This invention relates to explosives such as the nitro-compound explosives, and has for its objects an improved explosive and method of making the same, which explosive is more economical and safer to make and handle and more effective in use than explosives heretofore. Other objects and advantages will appear in the following description:

In the drawing attached hereto Figs. 1 to 5 are diagrammatic representations of molecular structure to which reference will be made in the specification.

Broadly, our invention relates to the production of a nitro-compound explosive from a basic mixture of nitro-compounds of the single benzene ring such as trinitrotoluene and/or its derivatives such as trinitrotoluene, picric acid, styrphic acid, 1.3.5 trinitro-2,4-dimethyl benzene with the addition of sufficient alkali, ammonium, or alkali earth nitrate to produce complete combustion. Other oxidizers may be used. In basic mixtures of the foregoing type, as is well known in the art, a very small amount of moisture, such as water, is present.

We have found that the foregoing basic explosive mixture is rendered highly explosive by the addition of a promoter or accelerating catalyst of specified molecular structure and a catalytic explosive such as the nitronaphthalenes or their derivatives, namely, α-monomononaphthalene, β-monomononaphthalene, (1.2) (1.3) (1.4) (1.5) (1.7) or (1.8)-dimononaphthalene, which sets off the basic explosive mixture at a rapid rate.

It is to be understood that the basic explosive mixture and the promoter and catalytic explosive are intimately mixed in our improved explosive.

If we find that the promoters or accelerating catalysts are very active and extremely efficient when they contain an essential atomic distance very closely approaching one of the essential atomic distances in the naphthalene compounds which is used as the catalytic explosive. These essential atomic distances are indicated by the dotted lines in Fig. 1 of the drawing and are according to modern X-ray investigations and calculated from the recently published results by Linus Pauling and M. L. Huggins (Zeitschrift für Kristallographie, vol. 57, page 205, 1934, published by Akademische Verlagsgesellschaft M. B. H., Leipzig) and from the findings of E. H. Westling published in Chemical News (London) July 17, 1931.

Referring to Fig. 1, the essential atomic distances in the naphthalene complex are:

<table>
<thead>
<tr>
<th>Distance</th>
<th>Angstrom units</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>3.83</td>
</tr>
<tr>
<td>b</td>
<td>4.19</td>
</tr>
<tr>
<td>c</td>
<td>4.54</td>
</tr>
<tr>
<td>d</td>
<td>5.19</td>
</tr>
</tbody>
</table>

We have found that such molecules as come near to the above distances in their essential atomic distance between the end atoms of their respective molecules, exclusive of hydrogen atoms, are very efficient promoters in a powder mixture containing nitro-derivatives of napthalene. Taking the carbon kernel as 0.9 angstrom units in thickness, we find from extensive experiments that all molecules having a molecular length falling between 3.73-3.93; 4.09-4.29; 4.74-4.94; and 5.03-5.23 angstrom units are extremely effective promoters in breaking the napthalene ring by collision.

For example, we have found that propionic acid or its alpha derivatives such as lactic acid, alanine, iso-butyric acid, a-chloropropionic acid, etc., or propanol or its alpha derivatives such as 1.1-dimethyl propanol, iso-butyl alcohol, etc., or its beta derivatives such as 2-methyl propanol, 2.2-dimethyl propanol, etc., or allyl alcohol and others, all have a distance within 0.9 angstrom units of being 3.83 angstrom units between their end atoms, and when any of these ingredients are added to a suitable explosive mixture containing nitronaphthalenes it produces a very good brute and great shattering power.

Similarly, we have found that 1.2-dichloroethane, ethylene chloride, and trans-dichloroethylene and others have atomic distances close to 4.19 angstrom units and act as good promoters in setting off a mixture containing nitronaphthalenes.

Butanol and its alpha derivatives such as 1-methyl butanol, 1.1-dimethyl butanol or beta derivatives such as 2-methyl butanol, 2.2-dimethyl butanol, or its gamma derivatives such as 3-methyl butanol, 3.3 dimethyl butanol, or its alpha and gamma derivatives such as 1.1.3.3-tetramethyl butanol or its alpha-beta-gamma derivatives such as 1.2.3-trimethyl butanol, or butyric acid or its alpha derivatives such as 1-hydroxy butyric acid, 1-methyl butyric acid, 1-amino butyric acid, or its beta derivatives such as 2-hydroxy butyric acid, 2-methyl butyric acid or butyric aldehyde or its alpha derivatives such as 1-methyl butyric aldehyde, or its beta derivatives such as 2-methyl butyric aldehyde propane-1,3-diol, glycerol, methoxyethanol, ethyl acetate, and methyl propionate, act as good promoters in setting off an explosive mixture containing nitronaphthalenes since they have atomic distances close to 4.84 angstrom units. The molecular length of butyric aldehyde is closest to 4.84 angstrom units, hence is the most effective of the compounds named.

Similarly, benzyl alcohol or its derivatives such as o-hydroxy benzyl alcohol, m-hydroxy benzyl alcohol, v-dihydroxy benzyl alcohol, o-methyl benzyl alcohol, m-methyl benzyl alcohol or benzaldehyde or its derivatives such as o-hydroxy
benzaldehyde, m-hydroxy benzaldehyde, v-di-
dimethyl benzaldehyde, or benzoic acid such as sal-
cyclic, m-hydroxy benzoic acid, o-methyl benzo-
cic acid, m-methyl benzoic acid, or p-hydroxy-
toluene, hydrochinone, quinone, nitrobenzene,
benzylamine, and anilines or the derivatives of any
of those above following and including p-hydroxy-
toluene come close to 5.13 in their molecular
lengths, hence are good promoters in an explosive
mixture containing nitronaphthalenes. Of the forego-
ing, benzoic acid has a slower braise than
benzaldehyde, their respective molecular lengths
being 5.18 and 5.11 angstrom units, which are
within the limits of the atomic distances which act
catalytically on the naphthalene complex.
We have tried many other substances, each ap-
proaching in its molecule one of the four essential
atomic distances 3.83; 4.19; 4.84; or 5.13 angstrom
units, and we find that the catalytic action will
best occur if the effective distance occurs only
at one place or direction in the molecule of the
promoter. Thus phthalic acid or phthalic alde-
hyde have the distance 5.18 or 5.11 in two direc-
tions, at an angle between the directions such that
the average distance becomes quite different to
5.18 or 5.11, the effective distance of benzoic acid
and therefore phthalic acid or phthalic aldehyde
is less efficient as a promoter than benzoic acid
or benzaldehyde, for the tendency of the molecules
to collide sideways prevents either of the useful
distance 5.18 in phthalic acid or either of the
useful distance 5.11 in phthalic aldehyde, to be
effective.
The reason for nitronaphthalene molecules to
decompose rapidly in the presence of a promoter is
the tendency of the naphthalene ring to break be-
tween the carbon atoms 1 and 2, and the carbon
atoms 4 and 5 as shown diagrammatically in
Figure 3 of the attached drawings (Figs. 2 to 5
inclusive showing the four possible ring frac-
tures). Of the four possibilities shown in Figs. 2 to 5,
inclusive, III and IV are identical and form a
benzole combination as well as a propyl radical F
according to the equation:
\[ \text{C}_6\text{H}_5\text{NO}_2 \rightarrow \text{C}_6\text{H}_4\text{C}'' \rightarrow \text{C}_6\text{H}_4\text{C}'' + \text{NO}_2' \]
where C6H4C" is the skeleton of benzaldehyde,
B, and C6H4C" an easily oxidized propionic residue
in the presence of either B or P the naphth-
aleine ring is broken into B and P, these decomposi-
tion products reacting again with the naphtha-
lene ring to produce B and P. As long as naph-
thalene containing the naphthalene ring is present,
this process will go on as a geometrically progressive
chain reaction of the type:
\[ B \lor P \]
and so on (as long as the naphthalene ring sys-
tem is present).
Some of the residues B will temporarily supply
a new molecule of benzaldehyde, thus acting as
additional promoter, while some of them, having
been newly formed, will be in active vibration and
oscillation and act as a disturbing and exciting
agency in the presence of nitrobenzene com-
products, such as trinitrotoluene, picric acid or tri-
nitrobenzene.

Therefore, a promoter containing the useful
atomic distance of about 3.83, 4.19, 4.84, or 5.13
angstrom units will first decompose the nitro-
naphthalene, then the residual compounds of
nitronaphthalene will partly act as catalysts to
the nitrobenzene compounds in the explosive
mixture, and will partly act as promoters in breaking
down more naphthalene rings and partly differentiate
themselves and aid in the explosion, thus behaving
as a catalytic explosive by taking an integral
part in the catalysis of the reaction as well as in
the combustion.
While both benzaldehyde residues and pro-
phonic residues are formed from the naphthalene
ring, and while also phthalic residues and
ethyl radicals may be formed in the splitting of
the ring, and while all these may act as catalysts
during the explosion, we find that for the initial
splitting of the naphthalene ring any compound
of the specified molecular length can act as a
promoter. In general, the relative amounts, by
weight, of the promoter we add to the nitro-
naphthalene may be from 0.2 to 4%.
The general formula (by weight) for our ex-
plosive mixture is thus:

\[ 0.005 \text{ to } 2\% \text{ promoter of approximate molecular length such as specified.} \]

\[ 5 \text{ to } 10\% \text{ catalytic explosive, such as nitro-
naphthalene derivatives.} \]

\[ 15 \text{ to } 55\% \text{ explosive, such as trinitrotoluene and its derivatives.} \]

\[ 40 \text{ to } 80\% \text{ oxidizer, such as the alkali nitrates which include ammonium nitrate.} \]

In making our explosive we first mix the or-
ganic substances by melting the nitronaphtha-
lene, incorporating the promoter and adding the
explosive, such as trinitrotoluene or its deriva-
tives. Into this mixture, while still in the molten
state, we incorporate the finely powdered nitrate
so that the granules of the latter are coated with
the organic explosive mixture. The mixture can
now be exploded by an ordinary detonating cap
or otherwise.
A typical formula for our explosive mixture is:

\[ \text{Alpha or beta-nitronaphthalene: } 7.5 \]

\[ 1.5\text{-dinitronaphthalene: } 0.4 \]

\[ \text{Normal butanol: } 0.1 \]

\[ \text{Trinitro benzene: } 33 \]

\[ \text{Sodium nitrates: } 59 \]

The above proportions are by weight, and the
resultant mixture will decompose completely and
produces only a white smoke and no nitrous gases.
Another good explosive mixture is:

\[ \text{Alpha-nitronaphthalene: } 7.15 \]

\[ 1.5\text{-dinitronaphthalene: } 48 \]

\[ \text{Proponic acid: } 0.8 \]

\[ 1.3\text{-trinitrotoluene: } 31.4 \]

\[ \text{Sodium nitrates: } 60.92 \]

This mixture explodes with a high brisance and
leaves on explosion a white smoke and no nitrous
gases.
A still further formula is:

\[ \text{Beta-nitronaphthalene: } 7.5 \]

\[ 1.5\text{-dinitronaphthalene: } 70 \]

\[ \text{Benzaldehyde: } 0.08 \]

\[ \text{Picric acid: } 33.12 \]

\[ \text{Sodium nitrates: } 58.8 \]

This mixture also explodes with a high brisance.
3. A nitro-compound explosive mixture including a nitro-derivative of naphthalene, an oxidizer, and an organic promoter in an amount not greater than 2% by weight of the entire mixture, said promoter being one in which the atomic distance between the opposite end atoms most remote from each other in each molecule therein exclusive of hydrogen is within .09 angstrom units of being equal to one of the four characteristic atomic distances of the naphthalene ring complex, namely 3.83; 4.19; 4.84; 5.13 angstrom units.

4. A nitro-compound explosive mixture including a nitro-derivative of naphthalene, an oxidizer, and a promoter, said promoter being benzaldehyde in an amount not greater than 2% by weight of the entire mixture.

5. A nitro-compound explosive mixture including a nitro-derivative of naphthalene, an oxidizer, and a promoter, said promoter being butanol in an amount not greater than 2% by weight of the entire mixture.

6. A nitro-compound explosive mixture including a nitro-derivative of naphthalene, an oxidizer, and a promoter, said promoter being propionic acid in an amount not greater than 2% by weight of the entire mixture.

7. A nitro-compound explosive mixture including a nitro-derivative of naphthalene, an oxidizer, and an organic promoter, said promoter being one of the compounds of a group in which the atomic distance between the opposite end atoms in each molecule therein measured in the direction of the greatest length of the molecule, exclusive of hydrogen, is within .09 angstrom units of being equal to one of the four characteristic atomic distances of the naphthalene ring complex, namely 3.83; 4.19; 4.84; 5.13 angstrom units.

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