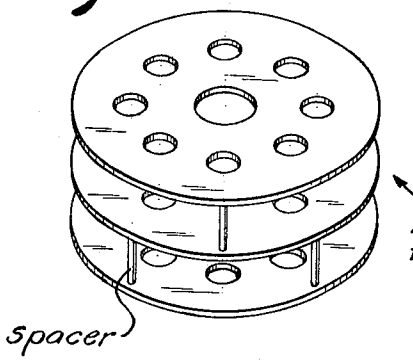
Jan. 28, 1964 C. E. GREBE ETAL 3,119,332

EXPLOSIVE COMPOSITIONS HAVING UPGRADED POWER FACTORS

Filed Sept. 6, 1960

Fig. 1



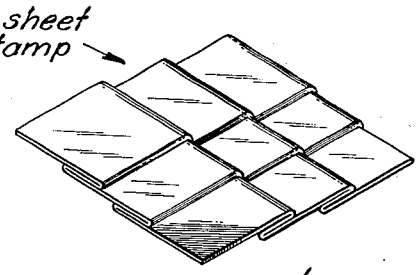


Fig. 2

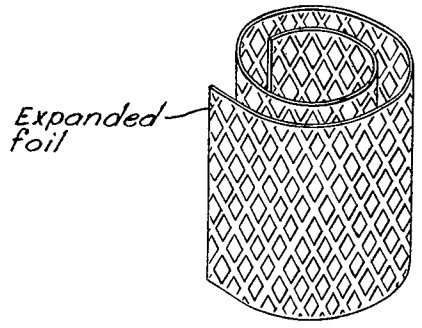


Fig. 3

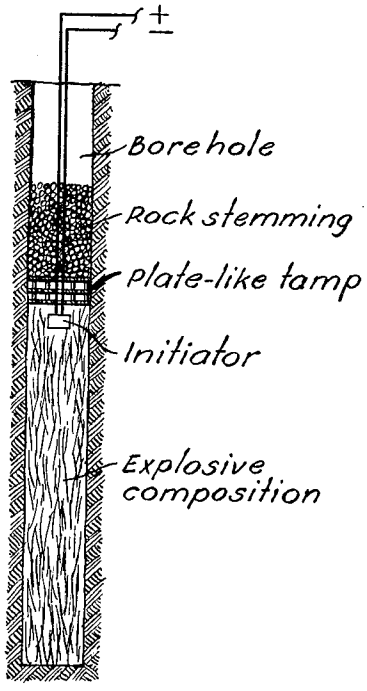


Fig. 5

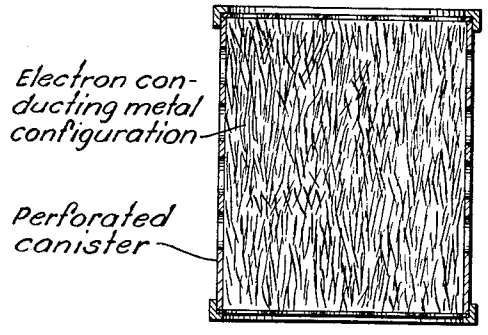


Fig. 4

INVENTORS.
Carl E. Grebe &
BY John C. Cline, deceased
by Bessie H. Cline, Administratrix
C Kenneth Bjork
AGENT

United States Patent Office 3,119,332 Patented Jan. 28, 1964

3,119,332

EXPLOSIVE COMPOSITIONS HAVING UPGRADED POWER FACTORS

Carl E. Grebe, Midland, and John C. Cline, deceased, late of Midland, by Bessie H. Cline, administratrix, Midland, Mich., assignors to The Dow Chemical Company, Midland, Mich., a corporation of Delaware

Filed Sept. 6, 1960, Ser. No. 54,321
7 Claims. (Cl. 102—23)

The present invention relates to improved explosive charges, to a process for the production of the novel charges and to a new method of blasting.

This application is a continuation-in-part of our co-pending application Serial No. 815,571 filed May 25, 1959, now abandoned.

Many attempts have been made to improve the blasting effect and power factor of explosive charges used in mining and similar operations. The various proposals included such measures as enclosing the explosive charge in cartridges or heavy cases of various kinds made from metals, including aluminum and aluminum alloys. Other attempts of improving the blasting techniques have been directed toward means and measures for directionalizing the blasting effect. Generally, this work was guided by the principle of mechanically or physically confining or directing the force developed by the detonation with the hope of concentrating the effect so that the maximum amount of work could be realized from the explosive at the location and in the direction which is most desired for the specific application.

In spite of all these efforts, present day explosive charges, as they are used in the mining industry and similar operations, are still amenable to improvement. This applies particularly to the possibility of upgrading the power factor or the ratio of inherent, usable energy converted into useful work. As is well known, generally the initial thermal heats of reaction are not effectively utilized with conventional explosive systems. The present invention makes an important contribution toward this end by devising novel charges and methods which permit an unexpected high degree of upgrading the power factor of the explosive.

It is a principal object of the present invention to provide explosive compositions having upgraded power factors by confining or impeding momentarily the outward flow of energy in the initial detonation wave front, not by structural confinement but by means hereinafter defined.

It is a further object of the present invention to provide a means whereby the energy of explosion is thus retained within the explosion reaction zone for sufficient time to permit its utilization by the explosive charge and thus its conversion into work.

These and other objects and advantages of the present invention will be apparent to one skilled in the art from the detailed description presented hereinafter.

In the drawings:

FIGURE 1 is a perspective view of a plurality of interconnected spaced apart perforated tamp elements for positioning above a load in a bore hole and indicate the plurality of spaced connectors therebetween.

FIGURE 2 is a partial perspective view of a modified sheet metal tamp prepared by the folding of foil, for example, as shown wherein one set of folds is parallel and spaced apart and a second series of plural parallel folds is transverse to the first folds, thus providing variant metal thicknesses throughout the tamp surface.

FIGURE 3 is a perspective view of an expanded metal foil spirally wound for use in an explosive composition.

FIGURE 4 is a full cross section elevation view of a perforated electron-conducting canister filled with an

electron-conducting metal configuration so spaced as to provide a cavernous structure throughout the canister.

FIGURE 5 is a schematic cross section elevational view of a loaded bore hole illustrating the positioning of an explosive composition having a core of an electron-conducting cavernous metal configuration, a shaped charge initiator, plate like tamp members and a rock stemming on top of the tamp.

The novel and greatly improved explosive charges of the present invention are characterized in that they contain a cavernous structure of an electron-conducting material which structure leaves a system of inter-connected interstices, cavities, holes and/or channels, within and throughout the structure. An explosive material is distributed and contained in the interstices or spaces of the structure so that the charge is, in effect, composed of an interconnected system of explosive material, contained within a structure of continuous electron-conducting material. Throughout the charge, the electron-conducting material should be coextensive (i.e., have the same dimensions) as the explosive or oxidizing salt. The term "cavernous" as used herein is meant to express the characteristic that a number of interconnected cavities, cells, or interstices of any desired shape are present within the structure.

The electron-conducting material is generally a metal and, preferably, one having a relatively high conductivity. Further advantages are realized if the metal is of a kind which is readily oxidized with the formation of high amounts of heat energy thus contributing to the end of producing useful work. This prerequisite is ideally fulfilled by the light metals, for example, magnesium or aluminum or their alloys. The function of the structure of the electron-conducting material is in no way identical or even comparable to that of the finely powdered metals, particularly those of light metals, which have been added to explosives in order to improve their performance. The effects and improvement produced by the present invention go much beyond the level of improvements which can be achieved by the admixture to the oxidizing explosives of individual, non-electrically conducting configurations of particulate metals alone.

The preferred metal conductors useful in the present invention are light metals, such as those found in the low atomic weight positions of groups I, II and III of the periodic classification of the elements. These include preferably magnesium, aluminum, magnesium alloys, aluminum alloys and aluminum-magnesium alloys and mixtures thereof. Other operative metals are iron, zinc, calcium, lithium, sodium, strontium, barium, beryllium, titanium, some rare earth metals, and many alloys of these metals.

The objectives of the invention are most readily achieved if irregularly shaped, elongated components or particles of the electron-conducting materials are used, i.e., particles having one dimension substantially smaller than the others. Among the multitude of useful particle shapes, circular, angular, curved, curled, tube like, cylindrical and/or rolled configurations are preferred. Also operative are chopped scraps and strands, machinings, band saw filing, millings, foils, bars, sponges, routings, wools, and the like. In general, the configuration is such that the energy-absorbing material will be substantially self-spacing when placed in the bore hole or other situs of the explosive charge. Expanded foils as shown in FIGURE 3, also may be used to contribute circuitry to the system. Too finely particulated metals do not permit, by their geometry, the establishment of contact between the individual particles and at the same time leave sufficiently big interstices to form the system of channels and cavities for the explosive. Furthermore, the coarser

components or elements used in the present invention do not have the disadvantages of the finely particulated metals which sometimes are too sensitive in explosive compositions and thus are hazardous. Furthermore, the larger particles remain principally in the metallic state even though their surface may be oxidized, as may not be the case with light metals such as aluminum and magnesium if they are employed in too finely particulated form. Regardless of the shape and size of the individual particles or components making up the cavernous structure, it is desirable that as large as possible an area be available for direct contact of individual components or particles of electron-conducting material within the structure. Further, it is desirable that the conducting metal be distributed substantially throughout the explosive in a manner such that the metal particles are in electrical contact throughout, whereby an electrical charge will be substantially immediately distributed throughout all of the electron-conducting material in contact with the explosive.

The novel charges and processes of the present invention have found applicability in a wide variety of organic and inorganic explosives, including solid, granular, slurries, wetted, liquid and gaseous systems. Included, for example, are nitroglycerine, trinitrotoluene, conventional plasticized explosives, and the like. Preferred explosives include, for example, oxidizing salts, such as the nitrates, nitrites, perchlorates, sulfates, chlorates, chromates, peroxides and many other salts capable of liberating oxygen upon detonation. However it has been found that the most striking improvements have been achieved with those charges which consist of or contain as an oxidizing constituent, ammonium nitrate. Explosive charges of this kind and type may be readily produced by the insertion of the irregularly shaped components or particles of the electron-conducting material into a bore hole or container and filling the interstices left within the cavernous structure thus obtained with the explosive which may be introduced, for instance, in the form of a liquid or slurry. In the case of ammonium nitrate explosive, the liquid is preferably an aqueous, ammoniacal or an aqueous ammoniacal solution and/or dispersion of the ammonium nitrate.

The following examples will serve to illustrate further the utility of the electron conducting structures in explosive compositions.

Example 1

A 5.5 pound explosive composition comprising (*a*) 72 percent by weight of a liquid ammoniacal ammonium nitrate solution, formed from 69.8 parts ammonium nirate, 23.8 parts liquid ammonia and 6.4 parts water, (*b*) 14 percent by weight of coarse magnesium machine chips, and (*c*) 14 percent by weight of coarse aluminum machine chips was prepared and placed in a flexible polyethylene bag. The metal particles formed a continuous, cavernous structure wherein electrical contact was maintained throughout the metal configuration. The test load was then placed in a 6 inch diameter by about 6 foot deep bore hole in the ground in the test area and tamped with about 4.5 feet of sand. The test load was permitted to stand one hour and then was fired electrically using a shaped charge detonator. The load was successfully detonated.

The blast produced a crater about 8 foot in diameter in the test area.

When the same amount of finely particulated metal was used in a similar charge and tested as above; i.e., (1) the metal particles were of a size such that a cavernous (electrically connected) structure was not present, (2) the metal particles were not self-spacing and (3) the metal particles were not in contact, craters of considerably smaller diameters resulted.

Example 2

In the manner of Example 1, an explosive composition comprising (*a*) 3.5 pounds of a liquid ammoniacal ammonium nitrate solution formed from 69.8 parts ammonium nitrate, 23.8 parts liquid ammonia, and 6.4 parts water, (*b*) about 1 pound of coarse magnesium chips and rotary filings and (*c*) about 1 pound of coarse aluminum machine chips was formed and placed in a polyethylene bag. The metal formed a cavernous structure coextensive with the explosive. The test load was placed in the bore hole, tamped, and fired successfully using the technique of Example 1.

The blast produced a crater about 10 feet in diameter and about 3.5 feet deep.

Example 3

Following the precedure of Example 2, a test load of the composition as used in Example 2 was prepared in which magnesium tubular straw-like curls were substituted for the magnesium coarse chips and rotary filings. Here again, the metal was coextensive with the ammonium nitrate solution. The test load was placed in the bore hole, tamped, and fired successfully.

The blast produced a crater about 12 feet in diameter and about 5 feet deep.

Example 4

A self-spacing cavernous structure of aluminum and magnesium and about 5 pounds of TNT were placed in a polyethylene bag and positioned in a 6 inch diameter by about 6 feet deep bore hole in the ground and was stemmed with about 4.5 feet of sand. The test load was immediately fired electrically using a shaped charge.

A crater of the order shown hereinbefore was produced.

In a comparative shot, 5 pounds of TNT were placed in a polyethylene bag and positioned in about a 6 foot deep bore hole and tamped with about 4.5 feet of sand. The test load was fired immediately using a shaped charge armed with an electric blasting cap.

A crater was produced which was about 8 feet in diameter but had virtually no depth.

Additional enhancement of the power factor and efficiency of the explosive charge of the present invention may often be achieved if the electrical-conducting charge is surrounded by or contained in a sheath of an electron conductor which likewise is advantageously a metal and preferably a light metal. This outer sheath may have a curved or curvilinear surface, and may have the form of a cylinder, canister, tube, and the like, which may be embossed or have a lattice-like form. These conductors are essentially containers placed in the reaction zone which effectively surround or jacket the explosive charges. These containers or sheaths are effective in impeding the surge of energy even when formed from thin foils or when they are perforated or open mesh expanded metal jackets.

Examples which will serve to illustrate the increased powers obtained when such a sheath or outer container is utilized in conjunction with the inner-circuitry continuous electron conducting configurations are presented as follows:

Example 5

Following the procedure and composition used in Example 1, an explosive composition was prepared, but this time it was placed in a thin-walled corrugated aluminum cylindrical container about 6 inches in diameter and about 7 inches in height instead of being placed in the polyethylene bag. The test load was fired successfully.

An excellent blast occurred and produced a crater about 11 feet in diameter in the test area.

Example 6

A 5.5 pound explosive composition as described in Example 1 was prepared utilizing coarse aluminum chips and turnings and coarse magnesium curled chips. The composition was placed in a canister of the type utilized in Example 5 of cylindrical shape and having the bottom tucked in. The test load was placed in a 6 inch diameter

by about 6 foot deep bore hole. The explosive product was tamped with about 4 feet of sand and fired electrically uing a shaped charge. The load was successfully detonated.

The blast produced a crater about 10 feet in diameter and about 3–4 feet deep.

In a comparative shot, a metal containing composition as above was prepared and placed directly in the bore hole without being enclosed in the outer canister. This explosive was detonated successfully but resulted in a crater of about 7.5 feet in diameter and somewhat more shallow than that of the shot described above.

Example 7

An initial metal loaded composition as described in Example 1 was prepared and 6 percent of its weight of water added thereto. The resulting composition was placed in a canister as described in Example 5 and loaded into the bore hole. This mix was detonated successfully.

The blast produced a crater of the same order as was obtained for the canister contained shot of Example 6.

Example 8

Following the method of Example 6, an explosive composition as described in Example 1 was prepared utilizing coarse aluminum machinings and magnesium ribbons (in flake form about ½ inch wide by 8 to 10 inches in length). The explosive was placed in a one gallon sheet metal container and positioned in a 6 foot deep bore hole and tamped with about 4.5 feet of sand. The charge was fired electrically using a shaped charge. Upon detonation, a crater about 10 feet in diameter was produced.

In a comparative test, a test load as described above was prepared. The load was placed in an identical sheet metal container as used in the first part of Example 8 above but aluminum foil was also wrapped around the side of the metal can. The bore hole was loaded, tamped and fired in the manner as described for the shots of Example 6.

The resulting blast produced a crater over 12 feet in diameter, the improvement over the result of the shot described above being attributed solely to the presence of the aluminum foil. No residue of the foil was found, although torn pieces of the sheet metal can were found.

Example 9

Following the procedure of Example 4, about 5 pounds of TNT with the appropriate magnesium and aluminum cavernous structure were placed in a polyethylene bag and the entire charge wrapped in aluminum foil. The load was positioned, stemmed and detonated in the manner of Example 4.

The load produced a crater somewhat larger than that produced in Example 4.

It was found also that the operation of the explosive charges of the present invention may be further improved by providing one or more nonstructural tamps, two embodiments of which are found in FIGURES 1 and 2. A well-designed tamp was found to effect a substantial reduction of the tendency in "rifling" from the bore hole. These tamps may be made of either conductive or nonconductive materials but those made of conducting materials achieved significant unexpectedly high tamping effect. Tamps that were most effective were ones having multiple closed electrical circuits in both horizontal and vertical planes and with enough surfaces to impede energy flow by reflection, refraction and absorption.

If possible, at least one of the plates or areas of the tamps should be in direct contact with the explosive and/or the electron-conducting material forming the cavernous structure in order to produce the highest possible directional effects in the charge. Further, the tamp should be located at a position with respect to the explosive so that it will have the desired directionalizing effect. The plate or plates making up the tamps need not be of heavy construction, and it is not required that they have the structural strength to divert the blast by their mechanical strength. They may, therefore, be made from relatively thin materials. The plate or plates or other elements making up the tamp may be perforated.

In some applications, it may be that these plates or metal shields are composed of several layers of expanded metal material so devised that both reflecting surfaces and plural overlays of closed electrical circuits in both vertical and horizontal planes are included.

Generally, the tamps may be made from a large variety of metals. These metals include iron, lead, tin, nickel, manganese, chromium, magnesium, aluminum and the like. The heavy metals tend somewhat to choke off and effectively drive the initial reaction forces downward whereas magnesium and aluminum not only do this but in addition also tend to enter into the system as reactants.

In the past "rifling" of holes has been controlled by using a long column of drill cuttings to stem (tamp) the hole above the charge. This tendency of shots to "rifle" is now being controlled by the tamping device. This allows loading a higher column of powder in the hole while still controlling the "rifling." In practice, the effectiveness of these novel tamps has permitted bore holes to be loaded and tamped with only about 8 feet of drill cuttings or other tamp material whereas under ordinary circumstances the same load required about 21 feet of tamping in order to prevent "rifling" of the explosive charge.

In test shots it has been demonstrated that the inductive tamping device tends to direct the explosive forces outward and downward, e.g., in tests in sand, extreme heat was found up to several feet or more below the level of the load where the tamping device was used. In comparative tests using conventional tamping and stemming materials, the heat penetration downward was not discernible for more than about several inches.

Observation of shots wherein the above-described features of the invention, including the nonstructural tamp, were employed in the reaction zone of the explosive mass indicated a strong confinement and use of the electrical and thermal energy attending the explosion to the situs of the blast with less indication of energy loss to the surrounding rock and upward through the bore hole. Substantial elimination of "rifling" is observed and an actual tendency in open pit blasting to concentrate the explosive energy in the useful work of breaking rock is achieved.

The following examples will serve to illustrate the effect of the directionalizing nonstructural tamp on the explosive compositions described heretofore.

Example 10

In taconite deposits, a standard series of bore holes was loaded with about 1100 pound loads of conventional ammonium nitrate explosives per hole (fertilizer grade ammonium nitrate prills wetted with fuel oil). Twenty-three feet of rock rubble were used as a tamp in order to prevent "rifling" of the explosive charge from the bore hole.

Utilizing a three-platter iron tamp, as illustrated in FIGURE 1, about 8 feet of rock rubble tamp permitted a second series of similarly loaded holes to be fired successfully without "rifling."

Example 11

Following the procedure of Example 9, about 5 pounds of TNT with the appropriate magnesium and aluminum cavernous structure was placed in a polyethylene bag, wrapped in aluminum foil as in Example 9, and a foil grid tamp made of aluminum and of the type illustrated in FIGURE 2 placed on the top of the charge. The resulting load was positioned, stemmed and detonated in the manner of Examples 4 and 9.

The load was successfully detonated, producing a crater

of a diameter similar to that of Example 9 but of greater depth.

While the compositions and processes of the present invention have been described fully in their application to oil well and mining operations, as for example in quarrying, construction and in porous rock blasting, these processes and compositions may also have applicability as solid fuels for many purposes.

The theoretical background underlying the present invention is not fully understood. A possible explanation is that the positioning of an electron-conducting and energy-absorbing material, preferably a coarse metal, in various ways within the reaction zone provides a substantial impeding effect to the movement of the free electrons emanating from the detonation wave front. In effect, electron "traps" are provided that readily receive the moving electron front, absorbing the heats of both the impact and of the strong electrical surge currents that are set up within the metal. The multiple impacts and the strong electrical surges cause large quantities of heat to be generated, readily raising the temperature of the metal. The heated metal may then undergo reaction with oxygen, nitrogen or other materials with the concomitant exothermal liberations of tremendous quantities of heat. This great effect, characteristically observed in all explosion systems where circuitry has been employed, together with the expansion of the end-products may be largely responsible for the unusually high power factors obtained with the explosive compositions of this invention.

It also appears that the free electrons impart to the energy-absorbing metal the electro-magnetic energy they are carrying. This energy adds to the electrical surge being generated within the metal by the moving electrons and thus contributes to the heating of the metal.

It further appears that at least a portion of the initial thermal heats of reaction also being carried in the initial detonation wave by the free electrons, are imparted to the metal, thereby contributing thermally to the eventual vaporization of the metal. It is possible that other portions of the initial heats of reaction are utilized in rapidly raising the temperature of the explosive material, e.g., an oxidizing salt, positioned immediately ahead of the shock front, especially with those heats or thermal energies being carried by the electrons that are reflected or refracted on the surface of the metal. In other respects, the reflection and refraction of the electrons, shock waves, or light waves carrying these thermal energies, may be viewed simply as a means of momentarily confining or impeding the outward progress of the energy so as to permit the thermal energies or heats as well as the electrical energies to be held in the reaction zone for sufficient time to materially raise the temperature of the explosive composition, including the oxidizing salt, for example.

As a consequence of the alteration of the normal path of the electronic front by the interpositioning of the generally curvilinear energy absorbing materials in the reaction zone, the course of the detonation wave or shock front is also altered, as discussed above. The shock wave then tends to follow the contours of the conducting metals so interposed and is likewise impeded in its progress. There is some evidence that such shock wave is sufficiently impeded in its progress so that the major shock waves emanating from the full detonation in the reaction zone catch up with the initial shock wave, which then function to amplify the major shock waves, resulting subsequently in greater movement of the burden.

While one possible theoretical basis of the enhanced power factors observed with the compositions of this invention is discussed above, other explanations may be considered. For example, the extremely high heats observed may cause the gaseous materials to be raised to the plasma state, i.e., the state at which they no longer respond to the ordinary gas laws. Thus, the confining or impeding of the electrons may produce a plasma of ions and free electrons which upon subsequent recombination produce a tremendous shock, thereby enhancing the power of the explosives.

Various modifications of the present invention can be utilized without departing from the spirit or scope thereof for it is understood that we limit ourselves only as defined in the appended claims.

We claim:

1. A method for upgrading the power factor of a metallized explosive in a bore hole which comprises;
   (*a*) providing in a bore hole a core of an electron conducting metal, said core forming a continuous structure wherein electron conducting contact is maintained throughout the metal configuration in said bore hole, said core having a system of inter-connected cavities within and throughout said structure,
   (*b*) distributing an explosive material within the interconnected cavities of said core thereby to provide an inter-connected system of said explosive material within said core of said metal.

2. A method for upgrading the power factor of a metallized explosive in a bore hole which comprises;
   (*a*) providing in a bore hole a core of an electron conducting light metal, said core forming a continuous structure wherein electron conducting contact is maintained throughout the light metal configuration in said bore hole, said core having a system of interconnected cavities within and throughout said structure,
   (*b*) distributing an explosive material within the interconnected cavities of said core thereby to provide an inter-connected system of said explosive material within said core of said light metal.

3. A method of upgrading the power factor of a metallized ammonium nitrate explosive in a bore hole which comprises;
   (*a*) introducing into a bore hole irregularly shaped particles of a light metal selected from the group consisting of magnesium, magnesium alloys, aluminum, aluminum alloys, magnesium-aluminum alloys and mixtures thereof, said metal particles being substantially self-spacing and forming a continuous structure wherein electron conducting contact is maintained throughout the configuration of said metal particles in said bore hole, said structure having a system of inter-connected interstices within and throughout said structure forming a system of channels and cavities therein,
   (*b*) placing a solution of ammonium nitrate within the inter-connected interstices of said metal structure to substantially fill said interstices.

4. A method for upgrading the power factor of an ammonium nitrate explosive in a bore hole which comprises;
   (*a*) introducing into a bore hole irregularly shaped particles of a light metal selected from the group consisting of magnesium, magnesium alloys, aluminum, aluminum alloys, magnesium-aluminum alloys and mixtures thereof, said metal particles being substantially self-spacing and forming a continuous structure wherein electron conducting contact is maintained throughout the configuration of said metal particles in said bore hole, said structure having a system of inter-connected interstices within and throughout said structure forming a system of channels and cavities therein,
   (*b*) surrounding said structure with a thin-walled aluminum sheath, and
   (*c*) placing a solution of ammonium nitrate within the inter-connected interstices of said metal structure to substantially fill said interstices.

5. A method for upgrading the power factor of an explosive metallized with a light metal which comprises;
   (*a*) providing in a bore hole a core of an electron conducting light metal, said core forming a continuous

structure wherein electron conducting contact is maintained throughout the metal configuration, said core having a system of inter-connected cavities within and throughout said structure,

(*b*) surrounding said core with a thin-walled electron conducting sheath,

(*c*) distributing an explosive material within the inter-connected cavities of said core thereby to provide an inter-connected system of said explosive material within said core of said light metal, and

(*d*) placing electron conducting, thin, plate-like tamp members on top of said explosive in said bore hole, at least one of said tamp members being in contact with said light metal core and said tamp members having insufficient structural strength to divert an explosive blast by their mechanical strength.

6. A method as defined in claim 5 wherein the light metal is a member selected from the group consisting of magnesium, magnesium alloys, aluminum, aluminum alloys, magnesium-aluminum binary alloys and mixtures thereof.

7. A method for upgrading the power factor of a metallized ammonium nitrate explosive in a bore hole which comprises;

(*a*) placing a thin-walled aluminum sheath around the wall of a bore hole so as to line said bore hole with said aluminum sheath,

(*b*) introducing a mixture of coarse magnesium and aluminum particles in said bore hole, said metal particles being substantially self-spacing and forming a continuous structure wherein electron conducting contact is maintained throughout the configuration of said metal particles in said bore hole, said structure having a system of inter-connected interstices within and throughout said structure forming a system of channels and cavities therein,

(*c*) placing an ammoniacal ammonium nitrate solution within the inter-connected interstices of said metal structure to substantially fill said interstices,

(*d*) placing at least one thin, circular aluminum plate-like tamp member on top of the explosive load, said member having insufficient structural strength to divert an explosive blast by its structural strength.

References Cited in the file of this patent

UNITED STATES PATENTS

456,978	Bolt	Aug. 4, 1891
971,264	Goodrow et al.	Sept. 27, 1910
1,530,692	Paulus	Mar. 24, 1925
1,767,182	Lisse	June 24, 1930
1,891,500	Burrows	Dec. 20, 1932
2,168,030	Holmes	Aug. 1, 1939
2,168,562	Davis	Aug. 8, 1939
2,449,645	Dupont et al.	Sept. 21, 1948
2,589,532	Byers	Mar. 18, 1952
2,887,953	Mager	May 26, 1959
3,022,735	Eberle	Feb. 27, 1962

FOREIGN PATENTS

192,824	Austria	Nov. 11, 1957