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SERIES SPARK GAP INITIATOR

Filed June 5, 1963

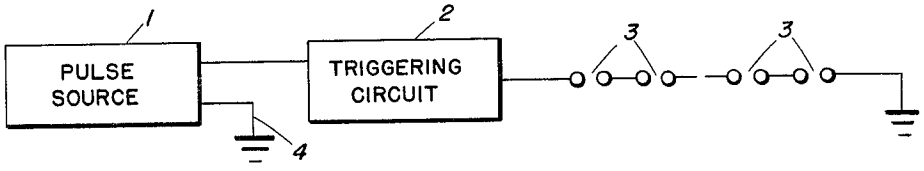


FIG. 1

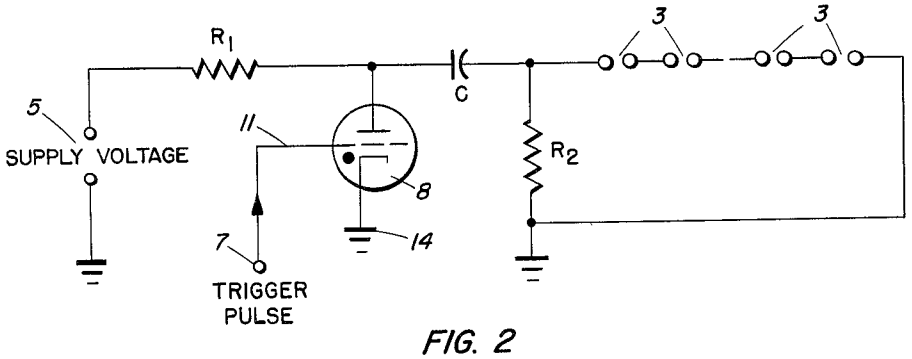


FIG. 2

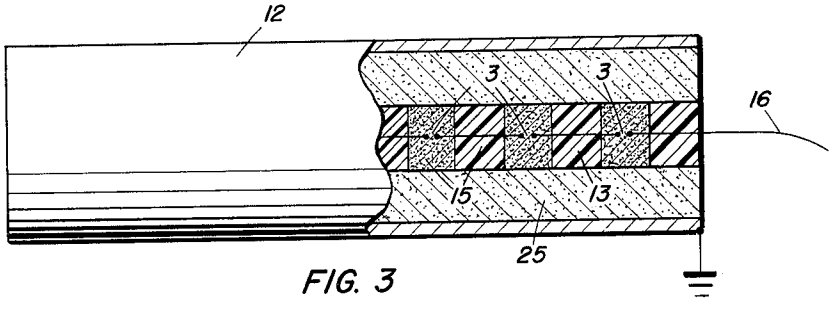


FIG. 3

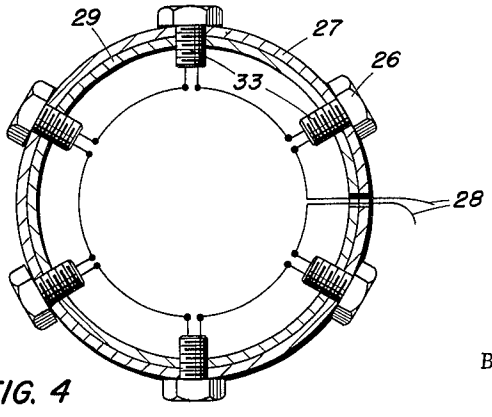


FIG. 4

INVENTORS
Warren L. Gilbertson
David D. Abernathy

BY Claude Funkhouser
ATTORNEY

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SERIES SPARK GAP INITIATOR

Warren L. Gilbertson, Fredericksburg, and David D. Abernathy, Dahlgren, Va., assignors to the United States of America as represented by the Secretary of the Navy

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1 Claim. (Cl. 102—70.2)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to electric spark ignition apparatus, and more specifically to a device capable of simultaneous multipoint spark ignition.

In prior multipoint ignition systems it has generally been the practice to resort to a group of parallel branches, each branch containing a spark gap being fired by a capacitor in that branch or by a single voltage source in series with the parallel branches. Or, if the series gaps were used, bridging wires designed to heat and burn were placed across each gap.

The former system, parallel spark ignition branches, suffers the severe disadvantage of a usual lack of firing simultaneously. This is a result of several possible causes: a very small variation in the electrical conduction properties of each branch, for example; further, a finite time is required for the pulsing voltage to travel to the several branch input points, resulting in differing branch ignition times. Also, standing or reflected waves could serve to strengthen or attenuate the line voltage at different points.

The series bridge wire does function satisfactorily for some applications, but not when true simultaneity is desired. If any one of the bridge wires has a physical imperfection or a slightly higher electrical conductivity, then it could burn open and cut the current off from those remaining.

In many applications, true simultaneity is not absolutely required. In many others, ordnance devices, for example, true and absolute simultaneity is a prime consideration. In high explosive devices, which utilize detonating rather than deflagrating compositions, it is often an object to cause the detonation of the explosive material to proceed in a certain fashion; for example, for the detonation wave to completely envelop the explosive material in the shortest possible time. While the velocity of the detonation wave in most solids is extremely high, if only one initiating point can be used, substantial time is required for the detonating wave to travel the length of the explosive material. A need is encountered, then, for a method of causing precisely simultaneous multipoint initiation of the detonation wave.

It is, therefore, an object of the present invention to provide a method capable of yielding true simultaneous multipoint ignition.

It is a further object of the present invention to provide a method capable of yielding simultaneous multipoint spark ignition.

It is a still further object of the present invention to provide a method capable of yielding simultaneous multipoint detonation wave initiation.

It is another object of the present invention to provide a method capable of yielding a cylindrical advancing detonation wave front.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in connection with the accompanying drawings wherein:

FIG. 1 is a partial block diagram of a general application of the present invention.

FIG. 2 is a schematic diagram of the present invention in combination with a particular triggering circuit.

FIG. 3 is an elevation view partially in section of the present invention utilized as an axial initiator.

FIG. 4 is a sectional view of the present invention utilized as a booster rocket jettisoning mechanism.

Referring now to FIG. 1, there is shown a series of spark gaps **3** connected to a source of voltage pulses **1** via a triggering circuit **2**. Contrary to what would be expected by consideration of classical electrical theory, it has been found that when a voltage is placed across a series of uniform spark gaps, such as those shown in FIG. 1, then at a time instantaneous with the initial application of voltage to the circuit, the entire input voltage to the circuit appears across each gap, regardless of the number of gaps in series. If a voltage is chosen sufficient to cause spark breakdown of any one of the gaps, and if the gaps are uniform, then contemporaneous with the initial application of voltage, and evidently before the first electron moves, the voltage appears across each of the gaps causing simultaneous breakdown of all of the gaps. When electrical breakdown of the gaps occurs, however, the available energy is then divided equally between the gaps if they are equal in all respects.

Referring to FIG. 2, there is shown a triggering circuit in combination with the series string of spark gaps **3**. It is emphasized that the triggering circuit shown is only one possible embodiment, and could be substituted for without departing from the scope of the invention. In FIG. 2, a voltage is applied at the input terminal **5** which will charge the capacitor C through R_1 and R_2. The thyratron **8** is normally non-conducting and will not be turned on until it is desired to fire the spark gaps **3**. When ignition is desired, a triggering pulse is applied at the input terminal **7** of the grid input line **11** of the thyratron **8**. When the thyratron becomes conducting, it serves to connect the capacitor C to ground **14** and cause it to discharge through the load resistance R_2, the load voltage being in turn applied to the series spark gap string.

To further explain the operation of the device, the following experimental data is given. Referring to FIG. 2:

Number of gaps	40.
Gap spacing	.010 inches.
Sparking medium	Air.
R_1	2 megohms.
R_2	50 kilohms.
C	3 mfd.
Supply voltage	5000 volts.

It is noted that to cause spark breakdown of any one of the gaps of the above size in air, about 1500 volts is required. While any amount slightly greater than 1500 would serve, 5000 volts was chosen because of its availability.

When the 5,000 volts is applied at the thrust **5**, the capacitor C begins to charge at a rate determined by the sum of the series resistances R_1 and R_2. The maximum current, which results when the voltage is initially applied, is approximately 2.5 milliamps. At this point, the voltage across the load resistance R_2 is only about 150 volts, which is insufficient to cause sparking of any of the gaps. From this maximum value the charging current decreases exponentially until the capacitor C has become charged to a voltage equal to the value of the input voltage, 5,000 volts. If the thyratron is then pulsed and thereby turned on, the capacitor C will discharge through the load resistance R_2 to ground. The maximum current will again be reached initially and will be approximately .1 amp value flowing through resistor R_2. The voltage across R_2 at that time will be 5,000 volts. When this value is initially reached, the gaps will break down

with an exact simultaneity, a current of hundreds of amperes flowing upon breakdown of the spark gaps.

An application of the invention is seen in FIG. 3, wherein an input lead **16** is provided with uniform gaps **3**. Around each gap is arranged a primary explosive **15** such as lead azide. Between the blocks of lead azide **15** are placed inert blocks **13**, the purpose of which is to attain a symmetrical shape for the secondary explosive **25**. The latter is arranged between the cylindrical bodies composed of primary explosive blocks **15** and the inert blocks **13**, and a metallic outer conductor **12**. At the end opposite to the input, the outer conductor **12** is shorted to the series gap line **16** to provide an electrical return path. As explained above, when the series gap line **16** is pulsed with a voltage sufficient to cause spark breakdown of one gap, all of the gaps will break down simultaneously. The result is a closely spaced group of spherical waves which result in an exactly cylindrically advancing detonation wave front a few inches from the gaps, extending radially from the series gap line **16** and causing an even detonation of the secondary explosive **25**.

A still further application of the invention is shown in FIG. 4. Therein, a series of explosive bolts **26** are connected to a series gap line **28**. Each gap **33** is connected across the explosive charge in each bolt **26**. The bolts are structural assembly holders for a rocket body **27, 29**. When the series gap line **28** is pulsed, the bolts will fire simultaneously, releasing the body **27** from the body **29** without skewing.

In summary, then, the invention provides multipoint simultaneous spark ignition. The principle disclosed herein may be utilized in several applications, including an axial detonation initiator and a booster rocket jettisoning mechanism.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What we claim as new and desire to secure by Letters Patent of the United States is:

The method of forming a cylindrical expanding detonation wavefront comprising the steps of:

(a) placing a series string of uniform spark gaps coaxially with a tubular metal shell;

(b) connecting one extremity of the series string to the corresponding extremity of said metal shell;

(c) placing a small charge of primary explosive around each of said spark gaps;

(d) placing small amounts of inert spacers between the individual charges of primary explosive so that the combination of the inert spacers and the primary explosive forms a cylinder body coaxially with said tubular metal shell;

(e) placing a secondary explosive in the volume remaining between the interior wall of said metal shell and the exterior of said cylindrical body formed of said inert spacers and said primary explosive; and

(f) causing a voltage to be applied between the extremity of the said series string of spark gaps and the corresponding extremity of said metal shell opposite the corresponding extremities which are connected, the amplitude of said voltage being slightly greater than the amplitude of the minimum voltage required to cause spark-over of any one of the spark gaps taken singly.

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BENJAMIN A. BORCHELT, *Primary Examiner.*

SAMUEL FEINBERG, *Examiner.*

L. L. HALLACHER, W. C. ROCH, *Assistant Examiners.*