April 22, 1958 A. B. MOORE 2,831,429

SHAPED CHARGE FOR PERFORATING OIL WELL CASING

Filed Feb. 17, 1955 2 Sheets-Sheet 1

FIG. 1

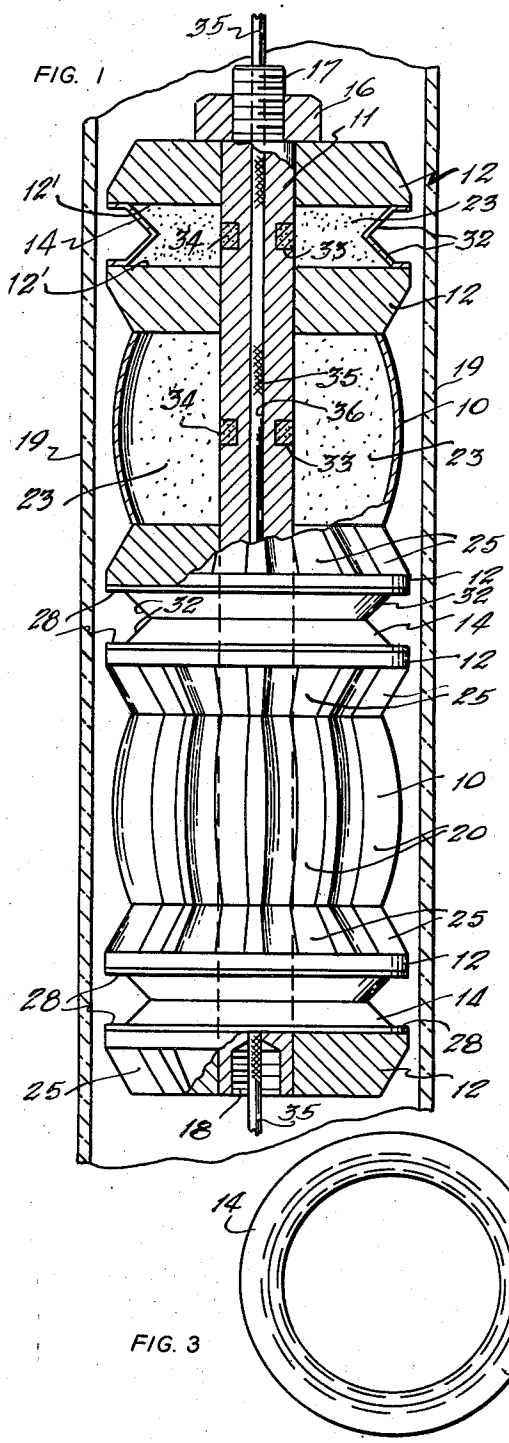


FIG. 2

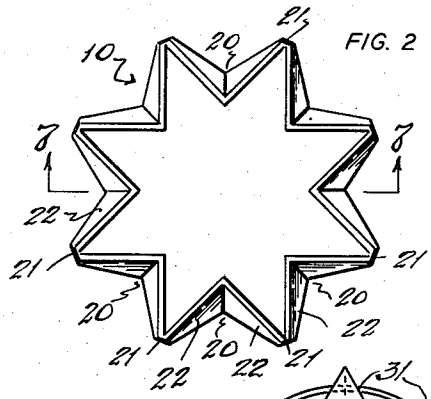


FIG. 4

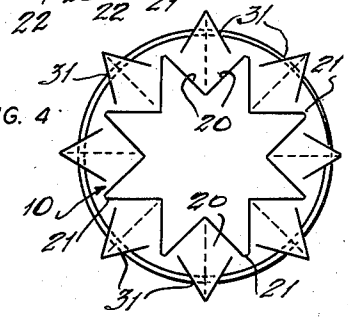


FIG. 5

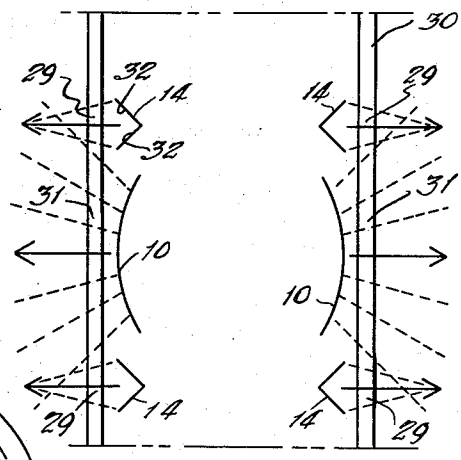


FIG. 3

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April 22, 1958 A. B. MOORE 2,831,429

SHAPED CHARGE FOR PERFORATING OIL WELL CASING

Filed Feb. 17, 1955 2 Sheets-Sheet 2

FIG. 6

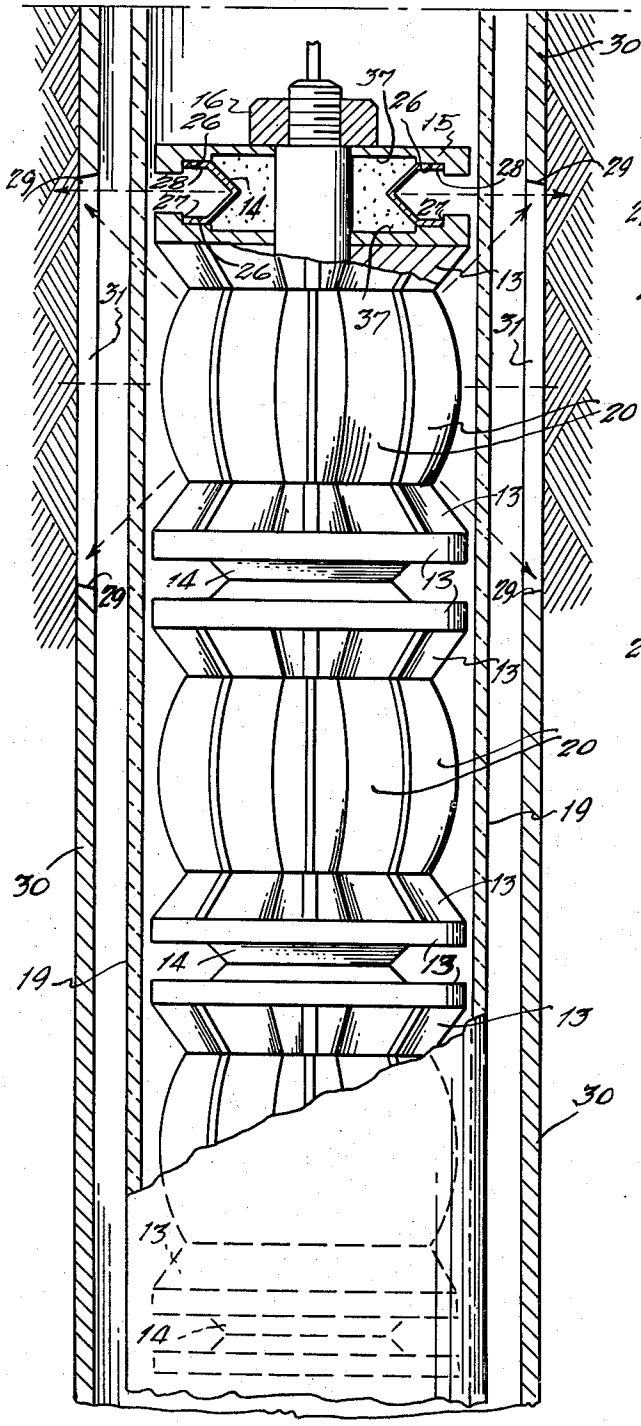


FIG. 7

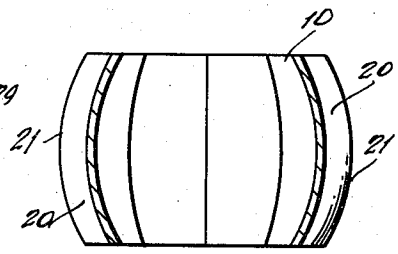


FIG. 8

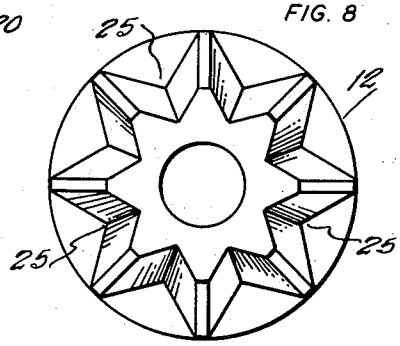
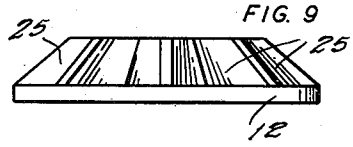


FIG. 9



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SHAPED CHARGE FOR PERFORATING OIL WELL CASING

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Application February 17, 1955, Serial No. 488,939

5 Claims. (Cl. 102—20)

This invention relates to a method for treating bore holes for oil wells, and in the perforating or severance of well casing in said bore holes, and to apparatus for the performance of said method as, for example, where normally productive formations have been sealed off by the accumulation of paraffin, asphalt, or other materials common to such formations, which present impediments to the free flow of oil into the bore-hole and thus interferes with the maximum production of the well.

Another object of the invention is that of providing a method and apparatus for perforating or dissecting oil well casing, both vertically and horizontally, so as to provide elongated openings therein at different elevations to encourage the flow of well fluids thereinto, and in such instances as where certain portions of a well casing may be liberated from its subterranean anchorage as when such casing is to be salvaged from non-productive wells, and the like, and which is incapable of being withdrawn until detached from any type of subterranean securement, such as cementing, and the like.

It is an object of the invention to provide apparatus by which an explosive can be employed based upon the so called "Munroe Principle" by which elongated slits or openings can be defined in oil well casing by inciting explosive materials formed in so called "shaped charges" having definite conformations capable of directing the force of the charges in controlled patterns, both vertically and horizontally, to produce rectangular openings of predetermined length longitudinally of the casing and spaced circumferentially thereof rather than circular perforations which are obviously less effective than slotted openings of relatively great length.

A still further object of the invention is that of providing charges shaped, in their containers, to insure a combination of both horizontal and vertical inclinations so as to produce intersecting cuts or ruptures which will form windows or elongated openings, or by which, when it is desired to sever a casing at a definite level in the bore-hole for salvage as when the casing has been securely anchored by some process of cementing, or the like.

Yet another object of the invention resides in the provision of a method and apparatus for use in relatively hard formations for fracturing the same in a horizontal radial pattern to form fluid passages and define channels by which mineral fluids can enter the accessible area for recovery through the bore-hole.

Broadly, the invention contemplates the provision of a method for perforating or severing oil well casing in the bore-hole, and fracturing or separating hard subterranean oil-bearing formations, and apparatus for performing the method, which utilizes shaped directional charges of an explosive by which accurate cuts can be accomplished in both horizontal and vertical planes at different elevations along a bore-hole.

While the foregoing objects are paramount other and lesser objects will become manifest as the description proceeds, taken in connection with the appended drawings wherein:

Figure 1 is a fragmentary illustration of one form of apparatus showing a multiple arrangement of liners, shown in partial section, in a refractory container.

Figure 2 is a plan view of one of the liners for providing a radial arrangement of vertical cuts.

Figure 3 is a plan view of the circular horizontal liner for horizontal cuts.

Figure 4 schematically illustrates the action of the vertical explosion on the casing, showing the direction of the shock waves to form vertical cuts.

Figure 5 is another schematic illustration showing the horizontal movement of the shock waves and showing the vertical radii of the vertical jets in dotted lines as projected through the casing.

Figure 6 illustrates a portion of a unit formed of a plurality of vertical and horizontal liners in a refractory container installed in a well casing, and indicating, by dotted lines, the horizontal and vertical action of the jets.

Figure 7 is a vertical sectional view of one of the vertical liners.

Figure 8 is a plan view of one of the end plates for the vertical liners showing its angular faces conforming to said vertical liners, and

Figure 9 is a side elevational view of one of the end plates, as illustrated in Figure 8.

It is desirable to penetrate the fluid-laden formations as far as possible in all directions from the bore-hole, where the porosity of such areas are heavily congested, and blast reservoirs and channels therein for the accumulation of oil which will subsequently find its way into the bore. It is also desirable to control the shots so that varying conditions of the several strata in a given well may be treated according to its peculiar characteristics. By providing for the direction of the jets in a radius vertically, while at the same time controlling a horizontal jet directed radially, a series of elongated slots or windows can result to admit well fluids to the casing at different levels.

It is desirable also to provide such devices formed in materials most suitable to the action of the explosives employed and having composition characteristics which will enable the same to be reduced to infinite particles and present the minimum of interference in drilling operations after the charges have been detonated in the bore-hole.

Accordingly, the apparatus primarily comprises a unitary structure of a plurality of individual liners **10** which are connected in axial alignment by a shaft or rod **11** concentrically thereof, as illustrated in Figures 1 and 6, and separated by spacer plates **12** or **13** which have conforming concavities therein, as shown in Figures 6, 8 and 9. The spacer plates **12** or **13** are arranged at each end of the liners **10** and these are spaced by rings or horizontal liners **14**, a locking plate **15** being applied to each end of the assembly and secured by a nut **16** threaded upon the rod **11**, in the manner shown in Figures 1 and 6.

A series of the unitary structures just described can be associated by threading the upper threaded end **17** of the rods **11** into the internally threaded sockets **18** on the lower ends thereof. It is therefore possible to locate several units in a well casing at different levels, if desirable, and spaced apart. Each arrangement of individual units, as shown in Figures 1 or 6, are preferably encased within a refractory tube **19**, such as a glass material having suitable tensility, and each section of the tube **19** can be joined by a light metal sleeve (not shown) which can function as a coupler. The assemblies can be extended to any desired and practicable length.

Each of the vertical containers or liners **10** are substantially cylindrical but also spheroidal in general form, having their outer diameters extended intermediate their open ends curving inwardly toward the ends which are open,

as illustrated in Figures 1, 5, 6 and 7, to present a bulbous appearance, but having convolutions in their walls defining spaced V-shaped or concave indentations **20** spaced about its perimeter which define arcuate ribs **21** therebetween to present the shape illustrated in Figures 2 and 7, with the diagrammatic illustration in Figure 5. As will presently become manifest, the angular surfaces **22** between the ribs **21** serve to direct or concentrate the force of the jet into a relatively narrow course, in the manner shown in Figure 4, so that a vertical cut can be accomplished by the explosive **23** contained in the containers or liners **10**.

Between each of the containers or liners **10** is arranged either of the spacer plates **12** or **13** which comprises a circular plate, shown in detail in Figures 8 and 9, formed preferably of zinc, or similar materials, due to the desirability of the dissolution or fragmentation of such materials to present a minimum of hazard in fouling the well with hard materials having some capability of deterring the drill bit if further drilling become necessary. The spacer plates **12** and **13** have a conformation of V-shaped angularly inclined recesses or concavities **25** conforming to the complementary features **20** and **21** of the liners **10** to present the structure shown in Figures 1 and 6 when these members are assembled. In Figure 1 the spacer plates **12** are illustrated as having regular surfaces **12'**.

The spacer plates **13**, shown in Figure 6, are formed with circular recesses **26** on their plane surfaces which are defined by circular shoulders **27** into which the parallel circular flanges **28** of the rings **14** are seated, as apparent in Figure 6. In the structure shown in Figure 1 the rings **14** are seated against the surfaces of the plates **12** which, as in the modified structure shown in Figure 6, closes each side of the rings **14** to provide a circular chamber for an explosive material **23**.

It is a phenomenon peculiar to the Munroe Principle that explosive charges shaped in the angular manner of those described and illustrated herein react to resistances presented by surfaces arranged at right angles to each other, or where right angular lines from their opposing surfaces can intersect, as illustrated in Figures 4 and 5. Thus the rings **14** have V-shaped perimeters between the flanges **28** thereof which will cause a convergence of the jet to effect a horizontal cut **29** in the well casing **30**, indicated by the dotted lines in Figure 5, acting in coordination with the vertical V-shaped recesses or concavities **20** formed about the liners **10** which effect the vertical or longitudinal cuts **31** also indicated by dotted lines in Figures 4 and 5.

The shapes of the charges of explosives **23**, present surfaces which are disposed at angles to each other, as between the surfaces **22** of the ribs **21** which form the indentations **20** of the liners **10**, and the right angularly disposed surfaces **32** of the V-shaped circumferential channel about the rings **14**. The arcuate formation of the concavities **20** in the liners **10** on a vertical plane will cause the effect of the detonation to be directed radially in a vertical plane, as shown in dotted lines in Figure 5, and in the V-shaped lines in Figure 4, while that of the rings **14** will be directed in a horizontal plane, the surfaces **32** causing the jet to converge into a relatively thin line, as indicated by the arrows in Figure 5, to effect a horizontal cut.

Referring to Figures 4 and 5 which illustrate the action of the explosive **23**, it will become apparent that there is a controlled focussing of the jet force both vertically and horizontally so that a predetermined cut can be accomplished on each plane. This action is illustrated by the arrows and by dotted lines in these views. In Figure 4 the solid V-shaped lines indicate a convergence of the jet action to effect the vertical cuts while Figure 5 shows the convergence of the jet from the ring **14** in dotted lines, the horizontal cuts being indicated by the arrows, and the radial action of the liner jets being shown in dotted lines which intersect the horizontal cuts effected by the rings **14**. This action is also indicated by dotted lines, with pointers, in Figure 6.

At intervals along the rods **11** are formed circumferential grooves **33** in which are arranged booster charges **34**, and these are placed intermediate the opposing sides or ends of the charges of the explosives **23** within the liners **10** and the rings **14**, as illustrated in Figure 1, which co-act with the primer cord or fuse **35** arranged through a concentric bore **36** longitudinally of the rods **11**. The angular concavities of the plates **12** or **13**, which conform to those of the liners **10**, serve the function of directing the jet downwardly and upwardly to intersect the radial jets of the vertical concavities **20** of the liners **10** to complete the vertical cuts in the casing **30**, and insure an intersection of the jet waves with the horizontal action of the rings **14**.

An important feature of the form of apparatus shown in Figure 6 is the recessed faces of the spacer plates **13** of this structure with the identical face of the locking plates **15**. As previously stated, the plates **13** have annular recesses **26** formed in their surfaces opposing the angular recesses or concavities **25** thereon, thus providing a seat for the lips or flanges **28** of the rings **14** which confine these members until the jet is formed. Concentric with the annular recess **26** in each of the members **13** is a circular recess **37** to accommodate additional explosive **23** on each side of the rings **14**, as apparent in Figure 6. The spacer plates **13** and the locking plates **15** thus provide a casing for the explosive **23** and confines the shock waves to afford greater effectiveness.

The shape of the liners **10**, as illustrated in Figure 2, for example, will insure radiation of the shock waves or jet in all directions horizontally, and by reason of the convex form of the members, radiation will occur vertically also to intersect the horizontally directed shock waves of the horizontal liner ring **14**, as demonstrated in Figures 4 and 5. It is not intended to limit the liners **10**, however, to any particular form as to the shape of the indentations or concavities **20**, or the number of these conformations, but it is of importance to shape these so as to accomplish the radiation desired. The overall shape of the units, when the liners **10** and the spacer plates **13** are combined, will effect the desired radial pattern in a manner to form both horizontal and vertical cuts in the casing **30**, or formation, without interference between the planes of force.

Manifestly, the structure herein shown and described is capable of certain changes and modifications from time to time, by persons skilled in the art, without departing from the spirit and intent of the invention or the scope of the appended claims.

What is claimed is:

1. Apparatus for perforating well casing in a bore hole comprising a truncated substantially spheroidal container formed with open ends and having an explosive therein, a series of convolutions formed by the wall of the container defining longitudinal concavities, the concavities being arcuate in a plane parallel to the axis of the container, a closure for each end of the container comprising a spacer plate having angularly inclined concavities formed thereabout complementing the longitudinal concavities of the container and defining a circumferential V-shaped juncture with the arcuate concavities, a ring container having an anular recessed face arranged adjacent each of the plates, an explosive in the ring container, and means for rigidly associating the containers and the spacer plates in axial alignment in a unitary structure.

2. A device for perforating oil well casing by explosives comprising a truncated substantially spheroidal container having open ends and convoluted walls defining arcuate longitudinal recesses about its perimeter, a spacer plate closing each end of the container and formed wtih angular recesses complementing those of the container and inclined at right angles inwardly with respect to the recesses of the container at each end thereof, an annular V-shaped casing arranged in a horizontal plane adjacent each of

the spacer plates, an explosive material in the container and the V-shaped casing, means for rigidly associating a plurality of the containers and the spacer plates in an operative unit, and a refractory casing for the unit.

3. In apparatus for perforating oil well casing by performing horizontal and vertical cuts therein by an explosive, a truncated substantially spheroidal container having a convoluted wall forming arcuate recesses therein axially of the container, spacer plates having angular recesses therein corresopnding to the recesses in the container and closing the ends of the container, the recesses in the plates being disposed at right angles to the ends of the recesses in the container, defining a V-shaped concavity circumferentially of the ends of the container, an annular container, formed with inwardly directed V-shaped walls and having parallel flanges extended from the walls, arranged adjacent each of the spacer plates, an explosive in the spheroidal container and in each of the annular containers, means rigidly associating said members in axial alignment, and a cylindrical container for said associated members.

4. A device for cutting oil well casing by explosives comprising a liner having a truncated substantially spheroidal form, open at each end, the liner having a convoluated wall defining axially arranged recesses, an explosive in the liner, a spacer plate at each end of the liner closing the ends of the liner and having angularly disposed recesses comformable to those of the liner and inclined inwardly to connect with the convolutions of the wall of

the spheroidal liner, an annular liner having an inwardly formed V-shaped face arranged adjacent each of the spacer plates opposite the substantially spheroidal liner, an explosive in the annular liner, means for associating a plurality of the substantially spheroidal liners, the spacer plates and the annular liners in a unitary assembly, and a refractory casing for the assembly.

5. A device for penetrating oil well casing and productive oil formations by explosives comprising a unitary structure consisting of a truncated spheroidal container having axially convoluted walls defining vertically arcuate spaced recesses and open at each end, spacer plates closing the ends and formed with axial recesses inclined inwardly to complement the recesses of the container, an annular casing having a V-shaped face presenting radially inwardly inclined surfaces about its circumference, an explosive in the container and the annular casing, means for associating the container, spacer plates and annular casing in a unit, means for detonating the explosives, and a refractory casing for the assembly.

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