Oct. 2, 1956 R. T. HARCUS 2,764,938

OPEN HOLE CARRIER

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Fig. 1.

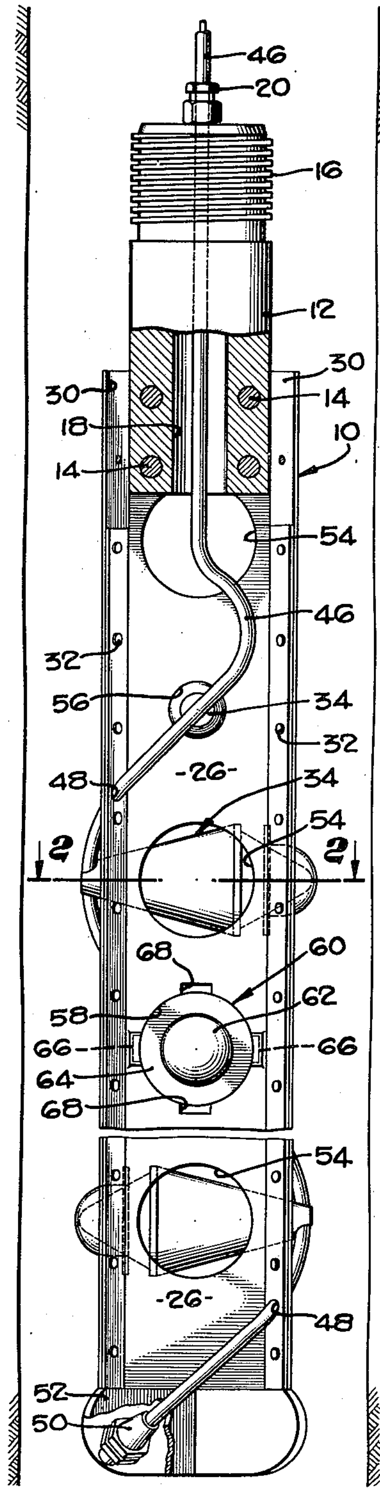


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Fig. 2.

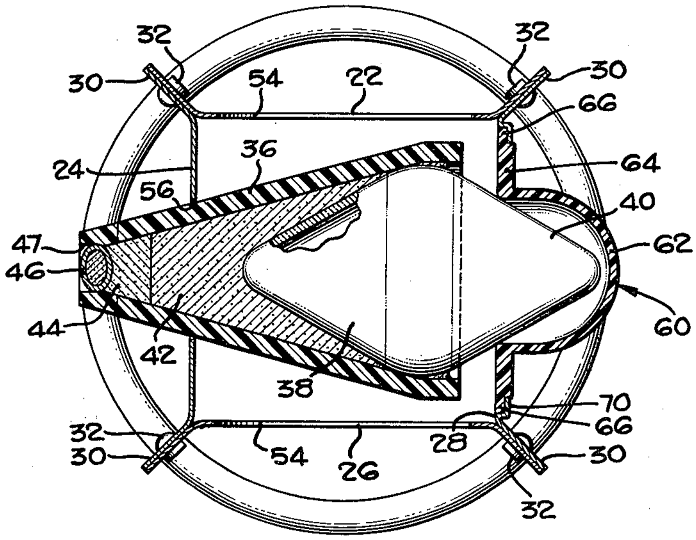
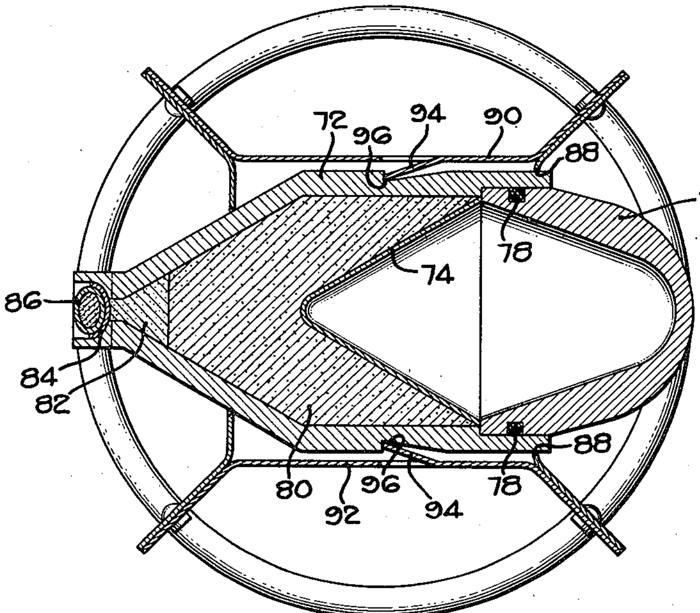



Fig. 3.

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# OPEN HOLE CARRIER

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6 Claims. (Cl. 102—20)

This invention relates to the penetrating of oil strata and particularly to a carrier and means for accomplishing this purpose.

It is well known that considerable amounts of oil exist in reservoirs below the surface of the earth which may have been tapped by wells but from which oil is either locked out by natural or man-made barriers which prevent its recovery. Such natural barriers may consist of hard, tight formations in which the oil is stored, the permeability of which is of such a low order that the oil cannot flow through the interstices and drain into the well. Formations of this type may be either limestone or dense sandstone.

Man-made barriers to the flow of oil from the reservoir into the well may exist as the result of the building up on the walls of the hole of an impermeable sheath formed by the action of the drilling mud, or may result from water or other filtrate from the drilling fluid permeating and wetting the surrounding formation for a distance of from several inches to a foot or more. Such mud sheath or water-wet zone surrounding the well must somehow be perforated in order to obtain production.

Prior practice with tight natural formations was to set off heavy charges of nitroglycerin in the well and, while this undoubtedly in many cases aids production in such tight formations, by reason of the dispersed effect of the explosion its effectiveness is limited and, further, the use of large amounts of nitroglycerin or similar explosives is dangerous to well equipment and must be followed by extensive cleaning out and bailing operations.

As regards man-made barriers, prior practice has been to attempt to penetrate the mud sheath or water-wet zone by the use of bullets, but it is difficult to impart to the bullets the energy necessary to bring about desired penetration.

Again, in many old wells wherein a good flow from reservoir to well had once existed, production becomes lower due to a clogged sand condition in the vicinity of the well bore, or where paraffin or other substances have coated the producing zone causing a decrease in the rate of flow. Here, as above, bullets have been used in an attempt to perforate such congested zones but subject to the same limitations as to penetrability as set forth above.

And further, aside from primary oil flow, certain practices are in use in the oil industry today which require or are greatly enhanced by the opening up of the oil-bearing formations. For example, with limestone formations it is common practice to treat the formations with acid to enlarge the interstices of the formation and thus facilitate the flow of oil into the well. If deep channels into the formation could be opened, the acidizing would be much more effective. Non-directional blasting has not been effective enough to do this because the energy is not concentrated enough; similarly bullet perforating has also proven unsatisfactory because of inadequate penetration and the bullets remaining to block the channels they create.

In addition to practices such as acidizing, certain sec-



ondary recovery methods, as water-flooding or gas injection, would be facilitated by the penetration of any natural or man-made barrier which might impede the flow of the driving medium into the formation.

In an effort to provide means for accomplishing the penetration through natural or man-made barriers from well into formation and to open up the formation to enhance the flow of oil therefrom, recourse has been had to the use of lined shaped charges. Such charges are explosives but, as contrasted with previous nitroglycerin practice, are explosives having a highly effective directional effect. Indeed such explosives, in addition to providing a directional effect achieve, by the provision of a cavity in the surface of an explosive, a liner in said cavity, and a closure for said lined cavity, an entirely new and different explosive effect, namely, the formation from the liner of a thin pencil-like jet traveling through the barrier and into the formation at speeds believed to exceed the rate of advance of the detonation wave of the explosive itself. However, difficulty in the use of such lined shaped charges has been occasioned by several factors. First, while a retrievable metal gun body carrying the charges might be thought advisable for lowering the charges into the well to the vicinity of the oil-bearing formation, the amount of explosive required for the charges, the general structure of the charges, the necessity of providing firing means for the charges and the limited confines of the well bore, have indicated that the retrievable gun is impractical, due to its space requirements.

Second, recourse to a dispensable carrier for the charges has presented the problem that the debris from the carrier, following its destruction by the explosive charges, is left in the well.

Third, assuming that a dispensable carrier may be built light enough and sufficiently frangible and drillable so that its remaining in the well will not make the whole operation infeasible, such carrier must not only be capable of carrying the charges in properly disposed positions, but it must be of a structure capable of securing the charges and capable of protecting the charges and associated firing means during the lowering of the carrier through the well bore to the oil-bearing formation.

It is therefore a general object of this invention to provide a means for achieving the opening up of tight formations by penetration thereinto, whether directly or through barriers such as mud sheaths or water-wet zones.

It is a further object of this invention to provide a novel and practicable shaped charge assembly.

Again it is an object of this invention to provide a carrier adapted to support and position shaped charges and their firing means as they are lowered into the well.

Moreover, it is another object of the invention to provide a carrier for shaped charges of simple, frangible, drillable construction, so that after detonation of the shaped charges within a well the remnants of the carrier will not interfere unduly with subsequent operations in the well.

It is a still further object of the invention to provide a shaped charge carrier of light construction, but still capable of safely securing and protecting shaped charges and their firing means.

Further objects of the invention will appear hereinafter.

In the drawings:

Figure 1 shows an elevational view of one embodiment of the invention in a well;

Figure 2 is an enlarged sectional view taken along the line 2—2 of Figure 1;

Figure 3 is an enlarged sectional view similar to the view of Figure 2 showing another embodiment of the invention.

Referring to the drawings, and particularly to Figures

1 and 2, the carrier **10** comprises a plurality of face members forming a polygon adapted to be affixed to an adapter **12** by means of machine screws or bolts **14** passing through holes in the said face members and in the adapter **12**. The adapter **12** is provided with a threaded end **16** which may thread into a sub or other hole member which is supported by a cable which may in turn be used for raising or lowering the unit in the well. The said adapter **12** is likewise provided with a bore **18** and fitting **20**, the purpose of which will be hereinafter described.

The polygonal carrier frame **10** as shown herein may consist of four face members **22**, **24**, **26**, **28**, said face members being formed of frangible, easily drillable material such as aluminum alloy and each terminating in flanges **30**. The flanges **30** are utilized as a means for assembling the carrier frame, said flanges being riveted together by the rivets **32** or, if it is desired, being spot-welded. Such flanges, as will be seen, extend outwardly from the carrier itself and, as will be hereinafter explained, form a protective guard for the entire structure.

The carrier **10** is adapted to support a number of lined shaped charge units **34**, each of said charge units consisting, in this embodiment of the invention, of a case **36** which may be of plastic or alloy material; a liner **38**, which may be of metal but which is shown here as constructed of glass; a closure **40**, the function of which is to exclude liquids from the cavity formed by the liner **38** and which is in this embodiment constructed of glass and is integral with the liner **38**; the explosive **42**; and booster **44**. The liner-closure unit **38**—**40** is cemented in place within the case **36**, and the charge is fired by a detonating fuse **46** passing through a groove **47** in the rear of the charge unit strung helically through the holes **48** in the flanges **30** of the carrier, through the bore **18** of the adapter **12** to the fitting **20**, where it is connected to the conductor of the cable in common manner. Such detonating fuse may consist of the well known Primacord encased in a tube made of material easily disintegrated by the detonation of the fuse but strong enough to take the pressure of a high head of well liquid, in this embodiment aluminum alloy. It will be noted that the detonating fuse **46** terminates in a fitting **50** affixed to a lower guide **52**. Such lower guide may consist of vertical plates affixed to the carrier structure by any common means.

As is apparent from the drawings, the face members **22**, **24**, **26** and **28** are provided with a plurality of holes **54** cut to reduce weight in the carrier and to provide less material which must remain at the bottom of the hole after operation of the unit. Each face member has interposed between the holes **54** the firing holes **56**, alternating with charge ports **58**. The firing holes **56** permit the projection of the rearward end of the charge unit therethrough to contact the detonating fuse **46**, and the charge ports **58** permit insertion of the charge unit into the carrier and a shooting of the jet through said ports.

Each charge unit **34** is first inserted in a port **58** until its rearward groove **47** contacts the detonating fuse **46**, whereupon a cap **60** consisting of a nose **62** and a flat circular base **64** having projecting lugs **66** is passed through the said port with said lugs **66** registering with cut-away portions **68** in the face member until the base **64** contacts the closure **40** of the charge unit. The cap **60** is then rotated until the lugs **66** engage in internal recesses in the face member formed by the raised portions **70** of said face member. Since there is a certain resiliency in the detonating fuse due to the encasing tube and the closure **40** of the charge unit presses against the base **64** of the cap **62**, the lugs **66** seat firmly in the recesses of the face member and secure the charge units.

As shown in Figure 1, proper aligning of the relative holes **54**, **56** and ports **58** of the various face members permits the progressive positioning of the charge units at 90° transverse intervals or phasing. As shown in Figure 1, the rearward end of the uppermost charge unit is shown. Next, the second charge unit is pointed to the right. The third charge unit is pointed at the observer, and the fourth charge unit is pointed to the left. This permits an effective pattern of penetration into the formation. Similarly, in an embodiment comprising an hexagonal carrier 60° or even 120° phasing would be advantageous. It will be appreciated that the embodiment herein shown sets forth a four-charge unit carrier and that many more charge units can be used in a longer assembly.

Thus the invention comprises a frangible, drillable, lightweight structure, admirably suited for positioning the charge units in the most advantageous manner for efficient penetration of the strata. It further provides a handy means for locking the charge units into position. Again, due to the helical wrapping of the detonating fuse, such fuse contacts the booster end of the charge units without the necessity of using any excess of detonating fuse and in such manner that interference between charges and premature explosions is eliminated. The passing of said fuse through the flanges which extend beyond the said fuse not only means that the charge units and the carrier itself are protected from the abrasive effect of the sides of the bore hole during lowering into the well, but that the detonating fuse is likewise protected. The carrier containing the charge units may be lowered to a depth adjacent any formation desired to be opened up, the Primacord detonated electrically through the conductor of the cable in common manner, and the lined shaped charges thus fired progressively, but due to the rapid rate of propagation of detonation along the fuse, almost simultaneously. The jets from the charges penetrate the mud sheath or water-wet zone about the bore hole, or the tight formation, as the case may be, and further penetrate on into the formation. Cracks in the formation develop radially from the holes in the formation caused by the jets and the formation is thus opened up either to increased production or to the forcing of secondary driving materials or acidizing materials into the said formation.

Figure 3 shows a modification of the charge and charge-securing means in the carrier. The lined shaped charge unit here shown comprises a case **72**; a liner, which in this instance may be copper or other metal, **74**; a closure **76** not integral with the liner but pressfitted into the case and sealed by an O-ring **78**; explosive **80**; a booster **82**; and a metal seal **84** forming the groove through which the detonating fuse **86** passes. A hole **88** is provided, similar to the holes **54** but without the cut-away portions **68**, and through this hole is inserted the charge unit. In the face members **90** and **92** are provided angle members **94**, punched from the said face members, and when the charge unit is passed into the carrier sufficiently for its booster end to abut the detonating fuse **86** the said angle members **94** snap into an angular groove **96** in the case **72**. Thus is secured that type of charge unit within the carrier and, as is obvious, this type holding means for this type charge unit may, as with the embodiment of Figures 1 and 2, be adapted for charges displaced transversely at 90° intervals or phases. It will also be appreciated that in the broad aspect of this invention other known embodiments of lined shaped charges not here shown may be used without departing from the broad principle of the invention.

While there has been described what are at present considered preferred embodiments of the present invention, it will be apparent to those skilled in the art that various modifications and changes may be made without departing from the essence of the invention, and it is intended to cover herein all such modifications and changes as come within the true scope and spirit of the appended claims.

I claim:

1. A shaped charge carrier comprising: a hollow body, said body being of polygonal cross-section and consisting

of a plurality of oppositely disposed parallel face members, each of said face members being affixed to its adjoining face members by means of connected edge flanges, opposite parallel face members having portions shaped to define support means, shaped charge units carried by said support means oriented to direct their energy generally perpendicular to the respective parallel face members supporting them, said edge flanges extending outwardly of said body to center the carrier and prevent rotation of the carrier within a well in which the carrier is lowered, and means holding said shaped charge units in place on said support means.

2. A shaped charge carrier comprising a hollow body, said body being of polygonal cross-section and consisting of a plurality of oppositely disposed parallel face members, each of said face members being affixed to its adjoining face members by means of connected edge flanges, opposite parallel face members having portions shaped to define support means, shaped charge units carried by said support means oriented to direct their energy generally perpendicular to the respective parallel face members supporting them, said edge flanges extending outwardly of said body and having perforations therein, a detonating fuse wound through said perforations in helical disposition to and externally of said face members, said fuse being connected to said shaped charge units so as to be capable of detonating them.

3. A shaped charge carrier comprising a hollow body, said body being of polygonal cross-section and consisting of a plurality of pairs of substantially flat oppositely disposed parallel face members, each of said face members being affixed to its adjoining face members by means of connected edge flanges, said edge flanges extending outwardly of said body to center the carrier and prevent rotation of the carrier within a well in which the carrier is lowered, axially spaced pairs of transversely aligned front and rear shaped charge unit receiving openings in said face member pairs, shaped charge units carried within said openings oriented to direct their energy generally perpendicular to the respective parallel face members supporting them, adjacent spaced pairs of openings being angularly offset with relation to each other whereby shaped charge units carried within said openings are set in angularly phased relationship.

4. A shaped charge carrier comprising a hollow body, said body being of polygonal cross-section and consisting of a plurality of pairs of substantially flat oppositely disposed parallel face members, each of said face members being affixed to its adjoining face members by means of connected edge flanges, said edge flanges extending outwardly of said body and having perforations therein, a detonating fuse wound through said perforations in helical disposition to and externally of said face members, said fuse being connected to shaped charge units carried within axially spaced pairs of transversely aligned front and rear openings in said face member pairs, adjacent spaced pairs of openings being angularly offset with relation to each other whereby the said shaped charge units are set in angularly phased relationship.

5. A shaped charge carrier as in claim 1 wherein said means holding said shaped charge units in place comprise caps abutting said charge units and having laterally projecting lugs engageable with said support means.

6. A shaped charge carrier as in claim 1 wherein said means holding said shaped charge units in place comprise grooves on said units and snap members on said face members engageable with said grooves.

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