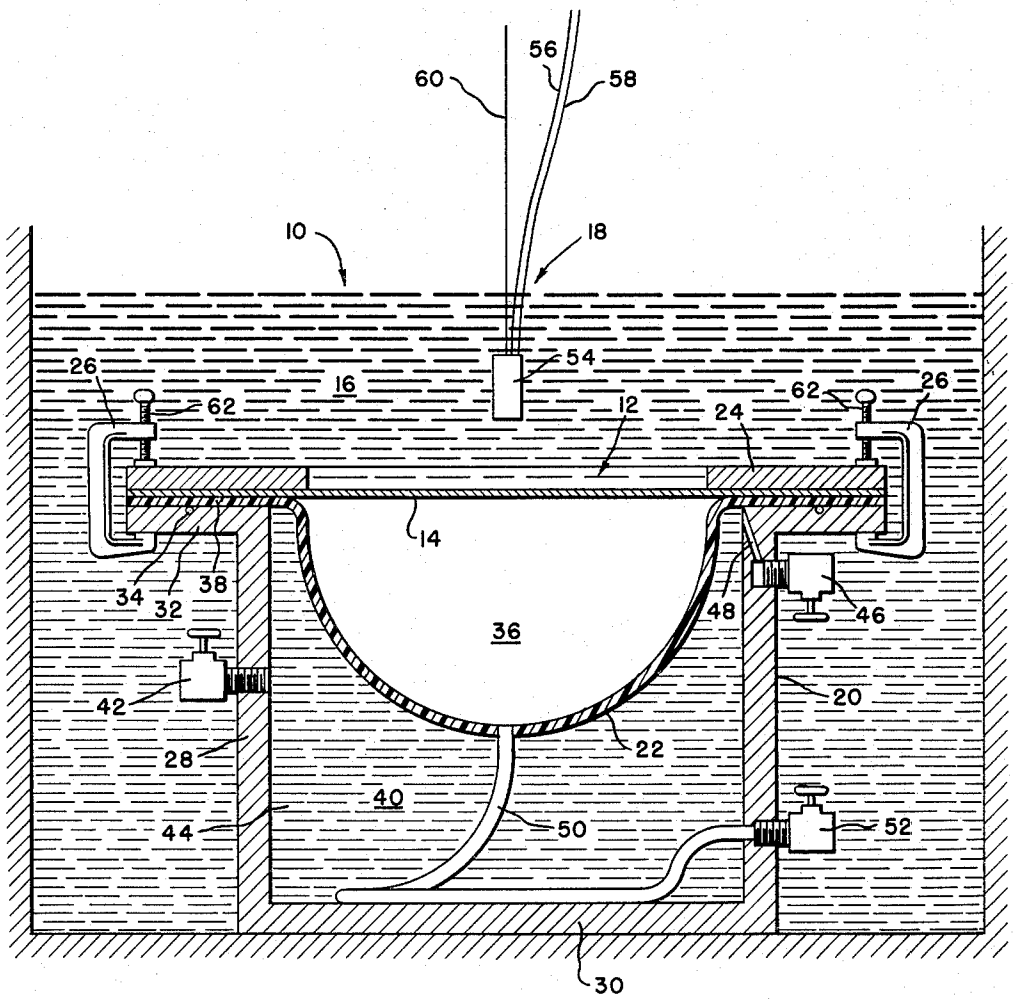
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METHOD AND APPARATUS FOR FORMING WORKPIECES

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METHOD AND APPARATUS FOR FORMING WORKPIECES

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This invention relates generally to the formation of workpieces, such as sheet metal blanks, and particularly to formation by the application of pressure, and is directed to a novel forming method to be carried out by a novel forming apparatus.

Heretofore, the formation of metal workpieces has been accomplished by the utilization of conventional metallic dies and hydraulic presses. Several disadvantages are inherent in such formation practice. Formation of large workpieces requires the provision of heavy, costly forming apparatus. In such cases, the dies used must be very thick and strong with large attendant weight to withstand the pressures to which they are subjected. For example, a one-piece die casting used to form aluminum domes for radar reflector antennas measures seventy-eight inches in diameter with a twenty-two inch contour depth, and weighs twenty tons. Fabrication of a die of this size usually requires approximately two to three weeks of time. Furthermore, very heavy handling equipment must be used to position the die for forming workpieces. Owing to these and other factors it is readily apparent that the provision of apparatus necessary to form objects heretofore involved great initial expenditures of money and costly subsequent maintenance and handling expenses.

The present invention resides in apparatus and method for formation of materials to assure the precise configuration of the forming surface of a die as a result of the pressure applied thereto by the application of shock waves generated by an ignited explosive change within a pressure transmitted medium.

In contrast the present invention provides distinct advantages over the prior formation practices. One advantage is that less costly dies can be used, providing savings from sixty-five to eighty-five percent of the cost of conventional steel dies. Another advantage is that the weight of equipment utilized is considerably reduced. For example, the hereinbefore mentioned conventional steel die weighing twenty tons could be replaced by a die wall weighing only two hundred and fifty pounds. Where it took two or three weeks to provide conventional dies in previous forming practices, the present invention utilizes forming members which can be available in two or three days. With the much lighter apparatus used, handling of parts can be accomplished mostly by hand, requiring little use of heavy handling equipment such as cranes.

Accordingly, it is an object of this invention to provide novel apparatus and method for forming workpieces to desired shapes.

Another object of the present invention resides in the provision of novel apparatus and method capable of forming workpieces to desired shapes simply and economically.

Still another object of the present invention is the provision of novel apparatus and method to form materials by utilizing pressure.

A further object of the invention is to provide for the forming of materials by the use of light weight forming parts which are readily available and easy to handle.

An object of the present invention is to provide novel

forming apparatus incorporating novel die forming means.

These and other objects and advantages of the invention will be more readily apparent to those skilled in the art from the following description of specific apparatus embodying and utilizing the novel method.

In the drawings:

The single figure is a partial cross-sectional view taken through the apparatus of the present invention.

Referring now to the single figure of the drawings, the apparatus associated with the present invention is generally designated by the numeral **10** and comprises a die arrangement **12**, a workpiece **14**, a body of pressure transmitting medium **16**, and shock wave generating apparatus **18**.

The die arrangement **12** generally includes a metallic container **20**, a thin die wall **22**, a draw ring **24**, and a plurality of clamps **26**. The container **20** is shown as being open-ended and includes an upright cylindrical wall **28** and a circular bottom wall **30**, but could be of any predetermined height, size or contour. Adjacent the open end of the container there is provided a circumferential flange **32** which carries an annular resilient seal element **34** positioned as by bonding in an appropriate circular groove.

The die wall **22** is illustrated as being shaped to form a hemispherical cavity **36**, but could be any desirable shape depending on the contour desired to be imparted to the workpiece **14** to be formed. The die wall is provided with a flat annular flange portion **38** and can be of any size as long as it is capable of being positioned with the flange portion **38** overlying the seal element **34** in the container flange **32**, as shown, to provide an enclosed space **40**. The die wall is preferably of laminated glass cloth, or the like. The die wall could be of molded plastic material or thin sheet metal.

A control valve **42** controls the flow of non-compressible fluid **44** from a source (not shown) through a suitable fluid line to the enclosed space **40** to back up the die wall **22**, as shown. The fluid is preferably water or the like.

An air relief valve **46** connects to a passage **48** in the wall **28** of the container and serves as a means to exhaust air from the space **40** as the fluid **42** is admitted thereto through the valve **42** to ensure complete evacuation of air, as will hereinafter be more fully disclosed.

A length of flexible tubing **50**, preferably of rubber, or the like, is suitably connected to the lowermost point in the cavity **36** and a control valve **52** positioned on the container outwardly of the space **40**. The flexible tubing **50** can be of any desired length, as long as it has sufficient length to facilitate connection of the die wall **22** thereto prior to positioning of the die wall on the container in preparation for forming. The control valve **52** is adapted to be connected by a suitable fluid line to apparatus capable of exhausting air from the cavity **36**, such as a vacuum pump (not shown).

The shock wave generating apparatus **18** consists of an explosive change or squib **54**. The squib can comprise any well known explosive substance such as dynamite, trinitrotoluene, or the like, suitably enclosed as in a plastic casing, or the like. A pair of electrical conduit wires **56** and **58** extend upwardly to a detonation generator (not shown), which is capable of generating electric current to actuate a detonator in the squib to deteriorate the explosive therein. A wire **60**, suitably attached to the squib and support means (not shown), serves to position the squib in the pressure transmitting medium **16** at a predetermined distance from the die arrangement.

In the practice of the invention, a thin, light weight die wall **22** is prepared with a cavity having the desired

contour. The die wall is then attached to the tubing **50** and placed over the open end of the container **20** with its flange portion **38** upon the container flange **32**. The workpiece **14**, to be formed, is placed upon the die wall **22** to cover the cavity **36**. The draw ring **24** is then positioned upon the workpiece and the clamps **26** slipped over the edges of the parts and tightened by means of screws **62**. When the clamps are adequately tightened, pressure sealing is effected between the die wall flange **38** and the container flange **32** by means of the seal element **34**. The die wall flange **38** and the workpiece **14** achieve their own sealing between adjacent contact surfaces due to the tightening force of the clamps **26**, and a restraining force is applied to the workpiece, as will be hereinafter more clearly apparent. Next, with both valves **42** and **46** opened, water from the source (not shown) is allowed to flow through the valve **42** into the space **40** until the space is completely filled with the water to back the die wall **22**, and all air has been evacuated from the space through passage **48** and the valve **46**. This condition will be achieved when it is observed that water flows from the space **40**, through the passage **48**, and out the valve **46**. Immediately, upon observation of water flow from the valve **46**, both valves **42** and **46** are closed. Air is then evacuated from the cavity **36** through the tubing **50** and valve **52** by means of the vacuum pump (not shown). The valve **52** is then closed and the assembled die apparatus is lowered into the pressure transmitting medium **16** in any desirable manner. The squib **54** is next located in the pressure transmitting medium in proper relations to the workpiece by means of the wire **60**. The detonation generator (not shown), is then actuated, thereby detonating the squib **54**. When the squib **54** is detonated, shock waves are produced through the medium **16**. As the shock waves contact the workpiece **14**, there is an extremely rapid, downward movement of that portion of the workpiece **14** above the cavity **36** into the cavity, thus forming the workpiece. As this forming takes place the restraining force of the draw ring **24** upon the workpiece is adequate to permit the dragging of the workpiece into the cavity, but will prevent any tendency of the workpiece to wrinkle during the forming action. Also, during this forming action, since the die wall **22** is backed by the incompressible medium **44**, any tendency of the die wall to move or distort as the workpiece is urged into the cavity **36** is adequately prevented, thus assuring perfect formation of the workpiece.

As described, the present invention is characterized as being simple, rapid, and economical in the formation of materials into desired shapes wherein a workpiece is caused to assume the shape of a thin die wall backed by an incompressible fluid by means of explosive energy produced in a pressure transmitting medium wherein the workpiece and die wall are submerged.

Although only the preferred embodiment of the invention has been disclosed, it is to be understood that the

invention is not limited thereto, as many variations and modifications will be apparent to those skilled in the art, and the invention is to be given the broadest possible interpretation within the scope and terms of the following claims.

What we claim is:

1. A method of forming comprising placing a thin inflexible die wall over an opening in a container, placing a workpiece over one side of said die wall to define an air space therebetween, securing the edges of said die wall and workpiece to said container to effect sealing therebetween, completely filling said container with an incompressible fluid to immovably back the other side of said die wall, evacuating air from said air space, immersing said die wall, container, and workpiece in a liquid adjacent an explosive charge, and igniting said explosive charge to produce shock waves in said liquid forcing said workpiece against said die wall.

2. Forming apparatus comprising a container having an opening, a thin inflexible die wall positioned over said opening, means for securing the edges of said die wall and a workpiece to said container to effect sealing therebetween, said die wall and workpiece defining an air space therebetween, an incompressible fluid completely filling said container to immovably back said die wall, means for evacuating air from the space between said die wall and workpiece, a body of liquid, an explosive charge in said liquid, said die wall, container, and workpiece being immersed in said liquid adjacent said explosive charge, and means for igniting said explosive charge to produce shock waves in said liquid forcing said workpiece against said die wall.

3. A forming die comprising a container having an opening, a thin inflexible die wall positioned over said opening, means for securing the edges of said die wall and a workpiece positioned over said die wall to said container to effect sealing therebetween, an incompressible fluid completely filling said container to immovably back said die wall, and means for evacuating air from the space between said die wall and workpiece.

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