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Voshall

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[45] **May 14, 1974**

[54] LASER INITIATED THREE ELECTRODE TYPE TRIGGERED VACUUM GAP DEVICE

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[52] U.S. Cl. **315/150,** 313/178, 315/36, 315/156
[51] Int. Cl. **H05b 41/04**
[58] Field of Search 315/36, 149, 150, 156, 315/157, 159; 313/174, 178

[56] **References Cited**

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[57] **ABSTRACT**

A three electrode triggered vacuum gap device with the triggering mechanism being laser initiated. The triggering mechanism comprises a gas-saturated portion, which when heated by a triggering laser beam releases a gas. The gas released by the triggering mechanism is then ionized by an electric field, existing between the trigger electrode and the main electrode, starting a low power arc. The low power arc is then magnetically forced between the main arcing electrodes to initiate a main power arc. The laser-initated trigger provides electrical isolation between the vacuum gap device and the triggering control circuit.

11 Claims, 6 Drawing Figures

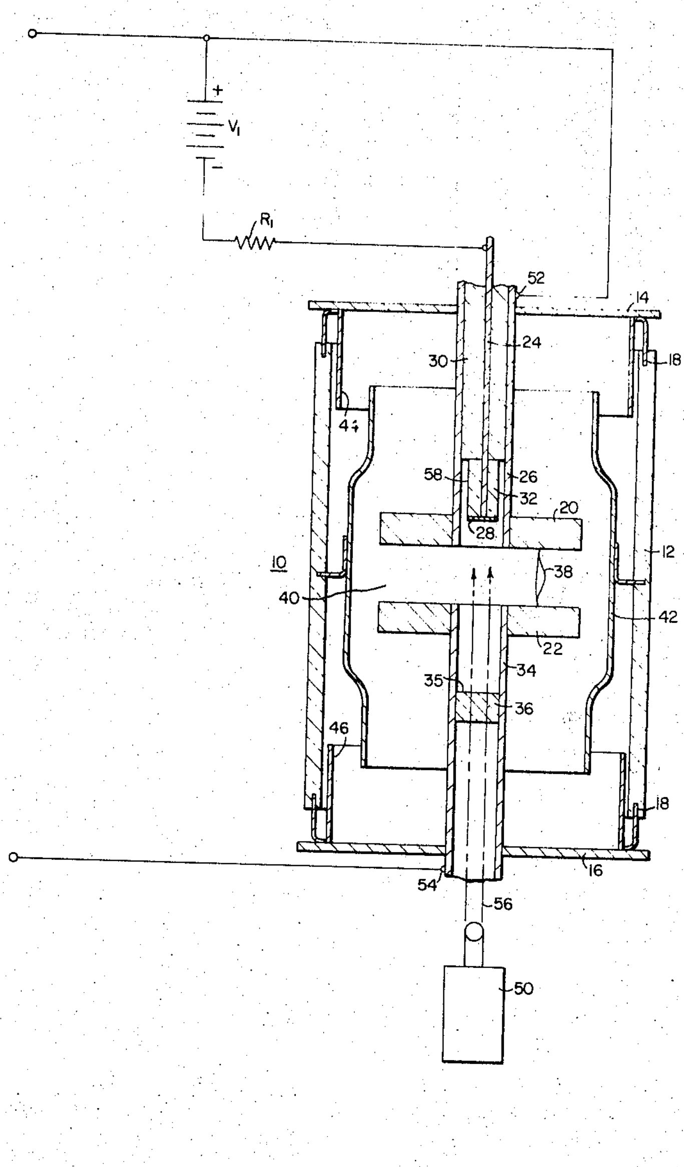
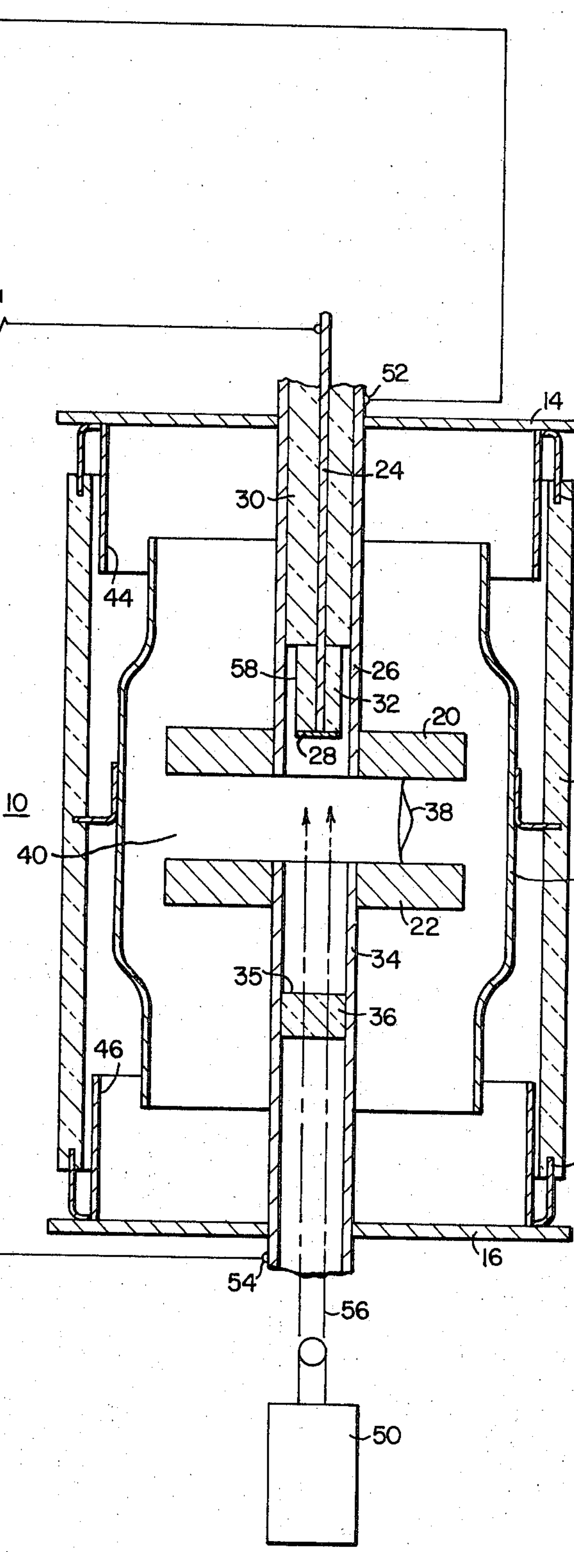


FIG.1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V1
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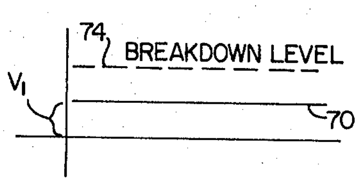
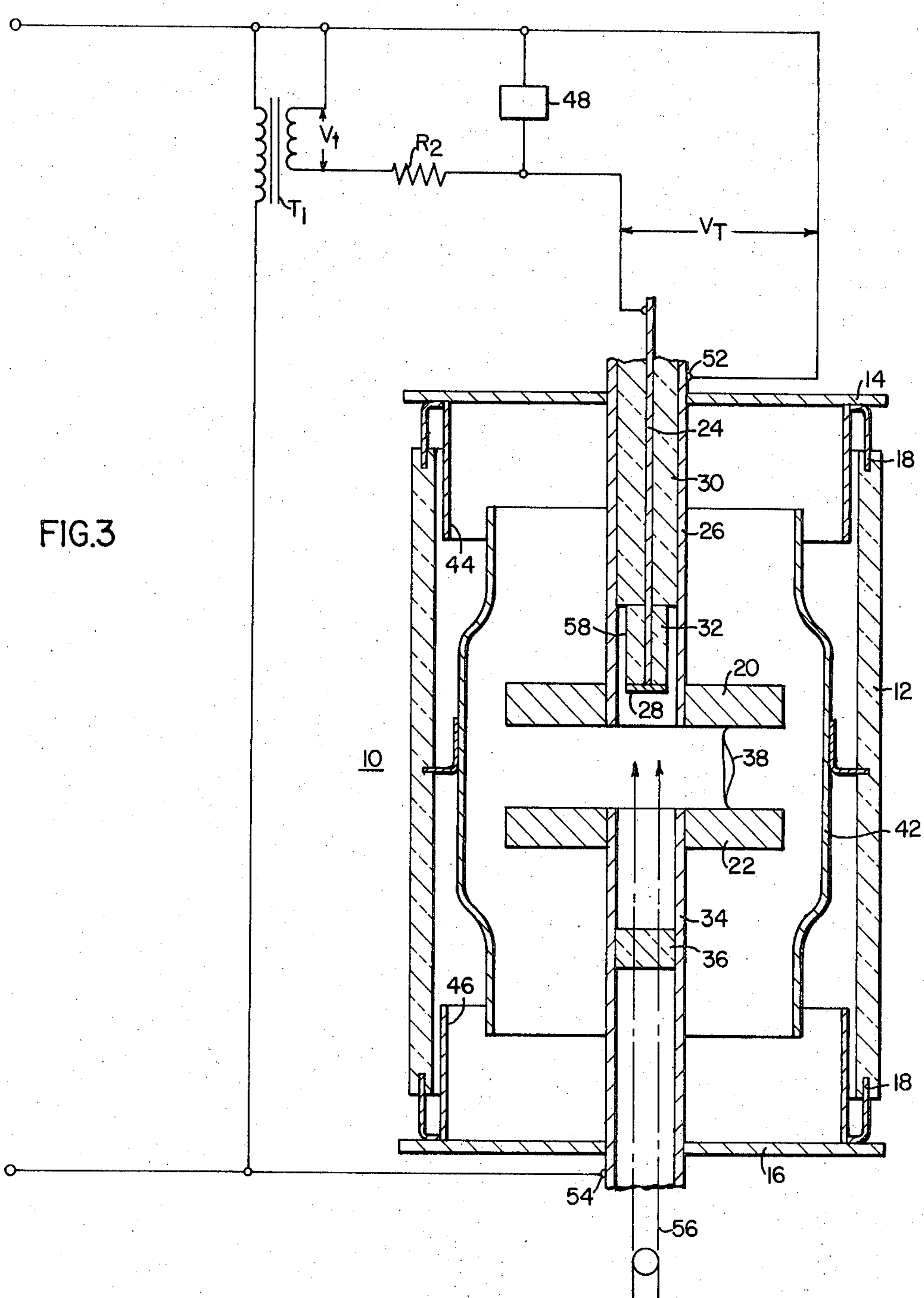

74
BREAKDOWN LEVEL
V1
70

FIG.2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V_t
R_2
T_1
V_T
52
14
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18
30
26
44
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32
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28
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56
50

FIG.3

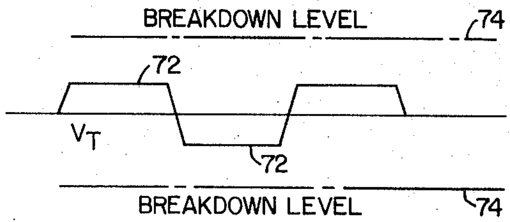
BREAKDOWN LEVEL
74
72
V_T
72
BREAKDOWN LEVEL
74

FIG.4

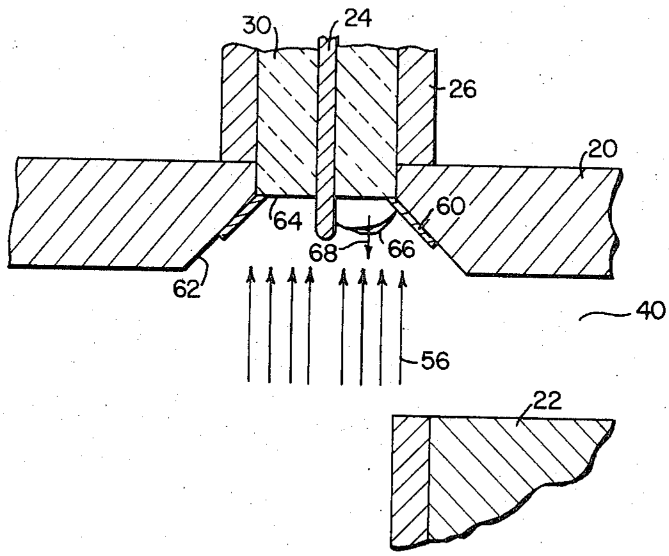

FIG.5

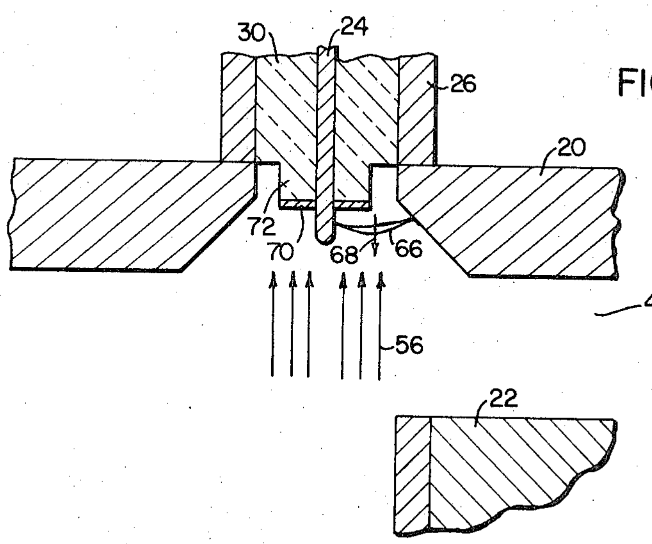

FIG.6

LASER INITIATED THREE ELECTRODE TYPE TRIGGERED VACUUM GAP DEVICE

BACKGROUND OF THE INVENTION

This invention relates to triggered electric vacuum gap devices and more particularly to the triggering mechanism used with such vacuum gap devices.

It is recognized by those skilled in the art that a vacuum gap device has several desirable characteristics such as its ability to withstand high voltages with a small electrode separation and its quick recovery of its dielectric strength after arching. These desirable characteristics have made the vacuum gap device attractive for an overvoltage protection device and a current switch. The use of the vacuum gap to limit voltage surges on transmission lines is well known in the art, as discussed by J.M. Lafferty in his article "Triggered Vacuum Gaps", Proceedings IEEE, Volume 54, No. 1, January 1966, page 23. Triggered vacuum gaps have a number of applications, such as high-speed circuit protection devices with high-voltage power transmission lines. Other applications include lightning arresters, over-voltage protection for series capacitors and parallel operation with switches and breakers.

It is not feasible to control the breakdown voltage of a vacuum gap device accurately by adjustment of the electrode spacing. It is necessary to provide an auxiliary trigger device to break down the vacuum gap when an external signal is applied. The triggering mechanism must break down the vaccum gap quickly with a minimum of jitter. It has been found that triggering breakdown of the gap by injecting a plasma into the main vacuum gap gives the most rapid breakdown with a minimum amount of voltage jitter. As discussed in U.S. Pat. No. 3,538,382 by Sidney R. Smith, Jr. issued Nov. 3, 1970, one desirable way of injecting plasma into the main vacuum gap is to provide an auxiliary gas-loaded triggering electrode that evolves a plasma when energized. However, the prior art triggered vacuum gap device, as disclosed in U.S. Pat. No. 3,538,382, requires a separate triggering and power supply circuits, at line potential, to operate the trigger. These circuits may have to be well insulated from ground potential, and this is especially true when the triggered gap is connected in series with one phase of a three-phase power line.

A method of breaking down the vacuum gap that has been found to be very effective and to give satisfactory performance is the use of gas-loaded electrodes. Hydrogen is the gas normally used due to its ease of loading and the rapidity with which it is released from the gas loaded electrode on heating. Only minute quantities of hydrogen are released with no resultant build-up of hydrogen pressure after repeated operation of the triggered vacuum gap. The plasma produced by the triggering electrode may be driven at a high velocity into the main vacuum gap, by the resultant magnetic field, to initiate a power arc between the main electrode.

SUMMARY OF THE INVENTION

According to the present invention a laser initiated three electrode type triggered vacuum gap device is provided. The triggered vacuum gap device comprises a pair of main arching electrodes within an insulating vacuum housing. The triggering electrode is positioned internal of one of the main electrodes, and is electrically insulated from the associated main electrode. A portion of the triggering electrode or the associated main electrode comprises a material that is saturated with a gas, such as hydrogen, that is rapidly released when the gas saturated portion is heated. It is to be understood that the gas saturated material can be a separate piece attached to the electrode or an integral portion of the electrode. A voltage potential is applied between the trigger electrode and its associated main electrode. The applied voltage is lower than the voltage required to cause a breakdown between the trigger electrode and the associated main electrode. To initiate a high-power arc, a laser beam is projected onto the gas-saturated material through a passage in the opposite main arcing electrode. This procedure liberates gas from the gas-saturated material into the discharge region, between the triggering electrode and the associated main electrode, producing a low-power arc. The low power arc forms quickly between the trigger electrode and the associated main electrode. When the disclosed device is operated on an alternating current power line having an operating frequency of 50 Hz or 60 Hz, the time duration of the laser beam is very short compared to the period of the power frequency. The main electrode, within which the trigger electrode is contained, is constructed so that a current loop flows through the arc and the trigger electrode and the associated main electrode to cause a magnetic force on the arc. The resultant magnetic force rapidly drives the arc into the interelectrode region of the main arching electrodes. The introduction of the low-power arc into the main interelectrode region initiates a power arc across the main arcing electrodes.

When initiating breakdown by a pulsed laser beam being directed onto the gas-saturated material, the energy of this laser beam must be sufficient to heat the gas-saturated material to the point to cause some of the absorbed gas to be quickly liberated from it.

In one embodiment of the invention the laser is directed onto the triggering electrode which comprises a portion saturated with a gas. The trigger electrode is disposed inside of an opening in the associated main electrode. The end portion of the trigger electrode, projecting inside the associated main electrode, is surrounded by an insulating piece that is smaller in diameter than the inner diameter of the opening through the associated main electrode. The trigger electrode is also recessed from the primary arching surface of the associated main arcing electrode. By this arrangement metal vapors and particles which are dispersed from the main electrode during power arcing are less likely to be deposited on the walls of the insulating material causing a shortening path to exist between the triggering electrode and the associated main electrode.

In another embodiment, the gas-saturated material is attached to the main electrode wall which has been beveled so that the laser beam can be focused on the gas-saturated material, rather than on the triggering electrode, in order to initiate the low-power arc.

In yet another embodiment, a gas-saturated metal disc is attached to the trigger electrode and a portion of the trigger electrode extends through the gas-saturated metal disc. The gas-saturated metal disc and the trigger electrodes are electrically insulated from the associated main electrode by vacuum and a solid high dielectric material. A portion of the solid insulating material between the metal disc and the associated main electrode is undercut to lessen the possibility of this area being coated with arc-generated metallic products and shorting the triggering electrode to the associated main electrode. A low-power laser beam can then be directed onto the gas-saturated metal disc to initiate a low-power arc, which in turn will cause a high power arc to form between the main arcing electrodes.

The invention disclosed in this specification differs from prior art three electrode triggered vacuum gap devices, as shown in U.S. Pat. No. 3,538,382, in that the low-power arc between the triggering electrode and the associated main electrode is laser initiated. The initiating laser and the related triggering control circuitry is electrically isolated from the vacuum gap device and can be located at a ground potential. Having the triggering control circuitry at ground potential is a desirable safety feature, and permits easy checking and maintenance of the control circuit while the vacuum gap device is in service.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention reference may be had to the preferred embodiment, exemplary of the invention, shown in the accompanying drawings in which:

FIG. 1 is a sectional view of a laser-initiated three-electrode type triggered vacuum gap device with a DC potential applied between the trigger electrode and the associated main electrode;

FIG. 2 is a graphic representation of the breakdown voltage and the applied DC voltage between the trigger electrode and the associated main electrode;

FIG. 3 is similar to FIG. 1 but showing an alternating current voltage applied between the trigger electrode and the associated main electrode;

FIG. 4 is a representation of the voltage applied and the breakdown voltage between the trigger electrode and the associated main electrode;

FIG. 5 is a view of another embodiment of the invention showing a portion of the main electrode through which the triggering electrode passes; and

FIG. 6 is a view similar to FIG. 5 showing another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and FIGS. 1 and 3 in particular, there is shown a three-electrode triggered vacuum gap device **10**. The vacuum gap device **10** comprises a highly evacuated tubular envelope **12** formed from glass of suitable ceramic material and a pair of metallic end caps **14** and **16** closing off the ends of the insulating envelope **12**. Suitable seals **18** are provided between the end caps **14** and **16** and the insulating envelope **12** to render the inside of the insulating envelope **12** vacuum tight. The vacuum in the envelope **12** under normal operating conditions is lower than 10^{-4} torr so that the mean free path of electrons will be longer than the potential breakdown distance within the tubular envelope **12**.

Disposed within the insulating envelope **12** are a pair of stationary main arcing electrodes **20** and **22** embodying the teachings of the present invention. As shown in FIGS. 1 and 3, these arching electrodes **20** and **22** are separated or spaced from one another to form an arching gap **40** therebetween. The upper electrode **20** is rigidly secured to a conducting metal tube **26** by a suitable means such as welding or brazing. The conducting tube **26** is secured at its upper end to the triggering end cap **14**. A triggering electrode **24** extends internal of the hollow conducting tube **26**. Attached to the end of the trigger electrode **24** which is disposed within the conducting tube **26** is a portion **28** made from a gas-saturated material. The trigger electrode **24** is insulated from the main electrode **20** and the conducting tube **26** by a solid insulating member **30**. A portion **32** of the insulating member **30** near the gas-saturated piece **28** is of a smaller diameter than the inner diameter of the conducting tube **26**. The portion of the insulating member **30** in contact with the conducting tube **26** provides a suitable vacuum seal within the conducting tube **26**.

The lower arcing contact **22** is joined to a conducting tube **34**. The conducting tube **34** is rigidly attached to the laser end cap **16**. Disposed within the conducting tube **34** is a transparent window member **36**. Member **36** provides a suitable vacuum seal for the center of conducting tube **34**. The transparent window member **36** is recessed axially from the end of the conducting tube **34** to which contact **22** is attached.

During operation of the vacuum gap device **10**, a metallic arc **38** is initiated between the separated electrodes **20** and **22** and serves as a vehicle for current conduction until the arc is extinguished. In an alternating current circuit the arc **38** is usually extinguished near the first current zero of the alternating current wave. The arc **38** that is established between electrodes **20** and **22** vaporizes and melts some of the electrode material. The vapors and particles are dispersed from the interelectrode arcing area **40** towards the inside of the insulating envelope **12**. The internal surfaces of the insulating envelope **12** are protected from condensation of the arc-generated metallic vapors and particles thereon by means of a tubular metallic shield **42**. The tubular metallic shield **42** is supported on the insulating envelope **12** and preferably electrically isolated from both end caps **14** and **16**. This shield **42** acts to intercept and condense arcgenerated metallic vapors before they can reach the insulating envelope **12**. To further reduce the chances of metallic vapors or particles bypassing the main shield **42** of a pair of end shields **44** and **46** are provided at the opposite ends of the main central shield **42**.

The window member **35** is recessed in the conducting tube **34**, toward the laser end cap **16**, a sufficient distance so that arc-generated metallic vapors and particles cannot easily condense on the surface of the window **36**, which is exposed to the internal environment of vacuum interrupter **10**. The upper portion **32** of the insulating member **30** is of a smaller diameter than the conducting tube **26**; so that, arc-generated metallic vapors and particles cannot readily condense on the insulating member **30**, so as to cause a short circuit current path between the trigger electrode **24** and the associated main electrode **20**.

In operation of the triggered vacuum gap **10**, a voltage is applied across the trigger electrode **24** and conducting stem **26**. The voltage applied between electrode **24** and stem **26** can be either direct current (DC) as shown in FIG. 1 or alternating current (AC) as shown in FIG. 3. A graphic representation of voltage applied between the trigger electrode **24** and the associated main electrode **20** is shown for a DC voltage level 70 in FIG. 2, and the maximum value of an AC voltage level 72 in FIG. 4. However, the applied voltage maximum 70 or 72 must be less than the vacuum breakdown value 74, but large enough to initiate a low-power arc when plasma is introduced into the interelectrode area between electrodes 20 and 24. As shown in FIG. 1, voltage applied between members 24 and 26 can be DC and can come from a DC supply indicated as V1. A trigger circuit limiting resistor R1 is placed in the circuit to limit the current during arcing. As shown in FIG. 2, the voltage output of V1, indicated by numeral 70, must be less than the breakdown level 74 between the trigger electrode 24 and the conducting tube 26. As shown in FIG. 3, the voltage applied between trigger electrode 24 and conducting stem 26 may be alternating. A step-down transformer T1 steps the main circuit voltage down to a suitable level or operation of the triggering mechanism. A voltage clipper 48 is provided to limit the voltage VT applied berween the trigger 24 and stem 26 to a voltage level 72 less than the breakdown level 74. As can be seen in FIG. 4, the maximum value 72 of the voltage VT applied between members 24 and 26 is less than the potential breakdown level 74 between these members 24 and 26. A resistor R2 is also provided to limit the magnitude of the current flowing through the trigger portion of the circuit during arcing between members 24 and 26. The main power connections of the circuit to be controlled are made to conducting stems 26 and 34, generally as indicated at 52 and 54, respectively.

A laser 50 and the related control circuitry (not shown) is provided to initiate operation of the vacuum gap device 10. To trigger the vacuum gap device 10 a pulse laser beam, indicated generally at 56, of sufficient intensity, passes through the window 36 and is focused on the gas-saturated portion 28 of the trigger electrode 24. The energy of this laser beam 56 is sufficient to heat the gas-saturated portion 28 of trigger electrode 24 to the point to cause some of the absorbed gas, such as hydrogen, to be liberated from portion 28. Portion 28 is heated by laser beam 56 and the gas is released in a period of time much less than the period of the power line frequency. When portion 28 is sufficiently heated, a gas discharge will occur between the trigger electrode 24 and adjacent main electrode 20 supported by conducting stem 26. This will cause a low-power arc to be formed between trigger electrode 24 and main electrode 20. Electrodes 20 and 24 are constructed so that the loop of current flowing through a low-power arc and electrodes 20 and 24 causes a magnetic force on the low-power arc. This magnetic force produced by the current loop, through the low-power arc, drives the low-power arc towards the interelectrode region 40 between the main electrodes 20 and 22. The introduction of the low-power arc into the region 40 indicates a power arc 38 across the main electrodes 20 and 22. When the vacuum gap device 10 is operated on an alternating current power line having a frequcncy of 50 Hz or 60 Hz, the time duration of the laser beam necessary to liberate the absorbed gas from portion 28 is very short compared to the period of the power frequency. The main power arc should be extinguished when the main power arc current reaches a current zero during the alternating current wave. The laser 50 which initiates operation of the vacuum gap device 10 and any related control circuitry can be completely electrically isolated from the vacuum gap 10. Since a portion 32 of insulating member 30 is of a smaller diameter than the inner diameter of the conducting stem 26 metal vapor and particles from the power arc 38 are less likely to be deposited on the outer surface 58 of portion 32. The window member 36 is recessed in stem 34 so that its inner surface 34 is shielded from most of the particles and vapors expelled from arc 38, and surface 35 is less likely to be coated with a metallic film, which would reduce the transparency of window 36.

Referring now to FIG. 5, there is shown a portion of the vacuum gap device 10 illustrating another embodiment of the invention. A gas-saturated metal piece 60 is attached to the main arching electrode 20. Note that a portion 62 of the inner diameter of main electrode 20 is beveled so that the gas-saturated metal part 60 is in position to be activated by a laser beam 56 projected through the stem 34 of the opposite electrode. The trigger electrode 24 extends through insulating member 30 and extends past the inner end 64 of insulating member 30. A voltage 70 or 72, less than the breakdown voltage 74 is applied between the trigger electrode 24 and the associated main electrode 20. As the laser beam 56 is focused on the gas-saturated metal piece 60, sufficient gas will be liberated from metal piece 60 to cause a low-power arc 66 to form between the trigger electrode 24 and the main electrode 20. As illustrated by the arrow 68, the low-power arc 66 is magnetically forced by the current flowing through the electrodes 20 and 24 into the main interelectrode area 40. As the arc 66 enters the main electrode area 40, a high-power arc forms between electrodes 20 and 22.

Referring now to FIG. 6, there is shown a trigger electrode configuration similar to that shown in FIG. 5 except that the gas-saturated metal piece 70 is attached to the trigger electrode 24 flush with insulating portion 30. As shown in FIG. 6, the trigger electrode 24 extends beyond the inner end of the insulating member 30, and passes through the gas-saturated metal disc 70. During operation of the vacuum gap device 10, the laser beam 56 is focused on the gas-saturated metal disc 70, so as to heat the disc 70 until the absorbed gas is released, thus causing a low-power arc 66 to form between the trigger electrode 24 and the associated main electrode 20. The low-power arc 66 is driven in the direction as indicated by arrows 68, due to the current flowing through the circuit comprising electrodes 20 and 24, into the main interelectrode area 40. The low-power arc 66 entering the interelectrode area 40 initiates a high-power arc between electrodes 20 and 22. A portion 72 of insulating member 30 is undercut in the vicinity of electrode 20 to lessen the possibility of arc-generated vapors or particles condensing on areas 72 and forming a conducting path betweeen the main electrode 20 and the trigger electrode 24.

The power of the laser beam 56 needed to initiate the trigger discharge by the gas-saturated piece 28, 60 or 70 can be calculated as follows. Consider the gas-saturated metal piece 28, 60 or 70 being an infinite plane. The temperature rise of the surface of metal piece 28, 60 or 70 as it being radiated by the laser beam 56 is given by the following formula:

$$\Delta T = (2P/JK)\sqrt{kt/\pi}$$

1

where P = radiation power density (watts/cm²)
K = thermal conductivity (cal/sec°K)

k = thermal diffusivity
t = time (sec)
J = 4.2 joules/cal

If the gas-saturated piece **28, 60** or **70** is made of titanium saturated with hydrogen, a large portion of the absorbed hydrogen will be evolved when the surface is heated to 1200°C. Assuming that 50 percent of the laser beam energy is absorbed by the gas-saturated piece **28, 60,** or **70,** a pulsed ruby laser having a beam power density of 10 MW/cm^2 and a pulse time duration of 10 nanoseconds (10×10^{-9} seconds) would be sufficient to heat the titanium surface to 1200°C. The time required to heat the surface of the gas saturated portion **28, 60** or **70,** if this portion **28, 60** or **70** is fabricated from titanium (Ti), to 1200°C can be calculated as follows:

Using a laser having a power density of 10×10^6 $watts/cm^2$ and assuming that 50 percent of the laser beam energy is absorbed by piece **28, 60** or **70.**

$P = 0.5 \times 10 \times 10^6$ $watts/cm^2 = 5 \times 10^6$ $watts/cm^2$
K varies in the range from 0.0425 to 0.0187 cal/sec°K for T;
$K \approx 0.2$ for Ti
J = 4.2 joules/cal
ΔT = 1200°C - 20°C (ambient) = 1180°C

Rearranging Equation 1 to solve for time (t) gives:

$$t = \pi/k\ (\Delta\ TJK/2P^2$$

2

substituting in the above values gives:

$$t = \Delta/0.2\ [(1.18 \times 10^3 \times 4.2 \times 4 \times 10^{-2})^2\ ]/[(10 \times 10^6)^2]$$

for K = 0.04 cal/sec°K
$= 2 \times 10^{-9}$ sec. = 6.2 N sec
for a value of K = 0.019 cal/sec.°K
$t = 1.3 \times 10^{-9}$ sec.

As can be seen, this time is very much less than the period for a 50 Hz or 60 Hz wave.

The energy requirement of the pulse laser per area per pulse, for K = 0.04 cal/sec°K is:

$(10 \times 10^6\ watts/cm^2) \times (6.2 \times 10^{-9}\ sec) = 6.2 \times 10^{-2}$ $joules/cm^2$

If the area of portion **28, 60** or **70** is 4 cm^2, the laser energy required is approximately 0.25 joules. Since it is necessary to liberate only a small amount of gas to start the low-power arc, a laser **50** having a beam of a somewhat lower power density, could be employed. In the example given, zirconium-aluminum alloy could be used instead of titanium for the gas-absorbed metal piece **28, 60** or **70.** The advantage of using zirconium-aluminum is that it has a faster pumping speed for hydrogen. This would help to ensure that the power arc is extinguished when the power arc current goes through a natural current zero.

The present invention has several advantages over prior art two electrode, laser initiated, vacuum gap devices, as shown, for example, in U.S. Pat. No. 3,295,011 issued Dec. 27, 1966 to S. Barbini. For example, the three electrode system has a more controlled and faster breakdown voltage. In the present invention, the breakdown mechanism is different from prior art devices, in that the laser beam impinges upon a gas-saturated material causing a small plasma to form between the trigger electrode **24** and the main electrode **20.** The plasma is then forced into main interelectrode region **40,** causing a breakdown between the main electrode **20** and **22.** In the prior art two electrode systems, the laser beam must melt a portion of the electrode surface and eject metal vapor into the gap **40** between the main electrodes **20** and **22.** This generally takes longer and is harder to control than the disclosed triggering means. In the prior art devices the laser beam is used so that thermic tearing away of the electrons alone produces triggering of the electric arc, while in the disclosed embodiment, the laser beam heats the gas-saturated material **28, 60** or **70** to release a gas, and this gas is then ionized by an existing electric field between the trigger electrode **24** and the associated main electrode **20.** The ionized gas conducts current and starts a low power arc between electrodes **20** and **24.**

I claim:

1. A triggered vacuum gap device comprising:
an evacuated envelope;
a first main arcing electrode disposed within said evacuated envelope;
a second main arcing electrode disposed within said evacuated envelope facing said first main arcing electrode, and spaced therefrom to form a first arcing gap therebetween;
a trigger electrode in close proximity to said second main electrode but electrically insulated therefrom by an open vacuum space, to form a second arcing gap therebetween;
a voltage source connected between said trigger electrode and said second main electrode to form an electric field therebetween which has a value lower than the breakdown potential between said trigger electrode and said second main electrode;
a gas-saturated metal piece located near said trigger electrode;
laser means for heating said gas-saturated metal piece to release a gas in the second arcing region between said trigger electrode and said second main electrode to initiate a low-power arc therebetween; and,
magnetic means comprising said second main arcing electrode and said trigger electrode disposed with respect to said second main arcing electrode to form a current loop through said low-power arc causing a magnetic force on said low-power arc for moving said low-power arc into the first arcing gap region between said first main contact and said second main contact to initiate a main power arc therebetween.

2. The apparatus as claimed in claim **1** wherein said triggering voltage source comprises a direct current supply and a current limiting resistor.

3. A triggered vacuum gap device as claimed in claim **1** wherein said trigger voltage source comprises an alternating current voltage supply, a voltage clipping device to limit peak value of said alternating voltage supply and a current limiting means.

4. A triggered vacuum gap device as claimed in claim **1** wherein a hollow conducting tube supports said first main arcing electrode, a transparent window supported in said hollow conducting tube, a laser beam projected from said laser means passing through said transparent window and said hollow conducting tube to impinge on said gas-saturated piece causing a gas to be released and initiating arcing between said trigger electrode and said second main arcing electrode.

5. A triggered vacuum gap as claimed in claim 4 comprising a second hollow conducting tube supporting said second main arcing electrode, a portion of said trigger electrode passing internal of said hollow conducting tube, insulating means for insulating said trigger electrode from said second hollow conducting tube, and said gas-saturated piece being attached to the end of said trigger electrode disposed within said hollow conducting tube.

6. A triggered vacuum gap as claimed in claim 5 wherein a portion of said insulating means in close proximity to said gas-saturated piece is of a smaller diameter than said hollow conducting tube to form a gap between a portion of said insulating means and the inner diameter of said second hollow conducting tube so that arc-generated metallic vapors and particles cannot condense on the solid dielectric between said trigger electrode and said second hollow conducting tube to cause a shorting path therebetween.

7. A triggered gap vacuum device as claimed in claim 1 wherein a bevel is formed on the inner diameter portion of said second main arcing electrode, said gas-saturated piece being mounted around said beveled portion of said second main arcing electrode so that when said laser means heats said gas-saturated piece, a low-power arc is formed between said beveled portion of said second main arcing electrode and said trigger electrode.

8. A triggered vacuum gap as claimed in claim 1, comprising: insulating means for supporting said trigger electrode, said gas-saturated piece comprises a metal disc that is saturated with hydrogen, said metal disc mounted at the end of said insulating means, said trigger electrode extending from said insulating means and passing through said gas-saturated metallic disc.

9. A triggered vacuum gap as claimed in claim 8 wherein said insulating means in the vicinity of said gas-saturated metallic disc is undercut to form a gap between said insulating means and said second main arcing electrode so that arc-generated metallic vapors and particles cannot coat the surface and form a shorting pass between said trigger electrode and said second main arcing electrode.

10. A triggered vacuum gap device comprising:

an evacuated envelope;

a first main arcing electrode disposed within said evacuated envelope;

a first hollow support being formed from a conducting material for supporting said first main arcing electrode;

a second main arcing electrode disposed within said evacuated envelope facing said first main arcing electrode and spaced therefrom to form first arcing gap therebetween;

a second hollow support being formed from a conducting material for supporting said second main arcing electrode;

a trigger electrode disposed within said second hollow support but electrically insulated therefrom to form a second arcing gap therebetween;

a voltage source connected between said trigger electrode and said second main arcing electrode to form an electric field therebetween which has a value lower than the breakdown potential between said trigger electrode and said second main electrode;

a gas-saturated metal piece located in close proximity to said trigger electrode;

laser means for heating said gas-saturated metal piece to release a gas in the second arcing gap between said trigger electrode and said second hollow support to initiate a low power arc therebetween; and,

said second hollow support and said trigger electrode being formed so that the magnetic field generated by the current flow when the low power arc is initiated forces the low power arc into the first arcing gap between said first main arcing electrode and said second main arcing electrode to initiate a main power arc therebetween.

11. A trigger vacuum gap device as claimed in claim 10 wherein:

said first hollow support comprises a hollow metallic tube extending through said evacuated envelope;

said laser means is disposed external to said evacuated envelope and directs a laser beam into said evacuated envelope through said first hollow support; and including,

a transparent member disposed within said hollow metallic tube through which the laser beam can pass and forming a vacuum tight seal with the inner surface of said hollow metallic tube.

* * * * *