Oct. 27, 1964 J. GLYMAN ETAL 3,153,848

METHOD FOR CONTROLLING SHOCK FORCES

Filed July 9, 1962 2 Sheets-Sheet 1

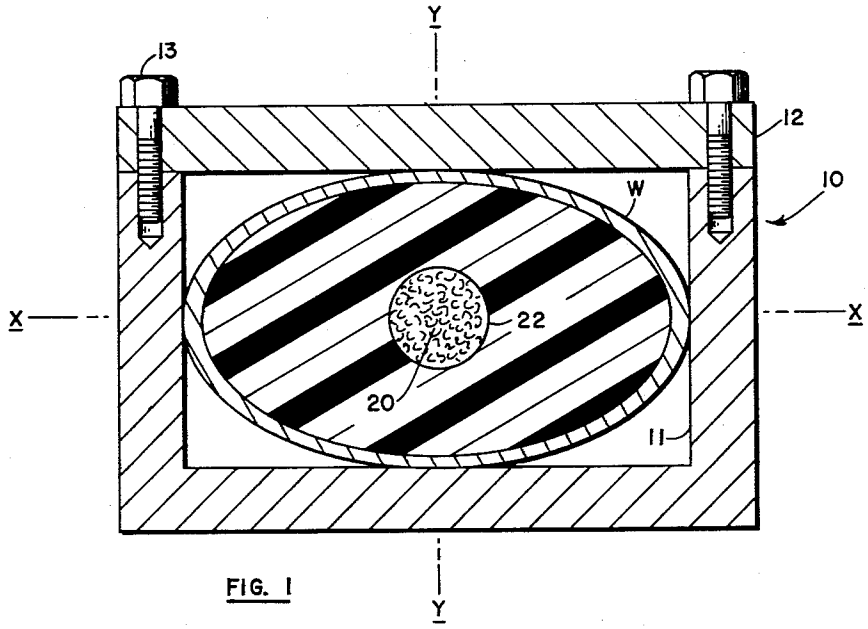


FIG. 1

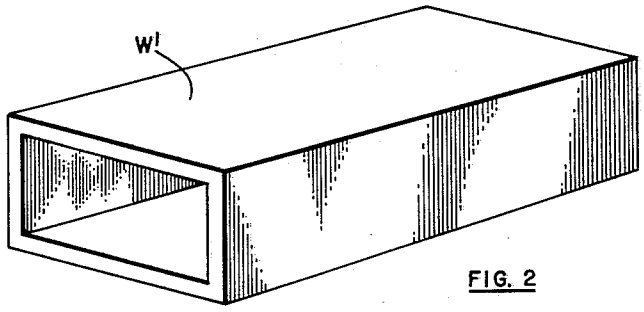


FIG. 2

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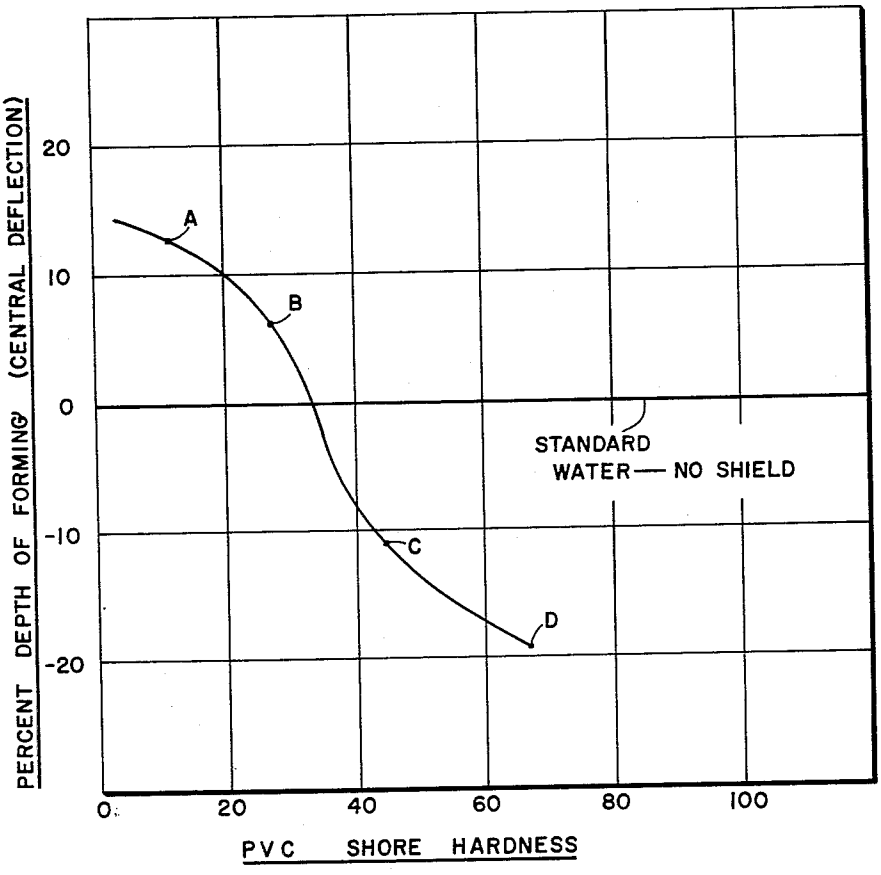


FIG. 3

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METHOD FOR CONTROLLING SHOCK FORCES

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6 Claims. (Cl. 29—421)

This invention relates to a method for controlling explosive forming forces and more particularly to precisely controlling and transmitting forces for forming and working of various parts.

The explosive or high energy forming of tubular structures, for example, has inherently provided that the stand-off distance of the internally confined explosive charge from workpiece be maintained within a limited range. Therefore, only the explosive weight could be changed to impart the desired explosive forming force to the inner walls of the structure to be formed. Many problems are encountered in such a procedure. For example, when the diameter of the explosive charge is below a certain minimum, it often fails to detonate. Conversely, when the diameter of the charge is increased to increase the weight and explosive force, the stand-off distance as measured from the inner walls of the structure to be formed is necessarily decreased. Such a decrease in stand-off distance often functions to over-form and damage the workpiece as well as the associated back-up die.

It is, therefore, an object of this invention to provide a method for precisely controlling the explosive forces imparted to form or work a piece of material.

Another object of this invention is to provide a method for expeditiously, accurately and inexpensively forming tubular shaped structures by the employment of explosive forces.

Another object of this invention is to provide an expeditious and economical method for explosively forming tubular shaped structures independent of the explosive charge stand-off distance and the weight of the charge.

The present invention overcomes these deficiencies by providing a unique method for precisely controlling the explosive forming forces imparted to a workpiece in the process of explosive forming. It is of particular importance that such a control be provided independent of the explosive charge stand-off distance and of the charge weight.

An explosive force or shock transmitting means, preferably comprising a natural or synthetic elastomeric material, but not restricted thereto as will be hereinafter more fully discussed, is formed around a standard explosive charge of predetermined weight. Such a material is selected to have a predetermined strength, hardness and elasticity. This structure is then constructed and arranged within a tubular workpiece to be formed. A female type die member is arranged around said workpiece. The explosive charge is then exploded to selectively transmit the explosive forces through the force transmitting means and onto the internal surfaces of the tubular structure. It is thus seen that the predetermined amount of forces which it is desired to impart to the tubular structure may be selectively controlled by simply varying the strength, hardness and elasticity of said force transmitting means.

In the accompanying drawings:

FIG. 1 represents a workpiece, die and charge arrangement according to this invention prior to explosive forming of the workpiece.

FIG. 2 illustrates the workpiece of FIG. 1 subsequent to explosive forming and,

FIG. 3 is a plot of test results more particularly emphasizing the novel concepts of this invention.

FIG. 1 discloses a tubular workpiece W prepared pursuant to the novel concepts of this invention and as it would appear prior to the explosive forming thereof. A female type die member **10** is constructed and arranged around the tubular structure W and defines a female type die cavity **11** therein. As shown for illustration purposes, the die member may constitute a two-piece die assembly having a cover member **12** which is adapted to be secured to the remainder of the die assembly by conventional fastening means such as bolts **13**. In such an event, it would be preferable to close the ends of the die (not shown) to more positively retain the explosive forces generated therein. It should be further understood that if so desired, the die assembly **12** may comprise a unitary tubular structure with no end walls formed thereon. The specific constructions and arrangements of the die assembly **12** and in particular the internal die configuration **11** thereof, comprise a matter of choice depending on the particular type of tubular structure **10** which is to be formed. For example, the internal female type die configuration **11** could comprise a circular, triangular, or elliptical shape, etc.

A standard explosive charge **20** is constructed and arranged within a force transmitting means **21**, as shown. The particular charge **20** which is utilized may comprise for example, dynamite, pentaerythritol tetranitrate (PETN), trinitrotoluene (TNT), cyclonite (RDX), or any other suitable standard explosive. As hereinbefore stated, the magnitude of explosive force or shocks imparted onto the tubular structure W has heretofore been primarily dependent on the stand-off distance the explosive charge **20** was arranged away therefrom and also the weight or intensity of said explosive charge. However, as will be hereinafter more fully explained, the magnitude of the explosive force which is imparted to the tubular structure W may be closely controlled by merely varying the configuration, strength, hardness and (or) elasticity of the force transmitting material **21**. Thus, a precise forming of the tubular structure into the configuration W' of FIG. 2 is virtually made independent of the aforementioned explosive charge **20** stand-off distance and (or) weight.

The elastomeric material or explosive force transmitting means **21** is preferably formed onto the explosive charge **20** by conventional molding methods or the like. The strength, hardness and elasticity of the force transmitting means **21** is primarily determined by the type of material utilized and may be further affected by varying the cure temperature, cure time and formulation thereof. It should be understood that alternatively, the force transmitting means **21** may be first formed with an aperture **22** and the explosive charge **20** subsequently constructed and arranged therein.

The particular material utilized for the force transmitting means **21** has been described as preferably comprising a natural or synthetic elastomeric material. However, it should be understood that other materials may be utilized therefor.

The novel concepts of this invention are particularly adapted for the employment of an explosive force transmitting means comprising an elastomeric material comprising all the natural and artificial rubbers and plastics including, but not restricted to natural rubber, polyurethane rubber, polysulfide rubber, chlorinated rubber, fluorinated rubber, and any plastic exhibiting rubbery or resilient properties.

Furthermore, both organic and inorganic gel type materials may be employed therefor. Examples of such organic gel type materials include starch, gums, gelatin, glue, ethyl cellulose, methyl cellulose, waxes, and any other types of naturally occurring or synthetic thickened type agents. Examples of inorganic gel type mixtures which are applicable to this invention comprise binders of ethyl silicate, sodium silicate, colloidal silica in combination

with reinforcing constituents of silicon, oxides, silicates of powdered metal or fiber, respectively. The latter mentioned inorganic gel type materials are particularly adapted for use in connection with operations utilizing extremely high explosive forces.

More specifically, the novel concepts of this invention are particularly adapted for use with an explosive force transmitting means comprising a polyvinyl chloride resin in combination with a suitable plasticizer and stabilizer. The plasticizer may be any organic or inorganic constituent which is capable of selectively varying the hardness and elasticity of the plasticizer depending on the particular relative proportion thereof which is used. Specific examples thereof will be hereinafter specifically set forth in Example I.

As above stated, the three basic controls whereby the strength, hardness and elasticity of the force transmitting means **21** may be selectively varied are the cure temperature, cure time and constituent formulation. The selection thereof for any particular application will depend on the specific design requirements. It should be further understood that design parameters may be selectively varied on various portions of a particular force transmitting means to afford a varied force transmitting function therethrough. For example, it may be desirable in certain applications to so construct and arrange the force transmitting means **21** (FIG. 1) so as to permit a greater magnitude of generated explosive force in the X—X direction than in the Y—Y direction.

Example I

FIG. 3 discloses the results of a series of tests utilizing force or shock transmitting media having various degrees of strengths, hardnesses and elasticities. The explosive charge utilized comprised a small quantity of TNT which was arranged at a stand-off distance of two inches from a standard No. 1100 aluminum workpiece. A small three-inch cup die having a one-half-inch drawn radius was constructed and arranged to support the workpiece in the conventional manner. The force transmitting media comprised the following constituents: Polyvinyl chloride (PVC), a plasticizer constituting dioctyl phthalate (DOP), and a stabilizer basically comprising lead carbonate.

The tested samples A through D approximated the following relative weight percentages:

	PVC (percent)	DOP (percent)	Stabilizer (percent)
A	60	39.9	0.1
B	50	49.9	0.1
C	40	59.9	0.1
D	30	69.9	0.1

It can be seen that by using water as a comparison as a forming media, that the central deflection of the test specimens A through D increased from approximately —20 percent to +15 percent and that hardness decreased from a shore hardness of 66 to 13. It is of interest to note that Sample A exhibited a greater force transmitting capacity than water.

In addition, to the specific example given, the concept of this invention can be extended to include other explosives as well as high energy working methods such as welding, hardening, compaction and encapsulating. In these cases, the workpiece can be tubing, sheet, powder or composite material. These materials can include metals, plastics, ceramics and cermets.

Although this invention has been described and illustrated in detail, it is to be understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

We claim:

1. In the method of working and forming a workpiece by a shock force the improvement which comprises controlling the explosive forces independent of explosive charge standoff distance and weight of charge by:
transmitting the shock force through an elastomeric material selected from the class consisting of solid organic polymers and relatively rigid gels,
and varying only the hardness of said organic polymers and gels according to the force desired.

2. The improvement set forth in claim 1 wherein the elastomeric material is a rubber.

3. The improvement set forth in claim 1 in which the elastomeric material is an organic gel.

4. The improvement set forth in claim 1 in which the elastomeric material is an inorganic gel.

5. The improvements set forth in claim 1 in which said elastomeric material is polyvinyl chloride in combination with a suitable plasticizer and a stabilizer.

6. The improvement of claim 5 in which the plasticizer is dioctyl phthalate and the stabilizer is lead carbonate.

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