Aug. 25, 1959 D. P. MacDOUGALL 2,900,905

PROJECTILE CAVITY CHARGES

Filed Oct. 15, 1951

FIG. 1

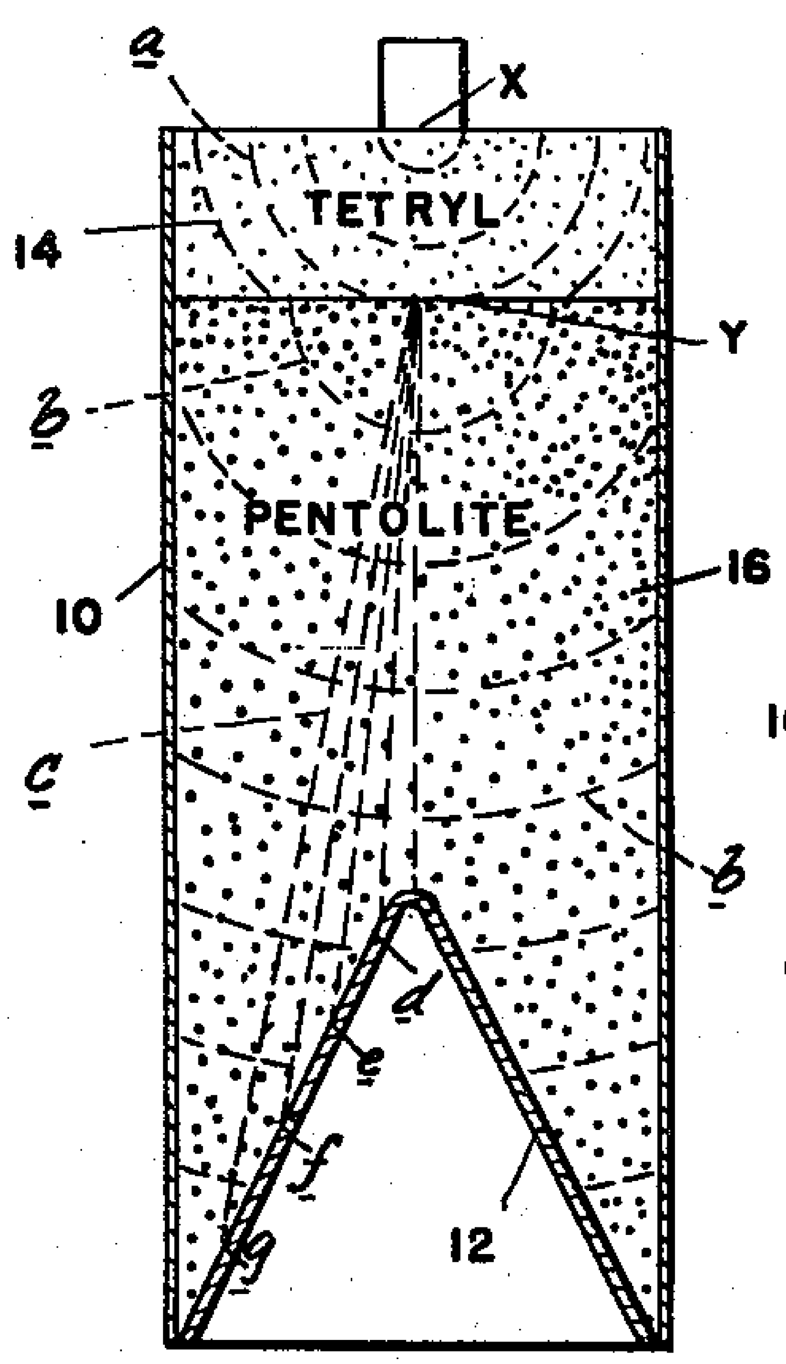


FIG. 2

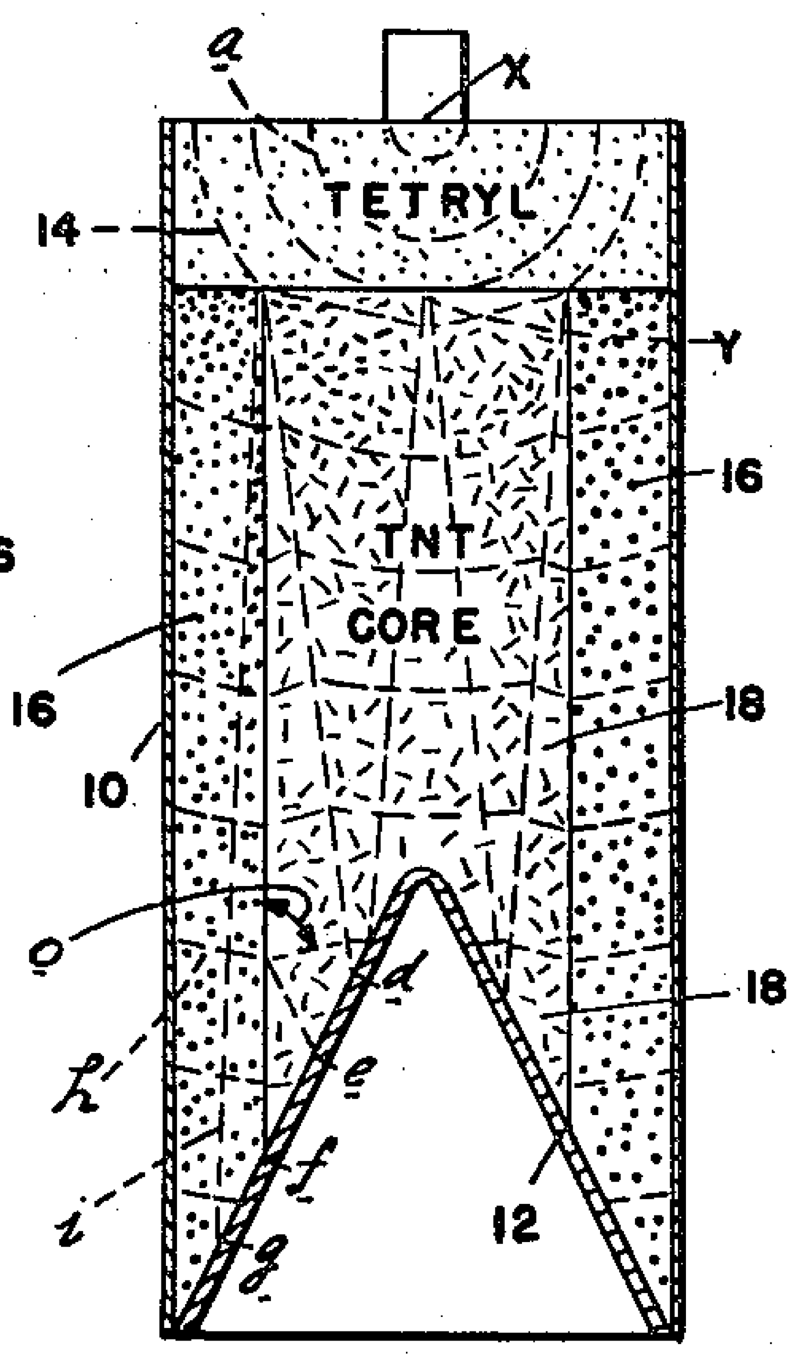


FIG. 3

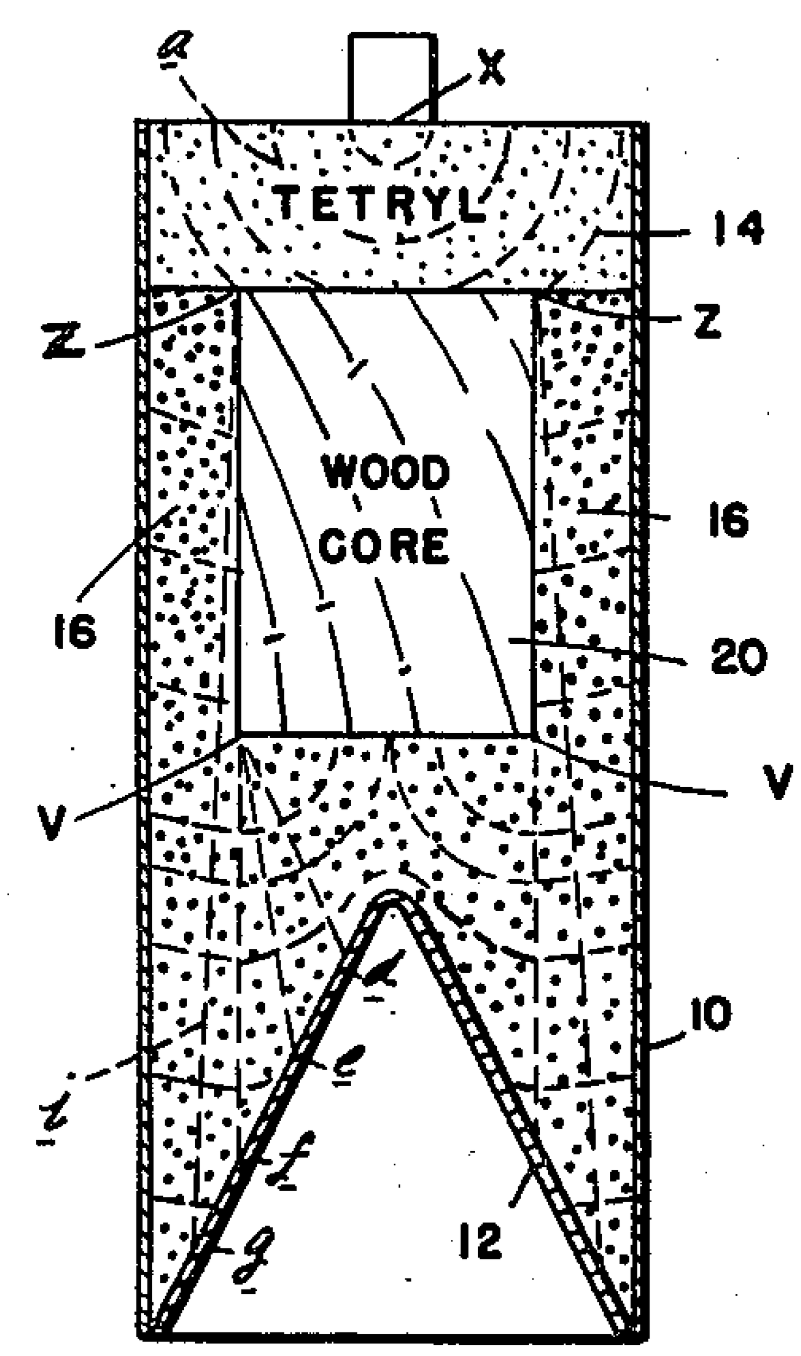


FIG. 4

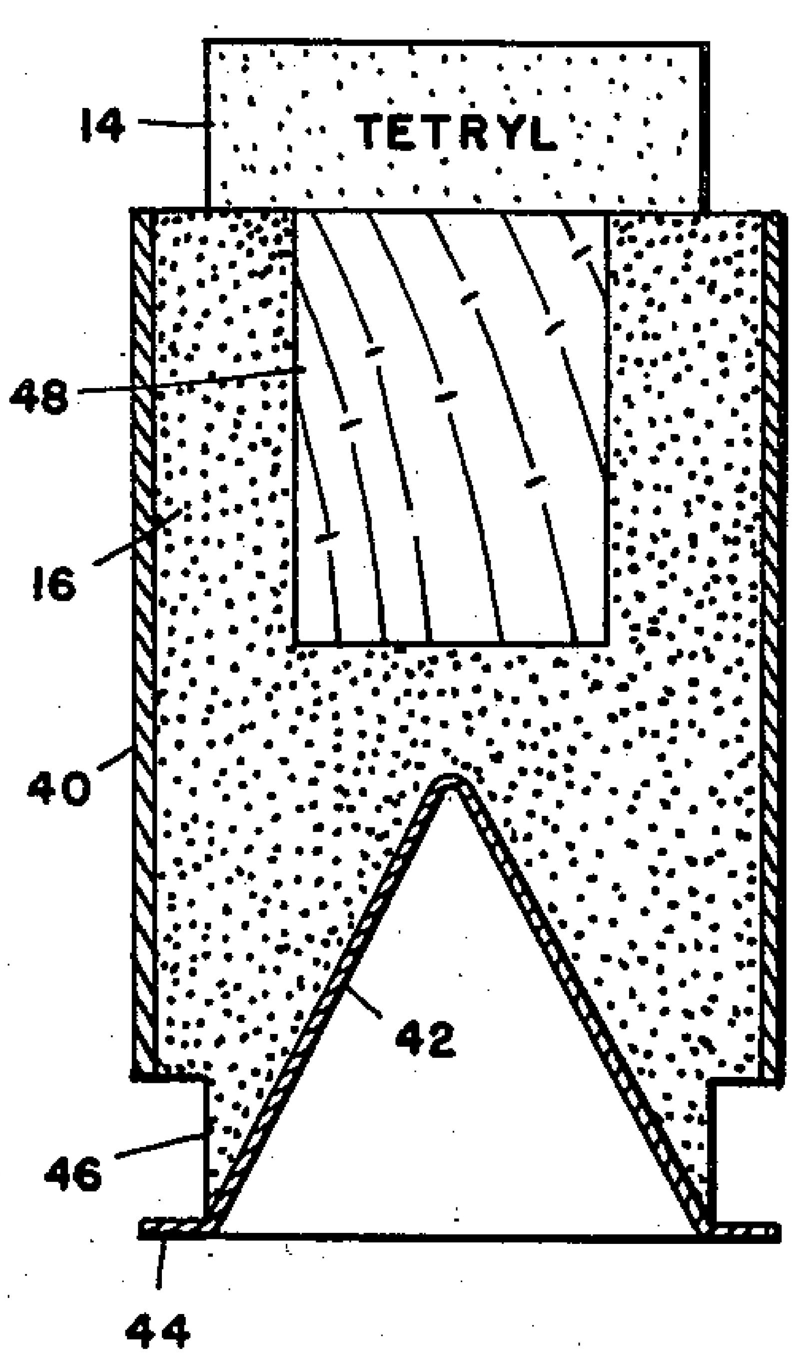


FIG. 5

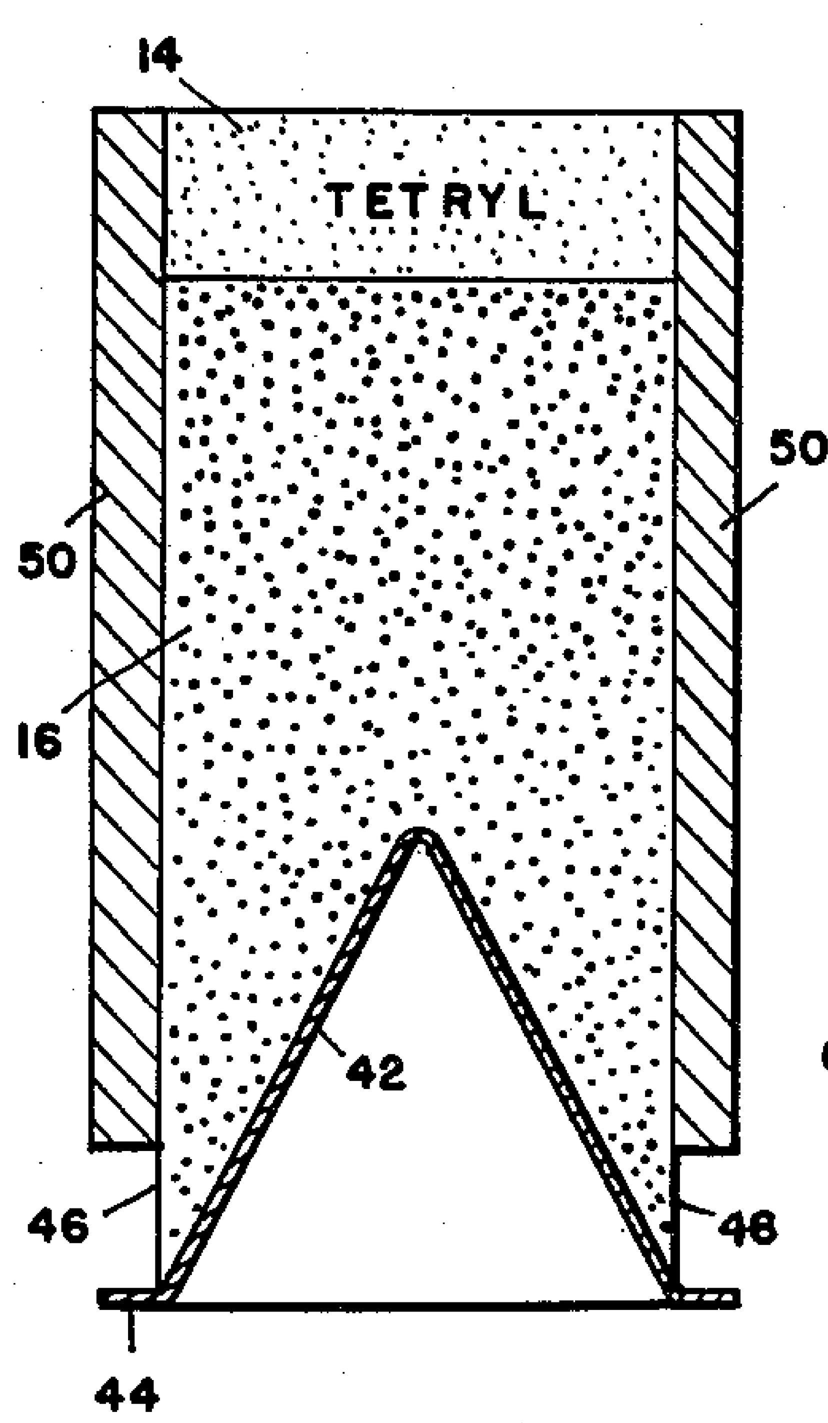
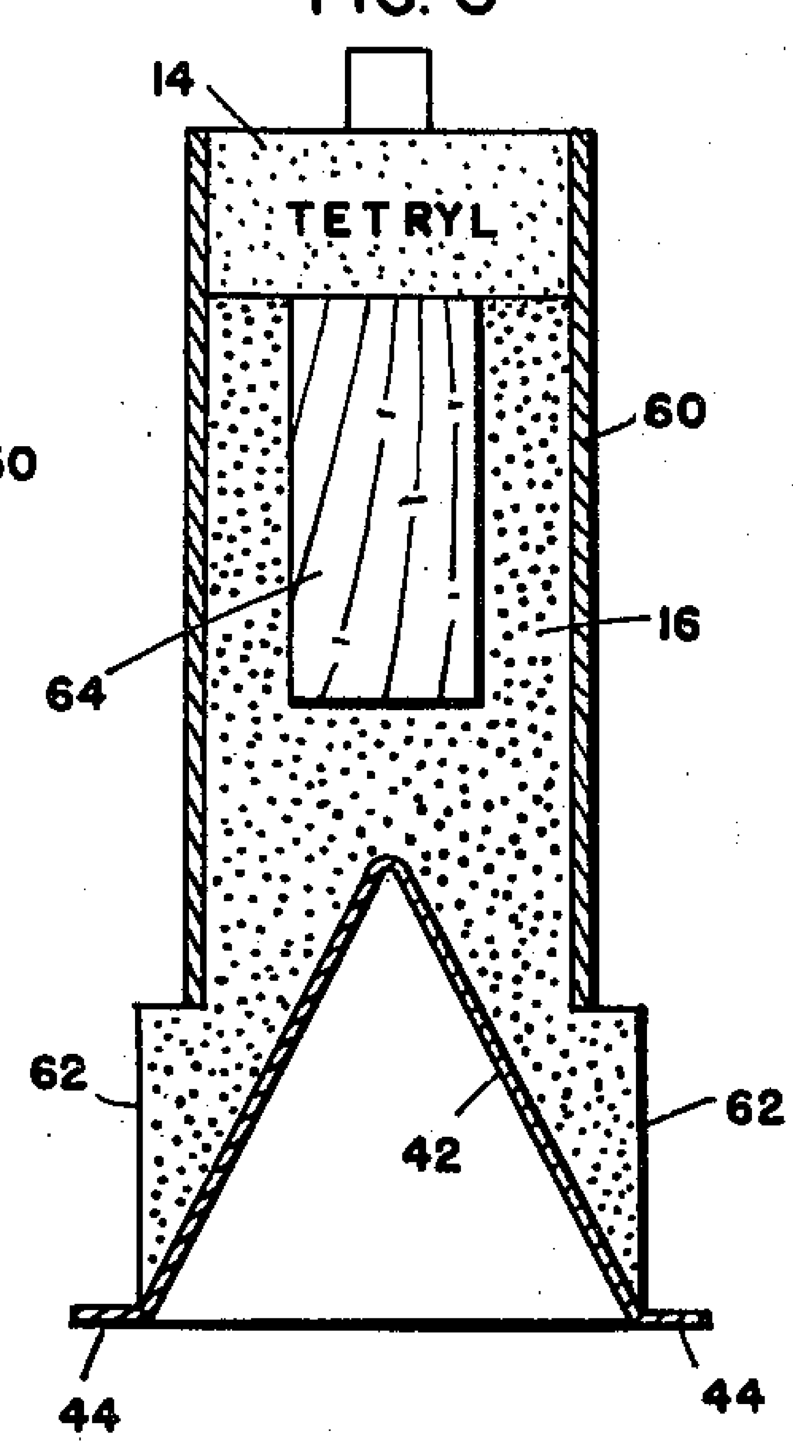


FIG. 6



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PROJECTILE CAVITY CHARGES

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3 Claims. (Cl. 102—24)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates in general to projectile cavity charges and is more particularly described as an improvement in the performance of such charges by controlling the detonation wave upon a projectile conical liner so that its incidence is more nearly normal to the surface than that obtained in a conventional cylindrical charge.

It has been determined that improvement in the performance of a projectile cone charge is obtained by the relatively simple modification of replacing the central core of the main cast pentolite filling with cast TNT or even an inert solid, such as wood or paraffin. Improvement in depth of penetration is observed without significant decrease in the hole diameter.

An important object of the invention is to improve the performance of a cavity charge in a projectile by shaping the detonation wave so that its incidence on a cavity liner surface is close to normal.

A further object of the invention is to control the shape of the detonation wave by using exposives of different detonation rates, and by inert cores terminating short of the apex of a conical liner, so that all of the cone surface is covered by explosive.

Still a further object of the invention is to partially confine the charge of a projectile, leaving the base around the lower half of the liner cone unconfined or lightly confined.

Other objects of the invention will appear in the specification and will be apparent from the accompanying drawings, in which—

Fig. 1 is a sectional view representing a coned charge for a projectile, detonated on the axis of symmetry at the top of the charge;

Fig. 2 is a similar view representing the angle of detonation upon a cone due to different explosives;

Fig. 3 is a similar view representing the detonation lines of force due to an inert core having a flat end terminating above the apex of the liner cone;

Fig. 4 is a sectional view representing a coned charge in a projectile shell with an inert core with a flat end terminating at a distance from the apex of the cone, leaving the base around the cone confined by an explosive belt larger than the cone base;

Fig. 5 is a sectional view representing a coned charge in projectile shell of steel tubing except for a short region above the cone base; and

Fig. 6 is a sectional view representing a coned charge in a projectile shell, with a normal amount of explosive around the base of the cone, but less than a normal amount in the upper part of the charge.

It is noted that both charges with TNT cores and with inert cores, such as wood, give increased penetrations for a projectile of about twenty percent over the standard charges. This indicates a method of increasing the effectiveness of shape charges by changing the form

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of the detonation wave. A further variation may be obtained by confinement of the charge, by increasing or decreasing the charge diameter relative to the cone base, and by a combination of these changes.

Referring now more particularly to the drawings, a cone charge for a projectile is represented in the drawings, particularly in Figs. 1, 2 and 3, comprising an outer shell **10** with a cone **12** extending into one end of the shell and a detonating charge **14** of tetryl or other explosive at the other end. Within the shell is an explosive **16**, such as pentolite, completely filling the shell around the cone as in Fig. 1; filling the space around an explosive core **18** of TNT or another explosive, which extends partially downward over the apex of the cone **12**; or extending around an inert symmetrical core **20** of wood, paraffin, or other material, which terminates in a flat end at a distance from the end of the cone.

Assuming that a standard coned charge, as in Fig. 1, is detonated on the axis of symmetry of the charge from a point X, the detonation waves proceed in spherical arcs *a* from the point of detonation of the tetryl toward the outer limits of the explosive charge. Assuming instantaneous detonataion of the pentolite **16**, a second origin of detonation may be created having a center at the point Y where the tetryl contacts the pentolite at the axis of symmetry, represented by the waves *b*. Lines *c* may be drawn from the point Y at right angles to the detonation waves, referred to as lines of force, which indicate that as the wave travels down the slope of the cavity liner cone **12**, each successive point nearer the base of the cone is hit by a line of force making a successively more acute angle with the cone. In the size shown in Fig. 1, for example, this angle may vary from about 18½° at the first point *d* to about 12½° at the point *g*. In this type of charge, as the overall length is changed, the angle between a line of force and a fixed point on the liner cone is correspondingly changed.

In the case of the TNT cored charge as shown by Fig. 2, the wave may be shaped from the original point Y of detonation and the fact that the faster acting pentolite is detonating down the sides of the core ahead of this wave. This latter factor causes the wave to assume an angle θ with the side of the core where the

$$\sin \theta = \frac{\text{velocity of TNT}}{\text{velocity of pentolite}}$$

which has been figured as 65°. The lines of force which are normal or perpendicular to a detonation wave *h* in the TNT are figured to meet the liner core approximately at an angle of 47½° in most of the area covered by the TNT between the points *d* and *f*, while even in the pentolite at the point *g*, the angle the lines of force make with the liner are much greater than noted in the standard charge.

In the case of the wood cored charges as shown in Fig. 3, there is an initial point X of detonation of the tetryl, the circle points Z, Z, where this detonation meets the pentolite at the top of the inert core, and the circle points V, V at the base of the core. Again the lines of force *i* normal to the wave meet the liner cone at an angle greater than in the standard charge and the penetration charge is accordingly increased. In this type of charge, the angles between the lines of force and the liner cone vary as the base of the cone is approached, as in the standard charge.

By confining the main charge, either by an explosive belt of external diameter larger than that of the cone base, or by steel tubing, except over the region immediately above the cone base, an improvement of about twenty percent in the depth of penetration has been noted. The length of this relatively unconfined region is not critical but for the sizes shown in Figs. 4 and 5, one-half an inch appears to be best.

In the form shown by Fig. 4, an outer confining tube **40** is somewhat larger at the inside than a space liner cone **42**, which has an outer flange **44** and a reduction offset **46** connects the tube to the base of the cone. In the tube is an inert block **48** spaced from the inner apex of the cone.

In Fig. 5, a heavy outer shell **50** contains the detonator **14** and the charge **16** which entirely covers the liner cone **42**, the inner surface of the shell being the same diameter as the base of the cone (inside of the flange **44**) and the relatively unconfined portion **46** of the shell being of the same diameter as the inside of the shell and the base of the cone.

In Fig. 6, a confining shell **60** is of less diameter than the base of the liner cone **42** and has an unconfining **62** offset which extends outwardly to the diameter of the base of the cone, thus providing a relatively unconfined belt closely surrounding the base portion of the cone. An inert circular core block **64** is surrounded by the explosive **16** and has a flat end which is spaced from the apex of the cone.

Ordinary confinement, either by steel tubing or by increasing the charge diameter beyond that of the cone base, has a major effect of increasing appreciably the hole diameter and volume. With heavier cones, performance is improved by shell confinement, partial confinement resulting in an even greater improvement in the depth, at the expense of some reduction in the hole diameter and volume, compared with a totally confined charge.

It seems probable that two effects of confinement are: (1) it results in increased pressure on the collapsing liner and (2) it causes collapse to progress farther down toward the cone base, so that portions nearer the skirt are thrown into the high velocity forward part of the charge. A confined charge with its lower end exposed is not feasible for practical purposes, but the results obtained with steel casings two inches in outside diameter and one and five-eighths inches internal diameter and with walls about one thirty-second of an inch over the last half-inch, around the cone base, were superior to those in which the charges are completely confined two inch outside diameter tubing and to unconfined charges. A confined charge shaped like that of Fig. 6, behaved like a normal one of the full diameter of the larger part near the base, but when it was unconfined for the full diameter of this size, the charge was ineffective for this shape.

Although the lines of force due to core modification are not shown in connection with various types of confined shells or tubes, they are operative in the same way as shown in Figs. 1, 2 and 3, the distribution for the

charges of Figs. 4 and 6 being substantially similar to Fig. 3, and for the charge of Fig. 5 being similar to Fig. 1, or to Fig. 2 if a core of different explosive composition is included. The results of the core modification and confined and partially confined charges are additive, cumulative, and apparently they mutually contribute to produce the same result.

While several forms of the invention have been shown and described in some detail, they should be regarded as illustrations or examples, and not as restrictions or limitations, as many changes in the construction, combination, and arrangement of the parts may be made without departing from the spirit and scope of the invention.

I claim:

1. A shaped explosive charge device comprising in combination a symmetrical shaped charge of explosive having a lined cavity at one end and detonating means at the other, an inert core intermediate the apex of the lined cavity and the detonating means, said charge having a reduced outer diameter over a portion of the end containing the lined cavity.

2. A shaped explosive charge device comprising in combination a symmetrical shaped charge, a lined cavity at one end and detonating means at the other, an inert core intermediate the apex of the lined cavity and the detonating means, said charge having a reduced outer diameter over a portion of the end containing the lined cavity, and an outer shell confining that portion of the explosive charge of unreduced diameter.

3. A shaped explosive charge device comprising in combination a symmetrical shaped charge, a lined cavity at one end and detonating means at the other, an inert core intermediate the apex of the lined cavity and the detonating means, said charge having a reduced outer diameter over a portion of the end containing the lined cavity, and an outer shell surrounding said explosive charge, the portion of the charge of reduced diameter being unconfined relative to that portion of the charge of unreduced diameter.

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