

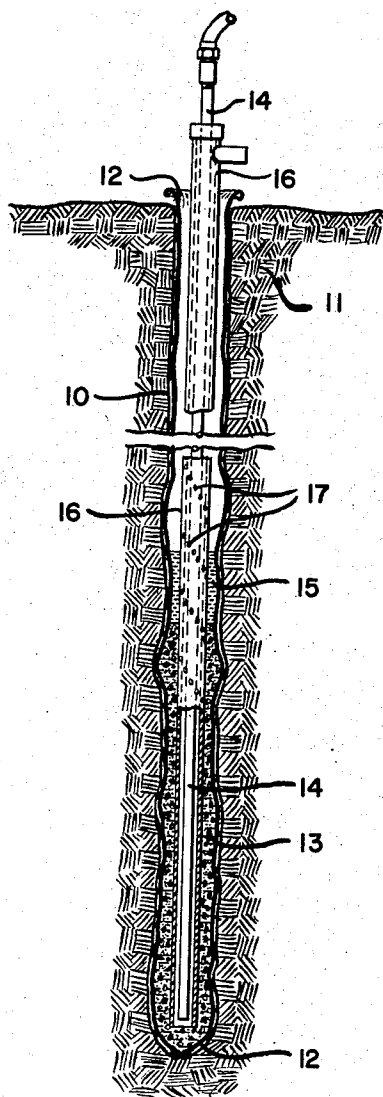
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F. W. BROWN

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EXPLOSIVES

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INVENTOR

Frederick Winfield Brown

*By Hooper, Leonard & Buell*  
his attorneys

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## EXPLOSIVES

Frederick Winfield Brown, Boulder, Colo.

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This invention relates to explosives and particularly to a low cost explosive mixture having great shattering power and gas forming ability.

There has long been a need for a high performance, low cost, safe explosive for use in mining and related industries and for other purposes where explosive mixtures may be used. Explosives of the fixed type have long been known, such as mixtures of explosive hydrocarbons, including trinitrotoluene, nitroglycerine and nitrates absorbed on a solid material or gelatinized in the form of cartridges. These fixed explosives have a relatively high efficiency but are comparatively expensive and are sensitive to shock. In an effort to overcome the expense of fixed explosives, it has heretofore been proposed to saturate carbon black with liquid oxygen for use as a low cost explosive. These liquid oxygen-carbon black explosives are generally known by the term L.O.X. The L.O.X. explosives are quite sensitive to fire and to impact detonation so long as sufficient oxygen for combustion remains in the mixture. They have the further disadvantage that a large excess of liquid oxygen must generally be added in order to retain sufficient oxygen in the mixture at the time when the explosion is desired. These two factors have made these L.O.X. explosives comparatively expensive and unsatisfactory for many uses. It has been proposed to overcome the problems of the L.O.X. explosives and the high cost of conventional fixed explosives by using a mixture of carbon black and ammonium nitrate to form a fixed explosive. In this mixture the amount of combustible must be controlled within relatively narrow limits or the explosive will be insensitive and cannot be detonated, and, even with the optimum mixture of carbon and ammonium nitrate, a relatively large amount of an expensive fixed explosive such as gelatin dynamite must be used with the ammonium nitrate and carbon to act as a booster in order to bring about the explosion. These ammonium nitrate carbon explosives do not have as high performance characteristics as the liquid oxygen carbon explosives or the previously used conventional fixed explosives, such as gelatin dynamite, but they do have the advantage of lower cost. The primary difficulties experienced with this type of explosive are the relatively low strength of the explosive, the need for a large diameter in the charge and correspondingly large shot holes, relatively low rate of detonation, need to maintain maximum pressure on the charge, problem of packaging, the need for careful control of the carbon-ammonium nitrate ratio and the need for a detonation booster. The carbon-ammonium nitrate explosives have the further disadvantage common to the L.O.X. type of a relatively low and narrow range of density.

The present invention provides an explosive which has a much lower fire sensitivity and detonation sensitivity than the L.O.X. explosives and is much less expensive. The explosive of the present invention does not have the criticality of the ammonium nitrate-carbon mixture. It does have much better performance characteristics

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than the L.O.X. explosives and the standard fixed explosives such as sixty (60%) percent gelatin dynamite type. The explosive of the present invention can be made with a variable density up to a relatively high density and higher gas releasing ability than either L.O.X. explosives or the carbon-ammonium nitrate explosives and at very low cost, so as to provide good shattering characteristics, along with the ability to do a large amount of work per unit volume.

I have discovered that ammonium nitrate admixed with certain carbonaceous materials in proper proportions and saturated with liquid oxygen will provide an explosive mixture far superior to anything heretofore proposed and at a cost below that of any of the heretofore proposed explosives. The explosive of my invention is less sensitive to detonation prior to the addition of liquid oxygen than is ammonium nitrate alone. It is also less sensitive to fire and to premature explosion than the L.O.X. types of explosives and yet is sufficiently sensitive to be exploded without the need of boosters, such as are required in the ammonium nitrate carbon explosives which have been heretofore proposed.

I have found that an explosive made up of ammonium nitrate and carbon black such as the group lamp black or gas black in the proportions of not less than about ten (10%) percent by weight lamp or carbon black and saturated with liquid oxygen has explosive properties far superior to any explosive heretofore proposed per unit cost. The preferred composition of my explosive is about twenty (20%) percent by weight of carbonaceous material and eighty (80%) percent by weight ammonium nitrate saturated with liquid oxygen. The proportion of carbonaceous material may be increased to eighty (80%) percent by weight or more but too large a proportion of carbonaceous material increases the shock or impact sensitivity as well as the cost.

I have found that a portion of the carbon black may be replaced with graphite or low volatile coal of fine particle sizes. There must, however, remain sufficient lamp black or gas black to coat the particles of graphite or low volatile coal. If sufficient lamp black is not retained to accomplish this purpose, the explosive is too sensitive to detonation. I have found that the amount of lamp black will vary depending on the particle size in the mixture which determines the amount needed to coat the particles of graphite or low volatile coal. This mixture, using graphite or low volatile coal coated with carbon black favors the production of free-pouring qualities and may be made to pour into a bore hole without the need for forming the material into a cartridge.

The explosive of this invention may have a wide range of densities depending upon its composition and the use to which it is to be put. For example, the density may be increased by the use of graphite or low volatile coal within the limits pointed out above. In addition, the density may be varied or controlled by controlling the physical size of the ammonium nitrate particles. Finely ground ammonium nitrate, for example, will produce higher densities than loose crystalline ammonium nitrate. By properly proportioning the materials it is thus possible to get a high density, freely pouring material which can be poured directly into the bore hole and saturated with oxygen in situ.

I have also found that the density and resistance to fire can be substantially improved by the presence of water in the mixture without material impairment of the explosive characteristics. For example, a cartridge made up of about twenty (20%) percent by weight carbon, about twenty (20%) percent by weight pelletized  $\text{NH}_4\text{NO}_3$  and the balance a solution in water of  $\text{NH}_4\text{NO}_3$  containing eighty-three (83%) percent by weight  $\text{NH}_4\text{NO}_3$ , will not ignite, even when saturated with liquid

oxygen whereas a plain L.O.X. cartridge under the same conditions will ignite and burn with an intense flame similar to that of an oxy-acetylene torch.

I have discovered a new method of blasting using the explosive of this invention which will be more readily understood by reference to the accompanying drawing showing a vertical section through a bore hole. I form a bore or shot hole 10 in the material 11 to be blasted. This may be done by conventional drilling or jet piercing. A flexible plastic liner 12, such as a polyethylene bag, is inserted into the hole 10, and a mixture 13 of about twenty (20%) percent by weight of a low volatile coal coated with lamp black and eighty (80%) percent by weight ammonium nitrate is poured into the bag. The mixture of ammonium nitrate and coal is preferably

Oxygen Explosives." U.S. Bureau of Mines Bulletin 472 (1949), particularly pages 61 to 64.

These methods give good values for E but somewhat less precise values for D. They are, however, quite adequate for a comparison of performance values of explosives. The values of D and E given in Table I are computed but the computed values check quite closely with actual measured values for sixty (60%) percent gelatin dynamite in liquid oxygen carbon explosives. In the table, it should be noted that the rate of a liquid oxygen explosive does not vary appreciably with the average oxygen condition over a wide range because the rate is determined by that of the liquid oxygen saturated core of the cartridge.

Table I.—Comparison of the explosive of this invention with other selected explosives

|    | Explosive                    | Composition, percent by wt.    | Oxygen condition, percent of stoichiometric | Absorbent density, gm./cc. | Overall density, gm./cc. | D meters/sec. | E calories/gm. | Ed calories/cc. | Ratio of D to 60% gel | Ratio of Ed to 60% gel | Ratio of B = EDd to 60% gel |
|----|------------------------------|--------------------------------|---------------------------------------------|----------------------------|--------------------------|---------------|----------------|-----------------|-----------------------|------------------------|-----------------------------|
| 1. | 60% gelatin dynamite.        |                                |                                             |                            | 1.45                     | 6,000         | 1,000          | 1,450           | 1.0                   | 1.0                    | 1.0                         |
| 2. | LOX                          | 76.8% oxygen                   | saturated, 124                              | 0.30                       | 1.24                     | 5,100         | 1,385          | 1,717           | .85                   | 1.18                   | 1.01                        |
| 3. | LOX                          | 23.2% lamp black               |                                             |                            |                          |               |                |                 |                       |                        |                             |
|    |                              | 74.6% oxygen                   | saturated, 110                              | 0.30                       | 1.135                    | 5,100         | 1,420          | 1,612           | .85                   | 1.11                   | .945                        |
|    |                              | 25.4% lamp black               |                                             |                            |                          |               |                |                 |                       |                        |                             |
| 4. | Explosive of this invention. | 46.5% $\text{NH}_4\text{NO}_3$ | saturated, 141                              | 0.82                       | 1.411                    | 6,440         | 974            | 1,374           | 1.07                  | .95                    | 1.02                        |
|    |                              | 41.9% oxygen                   |                                             |                            |                          |               |                |                 |                       |                        |                             |
|    |                              | 11.6% lamp black               | saturated, 100                              | 1.078                      | 1.495                    | 7,400         | 1,172          | 1,752           | 1.23                  | 1.21                   | 1.49                        |
| 5. | do.                          | 58.2% $\text{NH}_4\text{NO}_3$ |                                             |                            |                          |               |                |                 |                       |                        |                             |
|    |                              | 27.2% oxygen                   |                                             |                            |                          |               |                |                 |                       |                        |                             |
|    |                              | 14.6% lamp black               |                                             |                            |                          |               |                |                 |                       |                        |                             |

cooled to a temperature approximating that of liquid oxygen. An oxygen lance 14 is inserted through the mixture to the bottom of the bag and liquid oxygen is added until the mass of the mixture is saturated and a layer 15 of liquid oxygen lies above the mixture 13. Preferably, a bleeder line 16 surrounds the oxygen lance 14 and is provided with openings 17 therein to carry off any volatilized oxygen and prevent lifting of the charge by gas expansion. The bleeder line 16 and lance 14 are removed, the hole is stemmed and ready to be shot. This method of blasting is particularly advantageous where jet piercing is necessary because of the ability of the charge to conform to the irregularities of the shot hole. This method may be practiced using any free flowing composition according to this invention.

The performance of the explosive prepared according to my invention, is appreciably better than the standard liquid oxygen-carbon explosive, as well as the fixed explosives of the sixty (60%) percent gelatin dynamite type. It is generally accepted that for most blasting in heavy material, such as rock, it is desirable to make the energy release per unit volume and the rate of detonation as high as possible. The energy release per unit volume is the heat of explosion, E, times the overall density of the explosive cartridge, D. The rate of detonation, D, is the velocity of decomposition of an explosive column detonated at one end. The best single index of performance seems to be the so-called "brisance" which is most often defined as  $B = EdD$ . In Table I, I have given comparative performance values calculated for the explosive of my invention and other competitive explosives. The computations for the table were made using the methods outlined in the following publications:

- (1) F. W. Brown—"Theoretical Calculations for Explosives. I. Explosion Temperatures and Gaseous Products and Effects of Changes in Carbonaceous Materials." U.S. Bureau of Mines Technical Paper 632 (1941).
- (2) F. W. Brown—"Theoretical Calculations for Explosives. II. Explosion Pressures." U.S. Bureau of Mines Technical Paper 643 (1942).
- (3) W. E. Tournay, F. M. Bower and F. W. Brown—"Safety and Performance Characteristics of Liquid

An advantage of the explosive of my invention is that the density may be varied greatly. The density may be increased by increasing the fineness of the ammonium nitrate or by the addition of graphite or low volatile coal as previously explained without in any way detrimentally affecting the performance of the explosive and without detracting in any way from the advantages which have been set out above.

The explosive of my invention may be detonated with any conventional detonator, such as those used with the fixed explosives, and does not require the use of any special booster. It is an extremely low cost explosive but with a very high performance and fills the need for an explosive which may be safely and readily transported and handled prior to insertion in the bore hole and yet with sufficient sensitivity and detonatability to be fired without the conjoint use of expensive fixed explosives.

While I have described certain preferred forms and compositions of my invention and certain preferred methods of use, it will be understood that this invention may be otherwise embodied within the scope of the following claims.

I claim:

1. An explosive composition consisting essentially of at least about 10% to about 80% by weight of at least one material selected from the group consisting of lamp black and gas black, admixed with sufficient ammonium nitrate to make 100% by weight and the resulting mixture saturated with liquid oxygen.

2. An explosive composition consisting essentially of about 20% by weight of at least one material selected from the group consisting of lamp black and gas black, admixed with about 80% by weight ammonium nitrate, the resulting mixture being saturated with liquid oxygen.

3. An explosive composition consisting essentially of at least one base material selected from the group consisting of graphite and low volatile coal, coated with a material selected from the group consisting of lamp black and gas black, the total amount of base material and coating material being not less than about 10% to about 80% by weight admixed with sufficient ammonium

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nitrate to make 100% by weight and the resulting mixture saturated with liquid oxygen.

4. An explosive composition consisting essentially of at least one base material selected from the group consisting of graphite and low volatile coal coated with a material selected from the group consisting of lamp black and gas black, the total amount of the base material and coated material being about 20% by weight admixed with sufficient ammonium nitrate to make 100% by weight and the resulting mixture saturated with liquid oxygen. 10

5. An explosive composition consisting essentially of at least about 10% to about 80% by weight of at least one material selected from the group consisting of lamp black and gas black, up to about 10% by weight water admixed with sufficient ammonium nitrate to make 100% by weight and the resulting mixture saturated with liquid oxygen. 15

6. An explosive composition consisting essentially of at least one base material selected from the group consisting of graphite and low volatile coal, coated with a material selected from the group consisting of lamp black and gas black, the total amount of base material and coating material being not less than about 10% to about 20

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80% by weight, up to about 10% by weight water admixed with sufficient ammonium nitrate to make 100% by weight and the resulting mixture saturated with liquid oxygen.

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