Jan. 3, 1961 G. B. KISTIAKOWSKY ET AL 2,966,822

EXPLOSIVE STREAMER

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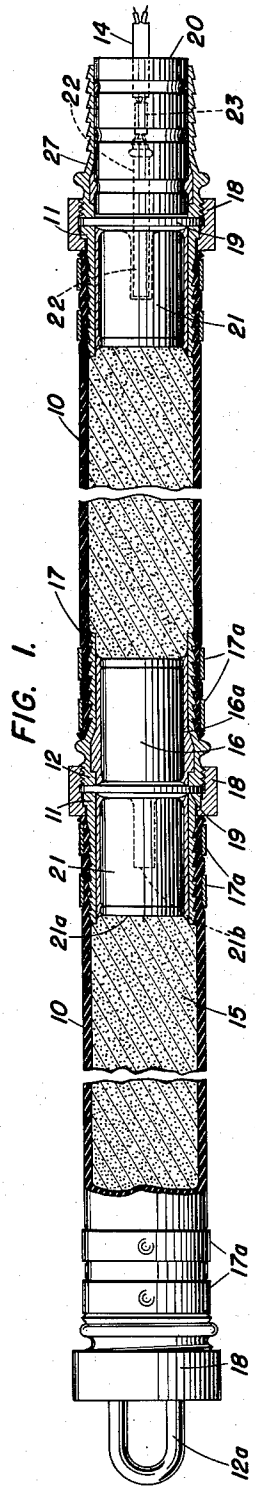


FIG. 1.

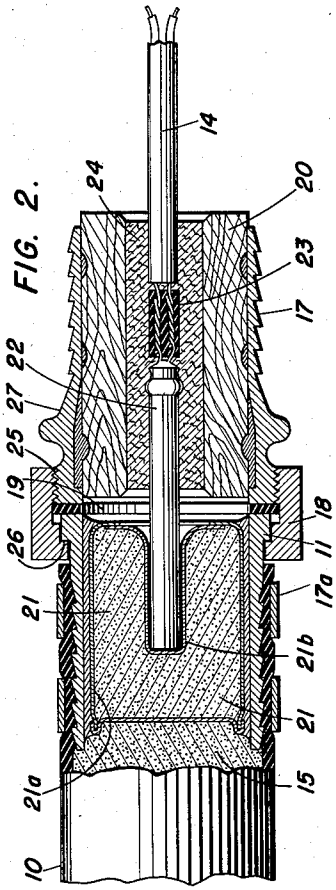


FIG. 2.

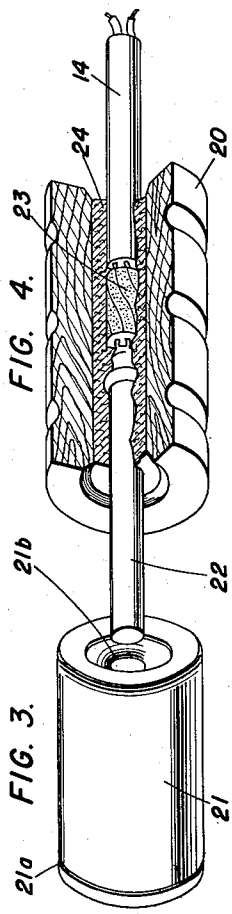


FIG. 4.

FIG. 3.

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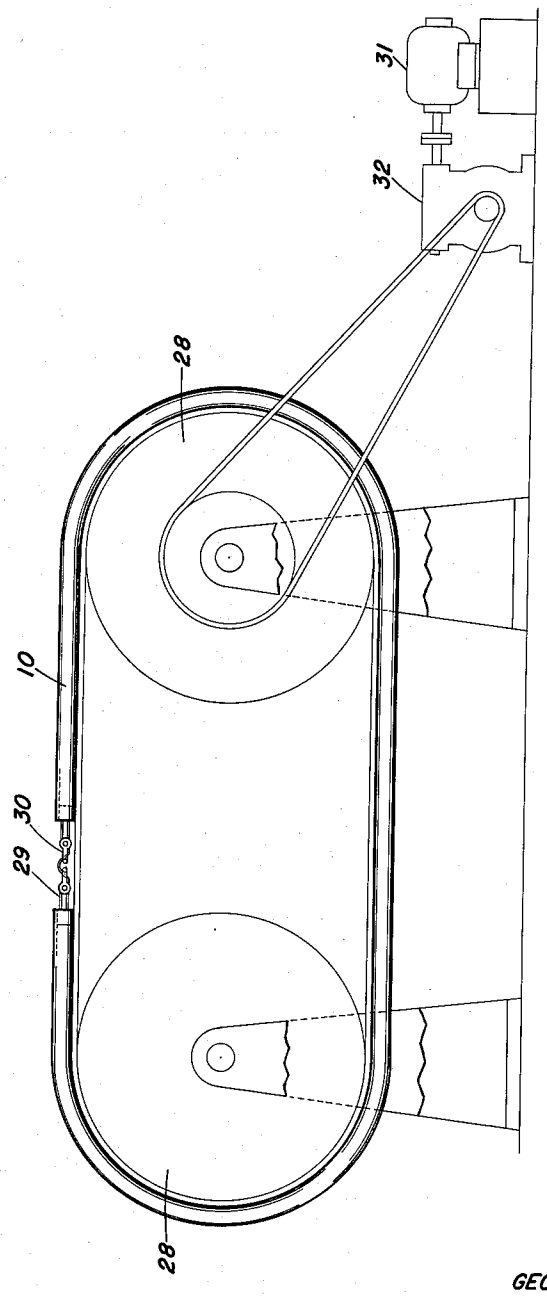


FIG. 5

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EXPLOSIVE STREAMER

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9 Claims. (Cl. 86—1)

This invention relates to explosive devices, explosives and methods of making the same and has particular relation to a process of making a flexible explosive which has particular use in a flexible explosive streamer.

Flexible explosive streamers may be employed in a variety of applications and they are particularly suited for use as the explosive component of an anti-torpedo system and as a demolition device for blasting and the like. One example of an anti-torpedo system in which the flexible explosive streamer of the present invention may be used as the explosive component is disclosed in co-pending application of Nelson N. Estes, Serial Number 517,201, of January 6, 1944, in which a plurality of explosive streamers are maintained within the water at a predetermined depth of submergence, and in spaced parallelism with respect to each other and to the towing vessel by means of a faired towing cable; the streamers being adapted to be fired in succession as successive torpedoes approach the vessel.

Explosive streamers heretofore have generally comprised a rubber hose or rubber covered fabric hose which is filled with a number of cans or other containers of explosives arranged at intervals along the length of the hose and maintained in position by means of a flexible supporting member placed between adjacent cans. The explosive train is maintained by means of primer fuzes connected between adjacent cans. Thus, it will be seen that the flexibility of explosive streamers of this type is due to the positioning of a plurality of containers of explosives within the streamer hose. Another type of flexible explosive streamer heretofore proposed utilizes as the explosive charge a flexible section, such as a cloth sack, packed with the explosive in powdered form. Such a construction is shown in co-pending application of Dickson S. McKinney et al., Serial Number 535,560, filed May 13, 1944.

The prior explosive streamers referred to above have the disadvantage that they are unable to contain a maximum volume of explosive charge per internal volume of the streamer hose when the explosive charge is confined in one or more containers. They have the further disadvantage that the rigidity of the streamer hose is not consistent throughout the length of the hose, thereby resulting in weakened portions of the hose which are easily collapsed. Another disadvantage of these explosive streamers is that they are difficult and cumbersome to load with known explosive charges.

In accordance with the present invention, it has been found that a flexible streamer hose or other container may be filled with molten, liquid explosive, such as trinitrotoluene, and that while the liquid explosive is cooling and solidifying in the container, it may be simultaneously subjected to a flexing operation thereby resulting in a flexible charge of fine-grained, solid explosive. It has been found that the explosive resulting from this flexing process is in the form of a flexible body of fine crystalline powder of rather uniform particle size having a density of about 1.4 grams per cubic centimeter.

An object of the present invention is to provide a process of forming a molten, liquid explosive directly into a solid explosive body which is in the form of a fine crystalline powder of rather uniform particle size.

Another object of the invention is to provide a method of loading a flexible streamer hose or other flexible container with an initial charge of molten, liquid explosive to form a solid, flexible explosive of granular structure.

Still another object of the invention is to provide a flexible explosive streamer which may be initially loaded with molten, liquid explosive.

A further object of the invention is to provide a flexible explosive streamer which will propagate detonation without fail, particularly when submerged under water in lengths up to 400 feet or more.

A still further object of the invention is to provide a flexible explosive streamer which is adapted for underwater use as an anti-torpedo device and as a demolition device, and is also adapted for above ground use and underground use as a demolition device.

Another object of the invention is to provide a flexible explosive streamer which will propagate detonation without fail when submerged or exposed in lengths up to 400 feet or more and yet be sufficiently insensitive to withstand rifle fire, rough handling and counter-mining without detonation; particularly, when exposed to underwater counter-mining by means of the explosion of a similar explosive streamer positioned parallel thereto at a distance of from 20 to 30 feet.

Another object is to provide a method of forming a fine-grained solid explosive composition of high density by solidifying a cooling body of a molten, liquid explosive while simultaneously subjecting the body of explosive to a flexing operation.

Another object is to provide a flexible streamer hose filled with a fine-grained explosive charge having a specific gravity of about 1.4 grams per cubic centimeter.

These and other objects of the invention will be better understood by reference to the accompanying description and drawing, in which:

Fig. 1 is a central longitudinal view of a pair of explosive streamer units connected in a streamer assembly, with the conductor cable and the male coupling assembly shown in elevation;

Fig. 2 is an enlarged sectional view of the coupling assembly at the right hand terminal shown in Fig. 1;

Fig. 3 is a perspective view of the booster shown in Fig. 2;

Fig. 4 is a perspective view, partly in section, of the terminal portion of the female coupling assembly shown in Fig. 2; and

Fig. 5 is a side elevation of a machine for subjecting the streamer hose to a flexing operation.

In a preferred embodiment of the invention, as shown in the drawing, the flexible explosive streamer comprises a streamer hose 10 made of rubber or rubber covered fabric, varying in internal diameter from about 1 to 6 inches or more, depending upon the type of demolition to be accomplished. In practice it has been found convenient to employ hose units of two inch inner diameter, single-ply, rubber hose of 25 feet in length; a number of these hose units being connected by means of coupling assemblies to form a continuous streamer which may be 400 feet or more in length, if desired. The flexible explosive charge 15, which fills the streamer hose 10, consists of a fine-grained, granular explosive formed by filling the hose with a molten, liquid explosive and flexing it during cooling and solidification of the explosive, which process is hereinafter fully described.

Each end of a hose unit has attached to it a coupling member, such as 11 and 12, which, when joined in

connecting several lengths of hose together, form a quick detachable union, as shown in Figs. 1 and 2. Each coupling member comprises a shell having a serrated or ridged outer surface **17** that is positioned within the hose and is held therein by bands **17***a* clamping the hose firmly against the ridges. The member **12** is provided with exterior screw-threads **25** at its outer end to receive a coupling nut **18**, which is held to the member **11** by a shoulder **26** to secure the two coupling members together. A washer **19** is interposed between the coupled members to provide a tight seal therebetween.

The coupling member **11** is provided with a booster **21**, preferably loaded with granular trinitrotoluene tetryl (trinitrophenyl-methyl-nitramine), pentaerythritol tetranitrate, or mixtures thereof, in a suitable can **21***a* which is sealed therein with a sealing compound such as a mixture of glycerine and litharge. The can is provided with a central longitudinal bore **21***b* extending inwardly from its outer end. The purpose of this bore is to receive an igniting electrode as will be explained hereinafter. The coupling member **12** is likewise provided with a can **16***a* of a similar booster charge **16**, which, when the two coupling members are joined, ignites the booster charge **21**.

If only one unit of hose is used, or if several are connected to form a streamer, the coupling **11** at the extremity of the line has attached to it a coupling member **27** similar to the one described above.

However, the booster **16** is replaced by a wood bushing **20**, Fig. 2, having a center hole in which is positioned an electrical blasting cap **22** which terminates at its inner end in the hollow center hole **21***b* of the booster **21**. The terminals of the blasting cap are connected to the conductor cable **14**, leading to a source of electrical current (not shown), by means of the splicer connection **23**, the splicer connection being sealed within the wood bushing by means of a suitable sealing compound **24**. The other end of the streamer is closed by a plate to which a tow fitting **12***a* is attached and which is held in place by a coupling nut **18**.

When used as a demolition device, the flexible explosive streamer may be laid adjacent to or wrapped around the object to be demolished; detonation being accomplished by electrically igniting the blasting cap. The flexible explosive streamer may also be used to form a ditch or channel either on the ground, underground or underwater.

In practicing the process of the present invention, the explosive, preferably trinitrotoluene, is heated in a melting kettle to a temperature of about 85° C. A 25 foot length of conventional 2 inch, single-ply, rubber hose is plugged at one end with a rubber plug. The empty hose is positioned in a steam tube, preferably a steam jacketed tube which is under 5 pounds steam pressure, the empty hose being heated for about 15 minutes before loading thereof. The empty hose is filled with molten, liquid trinitrotoluene at a temperature of 85° C. and the loaded hose is allowed to remain in the steam tube for about 5 minutes in order to insure that both the liquid explosive and the streamer hose are at a constant temperature, preferably about 85° C. The hose loaded with molten, liquid explosive is immediately subjected to a flexing operation. In a preferred embodiment, the flexing operation is effected by passing the streamer hose over the surface of a plurality of rotating bodies, such as wheels, barrels or pulleys. One type of flexing means which has been found advantageous comprises two pulleys **28** having a diameter of about 4 feet which are mounted with their horizontal shafts parallel and positioned about 6 to 7 feet apart. The streamer hose is mounted on the two pulleys in the form of a continuous belt; that is, the ends of the streamer hose are attached by means of a belt having eye bolts **29** and shackle bolts **30**, that are connected to tow fittings **12***a* at the ends of the hose. The pulleys are set in rotation by an electric motor **31** through a reduction drive **32** and as they rotate, each section of the streamer hose is periodically bent in passing the surface of the pulleys and is then stretched straight during its traverse between the pulleys. The rotation of the pulleys is adjusted so that the streamer hose makes 15 complete circuits of the pulleys per minute, and in this manner the hose is flexed 30 times per minute. The flexing operation is continued for about 1 hour and 45 minutes when the pulleys are operated at 30 revolutions per minute.

Thus, the term "flexing operation" is intended to define an alternate bending and straightening of a flexible body, the word "flexible" being synonomous with the term "non-rigid." During the flexing operation, which is preferably conducted in an air medium at room temperatures, the molten, liquid explosive is undergoing cooling and gradual solidification is taking place. If the molten, liquid explosive were permitted to cool and solidify in the hose without being subjected to the flexing operation, a solid cast body of explosive would be formed. However, the explosive resulting from this flexing operation is in the form of a fine, crystalline powder of uniform particle size, the mass of which is flexible and has a density of about 1.4 grams per cubic centimeter.

The consistency of the finished explosive is partially determined by the size and design of the hose used. Thus, commercial water hose having an inner diameter of 1½ inches and an outer diameter of 2 inches, when loaded with flexed trinitrotoluene, can be bent by hand to form a circle 2 feet in diameter. The consistency of the finished explosive is also partially determined by the type of flexing means employed. It has been found that by filling a length of hose with molten, liquid trinitrotoluene and flexing this hose by hand while the trinitrotoluene is cooling, that a flexible charge of fine-grained trinitrotoluene is obtained. In an alternate flexing operation, the hose may be wrapped on a wide, continuous belt maintained in an elliptical shape by a series of rollers pressing against its inside surface and held by brackets in a central shaft. As the shaft is set in motion, the belt is prevented from following the rollers by a suitable braking device, each portion of the belt with the hose wrapped thereon being subjected to periodic changes of its radius of curvature. Thus the hose may be flexed in a continuous, gentle fashion. In still another application of the flexing operation, the hose loaded with molten trinitrotoluene is caused to move in a sinusoidal type of motion. The finished explosive resulting from this operation is uniformly satisfactory except at the ends of the hose which are found to contain plugs of solid, cast explosive, due to the fact that sinusoidal motion cannot be readily carried to the terminal ends of the hose.

While the present invention has been described with particular reference to trinitrotoluene, it will be understood that mixtures of other explosives such as tetryl, cyclorite or, pentaerythritol tetranitrate with trinitrotoluene, such as a mixture of tetryl and trinitrotoluene may be employed. It will be further understood that while a streamer hose has been described, other suitable flexible containers may be utilized. It will be further understood that the flexing operation may be performed by a variety of flexing means and is not limited to the particular flexing means disclosed herein. It will be further understood that while air at room temperatures has been employed as a cooling medium, alternate cooling means such as water immersion, water spray, or air draft may be employed.

We claim:

1. A process of forming a fine-grained, flexible explosive body which comprises introducing a molten, liquid explosive material into a flexible container and thereafter cooling and solidifying the liquid explosive while simultaneously subjecting said container and explosive to a flexing operation.

2. The process set forth in claim 1 in which the ex-

plosive material comprises a major portion of trinitrotoluene.

3. The process as set forth in claim 2 in which the molten, liquid trinitrotoluene is introduced into the container at a temperature of about 85 degrees centigrade, and in which the cooling and solidification are accomplished at room temperatures.

4. A process of forming a flexible explosive streamer which comprises introducing a molten, liquid explosive material into a flexible tubing and thereafter cooling and solidifying the explosive material while simultaneously subjecting the tubing and the explosive material contained therein to a flexing operation.

5. The process as set forth in claim 4 in which the explosive material comprises a major portion of trinitrotoluene.

6. The process as set forth in claim 5 in which the molten trinitrotoluene is initially introduced into the flexible tubing at a temperature of about 85 degrees centigrade and is thereafter cooled and solidified at room temperatures.

7. A process of forming a flexible, explosive streamer which comprises heating a flexible tubing, introducing a liquid, molten explosive material into said tubing, and

thereafter cooling said tubing and explosive material while simultaneously subjecting said tubing and explosive material to a flexing operation whereby the explosive material is solidified in the form of a compact, fine-grained material.

8. The process as set forth in claim 7 wherein the flexing operation comprises alternately bending and straightening the flexible tubing.

9. The process as set forth in claim 7 wherein the flexing operation comprises passing the flexible tubing over a plurality of rotating bodies.

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