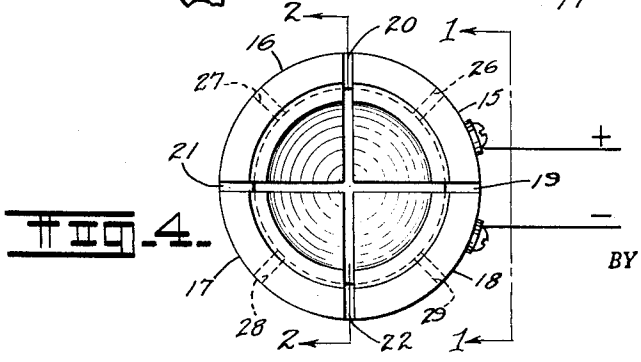


FIG. 4.



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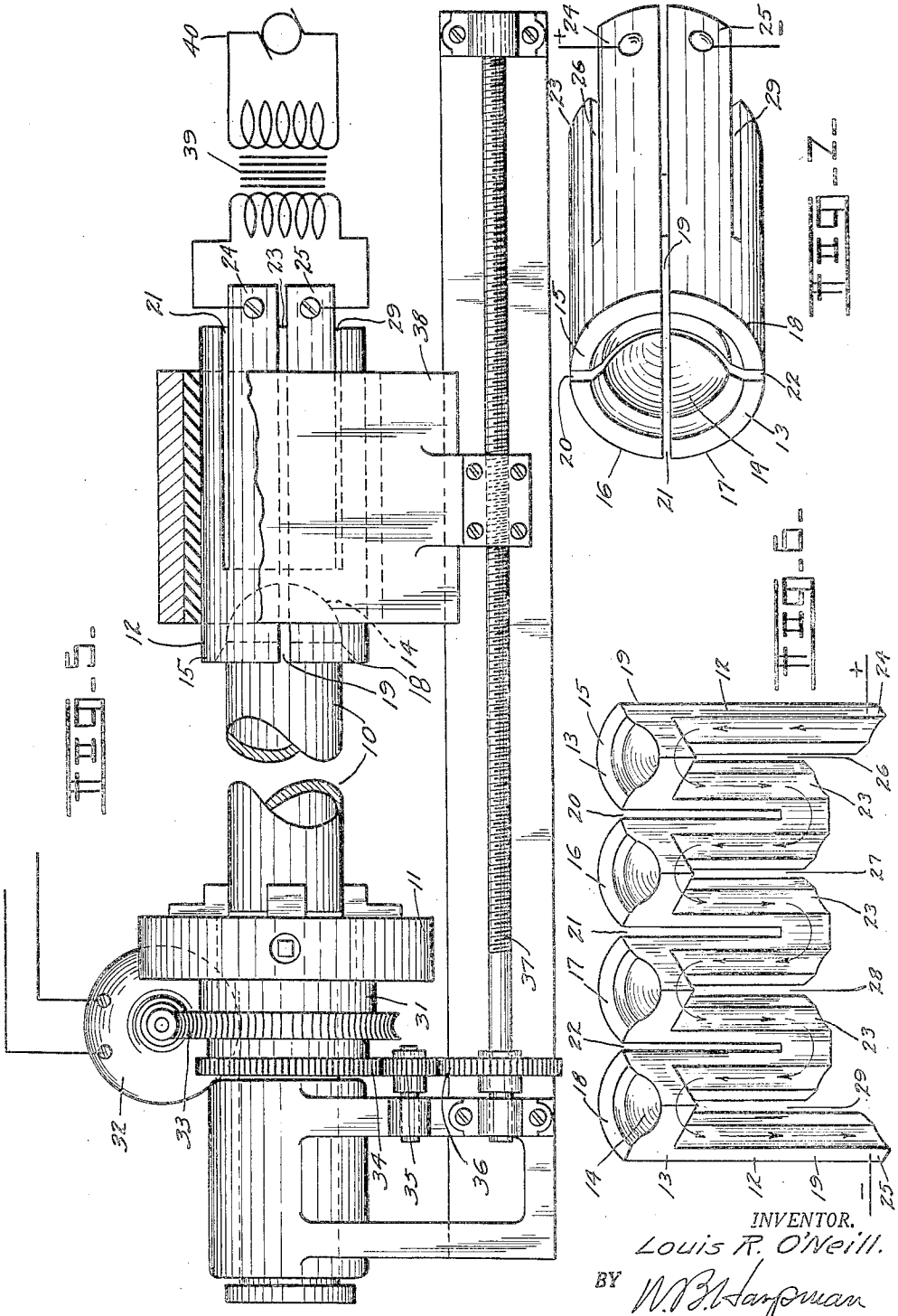


FIG. 5.

FIG. 7.

FIG. 6.

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METHOD AND APPARATUS FOR FORMING METALLIC BODIES

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10 Claims. (Cl. 219—3)

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This invention relates to an improved method and apparatus for shaping metallic bodies and particularly tubular or other hollow bodies.

The principal object of the invention is the provision of a method and apparatus for shaping metallic bodies.

A further object of the invention is the provision of a method and apparatus for the forming of tubular structures of various shapes.

A still further object of the invention is the provision of a method and apparatus for shaping a metallic body incorporating a lightweight resistance heated die for simultaneously heating and shaping the metallic body.

A still further object of the invention is the provision of a die formed of abrasion resistant material which also has a relatively high resistance to an electrical current passed therethrough.

A still further object of the invention is the provision of a combination heating means and die formed of an abrasion resistant and electrical resistant material in a manner to form a relatively tortuous passage for an electrical current passed therethrough whereby a maximum heating of the die may be achieved.

The method and apparatus for shaping metallic bodies disclosed herein comprises an improvement in the art wherein past and present practice has related to the utilization of combination electrode dies for conducting electrical currents through metallic bodies engaged therein for heating the metallic body by the resistance of the electrical current passed therethrough. Such combination electrode dies have accordingly been formed of materials such as copper having a high capacity for the current passed therethrough in order to avoid heating the dies which would obviously contribute to the rapid wearing away of the die surfaces as the metallic body was engaged thereagainst.

On the contrary, the present invention relates to the formation of a combination heating and shaping die from a relatively hard abrasion resistant material such as steel and forming the same in a manner requiring an electrical current passed therethrough to follow a tortuous path and heat the die itself to a temperature at which a metallic body introduced into the die may be shaped.

Those skilled in the art will recognize that by introducing a metallic body into a die such as disclosed herein, suitable working temperatures are readily achieved as the temperature of the die itself is imparted to the metallic body by convection. Additionally, the temperature of the metallic body is increased by frictional engagement with the die as it is customary to rotate the same when in engagement therewith.

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A futrher temperature increase results from a short circuiting effect of the metallic body with respect to the various sections of the die thereby generating a heat in the metallic body due to the resistance of the current flowing therethrough in such short circuiting action. The combination of these several heating means has been found to be adequate for the extremely rapid and efficient shaping of metallic bodies and particularly tubular bodies when engaged in a combination heating and shaping die such as disclosed herein.

The method and apparatus for forming metallic bodies enables various tubular products to be formed to various cross sections and tube ends to be closed at high production rates and low cost. For example, tube reducing, necking, closing, wall thickening and other forming operations may be economically and rapidly performed by utilizing the subject invention. Materials that can be formed by the method and apparatus disclosed herein include the entire range of carbon steels, most alloy steels (including stainless), copper alloys such as brass and bronze, and aluminum. However, the method and apparatus are not limited to these materials but can be used with any metal whether it will conduct an electrical current or not. Operator safety is insured by using low voltage high amperage current for the resistance heating of the combination die disclosed herein.

Contrary to past practices, no water cooling is used in connection with the heating and shaping die but rather the temperature of the die itself is used for the forming temperature of the metal body engaged thereagainst. There is no need of utilizing die inserts as the die itself is formed of material possessing the desired qualities contributing to a successful heating thereof and the long life thereof.

With the foregoing and other objects in view which will appear as the description proceeds, the invention resides in the combination and arrangement of parts and in the details of construction hereinafter described and claimed, it being understood that changes in the precise embodiment of the invention herein disclosed can be made within the scope of what is claimed without departing from the spirit of the invention.

The invention is illustrated in the accompanying drawing, wherein:

Figure 1 is a side view of a heating and shaping

die and work piece formed in accordance with this invention.

Figure 2 is a vertical section of the heating and shaping die and work piece shown in Figure 1.

Figure 3 is a vertical section of the heating and shaping die shown in Figure 1 and illustrating the work piece engaged therein.

Figure 4 is an end view of the heating and shaping die taken on line 4—4 of Figure 1. Lines 2—2 on Figure 4 indicate the cross section of Figure 2 and lines 1—1 on Figure 4 indicate the side view in Figure 1.

Figure 5 is a diagrammatic illustration of the apparatus utilizing the heating and shaping die disclosed herein.

Figure 6 is a diagrammatic view of the heating and shaping die, the same being in effect opened out to show the current path therethrough.

Figure 7 is a perspective view of the heating and shaping die disclosed herein.

By referring to the drawings and Figures 1 and 2 in particular it will be seen that the method selected for illustration involves the use of a die which functions not only as a forming member but also as a heating member and which is formed so that an electric current introduced thereinto follows a tortuous path therethrough and heats the die by reason of the resistance of the material of the die to the current. The die is accordingly connected with a suitable source of electrical energy for the indicated purpose.

In Figure 1 of the drawings a tubular work piece 10 is shown mounted for rotating and progressive motion as by a chuck 11 and the die is generally indicated by the numeral 12 and comprises an essentially cylindrical shaped body having a solid head end 13 in which a die cavity 14 is formed. The head end 13 is split into four quarters 15, 16, 17 and 18 by four longitudinally extending slots 19, 20, 21 and 22 arranged in a cross-like pattern and each of which bisects the die cavity 14 so that it is divided like the head end 13 of the die into four quarters. The longitudinally extending slot 19 runs the full longitudinal length of the die 12 while the longitudinally extending slots 20, 21 and 22 terminate inwardly from the back end 23 of the die 12. It will be observed that projections 24 and 25 are formed on two of the quarters 15 and 18 for the purpose of providing terminals to which the positive and negative sides of a suitable source of electrical energy may be connected.

In order that the die 12 may be so formed that a tortuous path is created for the heating current passed therethrough and the maximum temperature possible realized from the passage of the heating current, a plurality of secondary longitudinally extending slots 26, 27, 28 and 29 are formed in the cylindrical end of the die 12 and terminate adjacent the head end 13 of the die 12 as heretofore described. It will thus be seen that electrical current introduced into the projection 24 will flow toward the head end 13 of the die 12 around the innermost end of the slot 26 and toward the back end 23 of the die in the quarter of the die indicated by the numeral 15. It will then flow around the end of the slot 20 and enter the quarter 16 of the die where it will flow toward the head end 13 of the die and around the end of the slot 27. It will then flow toward the back end 23 of the die and around the end of the slot 21 and enter the quarter 17 whence it will flow toward the head end 13 of the die and around the end of the slot 28. It will then flow toward the back end 23 of the die and around the end of the slot 22 and

enter the quarter 18 of the die whence it will flow toward the head end 13 and around the end of the slot 29 and toward the back end 23 of the die and out to the projection 25 into the source of electrical current.

It will be observed that the current travels in alternate right and left directions longitudinally of each of the quarters 15, 16, 17 and 18 of the die and thereby achieves the tortuous path necessary to ultilize the maximum heating effects thereof. It will also be observed that the tortuous path leads through each of the four sections of the head end 13 of the die in which the die cavity 14 is formed.

When it is considered that the die is formed of material such as Nichrome having a suitable resistance to the heating current passed therethrough, it will be seen that the work piece 10 will be heated by engagement with the die cavity 14. It will also occur to those skilled in the art that as the work piece 10 is rotated when it is moved into the die cavity 14, the resulting friction will contribute to the rapid heating thereof and in addition the tendency of the work piece 10 to short circuit the tortuous path of the die will result in some resistance heating in the work piece itself.

In Figure 2 of the drawings a vertical cross section of the die shown in Figure 1 may be seen and it will be observed that the short circuiting effect and resistance heating in the work piece 10 resulting therefrom occurs between the quarters 16 and 17 of the die and across the longitudinally extending slot 21.

In Figure 3 of the drawings the work piece 10 has been moved into the die cavity 14 and the end thereof has been upset and closed. It will be noted that the point of closure occurs within the axis of rotation in the work piece where it is continuously subject to the intensive heat developed within the die by the heating current flowing therethrough. The temperature attained at this point is sufficient for welding purposes and the pressure at this point resulting from the urging of the work piece 10 into the die cavity 14 causes the heated metal to flow inwardly from the welded joint to form a protrusion 30 which carries with it any oxides or other impurities as may have been present in the end of the work piece. This results in a solid weld free from fissures and impurities.

By referring now to Figure 6 of the drawings a symbolic illustration of the die opened out with respect to the longitudinal slot 19 may be seen with each of the four quarters 15, 16, 17 and 18 positioned in side to side relation and the path of the current travel through the die will be seen to comprise the most effective path for the full utilization of the resistance heating thereof. This is particularly true with respect to the head end 13 of the die in which the die cavity 14 is located. It will be observed that each of the longitudinal slots 19, 20, 21 and 22 split the die cavity 14 so that the short circuiting effect of the work piece 10 may be utilized to achieve resistance heating within the work piece 10 itself as hereinbefore described.

In Figure 5 of the drawings apparatus for carrying out the invention is disclosed in schematic elevation. It will be seen that the work piece 10 is positioned in the chuck 11 which in turn is mounted on a rotatable body member 31 and adapted to be rotated by an electric motor 32 driving a worm gear 33. Reduction gears 34, 35 and 36 also impart movement to a longitudinally

extending shaft 37 to which a movable bracket 38 is secured enclosing the die heretofore referred to. A suitable source of electrical energy is indicated by the transformer 39 and a generator 40.

In Figure 7 of the drawings a perspective elevation of the die 12 illustrating the head end 13 thereof in which the die cavity 14 is formed may be seen and it will be readily apparent to those skilled in the art that engagement of a tubular metal blank in the die cavity 14 will enable the blank to be formed in accordance with the shape of the die cavity 14, suitable metal temperatures being obtained by convection from the die 12 itself and partially from the short circuiting effect of a tubular blank shorting the sections of the die 12 across the slots 19, 20, 21 and 22 as hereinbefore described.

It will also be seen that the several objects of the invention have been met by the combination heating and shaping die disclosed herein. The die and apparatus and its use represent a radical departure from the practices heretofore common in the art wherein large unwieldy, expensive and relatively soft conductors served as dies and means for imparting electrical resistance current to the work piece for heating the same by the resistance of the work piece to the heating current. In the present invention the die may obviously be of small lightweight construction, of highly durable abrasion resistant material and operative as a heating and shaping unit in a practice substantially contrary to that generally practiced in the art.

Having thus described my invention, what I claim is:

1. The method of treating metallic bodies comprising applying pressure contact between a body and a unitary forming means while relatively moving said body and means to effect engagement between the forming means and the body to be formed and simultaneously passing a heating current of electricity through the said unitary forming means to heat the same.

2. An improved forming method which includes producing relative rotation and shaping pressure between a metal blank and a unitary forming means and simultaneously passing a heating current of electricity through said unitary forming means.

3. An improved forming method which includes producing relative formation and shaping pressure between an end of a tubular blank and a unitary forming means and simultaneously passing a heating current of electricity through the said unitary forming means to heat the same.

4. Metal forming apparatus including forming means comprising a plurality of radially positioned segments spaced with respect to one another and having a die cavity formed partially in each of said segments and the said segments having slots formed in their ends opposite from the die cavity, the said slots terminating short of the die cavity and the said segments connected to one another at their said opposite ends whereby an electric current introduced into one of the segments will flow through the segment and adjacent the partial die cavity therein by reason of the slat in said segment and subsequently flow through each of the other segments in a similar pattern by reason of the said connections between the segments.

5. Metal forming apparatus including forming means comprising a cylindrical die having a head formed on one end thereof, the said die having a plurality of longitudinally extending slots positioned transversely of the said head thereof and into the cylindrical body thereof to a point inwardly from the opposite end of the said die, one of the said slots in the cylindrical body of the die extending the full length thereof, a die cavity formed in the head and of the said die and the cylindrical portion of the said die having a plurality of secondary slots positioned longitudinally therein and spaced between each of the first mentioned longitudinally extending slots whereby current introduced into the die on either side of the slot extending the full length of the cylindrical body thereof will follow a tortuous path around the said die and thereby heat the die cavity therein.

6. An apparatus of the class described comprising a plurality of electrically interconnected cooperating forming tools circumferentially arranged around a blank to be heated and formed, means to effect relative rotation of the said blank and tools in pressure contact with each other, and means to pass a heating current through the said circumferentially arranged forming tools whereby the same may be heated.

7. An apparatus of the class described comprising means to rotate a tubular blank to be formed, a relatively stationary unitary forming tool engaging said blank in the region of forming and constituting a relatively non-abrading resistance heating element, and means to pass a heating current through said forming tool whereby the same may be heated.

8. The method of treating metallic bodies comprising applying shaping temperature and pressure to a body by a plurality of circumferentially arranged resistance heating elements electrically connected to one another which cooperate to impart heat to the body, and relatively rotating said body and said elements.

9. In an apparatus for symmetrically forming circular articles in which the article is pressed against dies co-axial therewith and rotated relative thereto, wherein the said dies are formed as sections of a one-part element constituting a resistance heating element to supply heat to the article in the area being formed, and means to pass heating current through the said element and hence the die sections thereof.

10. In an apparatus for symmetrically forming cylindrical articles in which the workpiece is forced endwise against a die coaxial therewith and rotated relative thereto, wherein the said die is formed with circumferentially spaced slots therein to form a tortuous path for a heating current passed therethrough.

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