April 23, 1957 D. B. McCLOUD ET AL 2,789,504

HIGH EXPLOSIVES

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FIG. 1.

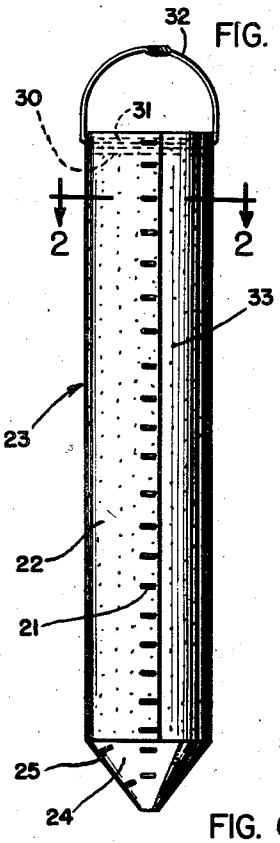


FIG. 2.

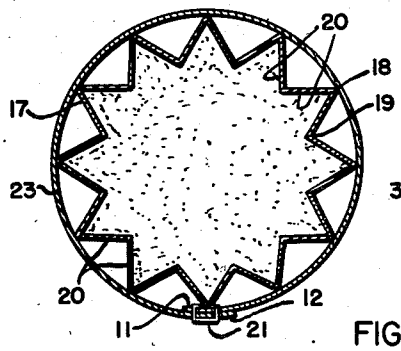


FIG. 3.

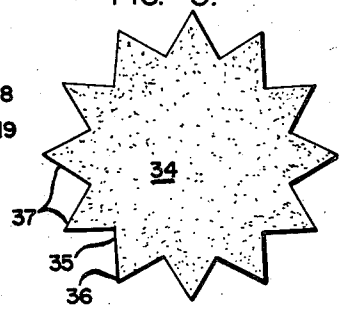


FIG. 5.



FIG. 4

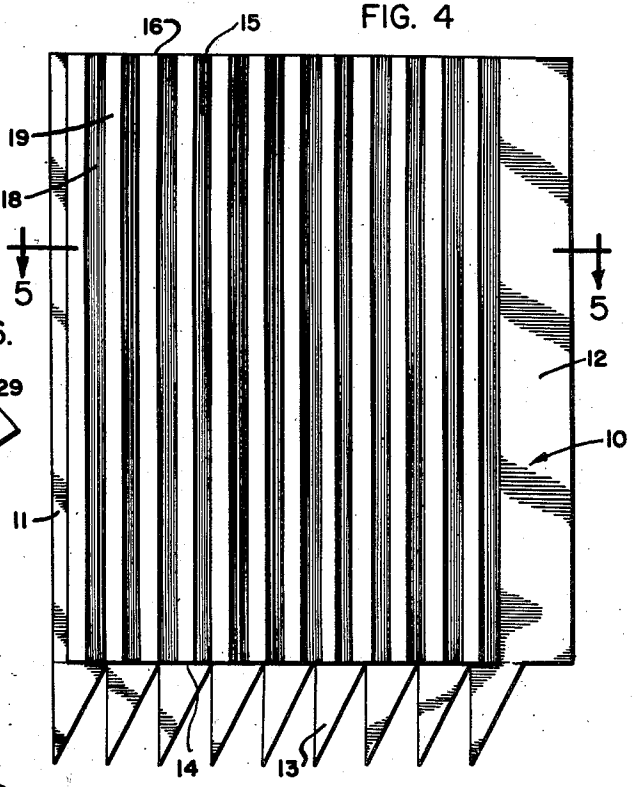


FIG. 6.

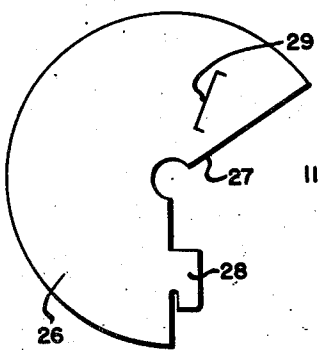
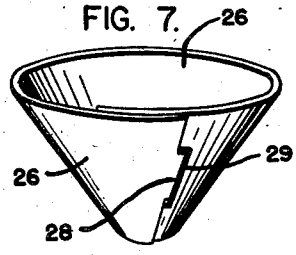


FIG. 7.



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April 23, 1957 D. B. McCLOUD ET AL 2,789,504

HIGH EXPLOSIVES

Filed Feb. 25, 1950 2 Sheets-Sheet 2

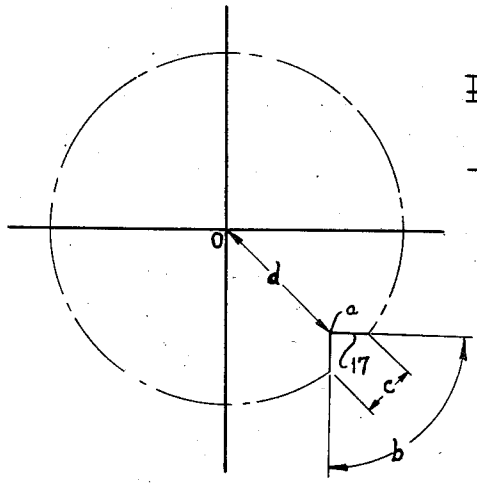


FIG. 8

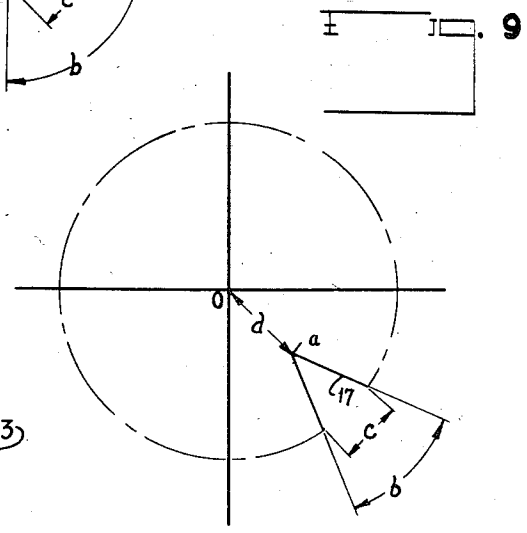


FIG. 9

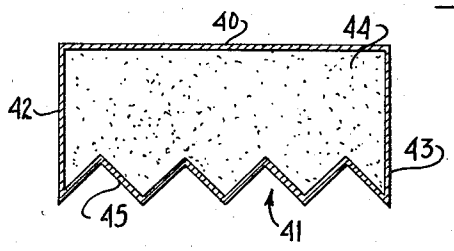


FIG. 10

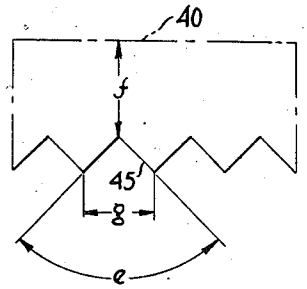


FIG. 11

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United States Patent Office 2,789,504 Patented Apr. 23, 1957

2,789,504

HIGH EXPLOSIVES

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Application February 25, 1950, Serial No. 146,212

6 Claims. (Cl. 102—24)

This invention relates to high explosives, more particularly those employing liquid oxygen impregnated carbonaceous material, encased in cartridges, and which are adapted for use in blasting operations where very hard materials such as rock, ore, and the like, are encountered. This application is a continuation in part of the copending application of Don B. McCloud and Mary McCloud, Serial Number 776,068, filed September 25, 1947, now abandoned, and entitled "High Explosives."

Liquid oxygen explosive consists of porous, combustible materials saturated with liquid oxygen, and for brevity known as "LOX." In the past, this explosive has been prepared by packing a porous type of carbon such as lampblack in a cloth bag with an expansible liner or stiffener inside the bag, then saturating the bag and contents by immersion in liquid oxygen. The porous carbon within the bag absorbs or adsorbs approximately three and one-half times its weight of liquid oxygen and such carbon-oxygen mixture constitutes the high explosive known as LOX. The bag of carbon is commonly called a cartridge and after saturation is called a saturated cartridge.

Heretofore, the outside diameter, and the elongated shape of an LOX cartridge, has been governed by the size and shape of a cloth bag used as an outer covering. An expansible sheath, or liner, when used inside of the cloth bag, has given a certain amount of longitudinal rigidity to a cartridge, but in every case the outer cloth covering or bag has been the means of retaining the porous, combustible ingredients within the cartridge, and such cartridge bag has been free to expand radially to its full elastic limit. It is necessary to pack or compress the porous, combustible ingredients to certain densities within the retaining medium of a cartridge so as to accomplish the desired carbon-oxygen ratio when a cartridge is saturated, and inasmuch as the cloth bag constitutes the retaining medium in all previously made cartridges, the size and the shape of the cloth bag determines the size and the shape of the cartridge. The most widely used filter for cartridges is a type of pure lampblack that is exceedingly soft and fluffy in its natural state. When such a filter is compressed in a cartridge, considerable tension is exerted on the cartridge bag which tends to bulge and stretch to its expansible limits. As a result of this, it has been impossible to manufacture cartridges of uniform, precise outside dimensions on a commercial basis. A type of cotton fabric known as osnaburg is universally used for cartridge bags, and these bags are made by folding a piece of cloth cut to suitable size and then sewing together one side and one end of the folded material. A slight deviation in the bag seam, a change in the fibres or weave of the cloth that might influence its stretching characteristics, or a change in the pressure required to compress the carbon content of a cartridge to its required density, cause variations in the diameter, size and shape of cartridges. The prohibitive cost of heavy, non-stretchable fabric cut and sewed with great accuracy, prohibits the commercial use of bags of this latter type.

It is also common practice in the industry to store cartridges in bins with one row of cartridges stacked upon another to a considerable height. Cartridges in the bottom layers of such a pile tend to lose their cylindrical shape due to the pressure on them when a flexible cloth bag is the shaping element.

LOX cartridges of precise and uniform outside dimensions are of great importance in modern blasting operations because of the comparatively recent development of so-called precision drilling of vertical blast holes into which the explosive is charged. Such holes formerly were drilled by means of a churn type drill that produced a hole through raising and dropping a heavy cylindrical shaped tool terminating in a rock cutting bit. Blast holes drilled in this manner often were irregular and hole diameters were not uniform in various types of earth and rock formations, and there was no urgent necessity for precise shape and dimensions of the cartridges. Comparatively recently, however, rotary drills, similar to those used for oil well drilling, have been adapted for blast hole drilling. These rotary drills produce smooth, straight blast holes of uniform diameter.

It is advantageous from a blasting standpoint to allow as little clearance as possible between explosive cartridges and the wall of the blast hole in which the cartridges are charged. Blast holes of precise, uniform diameter make it necessary to have similar precision and uniformity in cartridge diameter in order to get maximum results from blasting, and one phase of our invention is directed to this purpose, as will be more fully pointed out hereinafter.

Moreover, for the past several years, engineers and scientists, have been investigating the peculiar phenomenon exhibited by certain high explosives known as the "Munro effect." It has been demonstrated that the shape of an explosive charge sometimes controls to a large extent the direction in which a major amount of the forces are exerted when detonation occurs. It has also been demonstrated that by shaping the end of an explosive charge in the form of a hollowed-out cone, it is possible to have much of the explosive force directed away from such end, in a so-to-speak jet of explosive force. This principle was widely used during the recent war in the development of explosives known as "shaped charges." These shaped charges were used to drill holes in enemy pill boxes. The famed "bazooka" shell was a missile holding a shaped charge that would drill a hole through the steel shell of an armored vehicle. These are known examples of the peculiar jet-like forces that emanate from a properly shaped, hollowed-out surface of a high explosive. In usual mining or quarrying blast, holes are drilled into the rock at suitable intervals and to suitable depth after which the holes are charged with explosive. Each loaded or charged hole is actually a column imbedded in the rock. Ordinarily, upon detonation, the explosive charge in each blast hole, exerts its principal forces laterally in all directions. By utilizing this so-called "Munro effect" in a manner more fully set forth hereinafter, instead of the even dispersion of the explosive energy as now produced, the explosive force of a blasting cartridge, individually, or in a column of cartridges, is concentrated and focused in radial sheet-like zones, which will shatter or fragment the rock or the surrounding material of a blast hole on a much wider radius than was thought possible.

It is a general object of our invention, therefore, to provide a cartridge, especially one containing liquid oxygen-lampblack, which takes and retains a precisely accurate configuration and dimension suitable for ready

snug disposition in accurately drilled blast holes, and wherein the so-called "Munro effect," is utilized in connection with said cartridges in a manner highly efficacious in blasting operations.

A further object of the invention is to provide a liquid oxygen-lampblack cartridge, which entirely eliminates expensive and unsatisfactory cloth bags usually employed and as containers, and in which a casing of relatively cheap material, able to withstand the low temperature encountered, is formed to provide and retain precise and substantially fixed dimensions, both during and after loading operations so that the same may accurately fit the blast holes in the manner desired.

A still further object of the invention is to provide a liquid oxygen cartridge or container which comprises an accurately cut blank of relatively stiff non-elastic fibrous material, shaped about a mandrel to a true cylinder of the desired diameter, and the meeting edges fixed to preserve the exterior dimensions, the blank also being provided with shaped tongue accommodated in a conical cap secured to the tongues, and having an easily applied end closure applicable after filling, and in which the securing means of the closure provide a handle extension.

Another object of the invention is to provide a high explosive charge, which preferably takes a cylindrical formation, whether it be of the liquid-oxygen lampblack type, or of a shaped or moulded type containing other explosive ingredients, which has impressed or formed in its exterior surface a plurality of spaced grooves or slots, formed to produce the "Munro effect," along each groove or slot upon detonation of the cartridge.

Still another object of the invention is to provide in the liquid oxygen-lampblack type of the explosive, and other types as well, the "Munro effect" grooves, which are impressed and retained in the explosive material through the formation of the cartridge itself, and wherein the cartridge is of the type which takes and retains the configuration and dimensions necessary for ready insertion into accurately drilled blast holes.

Still another object of the invention is the provision of cartridges of the type referred to, which may be dropped one after the other into a blast hole and wherein the "Munro effect" grooves assume a haphazard alignment longitudinally, and deliver the "Munro effect" substantially to any portion of the wall of the blast holes surrounding the superposed cartridges.

In order to obtain the "Munro effect" the grooves must have certain characteristics. Each of these grooves is ordinarily defined by a pair of flat side walls which meet at an apex and the angle at this apex should be no greater than ninety degrees and no less than forty-five degrees. Thus, the permissible range of the angle at the apex is from forty-five to ninety degrees.

Another feature which is of critical importance is the ratio of the distance from the axis or center of the charge to the apex of any groove as compared to the distance across the mouth or open side of the groove. The distance from the center to the apex of the groove must be at least one and one-half times the distance across the mouth of the groove and no greater than three times the distance across the mouth of the groove.

An important object of the present invention is to provide a cartridge of the general character above indicated which is of generally cylindrical formation having longitudinal grooves in the cylinder surface and which grooves fulfill the specifications above outlined.

In order for the cartridge to have the "Munro effect," it is also essential that the explosive be of a closely compacted nature. A liquid-oxygen explosive is entirely satisfactory and any other explosive which might be substituted therefor must be of a closely compacted nature such as that provided by the explosives which are melted and formed in solid shape.

Certain types of commercial blasting portions require

that the explosive force be downwardly directed over a wide area. In view of this condition a further object is to provide an explosive cartridge of the general character above outlined which takes the form of a rectangular block having one face formed with grooves having the characteristics above outlined and which grooves will impart to the cartridge the shaped charge effect. In use such a cartridge is placed with the grooves faced downwardly in engagement with the surface which is to be shattered. These grooves will result in a shaped charge effect giving high penetration and good shattering effects.

Other and further objects of the invention will appear from the specification and claims hereinafter following, and from the accompanying drawings forming a part hereof, and in which:

Figure 1 is a side elevational view of the completed high explosive cartridge forming the subject matter of the invention.

Figure 2 is an enlarged transverse sectional view, corresponding substantially to the line 2—2 of Figure 1.

Figure 3 is a transverse sectional view of the explosive charge, similar to Figure 2, but shown with the cartridge or casing omitted.

Figure 4 is a plan view of the blank from which the body portion of the cartridge is constructed.

Figure 5 is a sectional view through the blank shown in Figure 4, and corresponding substantially to the line 5—5 of Figure 4.

Figure 6 is a plan view of a blank from which the nose portion of the cartridge is constructed.

Figure 7 is a perspective view of the blank shown in Figure 6 in its assembled condition.

Figure 8 is a diagrammatic view illustrating one limit of the permissible range as to the angle at the apex of the grooves and the ratio between the distance from the center to the apex of a groove to the distance across the mouth of a groove.

Figure 9 is another diagrammatic view bringing out the other limit as to the angle of the apex of the grooves and the ratio above identified.

Figure 10 is a cross section through a modified form of cartridge; and

Figure 11 is a diagrammatic view of the charge shown in Figure 10.

As shown in the drawings, the embodiment of the invention comprises a blank **10** of predetermined length and breadth, having side marginal edges **11** and **12**. At one end the blank is provided with a plurality of triangular tongues **13**, and the blank **10** is slightly scored along the base portions of the tongues **13**, as at **14**, to enable the tongues **13** to be readily bent inwardly toward each other for a purpose which will presently appear. The opposite end of the blank **10** is cut off square with the sides **11** and **12**, as indicated at **15**.

Fixed to one face of the blank **10**, as by suitable adhesive, is a corrugated sheet or liner **16**, the corrugations **17** of which are disposed longitudinally of the sheet and of the blank **10**. The corrugations **17** preferably extend the full length of the blank **10**, and at one set of ends terminate at the line of scoring **14**, the opposite ends of the corrugations **17** terminating flush with the opposite end **15** of the blank **10**. The corrugated sheet **16** also terminates short of the outer edge of the marginal portion **11** of the blank **10**, and a greater distance from the outer edge of the marginal portion **12** of the blank **10**. In cross section the corrugations **17** are triangular in shape, the crests **18** thereof being uniformly spaced apart, and defined between the crests **18**, are valleys or grooves **19**, the walls **20** of which diverge outwardly toward the crests **18**.

The blank **10** and the attached corrugated sheet or lining **16**, may be made of heavy kraft paper, chipboard, strawboard, plastic, or any other sheet material having the necessary strength and inelasticity.

As before pointed out, the blank **10** and the corrugated sheet **16** are of pre-dependent dimensions, dependent

upon the diameter and length of the cartridge to be constructed. The blank **10**, with its attached corrugated sheet or liner **16**, is adapted to be disposed about a cylindrical form or mandrel (not shown) of exact pre-determined dimensions, so that the blank **10** may be wrapped about the form or mandrel, with the liner **16** inside, until the opposite side edges of the sheet **16** meet and abut, while the marginal portions **11** and **12** of the sheet **10** will be overlapped. The margins **11** and **12** are then secured by suitable metallic clips or fasteners **21**, thereby fixing the outside diameter of the body portion **22** of the cartridge **23**, and disposing the corrugations **17** side by side continuously around the inside diameter of the cartridge **23**. Upon removal of the formed or shaped cartridge cylinder from the mandrel, it will present a continuous inelastic wall held against expansion by the metallic fasteners **21**.

In this condition the tongues **13** may be bent inwardly along the scoring **14**, to define a conical nose portion adapted to be accommodated within a cone-shaped nose piece **24**, secured to the tongues **13** by fasteners **25**. The nose piece **24** is preferably made up from a blank **26**, of suitable inelastic material similar to that constituting the body portion **22** of the cartridge **23**. As best shown in Figures 6 and 7 the blank **26** is preferably in the form of a cutout disk, cut out, as at **27**, to define a tongue **28**, and a slit **29**, so that when the blank **26** is rolled up, the tongue **28** may be inserted into the slit **29** and locked in the slit to maintain the blank **26** in hollow conical shape, adapted to overlie the tongues **13**, and to be secured to the tongues **13** by the fasteners **25**.

The cartridge **23** is now ready to be filled with carbonaceous material, in this embodiment, a particular grade of lampblack such as that heretofore referred to. The lampblack is introduced into the open rear end of the cartridge **23**, and being of a loose powdery character, flows into the cartridge **23** and in and about the corrugations **17**, and afterward, being tamped or pressed within the cartridge, the shape of contour of the corrugations **17** are impressed in the exterior surface of the charge in the form of longitudinally extending slots or grooves of triangular formation. When completely filled and packed, a closure **30**, in the form of a disk, may be inserted within the rear end of the cartridge **23**, and a strand of wire **31** extended through the wall of the cartridge in position to overlie the closure **23** and hold it in place. The ends of the wire **31** may be extended, and interwound, to form a handle **32** by which the cartridge **23** may be readily carried.

The cartridge **23**, when thus assembled and fully packed, is immersed in liquid oxygen for a pre-determined period, and to facilitate or hasten the impregnation of the carbonaceous material within the cartridge by the liquid oxygen, the body portion of the cartridge is provided with a plurality of pin holes **33** of extremely small size, of the order of the interstices between the fibres of a woven fabric.

The charge of explosive, proper, shown in Figure 3 apart from the cartridge itself, has an elongated body portion **34**, generally cylindrical in shape, and its exterior surface is characterized by a plurality of longitudinally extending grooves or slots **35**, spaced apart by the intervening defining ridges or crests **36**, each groove or slot **35** having walls **37—37** which extend from a point below the exterior surface of the charge, in divergent relation toward the exterior surface of the charge, thus providing a plurality of extended cavities or depressions, which upon detonation of the charge, exert the so-called "Munro effect" in a plurality of longitudinally extending radially directed zones of concentrated or intensified explosive effect. In this connection, it will be clear that though the charge proper, described in connection with Figure 3, requires the cartridge **23** to retain the same in unitary formation, nevertheless the invention contemplates the

formation of a charge from other explosive ingredients, which may be molded or otherwise formed to provide a unitary charge, characterized by the slots or grooves already referred to, and which produce the so-called "Munro effect" upon detonation of the charge.

Referring now more particularly to Figure 8, one of the corrugations **17** is therein illustrated as having an apex at *a* with the angle between the sides of the corrugations **17** represented at *b*. In Figure 8 this angle *b* is ninety degrees which is the maximum permissible size of the angle. The distance across the mouth of the corrugation is represented at *c* and the distance from the apex *a* to the center or axis of the cartridge which is depicted at *o* is represented by *d*. In Figure 8 *d* is three times as great as *c* which is one limit for this ratio.

In Figure 9 the reference characters *a*, *b*, *c*, and *d* depict the same elements that are illustrated in Figure 8. However, in Figure 9 the angle *b* is forty-five degrees which is the smallest permissible angle. Moreover, *d* is one and one-half times *c*.

Briefly summing up at this point, it is noted that the angle *b* has a permissible range of from forty-five to ninety degrees. Moreover, *d* must be from one and one-half to three times as great as *c*.

Referring to Figures 10 and 11, a modified form of the invention is therein illustrated. The charge is shown as being of generally rectangular formation including an upper face **40**, a lower corrugated face **41**, and side faces **42** and **43**. These faces are preferably defined by a cardboard casing or one of comparable material which encloses therewithin the explosive material represented at **44**. This material is preferably the carbon which is saturated with liquid oxygen. The corrugated face **41** includes a plurality of corrugations **45** which are in all respects similar to the corrugations **17** in the form of Figure 2.

As shown in Figure 11, the angle at the apex of one of the corrugations **45** is represented at *e*. The distance across the mouth of one of the corrugations is indicated at *g* and the distance from the apex to the face **40** is indicated at *f*. In accordance with the principle above explained, the angle *e* has a permissible range of forty-five to ninety degrees and the distance *f* must be from one and one-half to three times the distance *g*.

The explosive charge shown in Figure 10 is intended to be used by placing the corrugated face **41** downwardly and in engagement with a surface to be shattered. Upon detonation the corrugations **45** give the shaped charge effect which results in greatly improved penetrating effects.

Through the arrangement described, the high explosive cartridge is provided having a constant pre-determined diameter before and after filling and packing and after saturation with liquid oxygen, rendering the same suitable for insertion into accurately drilled blast holes, and by reason of the formation of the charge itself, upon detonation, the charge of explosive will exert the so-called "Munro effect" radially in a plurality of extended zones. Additionally, when the cartridges are packed haphazardly one on top of another in a blast hole, the column of explosive will exert its effect upon the wall of the blast hole radially in all directions.

Although the preceding description of the invention has been directed to explosives and explosive cartridges of cylindrical formation, and consequently of the type most used in commercial blasting operations, the invention obviously is not limited to cylindrically shaped explosive charges or explosive cartridges. Sometimes explosive charges are used to break boulders by a method known in the mining industry as "mud capping," "adobe blasting" or "bulldozing," which consists in placing an explosive charge on the surface of a boulder, covering the charge with mud or dirt, and then detonating the charge. The force of the explosion that strikes the surface of the boulder often is sufficient to break the boulder into pieces

of a size which may readily be handled. For this type of blasting an explosive charge which will present a flat surface next to the boulder would be more effective than a cylindrically shaped charge, because the explosive force emanates from the surface of the charge.

Thus in one adaptation of the invention the explosive charge would be of elongated box-like form, rectangular instead of circular in cross section, and encased in a box-shaped ribbed cartridge, similar to the cartridge **23**, with the projections or ribs inwardly disposed. In packing such a cartridge, it may be placed in a form to prevent distortion when carbonaceous material is compressed within it to the proper density, and after removal saturated with liquid oxygen. The explosive charge within the container will thus comprise a rectangular block having V-shaped grooves like the groove **35**, along each flat surface, other than the ends, which will give directional force to the energy released by the explosion in a manner already referred to. In addition to cylindrical and box-like shapes mentioned, other shapes might be used, but in each case the explosive will include a plurality of V-shaped slots or grooves of the character already described in detail.

While we have illustrated and described the preferred form of construction for carrying our invention into effect, this is capable of variation and modification without departing from the spirit of the invention. We, therefore, do not wish to be limited to the precise details of construction set forth, but desire to avail ourselves of such variations and modifications as come within the scope of the appended claims.

What is claimed is:

1. An explosive charge of generally cylindrical formation having longitudinally extending closely adjacent corrugations formed in its periphery, said corrugations being defined by grooves having side walls which meet at apices and open mouths with the side wall of one groove meeting the side wall of the next adjacent groove, the angle between the side walls at each apex ranging from forty-five to ninety degrees and the distance from the center of said charge to each apex being from one and one-half to three times the distance across the mouth of one of the grooves, said explosive charge being of a closely compacted homogeneous explosive material having high detonating properties.

2. An explosive charge of generally cylindrical formation having a plurality of longitudinally extending closely adjacent corrugations defined by a plurality of grooves with each groove being of substantially the same size and shape as any other groove, each of said grooves having a pair of side walls which meet at an apex and an open mouth with the side walls of every groove meeting the side walls of the next adjacent grooves, the angle between the side walls at each apex ranging from forty-five to ninety degrees and the distance from the center of said charge to each apex being from one and one-half to three times the distance across the mouth of one of the grooves, said explosive charge being of a closely compacted homogeneous liquid oxygen explosive material having high detonating properties.

3. A liquid oxygen explosive charge of generally cylindrical formation having longitudinally extending closely adjacent corrugations formed in its periphery, said corrugations being defined by grooves having side walls which meet at apices and open mouths with the side walls of every groove meeting the side walls of the next adjacent grooves, the angle between the side walls at each apex ranging from forty-five to ninety degrees and the distance from the center of said charge to each apex being from one and one-half to three times the distance across the mouth of one of the grooves, and a cylindrical casing enclosing said charge with said corrugations in engagement with the inner face of said casing.

4. A detonating explosive charge of generally cylindrical formation having a plurality of longitudinally extending closely adjacent corrugations defined by a plurality of grooves with each groove being of substantially the same size and shape as any other groove, each of said grooves having a pair of side walls which meet at an apex and an open mouth with the side walls of every groove meeting the side walls of the next adjacent grooves, the angle between the side walls at each apex ranging from forty-five to ninety degrees and the distance from the center of said charge to each apex being from one and one-half to three times the distance across the mouth of one of the grooves, said explosive charge comprising carbon saturated with liquid oxygen to provide a closely compacted mass.

5. In combination, an outer cylindrical casing, an inner casing having corrugations engaging the inner face of said outer casing, said corrugations being defined by longitudinally extending grooves with all of the grooves of substantially the same size and shape, each of said grooves having side walls which meet at an apex and an open mouth with the side walls of every groove meeting the side walls of the next adjacent groove, the angle between the side walls at said apex ranging from forty-five to ninety degrees and the distance from said apex to the center of said inner casing being from one and one-half to three times the distance across the mouth of one of the grooves, and a closely compacted homogeneous explosive material having high detonating properties completely filling said inner casing.

6. In combination, an outer cylindrical casing, an inner casing having corrugations engaging the inner face of said outer casing, said corrugations being defined by longitudinally extending grooves with all of the grooves of substantially the same size and shape, each of said grooves having side walls which meet at an apex and an open mouth with the side walls of every groove meeting the side walls of the next adjacent groove, the angle between the side walls at said apex ranging from forty-five to ninety degrees and the distance from said apex to the center of said inner casing being from one and one-half to three times the distance across the mouth of one of the grooves, and carbon saturated with liquid oxygen completely filling said inner casing.

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