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F. R. SEAVEY

2,420,201

BLASTING CAP

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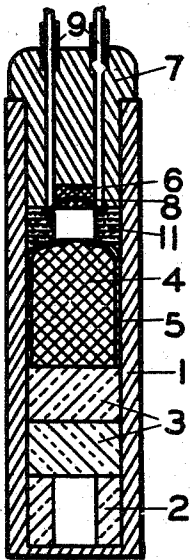


FIG. 1

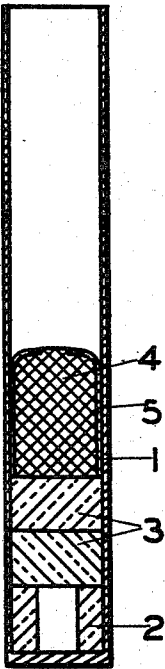


FIG. 2

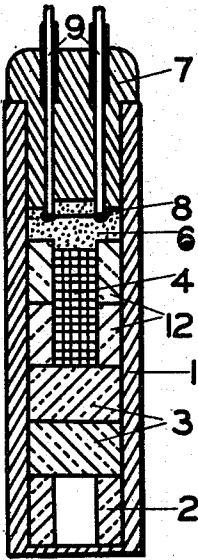


FIG. 3

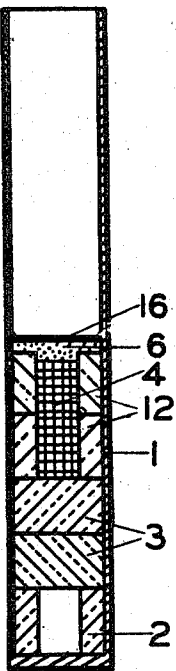


FIG. 4

INVENTOR.
FREDERICK R. SEAVEY

BY *Joe. Heischer*
ATTORNEY

UNITED STATES PATENT OFFICE

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BLASTING CAP

Frederick R. Seavey, Alton, Ill., assignor to Olin Industries, Inc., a corporation of Delaware

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2 Claims. (Cl. 102—29)

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This invention relates to explosion initiators, commonly referred to as blasting caps, of the character employed for initiating the explosion of larger charges of explosives as in blasting operations. This application is in part a continuation of co-pending application, S. N. 276,967, filed June 2, 1939, now U. S. 2,415,045.

Heretofore, the base charge in blasting caps, of the fuse, electric, or delay electric types, has been added in loose form and was subsequently pressed in place within the shell.

A disadvantage of this method of forming a base charge is that an undesirable density gradient results, the portion of the charge adjacent the press pin being of substantially higher density than that near the bottom of the cap. This is the reverse of the condition which would be most effective, because an increase in density renders it more difficult to detonate the secondary explosive used as the base charge and a reduction in density usually lowers both the rate of detonation and the brisance.

A further important disadvantage in the prior procedure of pressing the base charge within the shell is that the maximum pressure has been limited to below a value at which the unsupported shells are bulged or weakened.

Attempts to improve the uniformity and effectiveness by pressing the base charge as a number of successive increments have been attended by a substantial increase in the number of operations in the manufacturing process, and therefore in the cost, while failing to obviate all the other disadvantages.

The object of the present invention, generally stated, is to provide a blasting cap free from the disadvantages hereinbefore mentioned.

A further object of the invention is to provide a blasting cap having improved functioning characteristics.

Another object of the invention is to provide a blasting cap which may be loaded by an improved and simplified method of assembly.

Other objects will appear from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of an electric blasting cap illustrating one embodiment of the present invention;

Figure 2 is a similar view of a fuse blasting cap illustrating another embodiment of the present invention;

Figure 3 is a similar view of an electric blasting cap illustrating a further embodiment of the present invention;

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And Figure 4 is a similar view of a blasting cap embodying the principles of this invention.

In accordance with this invention, blasting caps are provided which lend themselves to an improved and simplified method of assembly and in which the detonating effect may be markedly accentuated. These and other advantages are secured by the provision of a novel form of base charge in compound blasting caps having a main charge of relatively insensitive secondary explosive and a superposed initiating charge of primary explosive.

The base or secondary explosive charge is provided, in accordance with this invention, as preformed self-sustaining tablets preferably with the bottom tablet having a hollow portion adjacent the base of the shell. Such tablets can be prepared having high density, uniform weight, and accurate dimensions at high rates of production by means of well-known automatic tablet-forming machinery, from powdered or granular secondary explosives such as tetryl, pentaerythritol tetranitrate, cyclotrimethylene-trinitramine, picric acid, trinitrotoluene, or mixtures thereof, which are useful for base charges of blasting caps. Likewise, the preformed base charge may at times be conveniently prepared at high density by casting the liquefied explosive in suitable molds. When the tablets are preformed by compressing the explosive in a suitable die, the height of each tablet is preferably made somewhat smaller than the diameter in order to obtain substantially uniform density.

A preformed base charge can thus be provided having a much higher density than a charge prepared by the conventional method of charging the loose powder into the blasting cap shell and compressing it therein because in the latter case, the applicable pressure is limited to a value below that at which the unsupported shell will bulge. Thus, while preformed tablets of tetryl can readily be prepared having a substantially uniform density of 1.60 to 1.65 or higher, the maximum average density of the same granular tetryl compressed in place in a blasting cap shell is about 1.40 to 1.50 (compressed at 4,000 to 6,000 lbs./sq. in.).

The preforming of the explosive base charge as tablets prior to insertion in the shell has enabled the provision of cavitated bottom tablets and thereby of a hollow space at the bottom of the cap charge which is not only of substantial height and width but also entirely enclosed within the shell. By reason of these two latter factors, means are provided for the utilization of the

Munroe effect to an extent heretofore impossible in blasting caps. The small cavity, heretofore commonly provided by indenting blasting caps at the base, has been external and tended to become filled, thus to have its potential effectiveness impaired, on insertion of the cap into the explosive charge intended to be detonated thereby.

In the illustrative embodiment of this invention shown in Figure 1, the blasting cap comprises a cylindrical housing or shell 1, molded of suitable organic plastic such as an ethyl cellulose composition, the base being substantially thinner than the side wall.

The base charge consists of 7 grains by weight of tetryl inserted in the cap as a series of three preformed tablets 0.16 inch high and 0.22 inch in diameter, prepared by compressing tetryl, mixed with a small percentage of graphite if desired, in a suitable die so as to result in a final density of about 1.60 for the explosive, and then firmly seated together in the shell 1. The bottom tablet 2, contacting the base of shell 1, is provided having an axial opening 0.10 inch in diameter and weighs 2 grains, while the two solid upper tablets 3, weigh 2.5 grains each.

The initiating charge 4 consists of 4 grains of mercury fulminate compressed so as to fill a copper ferrule 5, open at the bottom and enclosed at the top excepting for a central $\frac{1}{16}$ inch opening.

The cap is sealed by means of plug 7, of organic plastic, carrying lead wires 9, which are electrically connected through the bridge wire 8. The latter and the surrounding ignition composition 6 are disposed within a cavity in the base of plug 7. A spacing device such as washer 11, desirably made of resilient material such as cotton linters paper, may be interposed for insuring proper location and spacing of the components.

In the embodiment shown in Figure 2, a fuse blasting cap is provided in which the shell 1 is formed of a suitable metal such as copper, gilding metal, or aluminum. The base charge consists of preformed tablets of secondary explosive, the bottom tablet 2 having a hollow portion adjacent the shell base, while the upper tablets 3 are in the form of solid cylinders. A compressed initiating charge 4, such as mercury fulminate, lead azide, diazodinitrophenol, hexanitromannite, or a suitable mixture, is disposed within metal ferrule 5.

Figure 3 illustrates a further embodiment in which the blasting cap shell 1 of suitable organic plastic is loaded with a base charge consisting of preformed tablets of secondary explosive, both the top and bottom of the charge being cavitated. Thus, the tablets may be formed by compressing particles of tetryl, coated with up to 2.5% graphite, to suitable dimensions and at any desired controlled density. The cavitated tablets may consist of cylinders of the explosive provided with a central perforation 0.10 inch in diameter.

The upper tablets 12 are advantageous as housing for the initiating charge 4 in that, unlike metal or other inert ferrules, the tablets 12 enter into and contribute to the explosive action. Adequate confinement of the initiating charge 4 is provided for proper functioning, while greater protection against accidental detonation by shock is presented than by the metal ferrules heretofore in use. Another safety feature is that on explosion of the cap, the ferrule of explosive becomes converted into gaseous decomposition products. Tablets 12 are preferably of some-

what lower density than the remainder of the base charge, being thereby rendered more readily detonatable by the explosion of the initiating charge. Thus, in a preferred example, the tetryl base charge may consist of two tablets 12 having a density of about 1.50 (each tablet weighing 1.8 grains) and the remainder of the charge having a density of about 1.60 (two tablets 3 weighing 2.25 grains each and tablet 2 weighing 2.0 grains).

The shell 1 is sealed by organic plastic plug 7, carrying a pair of electrical lead wires 9 molded in place therein. The interior terminals of the lead wires 9 are bent in parallel relation at the base of plug 7 and are electrically connected through bridge wire 8, attached across the parallel portions of the lead wires, as disclosed and claimed in co-pending application S. N. 329,650, filed April 15, 1940, now U. S. 2,382,921.

A suitable ignition composition 6, which contacts bridge wire 8 and which may consist of 0.6 grain of fine mercury fulminate, is interposed between plug 7 and the initiating charge 4.

The initiating charge 4 may consist of the required amount of lead azide, compressed within the cavity of tablets 12. Preferably, however, the initiating charge is added in loose form after the base charge has been seated within the shell and is then caused to settle in position by tapping or vibrating the assembly.

Particularly effective results may be obtained by employing lead azide of high apparent density in the uncompressed state (settling to a density of at least 1.0 gram per cc. when tapped in a tube). For example, an excellent initiating charge consists of about 1.7 grains of the uncompressed crystalline material, containing 98.0 to 99.8% PbN_6 and having an apparent density of 1.5 to 2.5 g. per cc., which is produced by the gradual addition over about seventy minutes of 500 cc. of sodium azide solution (containing 26.8 g. NaN_3 per liter) to 575 cc. of lead nitrate solution (containing 13.3 grams of the salt per liter) maintained at about 40° C. and continuously agitated.

The manufacturing procedure involved in the production of the above-described blasting cap is characterized as an assembly operation from which the hazardous step of pressing an explosive charge, containing relatively sensitive initiator, within a shell has been eliminated.

The effectiveness of the resulting blasting cap is indicated by average lead plate perforations of 0.35 inch diameter when fired at room temperature and of 0.33 inch diameter when fired at liquid oxygen temperature.

Figure 4 shows an arrangement of base and initiating charge, similar to that of the above example, inserted in a metal case blasting cap. For use as a fuse-ignited cap, the ignition composition 6 may be provided as a compressed pad, covered, if desired, by a retaining film 16, for example of nitrocellulose. For electrical ignition, a bridge-wire plug and sealing assembly may be provided, for example as in the electric blasting cap described in U. S. Patent 1,673,584. Furthermore, a delay element may be interposed in accordance with the structure disclosed in U. S. Reissue Patent 19,661 or in U. S. Patent 2,133,119.

It will therefore be apparent that a preformed base charge in accordance with this invention is utilizable in all types of blasting caps, thus enabling the complete elimination of the step of compressing the base charge within the case. Also, the loading of the greatly elongated shells

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of ventless electric delay blasting caps may be facilitated thereby. Of further significance, however, is the fact that a base charge of greatly increased effectiveness may be secured in this manner.

The greater effectiveness of preformed blasting cap charges in accordance with this invention as compared with conventionally compressed charges is illustrated by the results, obtained by standard tests, listed in Table I. Series A caps were prepared as shown in Figure 2, having a base charge of 6.5 grains of tetryl at a density of about 1.65 inserted in flat-base metal No. 6 blasting cap shells, 0.235 inch in diameter. The charge was loaded as a bottom tablet 0.22 inch in diameter, 0.16 inch high, and having a central axial perforation 0.10 inch in diameter, and two solid cylindrical tablets 3, 0.22 inch in diameter, and 0.14 inch high. Series B consisted of shells, identical with those in Series A except for the provision of a conventional indentation in the base, which were charged with 6.5 grains of granular tetryl, compressed within the shell, in accordance with the prior art practice, at a pressure of 3300 lbs./sq. in. Both series of caps were provided with a 6 grain initiating charge of mercury fulminate, compressed in ferrule 5.

Table I

	Blasting Cap	
	A Preformed Tablets	B Pressed in Shell
Lead plate test—Average diameter of perforation.....inch.....	0.36	0.25
Heavy lead plate test—Average volume of cavity produced by firing cap on 0.50 in. thick plate.....cubic centimeter.....	0.50	0.37
Trauzl block expansion.....do.....	13.5	12.2
Insensitive dynamite tests. Per cent functioning at 14% Fe ₂ O ₃ per cent.....	80	0

Another comparative test involved caps similar to the above, except that the initiating charge consisted of 3.75 grains of diazodinitrophenol compressed into ferrule 5, a superposed ignition charge was used, and the tetryl base charge in Series B was pressed in the shells at 5000 lbs./sq. in. When fired on lead plates, perforations were produced averaging 0.23 inch in diameter for the prior art type (Series B) and 0.38 inch for the caps (Series A) loaded in accordance with this invention.

Table II lists the results of another series of comparative tests which involved identical metal shells, loaded with a constant weight of base charge (10 grains of tetryl) and the same initiating charge (5 grains of mercury fulminate). These results illustrate clearly the advantages of loading blasting caps in accordance with this invention, particularly the striking improvement due to the provision of an internal cavity of suitable height and width in the charge adjacent the bottom of the case.

Table II

Method of Loading Base Charge	Average Diameter of Lead Plate Perforation
	Inches
Pressed in shell.....	0.22
Preformed tablets (all solid).....	0.25
Preformed tablets (bottom tablet perforated).....	0.36

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The data of Table III illustrate the manner in which the optimum height of a cavity of given diameter at the bottom of the charge can be determined. The results listed were obtained with the use of blasting cap shells, plug and initiating charge as shown in Figure 1, the base charge being kept constant at 7 grains of tetryl in the form of preformed tablets. A cylindrical perforation having the indicated height was provided at the bottom of the charge. The data indicate that as the cavity increased in height, the effectiveness increased rapidly between heights of 0.08 to 0.12 inch and then rose gradually to a maximum.

Table III

	Height of Cavity (.10 in. diameter)	Diameter of Lead Plate Perforation
	Inches	Inches
(1).....	0.0	0.22
(2).....	0.04	0.23
(3).....	0.08	0.26
(4).....	0.12	0.36
(5).....	0.16	0.37
(6).....	0.32	0.37

As further illustration of the increased effectiveness obtained when the preformed explosive charge is provided with a proper cavity at the base, craters having volumes of 0.30 cc. and 0.50 cc. respectively were produced when caps of types 1 and 5 above were fired on $\frac{3}{4}$ inch thick lead plates.

The data of Table IV show the results obtained on varying the diameter of the central axial perforation of the bottom pellet. A diameter of about 0.10 inch yields excellent results and is preferred, since although larger diameters are somewhat more effective, such tablets are more difficult to manufacture and may be rather fragile.

Table IV

Diameter of Cavity (0.16 in. high) in Bottom Tablet	Diameter of Lead Plate Perforation
Inches	Inches
0.0	0.22
0.04	0.24
0.06	0.28
0.075	0.36
0.10	0.37
0.12	0.38
0.15	0.39

Table V shows the effect of variations in the height of an 0.075 inch diameter cylindrical perforation at the bottom of the charge of preformed explosive tablets.

Table V

Height of Cavity (0.075 in. diameter) from Base	Diameter of Lead Plate Perforation
Inches	Inches
0.0	0.22
0.04	0.29
0.08	0.33
0.16	0.36
0.32	0.38
0.48	0.38
0.64	0.38

The foregoing data establish the fact that in order to obtain the most effective concentration

of the explosive force (which is believed to be accomplished through acceleration of the explosion gases), it is necessary to provide a cavity at the base of the explosive charge having dimensions of height and diameter each above a minimum. In the case of tetryl tablets, 0.22 inch in diameter and compressed to a density of about 1.60, the optimum cylindrical cavity is established as one at least about 0.12 inch high and 0.075 inch in diameter.

The fact that the volume of the cavity is not the controlling factor is shown by the obtaining of an 0.28 inch lead plate perforation with the use of a bottom tablet having a cavity 0.14 inch in diameter and 0.08 inch in height, whereas, with a bottom tablet having an 0.10 inch diameter, 0.16 inch high cavity (providing substantially the same free volume—0.0012 cubic inches) a lead plate perforation 0.37 inch in diameter resulted. Furthermore, the use of a bottom tablet with a larger cavity (volume—0.0019 cubic inches) in the form of a prolate spheroid 0.14 inch in diameter and 0.08 inch in height, yielded a lead plate perforation of 0.30 inch.

The objects of this invention are therefore accomplished by the provision of blasting cap base charges which are preformed as tablets prior to insertion in the cap, the bottom tablet preferably being provided with a cavity adjacent the inner surface of the shell base. The tablets are provided having a density controlled at the desired value for the explosive being used as base charge. While the density may be uniform throughout the charge, the preferred condition is to provide tablets having density approaching the maximum at the base, and tablets of substantially lower density in the proximity of the initiating charge. The cavity in the bottom tablet is preferably of controlled dimensions of height and width so as to provide a desired concentration of the explosive force. While it is evident that no limitation exists to any particular form of cavity, a cylindrical perforation is preferred since such tablets are readily made in symmetrical form and can be easily controlled to produce the desired results.

The lead plate tests, referred to in the foregoing description, were carried out by placing the blasting cap under test in vertical position with its base in contact with the center of a lead plate, $\frac{3}{8}$ of an inch in thickness and $1\frac{1}{2}$ inches square, centrally placed over a $\frac{3}{4}$ inch diameter circular opening in a heavy metal block. Measurement was made of the perforation resulting in the lead plate after firing the cap. A procedure similar to the above was utilized in making tests with thicker lead plates, with the exception that the final measurement consisted in determining the volume of the resulting cavities.

The "insensitive dynamite test" is a standard test which has been in common use for comparing the initiating strength of blasting caps. In this test, cartridges $\frac{1}{4}$ inches in diameter and 4 inches long are charged with 75 grams of a mixture of ferric oxide and trinitrotoluene, in the form of powder passing through a 20 mesh screen, and compressed to a density of 0.93. The blasting cap under test is inserted in a cartridge and fired, a record being made of whether or not explosion of the TNT- Fe_2O_3 mixture is secured. The data in Table I under this heading were obtained by loading a number of cartridges with a mixture containing 14% iron oxide, inserting blasting caps of the two types under tests, and then firing these caps in alternate succession.

The results show far greater initiating strength for the blasting caps prepared in accordance with this invention.

It will be observed that this conclusion is paralleled by the results of the lead plate test; it has been found that such concordance is to be expected in tests involving similar blasting cap shells loaded with the same initiating and ignition charges and having base charges consisting of the same amount of a given secondary explosive.

The Trauzl block test involves the insertion of a blasting cap in a cylindrical axial cavity in an otherwise solid lead cylinder, firing the cap, and measuring the resulting expansion of the cavity.

Since variations in the specific embodiments which have been described may be made within the spirit and scope of this invention, the detail description is not to be considered as limitative except in the light of the appended claims.

Having now described the invention, what is claimed as new and is desired to be covered by Letters Patent is:

1. A blasting cap having a shell, an explosive initiating charge therein, and a base charge of secondary explosive in contact with the initiating charge, the said base charge being composed of a series of preformed tablets of explosive wherein each tablet has a substantially uniform high density, the top and bottom tablets are perforated so as to have the form of annular rings, and at least one solid tablet is disposed between the said perforated tablets, the initiating charge being disposed within the top perforation of the said base charge.

2. A blasting cap having a shell, an explosive initiating charge therein, and a base charge of secondary explosive in contact with the initiating charge, the said base charge being composed of a series of preformed tablets of explosive wherein each tablet has a substantially uniform high density, the top and bottom tablets are perforated so as to have the form of annular rings, and at least one solid tablet is disposed between the said perforated tablets, the initiating charge being disposed within the top perforation of the said base charge and the top tablet surrounding said initiating charge being of substantially lower density than the remainder of the base charge.

FREDERICK R. SEAVEY.

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