UNITED STATES PATENT OFFICE.

ALFRED NOBEL, OF PARIS, FRANCE.

CELLULOIDAL EXPLOSIVE AND PROCESS OF MAKING THE SAME.

SPECIFICATION forming part of Letters Patent No. 456,508, dated July 21, 1891.

Application filed March 22, 1889. Serial No. 304,348. (No specimens.) Patented in France November 28, 1887, No. 185,179; in Belgium January 27, 1888, No. 80,419; in England January 31, 1888, No. 1,471, and in Italy February 6, 1888, No. 22,994.

To all whom it may concern:

Be it known that I, ALFRED NOBEL, of 53 Avenue Malakoff, Paris, in the Republic of France, have invented an Improved Celluloidal Explosive and Process of Making the Same, (for which I have obtained patents in Great Britain, dated January 31, 1888, No. 1,471; in France, dated November 28, 1887, No. 185,179; in Italy, dated February 6, 1888, No. 22,994, and in Belgium, dated January 27, 1888, No. 80,419,) of which the following is a specification.

It is well known that the gelatinous compound commonly called "blasting-gelatine," and for which I obtained Letters Patent, dated April 4, 1876, No. 175,735, is composed of nitro-glycerine and soluble nitro-cellulose, the proportions adopted in practical use being from five to seven parts, by weight, of the nitro-cellulose to from ninety-three to ninety-seven parts of nitro-glycerine, to which is added a small portion of nitro-benzole or analogous matter when it is desirable to make said jelly less sensitive to concussion or percussion. This gelatinous compound, which, from possessing an eminently detonative character, has been extensively used for blasting rock, proved altogether too violent in its action for use as a propeller for projectiles.

Now the object of the present invention is so to modify the explosive character of this compound as to produce from the same materials an essentially new article of manufacture possessing the progressive explosiveness needed for propelling projectiles. This I effect by employing a process whereby I am enabled to incorporate with nitro-glycerine a quantity of soluble nitrated cellulose ten to twenty times greater than that which is contained in the aforesaid blasting-gelatine, and thereby to produce a substance which in its physical aspect as well as in its intrinsic explosive properties differs widely from the said blasting-gelatine, inasmuch as through the horny or celluloidal character which it assumes it is capable of being reduced to so-called "grains" akin to those of granulated gunpowder.

I will now proceed to describe the manufacture and mode of using the celluloidal explosive which forms the subject of the present invention.

I dissolve in one hundred parts, by weight, of nitro-glycerine, say, ten to fifteen parts, by weight, of camphor, and I add thereto, say, fifty to one hundred parts, by weight, of benzole as a diluent. To this mixture I add, say, one hundred parts, by weight, of dried pulped carded soluble nitrated cellulose, such as nitrated cotton fiber. I then mix the materials well until the nitro-cellulose has completely absorbed in its pores the aforesaid liquid and until the homogeneity of the compound is secured. This done I evaporate the benzole in the open air, or, better, in a closed chamber provided with a cooled condenser for the purpose of recovering the said benzole or the major part thereof. When the benzole is evaporated, I pass the material thus obtained for malaxation between steam-heated rollers, when it assumes the aspect and consistence of a somewhat soft celluloid. It is then ready to be rolled out into sheets of any required thickness. The sheets thus obtained I convert into so-called "grains" by cutting them up into cubes or small pieces of any desired shape, which reduction serves the same purpose as the process of granulation serves for gunpowder.

The addition of benzole, for which may be substituted any other volatile substance having the same property of mixing with nitro-glycerince and rendering nitro-cellulose insoluble therein, serves no other purpose than to faciliate by such insolubility the equal absorption and distribution of the aforesaid liquid into the fibers of the nitro-cellulose. As soon as the said benzole has been evaporated the nitro-cellulose begins to dissolve, and when dissolved the compound is subjected to the treatment already described.

The proportions of the ingredients above given are by no means absolute, but can be varied in a wide measure. The limits of such variation will be determined by the facility or resistance which the compound offers to the operation of reducing it to grains or small pieces. Thus if the aforesaid celluloidal substance contains more than two parts of nitro-glycerine to one part of nitro-cellulose it be-

comes almost too soft for a substance which has to be used in the form of grains or small cubes, and if, on the other hand, it contains as little as one part of nitro-glycerine to two parts of nitro-cellulose the celluloid obtained is more stiff and hard than needed and is less easy to manufacture than such celluloid containing no more than half its weight of nitro-cellulose.

When the aforesaid celluloidal substance is made to contain more than half its weight of dissolved nitrated cotton fiber, its formation in manner heretofore described becomes somewhat troublesome, in so far as it requires a prolonged malaxation between steam-heated rollers or similar treatment. I prefer in such case to substitute for the aforesaid benzole a volatile substance, such as acetate of amyl or of ethyl or acetone, wherein the nitro-cellulose is soluble, and wherewith the nitro-glycerine is miscible, and I add of such solvent the quantity needed for complete incorporation of the aforesaid ingredients. The proportion depends on the solvent's volatility and the temperature at which the malaxation is effected; but there is no mistaking, in practice, the proportion needed, since sufficient of the solvent must be added to obtain a translucent celluloidal substance. Moreover, for practical use the proportions above given of equal parts of nitro-cellulose and nitro-glycerine plus camphor give an excellent result, so that the addition herein referred to of an excess of nitro-cellulose, necessitating an extra addition of solvents, will be resorted to only in exceptional cases.

Of course the nitrated ingredients used—viz., nitro-glycerine and nitro-cellulose—are to be carefully deprived of adhering acids by methods of washing, which need not be specially described, since they are generally used in all dynamite and gun-cotton factories.

As with ordinary celluloid, so with the explosive celluloid herein described solid powdered substances may be kneaded in by malaxation between steam-heated rollers or otherwise. Thus said explosive celluloid may be mixed with pulverulent explosives, such as nitrated starch, nitrated dextrine, mealed gunpowder, or picrates; but it may also be mixed, and this is of importance with powdered oxidizers, such as nitrates or chlorates, for the purpose of furnishing the oxygen wanting for complete combustion and with a view to reduce the cost price of the explosive celluloid aforesaid.

The celluloidal explosive heretofore named, composed of one hundred parts of nitro-glycerine, one hundred parts of nitro-cellulose, and fifteen parts of camphor, contains approximately the oxygen needed to convert, by explosive combustion, all its constituent hydrogen into water vapor and all its carbon into carbonic oxide; but in order to obtain complete combustion and thereby convert said carbonic oxide into carbonic acid it would be necessary to incorporate with each one hundred parts of the aforesaid compound about eighty-two parts of nitrate or chlorate of potash, or sixty-nine parts of nitrate of soda, or one hundred parts of nitrate of baryta, or one hundred and sixty-three parts of nitrate of ammonia, or ninety-six parts of perchlorate of ammonia.

Bearing in mind that one part of hydrogen requires for its combustion eight parts of available oxygen and that each six parts of carbon require for transformation into carbonic oxide eight parts and for forming carbonic acid sixteen parts of available oxygen, it is easy by aid of chemical formulas to calculate the proportions of oxidizing nitrates or chlorates suitable for each particular case, it being understood that the quantity of oxidizers added should not exceed that needed for complete combustion. Of course, also, the quantity of powdered oxidizers which can be added is limited by the capability of easy practical incorporation by means of malaxation. The more nitro-glycerine and the less nitro-cellulose it contains the more soft and plastic the aforesaid explosive celluloid becomes, especially when heated, and the greater will be the proportion of powdered substances which can be practically incorporated.

The camphor or other predisposing solvent aforesaid contained in the said explosive celluloid may be partly and even almost entirely evaporated without very materially altering the explosive properties of said explosive celluloid. Such evaporation can be effected by long exposure to the air at the ordinary temperature; but it is much quickened by letting a current of air heated to, say, 50° centigrade percolate among the so-called grains of the said powder. Of course such evaporation of camphor or analogous inexplosive solvent reduces the amount of carbon and hydrogen contained in the said explosive celluloid, so that if oxidizing nitrates or chlorates be incorporated or mixed with the same their quantity should be proportionately reduced.

The explosive celluloid herein described can also be used for blasting rock, in which case the so-called "grains" may be compressed in similar manner as now practiced for gunpowder, so as to form cylinders or pellets suited for miners' use. Such compression may either be effected at a temperature (60° to 80° centigrade) at which the material becomes sticky or at the ordinary temperature by slightly moistening the grains with a solvent, such as acetone or an acetic ether. Of course the grains should not be so much compressed as to leave no air-space, upon which the quick spreading of the flame depends. The aforesaid powder can be fired without a detonator, thereby differing completely from the so-called "high explosives" now in use.

Whether for blasting or propelling purposes the explosive celluloid herein described has always to be used in a granulated state or in a state of such division as to present a sufficiently large surface for combustion. The

size of the grains or particles varies for each caliber of arms and other varied conditions, as is likewise the case with gunpowder; but otherwise the mode of using and firing does not materially differ from that explosive except as regards suiting the charge to the ratio of power.

Having now particularly described my invention, I claim—

1. A process for forming hard celluloidal explosives for propelling or filling projectiles or for blasting purposes, which consists in uniting nitro-cellulose and nitro-glycerine, in proportions substantially as set forth, by means of a volatile solvent, as acetone, camphor, or the like, and subsequently removing the volatile solvent therefrom and mechanically treating the same, substantially as specified.

2. The hard, horny, or celluloidal explosive in granular form for propelling or filling projectiles or for blasting purposes, containing nitro-cellulose and nitro-glycerine, the same being so far solid at ordinary temperatures as to be susceptible of being cut up into so-called "grains."

3. The celluloidal explosive above described, in dense, horny, granular form, solid at ordinary temperatures, composed of nitro-cellulose, nitro-glycerine, and suitable oxidants, as specified, and adapted for use for propelling or filling projectiles or for blasting purposes.

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