May 23, 1967 C. E. HOLTZ 3,320,889

DETONATION INITIATOR

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Fig. 1

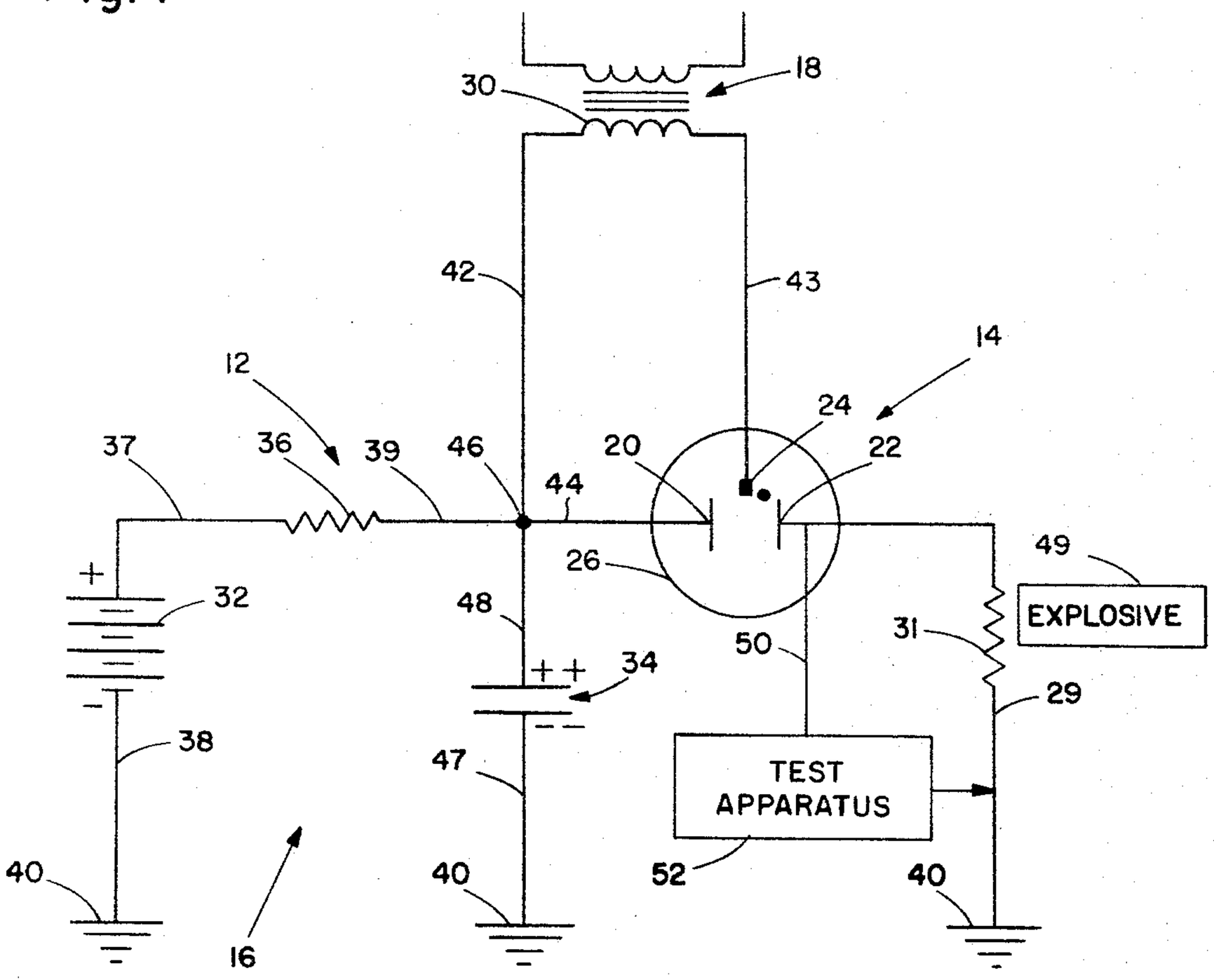

Fig. 3

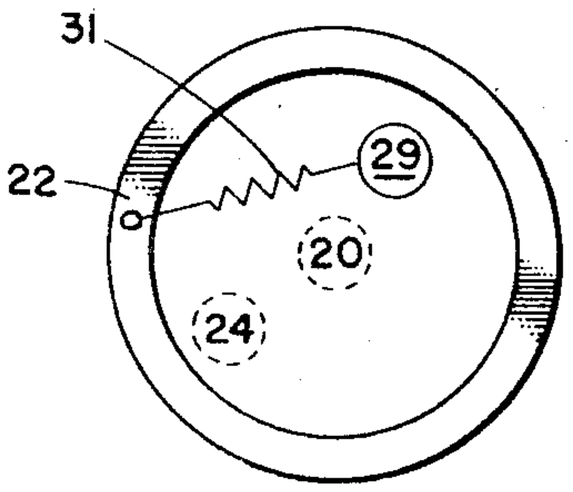

Fig. 4

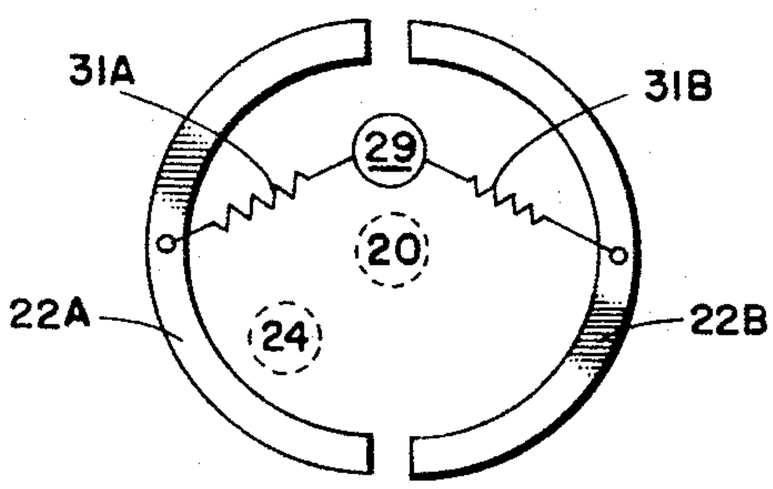

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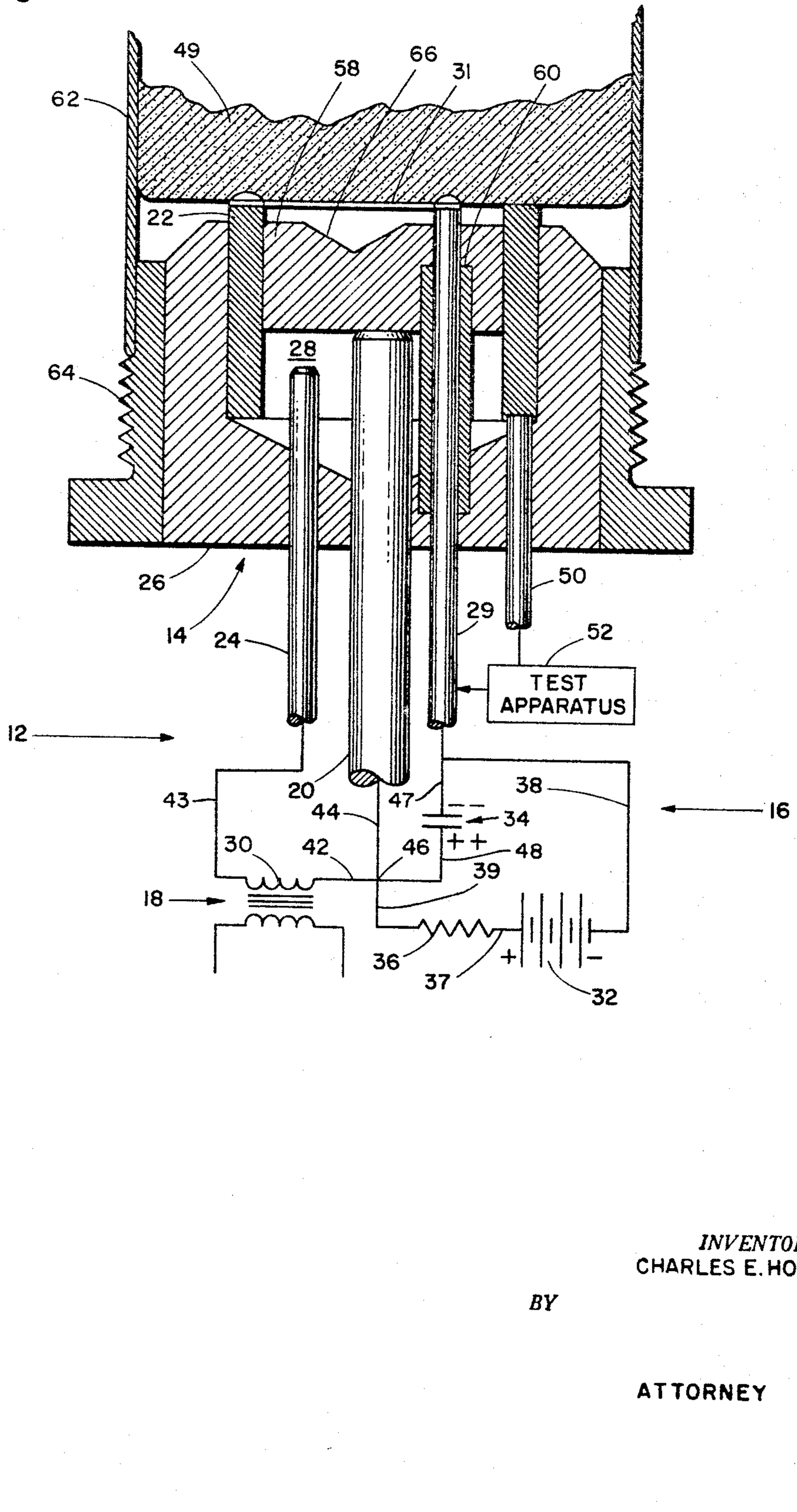
Fig. 2



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DETONATION INITIATOR

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The present invention relates generally to a detonation initiator, and more particularly to such an initator for electrical actuation from a remote location.

Detonation initiators, as the name implies, are devices for initiating detonation of a quantity of explosive material. Specifically as the term has reference here, this is a device that can accomplish detonation on a signal provided from a relatively great distance from the location of the explosive charge.

Of the many types of known initiators, one which has found increasing use because of simplicity of design, ruggedness and ease of actuation is the so-called exploding bridgewire, or vaporizing resistor type. Devices of this character include one or more electrical resistance elements that are maintained either in contact with, or in proximity to, the charge of explosive material to be set off. Actuation is effected by applying an electric current to the element of such magnitude as to vaporize it substantially instantaneously. The heat generated by the rapid destruction of the element effects the desired detonation of the explosive charge.

Heretofore, exploding bridgewire systems have consisted of three main parts: the vaporizing resistance member located immediately adjacent the charge; electrical firing apparatus disposed at a safe remote location; and interconnection cabling. These systems are found to suffer generally from the disadvantages of electrical losses in the cabling and cabling connectors, which can be of such size as to produce delayed detonation, or even a misfire. In order to alleviate this type of problem, the electric signal being transmitted is frequently increased in magnitude. However, this imposes additional requirements on the electrical equipment, as well as increasing safety problems and accordingly necessitating the taking of appropriate precautions.

It is, therefore, a primary object of the invention to provide a detonation initiator of increased reliability and efficiency.

It is a further object of the invention to provide an initiator of the vaporizing resistance element type actuable from a remote location by relatively low energy cabling signals.

Another object is the provision of such an initiator having a control spark gap integrally associated with the vaporizing element.

Still another object is the provision of an initiating device in which a spark gap is electrically arranged in series with the bridgewire or vaporizing element.

Yet another object is the provision of an initiator of highly uniform actuation characteristics permitting utilization in applications where multiple simultaneous initiations are required.

A further object is the provision of an initiating device of simplified and relatively inexpensive construction.

Other objects and advantages of the invention will be readily apparent to those skilled in the art after reference to the accompanying description and drawings.

Briefly, the objects of the invention are accomplished by providing a special structure including the vaporizing resistance element and spark gap integrally related. The structure is disposed at the side of the explosive charge, with energizing electrical circuitry remotely located. The

spark gap is enclosed in a gas-filled housing having external terminals for accommodating the resistance element.

In the drawings:

FIGURE 1 is a diagrammatic view showing the electrical circuitry including the invention and associated electrical apparatus for effecting detonation of an explosive charge.

FIGURE 2 is a longitudinal sectional view of the initiating device of the invention, and further including the circuital aspects of the electrical energizing apparatus.

FIGURE 3 is a stylized view of the electrodes included in the initiating device of FIGURE 2, and showing the relative disposition of the vaporizing resistance element and the spark gap.

FIGURE 4 is a stylized version of a further embodiment of the invention utilizing a pair of vaporizing resistance elements.

With reference now particularly to FIGURE 1, there is illustrated a detonation initiating system, indicated in its totality by the reference numeral **12**, including as a part thereof the novel initiator of the invention. In its major elements, the system comprises a gap switch **14**, a primary power source **16**, a secondary power source **18** and interconnecting circuitry for selectively delivering electric power to a vaporizing element **31**.

The gap switch is composed of first, second and third electrodes **20**, **22** and **24**, respectively, disposed in a mutually spaced relation within a body **26** defining a sealed enclosure or chamber. A suitable ionizable gas is provided in the chamber as indicated in the drawing by the dot convention. It is the primary function of this switch to present a relatively high electrical resistance path to the vaporizing element when the switch is in an unenergized state. However, when the potential of the third electrode is raised to a suitable level, ionization of the gas within the enclosure is effected and the resistance across electrodes **20**, **22** drops to a sufficiently low value that current from the primary power source destroys the bridgewire in the manner described.

As to connective aspects, the electrode **22**, acting as an output, is connected to one terminal of a vaporizing resistance element **31**, the other terminal of which is referenced to ground **40**, by lead **29**. A D.C. voltage source, such as a battery **32** has its positive terminal connected to a resistance **36** via lead **37**, and its negative terminal establishing the ground reference by lead **38**. The line **39** interconnects the other end of the resistance **36** and a common connection point **46**, which common point **46** is also connected with first electrode **20** by line **44**. A capacitance **34** has one side connected to ground by lead **47** and the other side to the common point **46** by lead **48**.

The secondary power source **18** consists of a transformer **30**, the primary side of which is supplied with A.C. power from a suitable source (not shown). The secondary side of the transformer is connected across common point **46** and the third electrode **24** by leads **42** and **43**, respectively.

In operation, assume that no A.C. power is impressed on the primary of the transformer **30** initially. The D.C. source **32** builds up a charge on the capacitance **34**, which simultaneously establishes a potential difference between electrodes **20** and **22**. It is important to note that the potential set up between these electrodes must be clearly insufficient to produce ionization in the enclosed gas, otherwise the vaporizing element will be fired uncontrollably. It is apparent, therefore, that at this time the gap switch presents a high resistance to the current path from the primary power source **16** to the element **31** and the system is in readiness to fire.

When it is desired to fire or detonate, a pulse of A.C. is applied to the primary of the transformer **30**. This places a momentary potential at the third electrode **24** with respect to electrode **20** of sufficient magnitude to ionize the gas in the enclosure. The lowered resistance across electrodes **20** and **22**, due to the ionization state of the gas, provides a discharge path for the capacitance **34** along line **48**, common point **46**, line **44**, electrodes **20** and **22**, through the resistance element **31** and lead **29** to ground. Vaporization of the element then takes place with consequent detonation of the explosive charge **49**. Thus, the gap switch serves as a means for isolating the element **31** from the energizing power source at all times other than when it is actually desired to detonate the explosive.

FIGURE 2 shows, in sectional view, the special initiator of the invention consisting of the gap switch **14** and vaporizing element **31** in an integral relationship. Although the specific geometry is not critical, for purposes of presentation it is assumed the explosive charge **49** is contained in a cylindrical container **62**. The container is provided with an outwardly extending portion that is free of explosive material and into which the initiator comprising the gap switch **14** and the vaporizing resistance element **31** is received.

Structurally, the initiator includes a cylindrical body **26**, one end of which is closed and the other end of which is open defining a chamber **28** therein. The body can be constructed of any of a number of good electrical insulating materials. Into the chamber **28** is received the second electrode **22** which is of a cylindrical shape (FIGURE 3), and so dimensioned that when one end is bottomed in the chamber the other end extends outwardly beyond the body **26**.

The first electrode **20** passes sealingly through the closed end wall of the body **26** to extend into the chamber **28** generally along the common axis of the body **26** and electrode **22**. Similarly, the third electrode **24** passes through the closed end of the body **26** to extend into the chamber **28** a distance slightly less than the electrode **20**. Both of these electrodes are of rodlike construction and are provided with external electrical connection means of conventional form (not definitively shown).

An insulating plug **58** is received within the outer end of the cylindrically shaped second electrode **22** so as to be sealingly related to the inner surface thereof and disposed inwardly from the outermost reaches of the electrode **22**. The relative dimensions of the plug **58** and first and second electrodes **20** and **22** are such that the inner surface of the plug **58** abuts against the end of the first electrode **20**. A concavity **66** is formed in the outer surface of the plug **58** for a purpose that will be set forth later below.

A ground connection lead **29** passes through the closed end of the body **26**, the chamber **28**, and the plug **58** to extend slightly above the outer surface of the plug **58** in substantially the same plane as the outermost reaches of the second electrode **22**. The portion of the lead **29** that is in the chamber **28** is completely covered by an insulation layer **60** for a purpose that will become clear later. Terminals are provided on the end of the lead **29** and on the outer edge of the second electrode **22**, across which is connected the bridgewire or vaporizing resistance element **31**.

Care must be taken to insure the hermetic condition of the chamber **28**, into which an ionizable gas is placed, such as neon, for example.

An outer sleeve **64** is secured over the body **26**. The sleeve **64** is of such dimensions that when received within the container **62**, there is a frictional securing relationship produced therebetween and the element **31** is disposed either in contact with the explosive charge **49** or closely adjacent thereto. Alternatively, the sleeve **64** can be provided with screw threads for being received within and secured by a similar set of threads on the interior of the container **62**.

Detonating the explosive charge **49** with the initiator described above is electrically the same as has already been set forth. That is, upon pulsing the transformer **30**, the gas within the chamber **28** is ionized, thereby reducing the electrical resistance between the first and second electrodes **20** and **22**. The capacitance **34** now discharges across the electrodes **20** and **22** vaporizing the element **31**. The concavity **66** serves to focus the radiant energy from the exploding bridgewire **31** onto the explosive charge **49** thereby enhancing the firing efficiency of the initiator.

There is provided in the practice of the invention an initiator having a controlled spark gap electrically connected in series with a vaporizing element so as to be integrally related into a single unit for ultimate affixing to an explosive charge. By this arrangement, stray currents induced into the cabling are prevented from setting off the vaporizing element. Also, since firing initiation is accomplished by merely raising the potential on the third electrode **24** to the ionization potential of the included gas, cabling and cabling connector losses are small. Similarly, such losses are slight for cabling and connectors associated with lead **20** and electrode **20**, since although the gas in non-ionized condition is substantially open-circuit, when the gas is ionized the resistance is quite low requiring a corresponding low amount of electric current to vaporize the element.

The initiator bridgewire is readily tested in a non-destructive manner by connecting suitable test apparatus **52** across lead **29** and lead **50** which is provided in electrical contact with the electrode **22**. Of course, since the other electrodes are exposed other tests can also be readily performed.

FIGURE 4 illustrates a modification of the invention in which there are utilized a pair of bridgewire elements, **31A** and **31B**. For best results, this arrangement requires the second electrode to be split into two equal half-cylinders, **22A** and **22B**, each electrically isolated from the other. Thus, on ionization of the gas, two current paths are established: electrode **20**, electrode **22A**, element **31A** and lead **29**; and electrode **20**, electrode **22B**, element **31B** and lead **29**. Not only does the use of two vaporizing elements enlarge the area of initiation and thereby reduce the possibility of misfire in that way, but also in case one of the elements is damaged, the other element can effect detonation.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment of the same, but that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

What I claim is:

1. Apparatus for initiating detonation of an explosive charge, comprising:

a support body disposed adjacent the charge;

a vaporizable two-terminal electric resistance element mounted on the exterior of the support body and in heat transferring relation to the explosive charge;

first, second, and third spaced electrodes having certain portions disposed within a sealed chamber in the support body and other portions extending outwardly of the body;

the other portion of the second electrode being electrically connected to one terminal of the resistance element;

an ionizable gas contained within the sealed chamber;

a first remotely located electric power source of magnitude sufficient to vaporize the resistance element;

interconnecting means relating the first power source to the first electrode and the other terminal of the resistance element;

a second remotely located electric power source of magnitude sufficient to ionize the gas in the sealed chamber; and

selectively switchable interconnecting means relating the second power source and the third electrode such that when electric power from said second power source is provided to the third electrode ionizing the gas within the sealed chamber a low resistance path is created between the first and second electrodes enabling said first power source to vaporize the resistance element for initiating detonation of the charge.

2. Apparatus for initiating detonation of an explosive charge as set forth in claim 1, in which the other portion of the second electrode extending outwardly of the body serves as a mounting means for the resistance element.

3. Apparatus for initiating detonation of an explosive charge as set forth in claim 1, in which the portion of the surface of the body directly opposite the resistance element is formed into a reflecting concavity directed toward the explosive charge.

4. Igniter apparatus for being received within a chamber containing an explosive charge to be detonated, comprising:

a tube-like electrode having its ends closed by insulative material to define a sealed chamber within;

a pair of elongated electrodes extending through the insulative material with one end of each disposed within the sealed chamber and the other ends lying outwardly of the insulative material;

an ionizable gas disposed within the sealed chamber;

vaporizable resistance means having a pair of terminals, one of which terminals is affixed to and electrically related with the tube-like electrode;

a selectively switchable remotely located source of electric power; and

interconnecting lead wires relating the source of power to the tube-like and elongated electrodes and the other terminal of the vaporizable resistance means.

5. Igniter apparatus as set forth in claim 4, in which the vaporizable resistance means is disposed in spaced and opposed relation to portions of the insulative material, which portions are formed into a concavity for reflecting

light and heat away therefrom more effectively upon vaporization of the resistance means.

6. Igniter apparatus for being received within a chamber containing an explosive charge to be detonated, comprising:

a tube-like electrode separated longitudinally to form a pair of electrically isolated shell electrodes and having its ends cosed by insulative material to define a sealed chamber within;

a pair of elongated electrodes extending through the insulative material with one end of each disposed within the sealed chamber and the other ends lying outwardly of the insulative material;

an ionizable gas disposed within the sealed chamber;

a pair of vaporizable resistance elements each having a pair of terminals, one terminal of each resistance element being connected to a respective shell electrode corresponding thereto;

a selectively switchable remotely located source of electric power; and

interconnecting lead wires relating the source of power to the shell electrodes, the elongated electrodes, and the other terminals of the pair of resistance elements; said interconnecting lead wires including an interconnecting lead wire connecting the other terminals of the resistance elements in common to the source of power, and separate interconnecting lead wires relating the respective shell electrodes to the source of power.

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