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2,980,018

WELL PERFORATOR SHAPED CHARGE

Filed Jan. 3, 1956

2 Sheets-Sheet 1

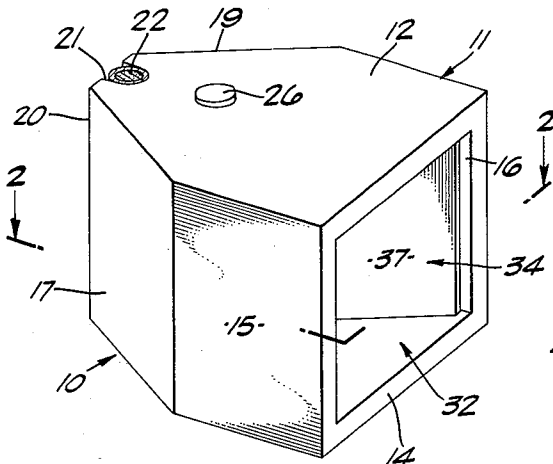


FIG. 1.

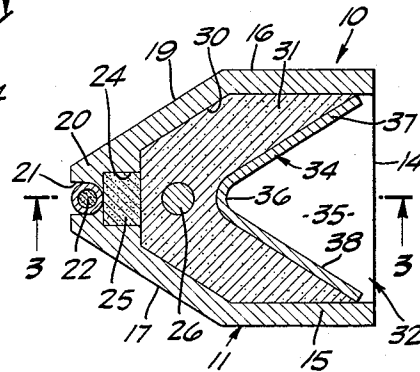


FIG. 2.

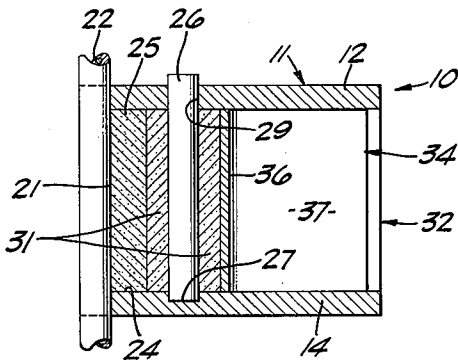


FIG. 3.

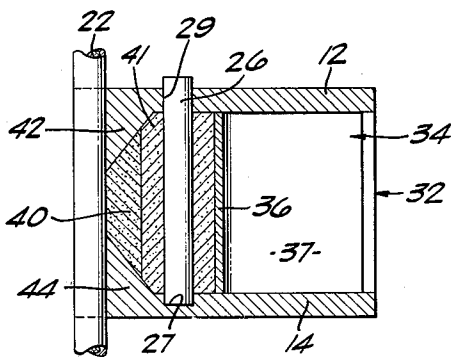


FIG. 5.

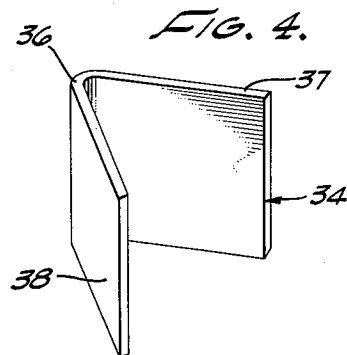


FIG. 4.

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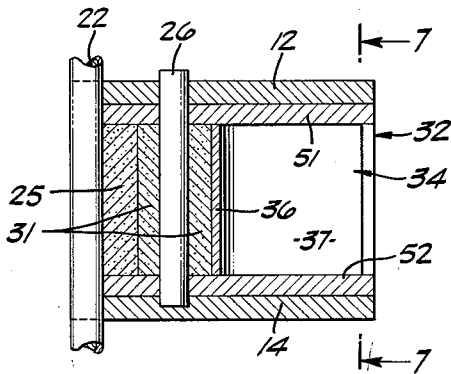


FIG. 6.

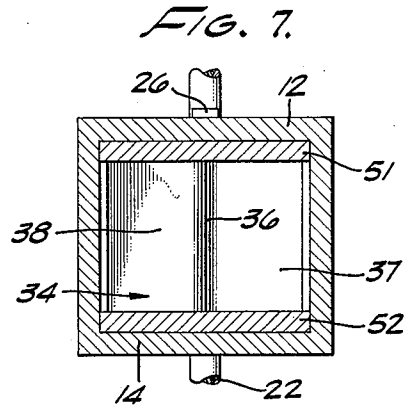
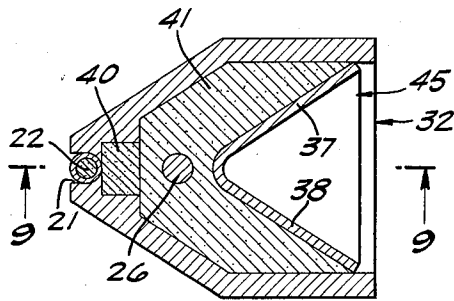
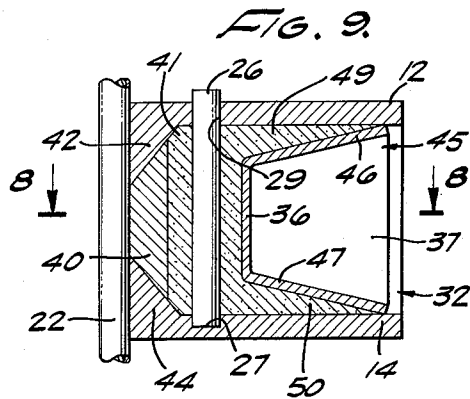
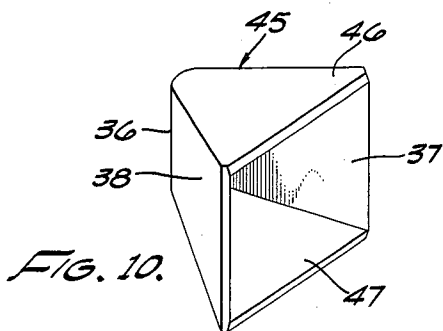


FIG. 8.



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WELL PERFORATOR SHAPED CHARGE

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5 Claims. (Cl. 102—20)

This invention relates to well perforators, and particularly to improvements in shaped charge means for producing openings in well casings and in the surrounding formations to permit entrance of production fluid into the well.

Well perforating operations have heretofore been accomplished usually by firing one or more solid projectiles or shaped charge jets through the casing and into the surrounding formation. This permits flow of fluid into the casing from the desired strata in the surrounding formation.

With either the solid projectile or the more recently developed shaped charge units, a substantially round hole is usually produced through the casing and extending into the formation. Certain practical limits exist on the size of the explosive charge which may be used, and size of perforation which may be made, since it is usually necessary that the perforation be accomplished without damage to the explosive carrier, and also always without permanent damage to the casing. If excessively large charges are used, the explosive carrier body and also the casing may be weakened and deformed, or even shattered.

With either the solid projectile or the shaped charge this limitation has sometimes prevented the formation of holes of the size desired by operators in the field, from a production capacity standpoint. In order to tap larger areas, the operator may shoot a plurality of charges in a single operation, as is conventional practice, but in view of the physical limitations on the spacing of individual charges in a gun, the number of holes per linear foot of casing which may be shot is necessarily limited, and in turn, the effective perforated area of the oil producing formation is correspondingly restricted.

Another disadvantage of the formation of large round perforation holes resides in the relative freedom for entrance of sand into the well casing which they permit.

A relatively long, narrow sheet of cutting gases exposes a greater surface or drainage area in the formation for a given weight of explosive than does a round jet. A jet which produces this linear type of penetration will also produce a linear slot in the casing, which will prevent the entrance of sand and other particles of a size which would readily pass through a round hole of the same cross-sectional area and clog up the tubing. The linearly slotted casing is thus more effective in screening out undesired material.

It is thus the primary object of this invention to provide improvements in shaped charge perforating units, making possible the formation of openings in the casing tapping larger areas without damage to the casing and with given weights of explosive.

It is a further object to provide means for producing a larger drainage area in the surrounding formation for a given weight of charge.

It is another object of the invention to provide means for perforating a greater vertical extent of a particular

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stratum surrounding the casing for a given weight of charge.

A related object is to provide means for preventing the entrance of sand and other relatively fine particles along with the oil flowing into the casing.

It is a further object to provide an improvement in shaped charge units effective to produce a more readily controllable vertically disposed cutting sheet of gases.

It is still a further object to provide a shaped charge unit adapted to produce a linear jet of limited cross-sectional extent in both length and width, but of substantially greater velocity and penetrating power for a given weight of charge.

The objects of this invention are accomplished by an improvement in the recently developed shaped charge type of perforator which makes it possible to produce a linear slit through the casing of accurately controllable length and width.

The invention, comprises, in brief, an improved form of charge having a V-shaped cavity elongated in the direction in which the vertical slot is to extend. The gaseous cutting sheet resulting from the explosive charge is strengthened in its cutting form by the use of a vertically disposed barrier rod positioned between the apical portion of the cavity liner and the booster charge, with the latter also extending parallel to the means for initiating explosion of the charges. The vertical extent of the slot produced may be controlled by limiting it both top and bottom by the charge case itself, which in some embodiments may be reinforced by relatively heavy metal backup plates extending over the top and bottom of the charge. An additional control feature is offered in one embodiment of the invention in which the booster charge flares outwardly from a central point in a vertical plane through the explosion initiating means and is terminally shielded therefrom by the case. In still another embodiment vertical control is obtained by providing a charge liner flaring outwardly in a vertical plane, with a portion of the explosive charge extending to the open end of the charge both above and below the liner, as well as along the sides thereof. These elements are all disposed evenly about an axis of symmetry.

These and other objects, advantages and features of novelty of the invention will become more apparent from the following specification, taken together with the accompanying drawings, in which:

Figure 1 is a perspective view of a shaped charge unit incorporating the present invention;

Figure 2 is a sectional view of the embodiment taken along the line indicated by 2—2 in Figure 1;

Figure 3 is a sectional view of the embodiments of Figures 1 and 2 taken as indicated by line 3—3 in Figure 2;

Figure 4 is a perspective view of the liner element employed in the embodiments of Figures 1 to 3 and 5 to 7, inclusive;

Figure 5 is a sectional view, taken in a plane similar to that of Figure 3, to show a modification in the form of the casing, the booster charge, and the adjacent portion of the main charge;

Figure 6 is a sectional view of another embodiment of the shaped charge unit of the invention, taken in a plane similar to that of Figures 3 and 5;

Figure 7 is a sectional view of the embodiment of the invention taken as indicated by line 7—7 in Figure 6;

Figure 8 is a sectional view of still another embodiment of the invention, taken in a plane indicated by line 8—8 in Figure 9;

Figure 9 is a sectional view of the embodiment of the invention shown taken as indicated by line 9—9 of Figure 8; and

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Figure 10 is a perspective view of the liner element employed with the embodiment of Figures 8 and 9.

The shaped charge unit as illustrated in the drawings is designed to be mounted within a carrier body or gun sealed against the entrance of well bore fluid under pressure by frangible ports through which the shaped charge jets may readily penetrate to perforate the casing and the formation surrounding the borehole. The details of such a gun have not been illustrated here since they form no part of the present invention. A suitable carrier is disclosed in copending application entitled "Gun Perforator," Serial No. 138,215, filed January 12, 1950, now Patent No. 2,742,857, to which attention is directed for details of construction.

The shaped charge unit of the invention has been illustrated in a preferred embodiment in Figures 1-4, inclusive. In these figures is shown a unit, generally designated as 10, formed symmetrically about its longitudinal axis in planes parallel to and normal to substantially planar top and bottom portions. The unit 10 has an outer housing 11 formed preferably of frangible ceramic material providing rigid support but reducible to very fine fragments when subjected to the shock wave produced by explosion of the shaped charge. The housing 11 is integrally formed with parallel top and bottom members 12 and 14, joined in spaced relation to each other by parallel end walls 15 and 16 and converging rear walls 17 and 19 merging centrally into a transverse rear wall 20.

The transverse rear wall 20 has formed in the outer portion thereof a vertically extending rounded groove 21 adapted to receive explosion initiating or detonator means 22. The detonator means may be any readily available commercial detonating fuse such as that known under the trademark "Primacord" to identify a fuse such as the RDX type having 98% cyclonite and 2% wax. Cyclonite is an abbreviation for cyclotrimethylene trinitramine. "Primacord" is also used to designate the PETN type, which is 100% pentaerythrite tetranitrate. A satisfactory concentration is provided by using a fuse having 50 grains of either material per foot.

The transverse rear wall 20 also has formed in the inner portion thereof a rectangular booster seat 24 to which the rounded groove is substantially tangent. A booster charge 25 is disposed in seat 24 and extends adjacent the Primacord 22 between the top 12 and the bottom 14 of the housing 11.

The booster seat 24 may be open in some cases along a very narrow slot to the detonator means receiving groove 21. In the more usual case it is desirable that the housing wall therebetween be made very thin, of the order of .01-.02 inch. to assist in retaining the booster charge in position, while yet offering a minimum of resistance to the transmission of the detonating wave from the Primacord to the booster.

Forwardly of the booster charge 25 is normally disposed a barrier 26, which may be a substantially cylindrical rod of steel or equivalent material extending between the top 12 and bottom 14. In the embodiment as shown a barrier receiving recess 27 is formed in the bottom 14, while a bore 29 extending through the top 12 permits the barrier to be inserted therethrough for assembly with the rest of the case. After the booster charge 25 has been placed in seat 24, barrier 26 is inserted and the main charge chamber 30 filled with the explosive 31. The explosive 31 surrounds the barrier 26 and extends forwardly therefrom toward the open forward end 32 of the housing 11. A liner 34, of V-shaped cross-section, is seated firmly in the explosive charge, and serves to define and limit the cavity 35 in the shaped charge, as well as to assist in retaining the compacted or cast explosive material 31 in position in the unit. The liner 34, seen most clearly in Figure 4, may be simply and economically formed by bending a thin flat rectangular strip of aluminum, copper or the

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like metal into a V-shaped portion about a rounded apex 36. The liner is then pressed into the surface of the main charge 30 by a hydraulic press or other suitable means of applying even pressure over the surface thereof. The width of the slot may be controlled by varying the angle of divergence of the liner walls.

The forward end 32 of the shaped charge unit is open, it being well known to those skilled in the art that such an open space is a requisite from the formation of a proper gaseous jet discharge. The unit is intended to be so mounted that an adequate stand-off distance is provided in the gun.

It will be observed that with this construction the apex 36 of the liner 34 is parallel to the barrier 26, the booster charge 25 and the detonator means 22. These elements are all disposed symmetrically about a plane through the central axis of the shaped charge unit so that a cutting sheet of gas will be formed in such projected plane at the open end 32 when the booster charge is initiated by a detonation wave traveling along the detonating means 22.

When the Primacord is detonated by well known initiating means, not shown in the figures, it detonates the booster charge 25, which in turn initiates the main charge 31 symmetrically about the beforementioned central plane of the case and charge. The presence of the barrier 26 tends to slow up the progress of the shock waves along the central axis of the device, and the waves passing on either side thereof will re-combine or impinge upon one another to produce a centrally directed cutting sheet of gaseous products having a velocity greater than would have been the case had the barrier not been present.

In Figure 5 is shown an embodiment, otherwise similar to that in Figures 1 to 4, except that the booster charge 40 has a restricted length of contact with the Primacord 22 and flares outwardly therefrom, when considered in section through the longitudinal axis of the Primacord, to obtain a more centralized initiation of the booster charge 40 and a more uniformly timed initiation of the main charge, here indicated as 41. In this embodiment, as in that of Figures 1 to 4, the presence of the barrier 26 is believed to assist in causing the building up, at least momentarily, of a high pressure zone therebehind by the explosively produced gases. The pressures there developed are substantially greater than if a barrier had not been present, due to the restriction of the available area through which the high velocity detonation waves may proceed and due to their impingement upon one another forward of the barrier. In addition, the buildup is made more even or uniform along the full vertical extent of the charge. This is accomplished by the use of a flared booster seat terminally shortened by an angularly extending top shoulder 42 and bottom shoulder 44. These shoulders provide angular limitations on the length of the seat, and act as barriers to shield the top and bottom of the booster and main charges from interference effects from the detonating wave in adjacent portions of the Primacord. The result is a more central initiation of the booster and main charge, so that the top and bottom portions develop their full explosion pressures more nearly simultaneously, thereby increasing the force, effectiveness and accuracy of the penetrating action.

Another variation in the construction of the embodiment of Figures 1 to 4 is illustrated in section from the side in Figure 6 and from the front in Figure 7. In Figures 6 and 7 additional means are disclosed for limiting the vertical extent of the slit produced. Here the top and bottom housing walls 12 and 14 are reinforced by heavy metal top and bottom barrier plates 51 and 52 respectively which provide additional insurance that the linear jet will not expand in a direction parallel to the length of the slit and to the axis of the Primacord

22, but will retain its sharp definition in length as well as in width.

Another embodiment is shown in Figures 8, 9 and 10 in which the advantages of central initiation utilized in the embodiment of Figure 5 are retained, together with an alternative method of securing a limitation of the vertical extent of the cutting sheet. It will be seen in Figure 9 that the top and bottom shoulders 42 and 44 respectively are used to shield the main charge and the booster charge near the top and bottom ends of the housing, as in the embodiment of Figure 5. The vertical limitation of the cutting jet sheet is obtained, however, by forming the liner, generally indicated as 45, with a flare toward the open end along two mutually perpendicular axes. Thus the charge case not only flares away from the apex 36 in a horizontal plane, as did that shown in Figures 4 to 7, inclusive, but also in a vertical plane, as may be seen in Figures 9 and 10. The liner has not only side portions 37 and 38, as does the form shown in Figures 1 to 7 inclusive, but, in addition, has a top member 46 and a bottom member 47 extending divergently toward the open end of the housing, but at a lesser angle than that of the side portions, as seen in Figures 9 and 10.

With this embodiment the charge body 41 has top portions 49 and bottom portions 50 extending toward the open end of the housing with the result that, when detonated, a portion of the explosive force is directed toward the center line of the device from the top and bottom portions, and combines with the remainder of the gaseous jet-forming explosive forces to produce a plain cutting sheet which will be of lesser vertical extent than that of the open end 32 of the housing.

In certain cases, the embodiments of Figures 6 and 7 described above may be modified by omitting the top and bottom barrier elements 51 and 52 and relying, for the formation of a cutting sheet of gases of the desired character, on the means such as those described above in connection with Figures 8-10 to produce more even detonation.

The embodiments described may also be utilized with guns or carriers of other than the sealed type by suitable adaptation. For this type of operation, usually employed in connection with so-called "open hole shooting," the shaped charge units must be individually sealed at their forward ends to prevent bore hole fluids from entering the charge cavity and so much of the space forward of the charge as is required for proper jet formation. Guns or carriers for this type of operation are well known in the art, and suitable sealing means which may be utilized in connection with this invention are disclosed in the pending application of Lorrain D. Meddick entitled "Debris-free Perforating Gun" filed Jan. 9, 1956, with Serial No. 557,953.

From the above description it will be apparent that I have provided a shaped charge device for cutting linear slits in casing and into the surrounding bore-hole formations, which slits may be accurately controlled in their width and vertical extent and may be employed to obtain a much greater area of perforation and drainage than is possible with round holes in the casing and the adjacent strata as heretofore usually employed.

It is to be understood that the foregoing is illustrative only of the best mode contemplated for accomplishing the invention, and that the invention is not to be limited thereby, but includes all modifications thereof within the scope of the invention as defined in the appended claims.

I claim:

1. A shaped charge perforator unit comprising in combination: a container of frangible material having an open end and a vertically grooved end opposite thereto adapted to receive elongated initiating means; an elongated initiating means in said groove; a booster charge disposed within said housing adjacent said initiating means; a main charge disposed within said housing; a

recess symmetrically formed within said main charge having a pair of substantially planar walls diverging outwardly toward said open end of said housing, the line of intersection of the planes of said walls being parallel to said initiating means; a metallic liner for said recess; a solid, linear barrier disposed in said explosive charge parallel to said line of intersection and located between said booster and said liner, the ends of said barrier being supported by said container; said booster charge being of lesser extent in the portion thereof adjacent and parallel to said initiating means than the vertical extent of said main charge, and expanding symmetrically away from said initiating means to intersect with said main charge; said container being arranged to form barriers between said initiating means and said expanding portion of said booster charge.

2. A shaped charge perforator unit comprising in combination: a container of frangible material having an open end and a vertically grooved end opposite thereto adapted to receive elongated initiating means; an elongated initiating means in said groove; a booster charge disposed within said housing adjacent said initiating means; a main charge disposed within said housing; a recess symmetrically formed within said main charge having a pair of substantially planar walls diverging outwardly toward said open end of said housing, the line of intersection of the planes of said walls being parallel to said initiating means; a metallic liner for said recess; a solid, linear barrier disposed in said explosive charge parallel to said line of intersection and located between said booster and said liner, the ends of said barrier being supported by said container, said booster charge extending closely adjacent said initiating means centrally of said container and expanding symmetrically away therefrom to intersect said main charge adjacent the upper and lower boundaries thereof; said container extending centrally inward about said expanding portion of said booster charge to shield it partially from said initiating means.

3. A shaped charge perforator unit comprising in combination: a container of frangible material having an open end and a vertically grooved end opposite thereto adapted to receive elongated initiating means; an elongated initiating means in said groove; a booster charge disposed within said housing adjacent said initiating means; a main charge disposed within said housing; a recess symmetrically formed within said main charge having a pair of substantially planar walls diverging outwardly toward said open end of said housing, the line of intersection of the planes of said walls being parallel to said initiating means; a metallic liner for said recess; a solid, linear barrier disposed in said explosive charge parallel to said line of intersection and located between said booster and said liner, the ends of said barrier being supported by said container, said booster charge extending closely adjacent said initiating means centrally of said container and expanding symmetrically away therefrom to intersect said main charge adjacent the upper and lower boundaries thereof; said container extending centrally inward between said expanding portion of said booster charge and said initiating means to shield the extremities of said charge partially therefrom.

4. A shaped charge perforator unit comprising in combination: a container having a pair of side walls, top and bottom walls transverse to said side walls, and front and rear ends extending in planes transversely of said walls; an explosive charge disposed in said container; a cavity formed in said charge having a pair of substantially planar walls extending transversely of the top and bottom walls of said container and diverging from each other symmetrically toward the front end of said container; metallic liner means disposed on said pair of substantially planar walls; a solid, linear barrier disposed in said explosive charge extending parallel to the line of intersection of the planes of said diverging planar

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walls, said barrier being further disposed rearwardly of the inner end of said cavity and symmetrically with respect to the plane bisecting the dihedral angle between said diverging planar walls, the bottom wall of said container providing a recess receiving the bottom end of said barrier and the top wall of said container providing a bore extending therethrough and receiving the top end of said barrier; and means for initiating detonation of said charge rearwardly of said barrier.

5. A shaped charge perforator unit comprising in combination: a container having a pair of side walls, top and bottom walls transverse to said side walls, and front and rear ends extending in planes transversely of said walls; an explosive charge disposed in said container; a cavity formed in said charge having a pair of substantially planar walls extending transversely of the top and bottom walls of said container and diverging from each other symmetrically toward the front end of said container; metallic liner means disposed on said pair of substantially planar walls; a solid, linear barrier disposed in said explosive charge extending parallel to the line of intersection of the planes of said diverging planar walls, said barrier being further disposed rearwardly of the inner end of said cavity and symmetrically with respect to the

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plane bisecting the dihedral angle between said diverging planar walls, said barrier extending from the top wall to the bottom wall of said container; means connecting the upper and lower ends of said barrier to the top and bottom walls, respectively, of said container; and means for initiating detonation of said charge rearwardly of said barrier.

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