

Nov. 26, 1940.

H. DEBOR ET AL

2,222,762

HOLLOW METAL BODIES AND MEANS FOR PRODUCING SAME

Filed March 30, 1938

4 Sheets-Sheet 1

Fig. 1.

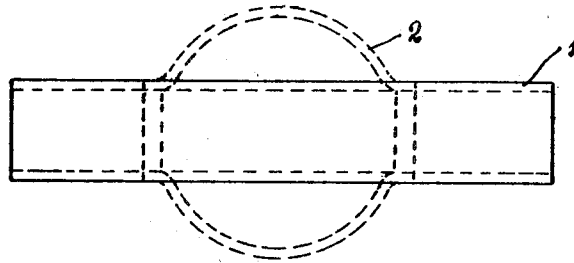


Fig. 2.

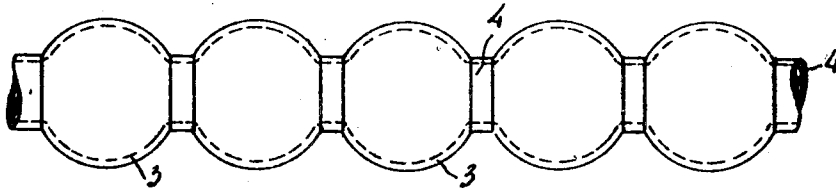


Fig. 3.

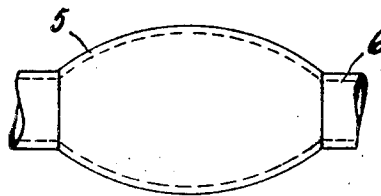
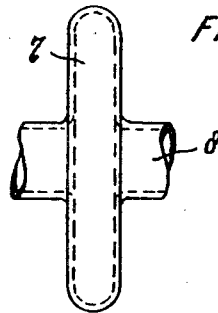


Fig. 4.



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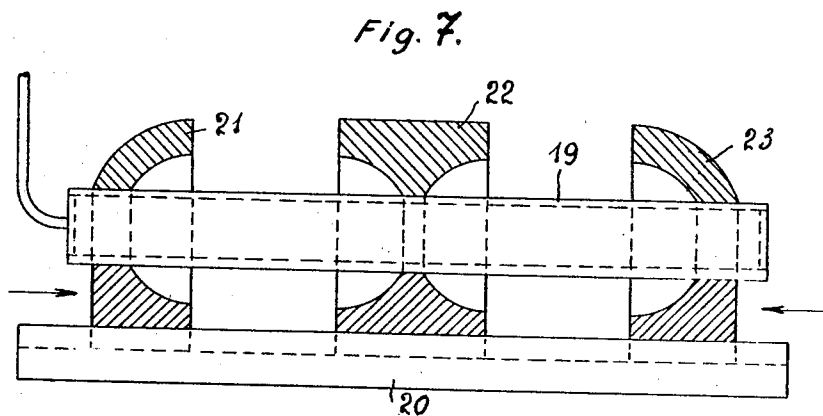
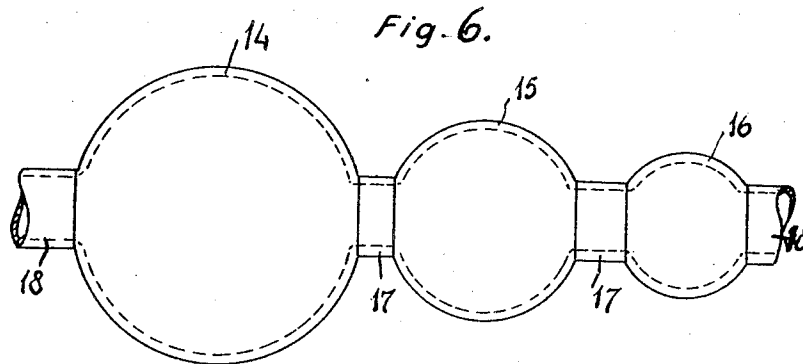
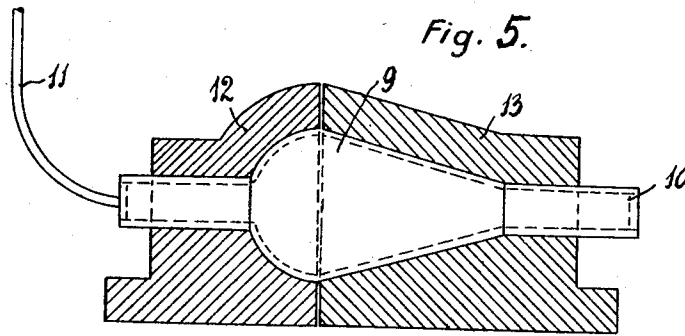
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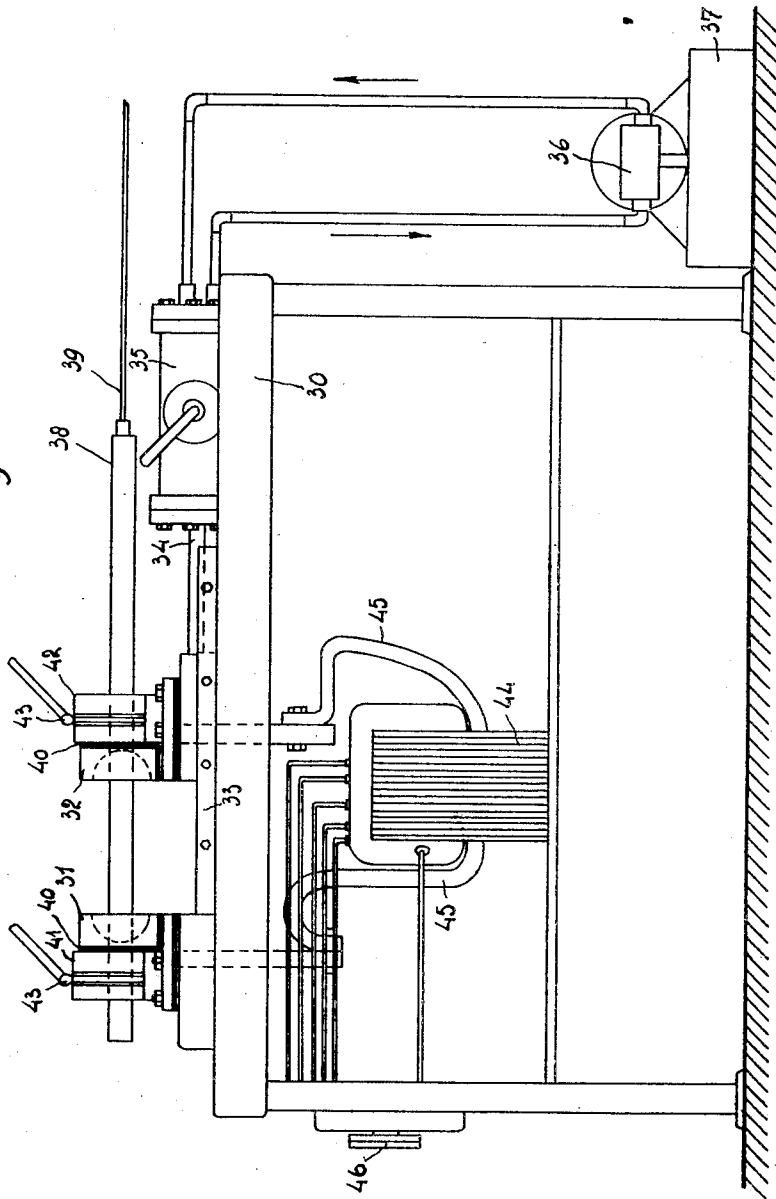
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Fig. 8.



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HOLLOW METAL BODIES AND MEANS FOR PRODUCING SAME

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4 Sheets-Sheet 4

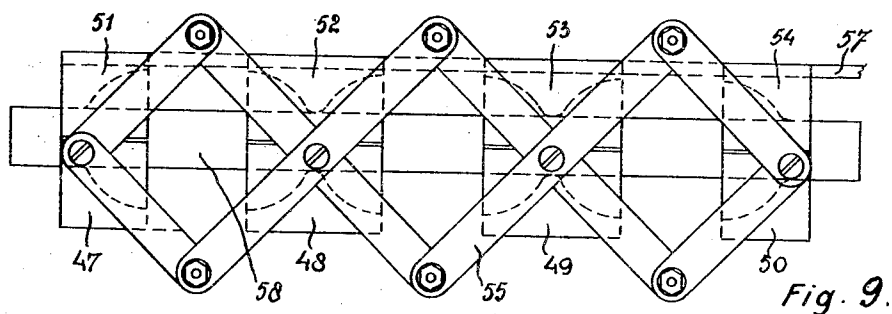


Fig. 9.

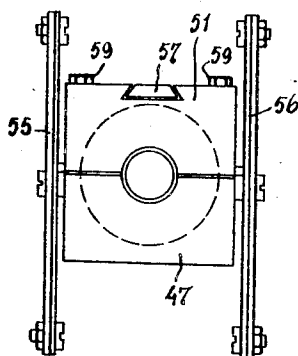


Fig. 10.

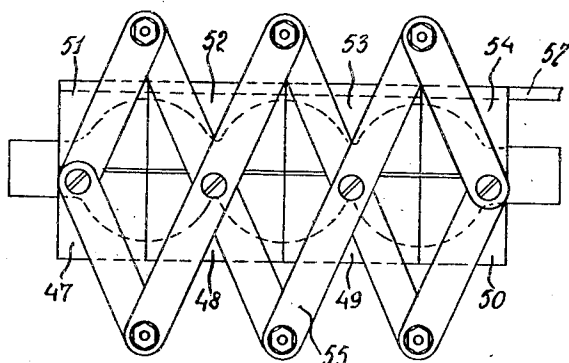


Fig. 11.

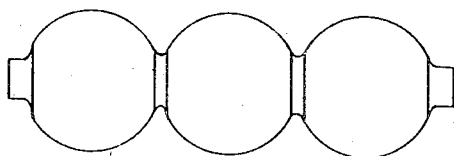


Fig. 12.

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UNITED STATES PATENT OFFICE

2,222,762

HOLLOW METAL BODIES AND MEANS FOR
PRODUCING SAME

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ermenzing, near Munich, Germany, assignors
to Dominion Oxygen Company, Limited, a cor-
poration of the Dominion of Canada

Application March 30, 1938, Serial No. 198,836
In Germany April 1, 1937

6 Claims. (Cl. 219—3)

This invention relates to pressure resistive hol-
low metal bodies and also to the process and
the means for producing such bodies.

The new hollow bodies, which are particularly
5 adapted for use as pressure vessels, or containers
for gases under high pressure, can be produced
from tubular bodies by expanding the walls of
such bodies to form one or more enlarged zones.
The zones may comprise spaced spheroids joined
10 together by parts of the initial tube. Owing to
the particular mode of production the wall thick-
ness of the original tube is reduced by only a
minor predetermined amount, or is not reduced
at all during the expanding operation, and the
15 enlarged container may have the same pressure
resistivity as the initial tubular body.

According to this invention the hollow body to
be expanded, for instance a cylindrical tube, pref-
erably is placed within a suitable mold and is
20 heated to the temperature at which the metal
possesses the plasticity which is most advan-
tageous for expanding. By exerting an axially
directed compressive force against the ends of the
tube and simultaneously applying a high fluid
25 pressure within the tube, the tube wall is axially
compressed or upset, while portions of the wall
are expanded against the walls of the mold sur-
rounding the tube. By suitably adjusting the
axial thrust and the expanding pressure, the
30 newly formed hollow body may be made to pos-
sess the same wall thickness and resistivity to
pressure as the tube before expansion. Other-
wise, the wall of the completed vessel may be
made thinner than the original tube wall, with
35 a resulting lower resistivity to pressure.

Preferably the tube or other hollow metal body
is inserted as resistance in an electrical circuit
and is thus heated up quickly and uniformly, and
the metal easily may be maintained at the re-
quired plasticity until the expansion has been
40 carried through. Resistance heating provides a
simple method of heating up the workpiece and
retaining the heat therein, and also facilitates
subjecting it to a subsequent heat treatment, if
this should be desirable. For instance, if the
45 expanded hollow steel body, in order to obtain
the best properties, must be subjected to heat
treatment, this may be rendered possible directly
after the expansion, merely by controlling the
50 current so as either to lower or raise the tempera-
ture, or to effect these changes in suitable suc-
cession. Each expanded steel body thus may be
uniformly treated directly after expansion, while
the product is still under pressure in the mold.
55 If a cylindrical tube is to be converted, for

example into a generally spherical hollow body,
the wall thickness may be maintained without
any substantial change during the outward ex-
pansion of the tube wall by the axial crowding
together or upsetting of the tube wall in propor-
tion to the size of the spherical body. Thus, for
instance, a cylindrical tube 50 mm. in diameter
and 200 mm. long may be converted into a
spherical hollow body 100 mm. in diameter. The
pressure capacity of the body remains substan-
tially the same; however the volume of the
10 spherical body becomes about 523 cubic centi-
meters as compared with about 392 cubic centi-
meters in the cylindrical tube. Substantially no
weakening nor reinforcing of the wall ordinarily
takes place, although the metal particles are
15 rearranged by forcing the plastic material into
the parts of the tube undergoing expansion.

If the tube is not upset or crowded together
sufficiently, the outward pressure of the fluid act-
ing on the hot metal causes a stretching and a
20 consequent thinning of the material. However,
this stretching effect can be limited at will by
the extent of the axial compression.

In the annexed drawings several forms of the
25 invention are illustrated.

Fig. 1 is an elevational view of a tubular blank
which may be expanded into spherical shape as
indicated by dotted lines;

Fig. 2 is an elevational view of a portion of a
30 pressure vessel made according to the present
invention comprising a plurality of interconnect-
ing spheroidal zones;

Fig. 3 is an elevational view of an enlarged
ellipsoidal zone formed from a tubular blank;

Fig. 4 is an elevational view of a flattened
enlarged zone which may be made according to
the present invention;

Fig. 5 is a sectional view through a pear-shaped
mold showing a completed pear-shaped hollow
40 body expanded from a tubular blank;

Fig. 6 is an elevational view of a hollow body
with interconnecting enlarged spheroidal zones
of unequal size;

Fig. 7 is a sectional view through a modified
45 mold in separated position adapted to form two
spheroids simultaneously during the forming
operation;

Fig. 8 is a semi-diagrammatic view of a mold-
ing apparatus provided with electrical heating
50 means;

Fig. 9 is a side elevational view of modified
apparatus having axially aligned mold portions
interconnected by lazy tongs, with the mold por-
tions shown in extended position;

55

Figs. 10 and 11 are end and side elevational views, respectively, of the apparatus shown in Fig. 9 but with the mold portions compressed into juxtaposed position; and

5 Fig. 12 is an elevational view of a completed container such as may be made with the apparatus shown in Figs. 9, 10, and 11.

Fig. 1 shows a cylindrical steel tube 1, and (in dotted lines) the spheroidal hollow body 2 which is obtained when the tube 1, on being heated to a high temperature, is upset by an axially directed pressure exerted on its two ends, while expanded by means of fluid under pressure introduced within the tube. The drawing shows how the upsetting operation causes the ends of the tube to approach one another; and how the main part of the tube between the ends has been converted into a spheroidal body. The wall thickness remains substantially the same as in the original tube.

Fig. 2 discloses how, in a similar manner, a cylindrical tube may be transformed into a container consisting of a plurality of separate expanded zones, interconnected by short tubular parts. Each expanded spheroidal zone 3 is formed by heating, upsetting, and expanding a separate part of the tube 4. The upsetting and expanding can be effected separately for each tube section or simultaneously for two or more sections, as will be described hereinafter.

In Fig. 3 a hollow body 5, having the form of an ellipsoid is produced by expanding a tube 6 in the manner described.

Fig. 4 illustrates a tube which has been expanded to an enlarged hollow body 7 of wheel section, having tubular extensions or axles 8.

Fig. 5 discloses apparatus for producing a pear-shaped hollow body 9 from a tubular section 10. The tube is closed at the ends and is secured to the separated halves 12 and 13 of a mold having a recess of the desired shape. The tube 10 is heated and compressed fluid passes into the highly heated tube through a supply pipe 11, while the halves 12 and 13, seated on the tube ends, are forced towards each other. The metal in the tube is upset as the central portion is expanded into conformity with the mold contour.

Fig. 6 illustrates a metal body formed with three generally spherical hollow bodies or zones 14, 15, and 16 of different sizes, which are interconnected by tubular sections 17 and are formed with tubular terminal extensions 18. In order that the three spherical zones might possess equal resistivity to pressure, each of them must be formed with a wall of a thickness proportionate to its diameter. The largest hollow enlarged zone 14 must have the same wall thickness as the initial tube when expanded to a predetermined degree, and the middle hollow zone has a wall that is stretched and thinned somewhat by expansion by proportionately decreasing the length of the tube section from which it is formed. The smallest zone is formed from a still shorter tube section.

Fig. 7 is a diagrammatic illustration of apparatus for producing a vessel having two juxtaposed spheroidal zones. A tube 19, closed at both ends, is surrounded by a mold in three parts, comprising axially spaced terminal molds 21 and 23, and intermediate molds formed in a body or portion 22. The tube 19 is firmly seated in the mold, being secured preferably to the portions 21 and 23, and the tube is heated in any convenient manner. Gas or other fluid under pressure is forced into the tube and axial pressure

is exerted on the terminal molds 21 and 23 whereby they are forced from opposite directions toward the portion 22. Consequently, the two tube sections are expanded within the mold recesses formed by the juxtaposed parts of the mold, against which the heated and expanded walls may apply themselves. The product resulting from these operations comprises a pair of spherical bodies of the same wall thickness as the tube 19, which bodies are connected with a short tubular section.

It is also possible to force the tube into a closed mold from one or both sides. In such case, for instance, the mold of Fig. 5 may be closed from the start of operations, and the tube, being loosely displaceable therein, can be forced into the mold by axially compressing the ends of the tube.

Fig. 8 illustrates by way of example an apparatus for carrying out the process. One of the mold halves 31 is firmly secured on a machine bed 30, the other half 32 being displaceable with respect to the half 31, as by sliding along guides 33. A piston rod 34 forces the half 32 leftward as pump 36 forces oil from a vat 37 into a cylinder 35. The steel tube 38 extends through axial apertures in the mold and is closed at one end, while a pipe 39 serves to introduce gas or other fluid under pressure from the other end. Electrodes 41 and 42 are fixed to the tube adjacent to the mold sections 31 and 32 by means of clamps 43, and are separated from the halves of the mold by insulating layers 40. Current is supplied to the electrodes from the secondary circuit of a transformer 44 through conductors 45, which current is controlled by a step switch 46. On the circuit being closed, the tube is heated up and when the metal has reached suitable plasticity, the pump 36 is set in operation to force the piston leftward so as to urge the part 32 of the mold against the part 31 and to upset the plastic wall of the tube between the two halves of the mold. At the same time gas under pressure is introduced through the pipe 39 and the tube 38 is expanded so that by the time the mold is closed the spherical body is completely formed. The current may be shut off automatically or by hand after which the top parts of the mold and the electrodes may be removed and the workpiece withdrawn from the bottom parts of the mold, or the pressure vessel may be left within the mold and post heat-treated by reducing or alternating the flow of current as desired.

Figs. 9, 10, and 11 illustrate means for uniformly displacing the parts of a mold designed for the production of a container with three spheroidal hollow bodies of the type shown in Fig. 12. Four bottom half portions 47, 48, 49, and 50, and four top halves 51, 52, 53, and 54 constitute the mold. The bottom halves are coupled with each other by means of lazy tongs 55 and 56 which distribute to the adjoining intermediate mold portions 48 and 49, the motion and pressure applied to the terminal mold portions 47 and 50 so that all parts are uniformly and simultaneously displaced. The top parts are guided by means of a guide ledge 57. When the mold is in the separated or extended position shown in Fig. 9 and prior to the compression operation, the tube 58 may be fixed to the mold portions as by securing the tube with respect to the end parts 47, 51, 50, and 54 by means of screws 59.

Various changes may be made in the details disclosed in the foregoing specification without

departing from the invention or sacrificing the advantages thereof.

We claim:

1. A method of forming and treating a hollow metal body comprising enclosing portions of a tube within a mold; locally heating said portions to a high temperature; applying pressure within said tube to expand the heated portions outwardly into contact with said mold; and during the period of such applied pressure heat-treating the newly-formed body by varying the temperature applied thereto while said body remains in contact with said mold.

2. A method of forming and treating a hollow metal body comprising enclosing portions of a tubular body within a mold; passing an electric current through said portions to heat the same to a high temperature; applying fluid pressure within said tubular body to expand the heated portions outwardly into contact with said mold; and during the period of such applied fluid pressure applying a post heat-treatment to said body by disrupting the flow of electric current upon the completion of the expanding operation to permit partial cooling of said body, and subsequently passing electric current through the partially cooled body while said body is enclosed within said mold to effect an increase in the temperature of said body.

3. An apparatus for forming a plurality of expanded zones on a tubular body, comprising a pair of terminal molds and a plurality of intermediate molds, said molds being secured to and disposed along said tubular body in axially spaced relation, and being provided with recesses adapted when adjoining molds are pressed into juxtaposed relation to define the contour of said expanded zones; means for locally heating the portion of the tubular body between said terminal molds; means for applying fluid pressure within said tubular body to expand said body into conformity with said molds; and means for compressing all of said molds into juxtaposed relation and for upsetting the tubular body within said molds, comprising pressure-applying means acting inwardly against said terminal molds, and

means for distributing to adjoining molds the pressure and motion applied to said terminal molds so that the respective adjoining molds simultaneously approach each other at predetermined rates.

4. An apparatus as claimed in claim 3 wherein such means for distributing the motion comprises lazy tongs extending between said terminal molds, said tongs being pivoted to said respective intermediate molds.

5. A method of forming a pressure vessel having interconnected spheroidal zones of respectively different diameters, comprising expanding a metal tube having a uniform wall at zones spaced along the length of said tube; compressing the portions of said tube adjacent to said respective zones axially during such expanding operation to upset the wall of said tube and to flow metal into the region of said zones; and regulating the amount said portions are compressed in accordance with the diameter of the respective spheroidal zones, whereby the wall thickness of said zones increases in proportion to the diameter.

6. An apparatus for forming a plurality of expanded zones on a tubular body, comprising a pair of terminal molds and a plurality of intermediate molds, said molds being secured to and disposed along said tubular body in axially spaced relation, and being provided with recesses adapted when adjoining molds are pressed into juxtaposed relation to define the contour of said expanded zones; means for applying fluid pressure within said tubular body to expand said body into conformity with said molds; and means for compressing all of said molds into juxtaposed relation and for upsetting the tubular body within said molds, comprising pressure-applying means acting inwardly against said terminal molds, and means for distributing to adjoining molds the pressure and motion applied to said terminal molds so that the respective adjoining molds simultaneously approach each other at predetermined rates.

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