This invention relates to shaped explosive charges and more particularly to new and improved shaped explosive charge devices which are capable of producing in hard materials greatly improved cracking or breaking effects which in certain cases may occur after perforation has taken place.

This application is a continuation of application Serial No. 614,395, filed October 8, 1956.

In petroleum technology, shaped explosive charge devices are frequently employed to perforate well casing and any surrounding body of cement and formation material in order to bring a well into production. While the perforating jets from such devices do penetrate the casing effectively and produce cracks in any surrounding cement, sometimes such cracking of the cement is only partially effective so that the thoroughflow of fluid from any oil containing stratum behind the cement through the cracks and perforations is relatively small.

Shaped charge devices of this general character have also not been found entirely satisfactory for breaking up large blocks of rock in quarries or the like, since the number of fragments produced is often very small. It is an object of the invention, accordingly, to provide new and improved shaped explosive charge devices of the above character which are capable of producing increased cracking and breaking effects.

Another object of the invention is to provide new and improved shaped explosive charge devices of the above character which, in well casing perforating operations, provide for the cleaning of the perforations which otherwise might be completely or partially plugged up with foreign matter of one kind or another.

To this end, the invention consists in providing between the actual explosive charge and the cavity which characterizes the shaped or hollow charge a substance or a mixture of substances which is adapted to produce a highly exothermic chemical reaction under the action of the explosion. The chemical reaction may result from the interaction between the ingredients of the substance or mixture of substances, or it may involve said ingredients and the products of the explosion or even the components of the target. While the reaction should be of a highly exothermic character, it should not be explosive; in fact, it should have a speed of propagation which is substantially lower than the speed of detonation of the explosive forming the actual charge.

In practice, this result may be obtained by coating the usual charge liner, whether of metal or otherwise, which generally separates the explosive from the free space in the cavity of the charge with a layer of such a substance or mixture of substances. This layer may be disposed either over the whole surface of the liner, or only on part of the surface in the shape of a ring or separated elements, for example.

The active substance may furthermore be arranged either on the outer surface of the liner or on the surface thereof facing the explosive, or again on both surfaces. Alternatively, the charge liner may be made out of a substance or mixture of substances having the properties defined hereinafore.

It has been found that shaped explosive charge devices constructed according to the invention have a much higher breaking action than that of conventional hollow charges. This action affects the material which has been previously perforated by the charge by reason of the fact that the exothermic reaction progresses only inside the mass of material which is to be cracked. Such cracking and breaking effects are not obtained when conventional shaped charge devices are used.

As mentioned hereinafore, the invention is applicable in particular to shaped explosive charge devices which serve for perforating the casing lining the side wall of a well together with any cement lying behind said casing, said devices being used at the level of the oil carrying strata for the purpose of bringing the well into production. With conventional shaped charges, the perforating jet generally perforates the casing and the surrounding cement fairly effectively but the cracks obtained in the cement are generally insufficient and consequently the fluid lying inside the oil containing strata behind the cement can flow through the cracks and perforations only with a very small throughput.

With shaped charges according to the invention, it is possible to produce in the cement masses and in the adjacent strata of the ground, large cracks which remain open as mentioned hereinafore and through which the fluid may flow out until it reaches the perforations in the casing. This obviously increases to a considerable extent the throughput of fluid passing out of said perforations.

In the case of block breaking charges, these improved shaped charges enable large blocks to be broken into a great number of fragments, whereas the conventional shaped charges produce a very small number of fragments.

Among the substances or mixtures of substances which may be used to produce the desired reactions, may be mentioned more particularly titanium alone, or any other metal forming part of the titanium group, such as zirconium, hafnium, thorium, etc., or a mixture or alloy of such metals.

Any of the following mixtures may also be used.

\[ \text{Ti} + \text{C} \]

\[ \text{Ca} + \text{Si} \]

\[ 8 \text{Al} + 3 \text{KClO}_4 \]

\[ 3 \text{PbO}_2 + 4 \text{Al} \]

Various embodiments of the invention have been shown diagrammatically on the accompanying drawings.

FIG. 1 is a view in longitudinal section of a shaped charge according to a first embodiment of the invention.

FIGS. 2, 3, 4, 5 and 6, are similar views of other embodiments of shaped explosive charge devices according to the invention;

FIG. 7 is a view in longitudinal section of a casing perforating device in which any of the charges shown in FIGS. 1–6, inclusive, may be employed; and

FIG. 8 is a view in longitudinal section of another embodiment of the invention.

In FIG. 1, 1 denotes the casing of a shaped explosive charge device in which is formed a chamber containing an explosive charge 2 which is adapted to be detonated by a detonating device of any suitable type 3 set, for instance, at the rear of the charge. Formed in the explosive charge 2 in a conical cavity 4 provided with a liner 5, which, according to the invention, is made of titanium, for instance, or of any other substance capable of creating a highly exothermic reaction upon detonation of the charge.

In the embodiment of FIG. 2, the conical liner 5 is made of copper or of any other "neutral" substance, but
3 this liner has a coating 6 on its outer surface of a sub-
stance capable of creating an exothermic reaction of the
type hereinabove indicated, the thickness of said coating
(titanium, for instance) being approximately 1 mm.
The charge shown in FIG. 3 differs from that shown
in FIG. 2 only in that the coating 6 intended to create
the exothermic reaction is disposed behind the liner 5.
The device shown in FIG. 4 is the same as that of FIG.
2, but with the difference that the coating 7 is not laid
down over the whole surface of the liner 5 but is in the
form of a jacketed cone ring.
In FIG. 5, a corresponding ring 7' is set behind the
liner 5.
Lastly, in FIG. 6, the ring of FIG. 4 is replaced by
discrete portions 13 evenly distributed over the surface
of the liner.
All of the shaped charge devices shown in the figures
described above can be used either directly as block
breakers or for perforating the casing lining the inner
wall of an oil well.
FIG. 7 shows a charge of one of the hereinabove types
shown in FIGS. 1–6, inclusive, embodied in casing per-
forating jet 14.
In FIG. 7, 8 denotes a cylindrical hollow extended
body which is adapted to house a stack of longitudinally
spaced apart shaped explosive charge devices (only one
of which is shown in the figure) for perforating the cas-
ing 9 lining the inner wall of an oil well, together with
any body of cement lying between the casing and the
well wall. 1 denotes the shaped charge case; 3 a de-
notating device comprising a length of primacord which
is in detonating relation to all the charges in the appa-
ratus; 2 the explosive charge; and 5 the liner set in the
forward cavity of the charge. The whole shaped charge
assembly is introduced laterally through an opening in
the forward wall of the cylinder 8 and is retained in
place by a plug 10 screwed in the said opening, the case
bearing on the front edge of the opening on the one
hand, and in the recess 11 formed in the rear wall of
the cylinder 8 on the other hand. The plug 10 is intended
to be perforated in its center by the jet.

According to the invention, the liner 5 is made either
of a material creating an exothermic reaction or of a
neutral material coated entirely or partly with a substance
having these properties, as in FIGS. 1–6, inclusive.

Experiments have shown that the use of such a shaped
charge in this particular case not only enables a better
splitting of the cement and of the geologic strata lying
behind the tubing 9 to be obtained, but also acts to clean
out the perforations which otherwise might fill up with
foreign matter of one kind or another. By keeping the
perforations clean and free of foreign matter in this man-
ner, the throughput of the fluid from the formations is,
of course, increased.

The embodiment of FIG. 8 comprises a device having
one of the shaped explosive charges shown in FIGS. 1–6,
inclusive, assembled in a well known manner into a hous-
ing 1 provided with a tightly-fitting stopper 12. In this
embodiment, the assembly constitutes a complete unit
which is pressure-resistant and capable of being freely
lowered down a bore hole without being placed inside
a housing, such as the housing 8 in FIG. 7. If desired,
a plurality of devices as in FIG. 8 may be suspended in
a well-known manner one above the other inside the bore
hole. Also, devices of this type can, without modifi-
cation, be used as block breakers.

It is obvious that the specific embodiments described
above are susceptible of modification in form and detail
within the spirit of the invention. Therefore, the latter
is not to be limited to the exemplary devices herein dis-
closed, but comprehends all variations thereof falling
within the scope of the following claims.

I claim:
1. A shaped explosive charge device for perforating
formation materials and cracking such materials or clean-
ing the resulting perforation comprising an explosive
charge having a hollow cavity formed in the front part
thereof, a liner for the entirety of said cavity disposed
in contact with said explosive charge, said liner having
a substantially uniform wall thickness and being com-
posed substantially entirely of a reactive metal and co-
operating with said explosive charge for forming a per-
forating jet which can penetrate said formation materials,
said reactive metal being capable of producing a highly
exothermic reaction in the penetrated formation materials
and capable of exerting cracking forces therein, the reac-
tion of said reactive metal having a rate of propagation
which is lower than the rate of detonation of said explo-
sive charge, said cavity being otherwise free of any mass.
2. A shaped explosive charge device for perforating
earth formations and cracking such earth formations
adjacent a well bore or cleaning the resulting perforation
comprising an explosive charge having a hollow cavity
formed in the front part thereof, a liner for the entirety
of said cavity disposed in contact with said explosive
charge, said liner being composed substantially entirely
of a reactive metal and cooperating with said explosive
charge for forming a perforating jet which can penetrate
said formation materials, said reactive metal being capable
of producing a highly exothermic reaction in the penetra-
ted formation and capable of exerting cracking forces ther-
in, the reaction of said reactive metal having a rate of
propagation which is slower than the rate of detonation
of said explosive charge, said cavity being otherwise free
of any mass.
3. A shaped explosive charge device for perforating
formation materials and cracking such materials or clean-
ing the resulting perforation comprising an explosive
charge having a generally hollow cavity formed in the
front part thereof, a liner for said entire cavity in con-
tact with said explosive charge and capable of collapsing
upon detonation of said charge to form a fluid jet, said
liner being composed substantially entirely of a metal of
the group consisting of titanium, zirconium, hafnium,
thorium and mixtures thereof and being capable of pro-
ducing, a highly exothermic reaction in the penetrated
formation materials and capable of exerting cracking
forces therein, the reaction of said metal liner having a
rate of propagation which is slower than the rate of deto-
nation of said explosive charge, said cavity being other-
wise free of any mass.
4. A only a shaped explosive charge device for perforating
formation materials and cracking such materials or clean-
ing the resulting perforation comprising an explosive
charge having a generally hollow cavity formed in the
front part thereof, a liner for said entire cavity in con-
tact with said explosive charge and capable of collapsing
upon detonation of said charge to form a fluid jet, said
liner being composed substantially entirely of titanium
and being capable of producing, a highly exothermic
reaction in the penetrated formation materials and capa-
bile of exerting cracking forces therein, the reaction of said
metal liner having a rate of propagation which is slower
than the rate of detonation of said explosive charge,
said cavity being otherwise free of any mass.
5. A shaped explosive charge device for perforating
formation materials and cracking such materials or clean-
ing the resulting perforation comprising an explosive
charge having a generally hollow cavity formed in the
front part thereof, a liner for said entire cavity in con-
tact with said explosive charge and capable of collapsing
upon detonation of said charge to form a fluid jet, said
liner being composed substantially entirely of thorium
and being capable of producing, a highly exothermic
reaction in the penetrated formation materials and capa-
bile of exerting cracking forces therein, the reaction hav-
ing a rate of propagation which is slower than the rate
of detonation of said explosive charge, said cavity being
otherwise free of any mass.
6. A shaped explosive charge device for perforating formation materials and cracking such materials or cleaning the resulting perforation comprising an explosive charge having a generally conical cavity formed in the front part thereof, a liner for said entire charge in contact with said explosive charge and capable of collapsing upon detonation of said charge to form a fluid jet, said liner being composed substantially entirely of titanium and being capable of producing, when ignited, a highly exothermic reaction having a rate of propagation which is slower than the rate of detonation of said explosive charge to exert cracking forces in said mass of material when the mass of material is penetrated, said cavity being otherwise free of any mass.

7. The method of penetrating earth formations surrounding a well bore by means of a shaped explosive charge including the steps of providing a liner for said charge comprising at least in substantial part of a reactive metal capable of producing when activated, a highly exothermic reaction, detonating said charge to produce a perforation in said formation and carry the reactive metal of said liner into the perforation for activation therein, activating said reactive metal in said perforation to create pressure forces in the formation masses surrounding the perforation effective to crack the masses and maintain the perforation substantially free of debris.

9. The method of penetrating earth formations surrounding a well bore by means of a shaped explosive charge comprising at least in substantial part of titanium capable of producing when activated, a highly exothermic reaction, detonating said charge to produce a perforation in said formation and carry the titanium of said liner into the perforation for activation therein, activating said titanium in said perforation to create pressure forces in the formation masses surrounding the perforation effective to crack the masses and maintain the perforation substantially free of debris.

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