Feb. 2, 1960 D. J. ANDREW ET AL 2,923,239

IGNITION TRANSMISSION LINE AND SYSTEMS INCLUDING THE SAME

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Fig 1

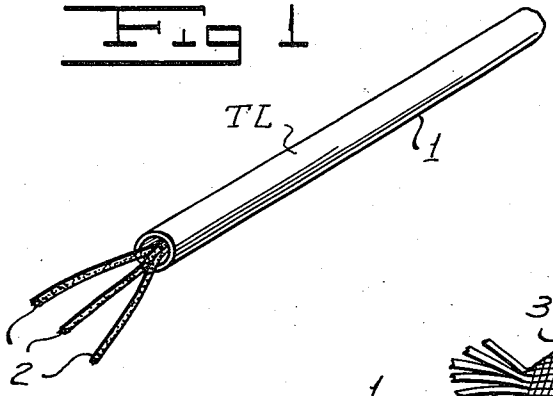



Fig 2

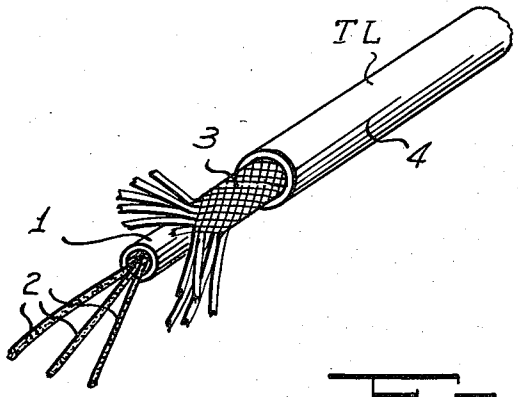



Fig 1A

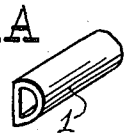



Fig 3

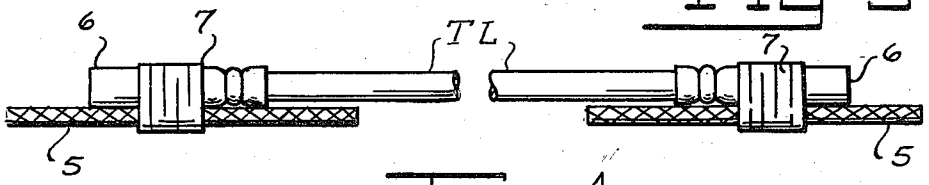



Fig 4

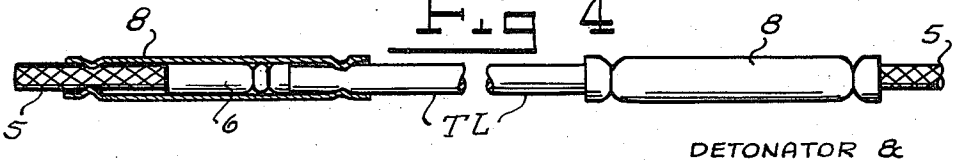
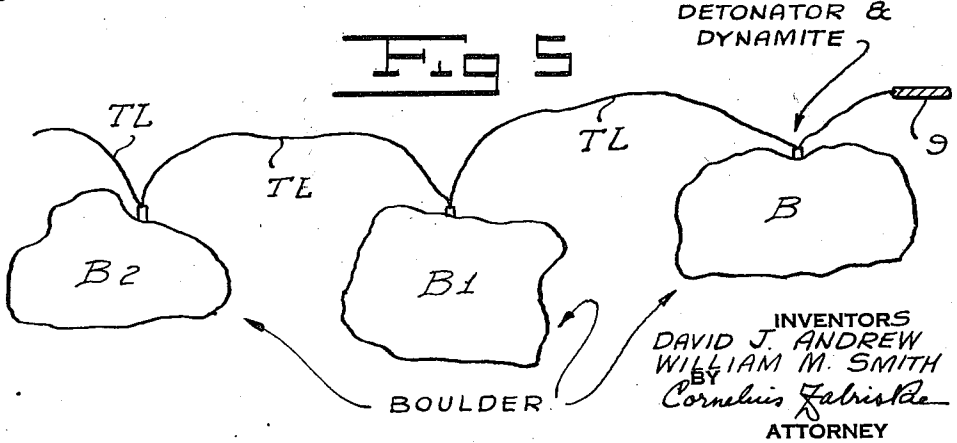



Fig 5



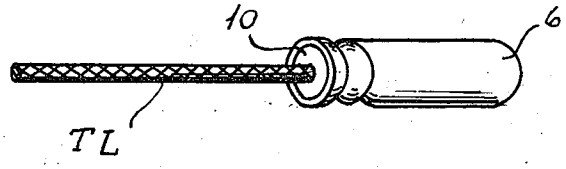

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# IGNITION TRANSMISSION LINE AND SYSTEMS INCLUDING THE SAME

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Fig 6



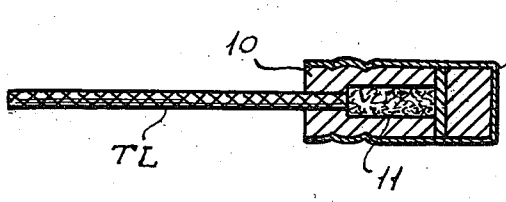




Fig 7

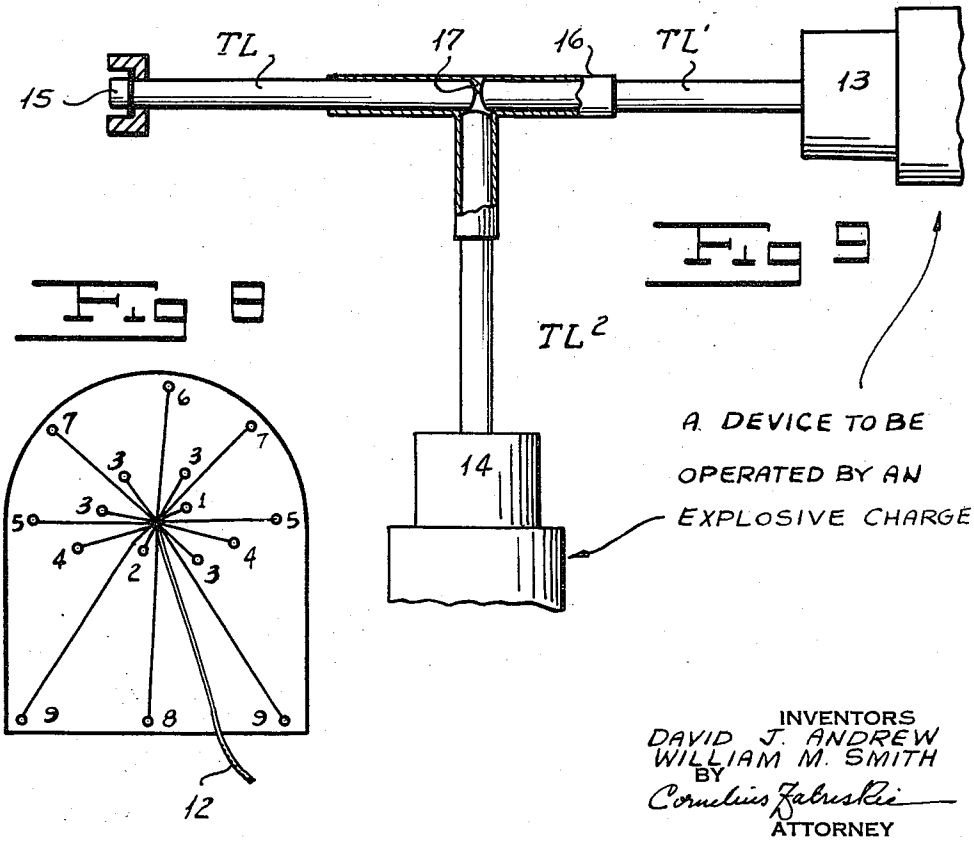



Fig 9

Fig 8




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United States Patent Office 2,923,239 Patented Feb. 2, 1960



2,923,239

# IGNITION TRANSMISSION LINE AND SYSTEMS INCLUDING THE SAME

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Application July 26, 1957, Serial No. 674,323

1 Claim. (Cl. 102—27)

This invention is an ignition transmission line adapted for use in systems, examples of which are hereinafter described, for initiating or igniting explosives. In carrying out its functions, the ignition transmission line of this invention may be used in blasting or for remotely actuated devices.

In the explosives art the most common systems employed are those used in connection with blasting, such, for example, as in quarries, excavations, mining, ditching, and the like. For these uses, fuses are commonly employed. These are generally of two types, namely, detonating fuse and safety fuse.

Detonating fuse of commerce has a core of high explosives, tightly enclosed in textile wrappings and waterproofing coatings. It is an explosive fuse and is used to connect a number of explosive charges and initiate the charges so connected. It requires a blasting cap or detonator for its initiation. Once initiated, it propagates at a rate of from 15,000 to 25,000 feet per second.

Safety fuse is a fuse by which a flame is conveyed at a uniform and continuous rate for the direct firing of an explosive charge, such, e.g., as the ignition of black powder, or the indirect firing to ignite a blasting cap to detonate dynamite. Safety fuse consists of a train of black powder tightly wrapped and enclosed in various coverings of textiles and waterproofing materials. It is ignited by a flame and burns at a relatively slow rate, usually in the range of 90–200 seconds per yard.

Detonating fuse propagates at a rate too fast to provide adequate delay between drill holes of a blast, to effect relief of burden and maximum results at minimum ground vibration. Safety fuse burns so slowly that it is unsuited for many types of blasts.

Various devices have been used to supply intermediate speeds of propagation. These devices, in every case of which we are aware, comprise cartridges of one form or another which are manufactured in a few standard sizes and are of a relatively limited scope of operation to which the blaster is confined. Generally referred to as delayed timers, they are relatively expensive devices and constitute, in effect, adjuncts or accessories to a blasting system. An example of such device is shown in Patent No. 2,475,875, issued July 12, 1949, to E. I. du Pont de Nemours, as assignee of Lawton A. Burrows et al. In spite of their limited scope, delayed timers of this general character are the best heretofore known for use where delayed firing is required, and, even with the best of these, a definite time lag is impossible of accomplishment. Moreover, because of their tendency to fail in operation, such devices have been commonly employed in parallel in a system, generally in a second detonating fuse trunk line, so that, if one does not operate properly, another probably will.

With the foregoing considerations in mind, the object of the present invention is to provide a fuse-like ignition transmission line which will overcome all the objections heretofore inherent in delay timers of the prior art and will permit the blasting foreman or other operator to



control, within wide limits, delay between "shots" and thereby permit the choice of indefinite ranges with a high degree of accuracy and at relatively little expense as compared with prior practice.

The ignition transmission line of this invention comprises, fundamentally, a plurality of fiber strands, preferably of cotton yarn, with an appropriate combustible composition. It may conveniently be black powder. This powder is usually in finely divided form and is admixed with a lacquer or other appropriate bonding agent. The strands, carrying the combustible composition may, for convenience, be referred to as the core. This core is enclosed within an envelope of any suitable organic plastic, such, for example, as polyethylene.

According to the present invention, the plastic envelope must be of tubular formation, circumferentially closed throughout its entire periphery, and it must loosely embrace the core to provide, about the core, a conduit through which the combustion flame may course as the combustion propagates.

A core of the character described, loosely enclosed within an envelope of the kind stated constitutes the fundamental structure of this invention and may be used as such in numerous environments and for various purposes. However, for other purposes and uses, the fundamental structure is externally reinforced as, for example, by enclosing such structure within one or more additional envelopes hereinafter more fully described, but intended primarily to confine the effects of the burning in order to get increased pressure and high burning rate and at the same time obtain a more uniform speed of burning throughout the line. The reinforcing envelopes also minimize side effects.

In addition to the ignition transmission line of this invention, the invention also includes systems employing the same, to carry out various operations hereinafter more fully described, and with respect to which, the present invention has outstanding utility.

Features of the invention, other than those adverted to, will be apparent from the hereinafter detailed description and appended claims when read in conjunction with the accompanying drawings.

The accompanying drawings illustrate different practical embodiments of the invention, but the constructions therein shown are to be understood as illustrative, only, and not as defining the limits of the invention.

Fig. 1 is a perspective view showing one end portion of the ignition transmission line of this invention with the core extended beyond one end thereof, in the interest of clearness.

Fig. 1A shows the same fundamental structure as illustrated in Fig. 1, but with the tubular envelope of D-shape or semi-circular cross section.

Fig. 2 is a view similar to Fig. 1, but illustrates the structure of Fig. 1, enclosed within a plurality of reinforcing envelopes.

Figs. 3 and 4 are schematic views showing different methods of connecting the transmission line of this invention into a system employing detonating fuse.

Fig. 5 shows a system employing the present invention in connection with fragmentation of boulders and secondary blasting.

Fig. 6 is a perspective view showing the transmission line of the present invention, one end of which is equipped with a fitting containing a delay pellet constituted to permit its insertion into a detonator.

Fig. 7 is a central longitudinal section through the structure shown in Fig. 6.

Fig. 8 shows a typical hook-up embodying the present invention, such as appropriate for tunnel blasting.

Fig. 9 shows a connector adapted to be used with the

transmission line of this invention to connect a trunk line with a branch line.

Fig. 1 of the drawings shows the fundamental structure of this invention. In said figure, **1** designates a cylindrical tube or sleeve which, in practice, is preferably of polyethylene and may be conveniently formed by an extrusion process. In lieu of this particular plastic we may employ other organic plastics, such, for example, as polyvinyl chloride, polyvinylidene chloride, or similar thermoplastics. In some cases rubber or some other elastomeric material may be used to advantage. This cylindrical tube is shown in Fig. 1 as circular in form, although the invention is not limited to this cross sectional shape as any other appropriate cross sectional shape may be employed, such, for example, as the semi-cylindrical or D-form shown in Fig. 1A.

Extending loosely through the tube **1** are a plurality of strands of yarn **2**. This yarn may conveniently be of cotton, although in practice it may be jute, a synthetic, or may be in the form of a twisted paper yarn. Fiber-glass may be employed in some cases, although cotton or some other soft fiber is ordinarily better adapted for use. The strands **2** are coated with a combustible material. Finely divided particles or grains of black powder have been found satisfactory.

"Black powder," as here referred to, comprises an intimate mixture of potassium or sodium nitrate, charcoal and sulphur, compounded according to standard procedure. However, in lieu of this conventional black powder, any of the following mixtures may be employed, viz.: potassium perchlorate and carbon; potassium nitrate and carbon; potassium nitrate, lead oxide and silicon, and others. The combustible material should be one which, upon burning, will produce a gas and this combustible material, in practice, will comprise an oxidizer and a fuel. In general, conventional deflagrating explosives will perform satisfactorily while detonating high explosives are not suitable.

In practice the combustible mixture and an appropriate binder may be applied to the strands by an extrusion process or by dipping, spraying, or in any other appropriate manner which will cause a coating of the fibers by such combustible material. Any appropriate binder may be used, such, for example, as nitrocellulose, starch, animal glue, wax, or a synthetic resin. A combustible binder is preferred, particularly nitrocellulose.

After said fibers have been thus treated, they are gathered together, either in parallel form or twisted as may be desired and, while in this assembled relation, the tubular casing **1** is formed thereabout. This casing may be formed by extrusion or otherwise, but in any event it should be applied loosely about the assembled strands, so as not to compress the same but rather leave some space about them to permit of flame propagation longitudinally of the conduit thus provided within the casing and about the strands.

The fundamental structure shown in Fig. 1 may be used for various purposes and in various systems, examples of which will be hereinafter described. However, for certain uses, it is desirable that this fundamental structure be covered or enclosed within one or more additional envelopes after the manner shown for example in Fig. 2. By reference to this latter figure it will be noted that the fundamental structure of Fig. 1 is enclosed within a second envelope **3** of fiber-glass, cotton, linen, rayon, nylon, or even wire. This envelope may be applied by braiding it closely about the casing **1** or it may be wrapped or "served," as desired. In practice, we prefer to employ fiber-glass because of its low elongation characteristics and because it forms a strong binder about the casing **1** and thus assists in reinforcing said casing against the pressure of gases generated during the burning of the combustible material on the strands **2**.

After the envelope **3** is in place, there is next applied over the exterior of the braid, a jacket **4** of some organic plastic or rubber. In some cases a wax composition or glue size jacket may be used. A polyethylene jacket **4** may be conveniently applied by an extrusion process to produce an end product which embodies a casing **1** through which loosely passes the combustion material carrying strands **2**, while over this casing is tightly wrapped the intermediate envelope **3**, this being finally encased within a close fitting jacket **4**.

This resulting end product provides, within the casing **1**, an oversized conduit for the burning combustible material on the strands **2** and that conduit is encased within a plurality of close fitting superimposed envelopes of adequate strength to reinforce the casing **1** against rupture during the combustion period.

The provision of such an oversized conduit confines the products of combustion, giving increased pressure and high burning rate. This burning rate will, however, be very materially lower than the propagation rate of detonating fuse, but faster than conventional safety fuse. Such being the case, the overall elapsed time of burning from one end of our transmission line to its other end will depend, in practical operation, upon the length of the transmission line used. The operator may thus choose a length of our transmission line appropriate to the amount of time delay desired and that delay will be substantially proportional to the length of the line employed.

The transmission line of this invention is adapted to various uses, all primarily intended for employment where controlled elapsed time of transmission is essential, such, for example, as illustrated in Figs. 3 and 4.

As used in a trunk line, such as indicated in Fig. 3, the main portion of such trunk line consists of conventional detonating fuse **5**, which, if used alone, would cause initiation of the explosive charges too soon where it is desirable to delay such initiation. In such case, an appropriate length of our transmission line, generally indicated by the reference character TL, is used to interconnect the ends of a gap in the detonating fuse **5**. The opposite ends of our transmission line TL are equipped with blasting caps **6** which are taped, as shown at **7**, or otherwise secured to the detonating fuse terminals at the opposite sides of the gap. With this arrangement, the transmission line TL will delay the firing of the explosive charge in accordance with the length of the part TL. An important advantage of this hook-up is that it may be ignited from either end and will function perfectly in either direction.

In the structure of Fig. 4, a length of our transmission line TL, of any desired dimensions according to the timing desired, is aligned with the opposite terminii of a gap in the detonating fuse **5**, with a blasting cap **6** interposed between each end of the part TL and the corresponding end of the gap in the detonating fuse. A sleeve **8** preferably encloses each end of the detonating fuse and the part TL and associated blasting cap.

Fig. 5 shows another use of the transmission line of this invention, more particularly in the fragmentation blasting of boulders and the like. In utilizing the invention for this use we find it convenient and economical to employ the fundamental structure of this invention shown in Fig. 1.

In Fig. 5 a plurality of boulders B, B1 and B2 are each equipped with a blasting cap of conventional form inserted in explosive charges. The several blasting caps are connected to one another by our transmission line TL, so as to detonate said caps in timed succession. While a series connection is shown, a looped or parallel connection may be used, although it is not essential. In the arrangement shown, ignition may be had through a considerable length of safety fuse, indicated at **9**, and the successive boulders B, B1 and B2 will be successively blasted with intervening delay according to the length of the transmission line TL. This will insure successive firing and reduce the noise heretofore encountered in the use of detonating fuse or electric detonator hook-ups.

Use of our transmission line for the purposes indicated in Fig. 5 involves marked economy and efficiency over prior practice utilizing detonating fuse, electric caps or safety fuse and Quarrycord. It also offers great protection against misfiring because of the water impervious character of our transmission line.

In using such a hook-up, as shown in Fig. 5, it is to advantage sometimes to employ the D-shaped structure shown in Fig. 1A of the drawings. When thus employed the end portions of the fundamental element may be returned or bent back upon themselves so as to form at each terminal of the part TL a circular portion which is better adapted to fit into the socket of the detonating or blasting cap.

While the ignition transmission line of this invention may be used solely to control propagation time, it may be also used in conjunction with delay devices attached as fittings, such, as shown, for example, in Figs. 6 and 7. The fitting **10**, shown in these figures, is integrally or otherwise attached to one end of the transmission line TL and may conveniently be of plastic material. It is provided in its outer end with a socket **11** in which is contained any appropriate conventional delay combustion material. Red lead and silicon, black powder, boron and an oxidizer and other mixtures provide suitable delay compositions. The length of such delay combustion employed will vary according to the time interval of delay desired and each terminal is colored or otherwise marked according to the amount of delay which that particular fitting will provide. This fitting **10** is introduced into a conventional blasting cap, indicated at **6**, in Figs. 6 and 7 and serves to detonate that cap at the completion of the corresponding delay period.

Fig. 8 shows one illustrative blasting round, such as is appropriate for tunnel work. In this figure a number of combination fixtures and blasting caps, such as shown in Figs. 6 and 7, are placed in drill holes loaded with dynamite and the transmission lines TL leading to the several drill holes are led to an appropriate juncture where the ignition can be accomplished either by safety fuse or electric ignition, indicated generally at **12**. The advantages of such a system are that it is not affected by stray currents, and that it is economical and efficient.

In the description as thus far advanced we have dealt with this invention primarily from the standpoint of blasting. The invention, however, is adapted for much wider use and Fig. 9 shows one adaptation. In this figure, **13** and **14** indicate explosive charges, e.g., powder charges, for actuating some apparatus, such as a piston, explosive bolt, round of ammunition or any one or more of a variety of devices which it is desired to activate by an explosive charge or charges. These devices may be of the same kind or different kinds. The powder charges are adapted to be initiated from any suitable source, such as percussion or electric primer, indicated at **15**, and this primer is connected to the several charges through the ignition transmission line of our invention. Ordinarily the transmission line TL of Fig. 2 will be used for this purpose, although in some uses the transmission line TL of Fig. 1 may be employed. A convenient method of making the connections is through the use of a illustrated the connector is of T-shaped tubular form, connector **16**, such as shown in this figure. As here although it could be Y or any other shape which will bring all contiguous ends of the transmission lines TL in juxtaposed relation to one another, so that flame will be positively and definitely communicated from one to the other or others. As shown in Fig. 9, the two sections TL and TL′ are arranged in alignment with their contiguous ends abutting a stop **17** which assures that these ends be juxtaposed with the end of the branch $TL^2$. The connector employed is preferably of metal, although it may be made of any material which will hold the respective ends of the several line sections in the relation indicated.



In the system of Fig. 9, a single T connector is shown, although in practice any of the sections TL, TL′, $TL^2$ may be equipped with additional connectors of T-shape or any other form, where a greater number of charges are involved in the system.

A system, such as shown in Fig. 9, may be ignited by any source of flame, such as a percussion primer or an electrical primer as well as any other common method. By the use of properly designed connectors, the energy can be directed along any number of branching connections to actuate any desired number of charges. Either mechanical or electrical operation may be initiated by the explosive charges in the main and branch connections of the transmission line.

Systems, such as indicated in Fig. 9, offer considerable advantage in the use of stage separation in guided missiles or "destruct systems" in military equipment. They also afford a replacement to many electrical, hydraulic or pneumatic systems, over which conventional systems it offers many advantages. Our systems are not affected by stray currents as are electrical systems. Moreover, minor gaps, such as may be caused by penetration of rifle bullets that will cause failures in electric, hydraulic and pneumatic systems, will not cause failures in our systems.

Moreover, pneumatic and hydraulic systems require heavy tubular lines and both of such systems require pressure sources and booster cylinders, all of which add to the weight and expense thereof. The ignition transmission line of this invention is free from these disadvantages and it is basically a system which is cheap and light in weight. Hydraulic and pneumatic systems are also limited to operating temperatures. Our transmission line functions satisfactorily over an extremely wide range of temperatures, from very low temperatures (−65° F. and lower) to very high temperatures (400° F. and higher).

In Fig. 9 we have shown, for the purpose of illustration, the operation of this system in connection with a plurality of explosive charges for operating a number of devices. It should be understood, however, that if only one device is to be operated or a plurality of devices are to be operated from a single explosive charge, then and in that event no connector is necessary and the ignition transmission line may extend directly from the point of ignition to the explosive charge without branch ignition transmission lines.

Our ignition transmission line is useful for providing delay intervals for other types of blasting. For example, in seismic prospecting it is advantageous in some instances to provide delays between blasts of charges of somewhere from 1 to 5 milliseconds. The ignition transmission line of our invention is well suited for doing this and offers advantages in choice of time and economy over any presently available devices.

Still another system of blasting where our ignition transmission line may be applicable is in bottom initiation of cap sensitive explosives. In some blasting it is desirable to initiate the explosives at the bottom to get maximum breakage with minimum cutoffs in the explosive columns due to ground movement. Conventionally this can be done with delay electric blasting caps placed at the bottom of the hole. With cap sensitive explosives this cannot be done with conventional detonating fuse because the explosive columns are initiated at the top as the detonating fuse propagates along its length. Electric blasting in these circumstances, however, is subject to hazards due to stray currents and lightning discharge. For that reason it would be desirable if a system not subject to the stray current hazards could be devised that would permit bottom initiation. The ignition transmission line of this device will accomplish such a purpose. That is to say, this ignition transmission line will not initiate explosives laid alongside it, but will propagate beyond them to a detonator at the

bottom of the hole, hence accomplishing bottom hole initiation. It is further noted that in this type of blasting it is generally necessary to provide delay between initiation of subsequent holes in the blast. The ignition transmission line of this invention provides this delay and therefore accomplishes a dual purpose.

It will be apparent from the foregoing description that this invention fulfills a void in this art in that it provides a highly efficient and dependable ignition transmission line which makes possible the elimination of the costly and undependable delay devices heretofore considered necessary and it accomplishes this result in the various systems to which reference has been made in a highly efficient and dependable manner and at cost factors appreciably below those incident to present-day conventional practice.

The foregoing detailed description sets forth the invention in its preferred practical forms, but the invention is to be understood as fully commensurate with the appended claim.

Having thus fully described the invention, what we claim as new and desire to secure by Letters Patent is:

An ignition transmission line comprising: at least one strand carrying a combustible composition, an imperforate tubular casing enclosing said strand and providing between the inner surface of the casing and the exterior surface of the strand a conduit through which



flame may freely pass, and an envelope extending uninterruptedly longitudinally of and tightly embracing said tubular casing and of sufficient inherent strength to withstand the deflagration pressures of the combustible composition without rupture, said envelope comprising interlaced fiberglass filaments spirally wrapped about the casing.

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