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3,500,118

ELECTRODELESS GASEOUS ELECTRIC DISCHARGE DEVICES UTILIZING FERRITE CORES

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Int. Cl. H01j 7/44, 13/46
U.S. Cl. 315—57 9 Claims

ABSTRACT OF THE DISCLOSURE

A gaseous discharge light source includes a non-conducting light transmissive hermetically sealed envelope in the form of a closed loop containing an ionizable gas. Envelope is electromagnetically coupled to a source of R.F. energy, generating power at a frequency, preferably of 100 kc. to 500 kc., by a ferrite core. Energy source comprises a low cost solid state oscillator circuit producing a relatively low voltage. Envelope may be coated on the interior thereof with a fluorescent phosphor emitting visible light when irradiated by excited specie of the ionizable gas. Instantaneous starting is achieved by inducing a high starting voltage into the envelope by a step-up secondary winding on the ferrite core.

The present invention relates to improved gaseous electric discharge devices and more particularly to such devices in which electrodes are eliminated.

The electric lamp technology has long sought electric discharge devices which produce visible light for general illumination purposes without the utilization of electrodes as the foot-points of a glow or arc discharge. Although the concept of electrodeless discharge lamps is very old, such lamps have always included the concept of coupling electrical energy into an hermetically sealed gaseous containing envelope by means of a ferro-magnetic or air core transformer to avoid the use of electrodes. Such devices have never proved practical or commercially feasible, because it has been impossible to achieve any reasonable efficiency of light emission due to the utilization of iron or air core transformers because of core losses, among other factors.

Accordingly it is an object of the present invention to provide improved electrodeless gaseous arc discharge apparatus.

Another object of the present invention is to provide fluorescent lamp apparatus in which the sole limitation placed upon the operation of the lamps is the inherent limitation of efficiency in the lamp phosphor itself.

Yet another object of the present invention is to provide a gaseous electrode discharge light source and a low-cost, low-voltage power supply therefor.

Still another object of the present invention is to provide gaseous arc electrodeless discharge devices and simple and inexpensive means for instantaneously initiating operation thereof.

Briefly stated, in accord with one embodiment of the present invention, I provide efficient electrodeless gaseous discharge device light sources wherein an evacuable and hermetically sealed envelope forms a closed loop which forms the secondary of a transformer. The envelope is filled with an ionizable vapor capable of emitting radiant energy when excited and ionized either for illumination purposes or for the excitation of a luminescent phosphor. Energy is coupled into the vapor containing envelope by means of a ferrite core having relatively low losses at radio frequencies of higher than 50 kilocycles per second. The primary winding upon the ferrite core is connected with a low cost, solid state oscillator circuit, producing electromagnetic oscillations at radio frequencies in excess

of approximately 50 kc. and preferably in the range of 100 to 500 kilocycles at a relatively low voltage, the order of magnitude of the voltage necessary to cause operation of the lamp.

In accord with a preferred embodiment of the present invention the interior of the evacuable envelope is coated with a luminescent phosphor which is excited to emission of visible light by absorption of radiation emitted by the excited ionizable vapor within the envelope. In further accord with another preferred embodiment of the present invention, instantaneous starting of the vapor discharge lamp is achieved by a secondary winding on the ferrite core which couples a very high starting voltage into the vapor containing envelope.

The novel features believed characteristic of the present invention are set forth in the appended claims.

The invention itself, together with further objects and advantages thereof, may best be understood with reference to the following detailed description taken in connection with the appended drawing in which:

FIG. 1 illustrates, in perspective, a luminaire including a light source constructed in accord with the present invention,

FIG. 2 illustrates, partially in schematic and partially in vertical cross-section, the device of FIG. 1 and the operating voltage source,

FIG. 3 illustrates in vertical cross-section an alternative embodiment to the device of FIG. 1,

FIG. 4 illustrates a horizontal cross-sectional view of the device of FIG. 3,

FIG. 5 illustrates yet another alternative embodiment of the invention,

FIG. 6 illustrates a further alternative for the arrangement of the ferrite core in accord with the present invention, and

FIG. 7 illustrates a schematic circuit for an inexpensive radio frequency oscillator constructed in accord with the present invention.

In FIG. 1, a lighting fixture indicated generally as **10** includes a reflecting shield **11** having supported therein an hermetically sealed, hollow, tubular envelope **12** supported upon support clamps **13** and **14**. Envelope **12** is encircled by a pair of annular ferrite cores **15** and **16** which are coupled to a source of electromagnetic energy (not shown).

FIG. 2 illustrates, partially in cross-section and partially in block schematic diagram, the apparatus illustrated in FIG. 1. In FIG. 2, evacuable envelope **12** is surrounded by core **15**, and core **16** (shielded from view). Core **15** is wound with a plurality of turns **17** of wire which are connected to radio frequency oscillator **19** energized from a conventional 60 cycle alternating current source **20**. In practice, core **15** serves as the coupling member of a transformer of which winding **17** constitutes the primary and ionized vaporized material within envelope **12** constitutes a one-turn secondary. As is illustrated in FIG. 1 of the drawings, a plurality of coupling cores may be utilized to energize simultaneously the ionizable vapors within envelope **12**. The core primary windings for the plurality of circuit may be connected in series, parallel, or series parallel circuit relationship with no impedance matching problems.

The device of FIG. 1 and the cross-sectional view of FIG. 2 illustrates one embodiment of the invention wherein a high intensity light source may be desired. In the alternative, it may be desirable that a household fixture, which may be substituted for a conventional fluorescent lamp utilizing ballast transformers and electrodes, be provided.

For utilization in a conventional household installation, a device illustrated in vertical section in FIG. 3 may be utilized. In FIG. 3 a case **21** which may contain

radio frequency oscillator **19** is utilized to support cores **15** and **16** about which are wound primary windings for activation of the ionizable vapors within envelope **12**.

In FIG. 4 of the drawing a plan view, taken from below the device of FIG. 3, illustrates how such an arrangement may conveniently be utilized to substitute for a conventional fluorescent fixture wherein elongated envelope 12 is substituted for a pair of parallel conventional fluorescent lamps.

Envelope **12** is filled with a sufficient quantity of mercury to provide a vapor pressure, at an operating temperature of approximately 40° C., of approximately 5 to 10 and preferably 7 microns and is filled to excess to insure such partial pressure. For example, an envelope having a volume of approximately 30 cubic inches was filled with 50 milligrams of mercury to provide a suitable operating partial mercury vapor pressure. For purposes of starting an electric discharge within envelope **12**, a partial pressure argon of approximately 1 to 5 and preferably approximately 2.5 millimeters of mercury is added. In the lamp described above, 2.5 millimeters of argon was used. Radio frequency oscillator **19** produces oscillations within the frequency range of 100 to 500 kilocycles per second and provides a relatively low voltage output of the order of 50 to 100 volts RMS alternating current at currents of approximately 0.25 to 1.0 ampere. The above lamp was excited with 400 kilocycle radio frequency oscillations, applying to the ionized vapor within the single turn of the secondary voltage of approximately 70 volts. Since the lamp had a path length of approximately 35 inches in length, the voltage gradient along the discharge path was approximately 2 volts per inch. Suitable operating voltage gradients are in the range of 0.5 to 5 volts per inch. The current measured by a sensing coil indicated a current within the arc of approximately 0.5 ampere. Under these circumstances, the calculated heating loss within ferrite core **15** and **16** was approximately 9 watts and amounted to, on the basis of a power input of 42 watts, a loss of approximately 21%.

In accord with the present invention utilizing ferrite cores I am able to provide high efficiency light from an ionizable gaseous source when the core loss is anything less than 50%.

I am aware that it has been proposed in the prior art to excite electrodeless gaseous discharge lamps using electromagnetic induction to transfer electric energy into the discharge vessel. Experiments along this line disclose that heretofore such means have been highly impracticable. If an air core transformer is utilized, the inefficiency of the coupling procedure in order to achieve a reasonable power input to the gaseous discharge results in a loss of power by radiation which is prohibitive, and which may be dangerous. Accordingly such devices have never been successfully operated for useful periods at any reasonable efficiency.

Another alternative that has been proposed in the prior art is the utilization of an iron or ferromagnetic cores. Such cores, however, may be utilized only on very low frequencies in order that heating of the iron and eddy currents do not cause core failure. Utilizing alternating current, it is exceedingly difficult to operate an iron core transformer for the purpose of transferring energy of this nature at frequencies in excess of 5 or 10 kilocycles per second. Based upon experimental and calculated results obtained at this laboratory, it has been determined that for an iron core transformer operating at 50 kilocycles in frequency, core losses in power are in the range of approximately 80 to 90%. Accordingly, from the foregoing it may readily be appreciated that air core and iron core transformers are, from a practical point of view, inoperative to operate at the high radio frequency voltages incurrence that I find necessary for efficient operation of gaseous discharge lamps in accord with the invention.

In accord with a preferred embodiment of the present invention, the interior surface of the envelope **12** is coated with a conventional fluorescent phosphor such as a calcium halo-apatate, which phosphors are well known to the art. These phosphors are capable of absorbing the ultraviolet radiation of mercury which is generally peaked at about 2537 AU and, upon stimulation thereby, emitting radiation within the visible spectrum to produce a highly efficient and pleasing light output. In this embodiment of the invention, the electric discharge is not relied upon to produce the light emission, but rather, to produce radiation which causes light to be emitted from a luminescent phosphor. This allows for a relatively low power input to the ionizable gas since the gas itself is not relied upon for the necessary light emission but only for radiation to stimulate the phosphor.

Lamps constructed in accord with the preferred embodiment of the present invention are highly useful in that the electrodes which are the source of many of the limitations in present day fluorescent lamps are eliminated. Thus, for example, burnout of an electrode can never be the cause of a failure of a lamp in accord with the present invention. Similarly, sputtering of electrode materials upon the interior surface of the lamp walls, causing darkening thereof, is completely eliminated. Likewise, and of equal importance, the problems of metal to glass or ceramic seals are completely eliminated. In electric discharge lamps of the prior art, emphasis has been placed, in obtaining greater efficiencies, in producing lamp envelopes fabricated from material which will withstand higher operating temperatures, as for example, fused quartz, high density alumina and similar ceramic materials. With these materials the differential coefficient of expansion between the lamp envelope and tungsten, nickel and other metals conventionally utilized to pass electric leads through the envelopes becomes an increasingly difficult problem. A high proportion of lamp failures, in the most sophisticated designs, result from failure of a metal to glass or metal to quartz or ceramic seal. In accord with the present invention, all electrodes within the envelope are eliminated and, likewise, all metal to glass, Pyrex or ceramic seals, thus eliminating one of the greatest causes of lamp failure.

In accord with a further embodiment of the present invention, I provide an instantaneously starting lamp. As is well known to the art, although a relatively low voltage is sufficient to maintain a gaseous arc discharge in operation, once the arc has been struck, a high voltage is generally required to cause initial breakdown. This is so, even in the presence of a readily ionizable inert gas, such as argon, to cause an initial breakdown to facilitate ionization of mercury, the common discharge carrying metallic vapor utilized in gaseous vapor discharge lamps. In many instances, this high voltage for starting is provided by a mechanical starter, with capacitive or inductive elements, which suddenly separates causing a high voltage surge to electrodes of the device in order to cause initial ionization. Alternative arrangements involve the use of ballast transformers to provide the necessary voltage. In accord with the present invention, I find that this problem may be rapidly, inexpensively and easily solved by my discovery that an auxiliary secondary winding upon the ferrite core, with sufficient turns to cause it to operate as a step-up secondary, may be utilized to tap off a very high voltage which may be applied to the lamp to cause the induction of a high starting voltage, which rapidly causes the initial breakdown necessary for operation of lamps in accord with the present invention.

The aforementioned starting means is illustrated in greater particularity in FIG. 3 of the drawing wherein, at the broken apart portion of the left end of the fixture, core **15** may be seen to be encircled by a large number of turns constituting an auxiliary secondary winding **22**, which is connected with a pair of spaced probes **23** and **24** which are in contact with respective portions of the lamp envelope **12** on the side thereof that is away from the direction of light propagation. Alternatively, the probes may enter the envelope, although generally this is to be avoided because of seal problems. Conveniently, in the aforemen-

tioned embodiment of the invention wherein the primary winding on ferrite core **15** constituted 3 turns, a 10 turn auxiliary secondary **22** was utilized to cause a voltage of approximately 2000 peak-to-peak volts to be applied to cause instantaneous starting. This instantaneous starting arrangement has the advantage over other instantaneous starting arrangements in that it requires no auxiliary member which must separate to cause a high voltage transient and the high voltage is applied to the lamp at all times, but without any deleterious effect, even with long life lamp operation.

FIG. 5 of the drawing illustrates an alternative embodiment of the invention wherein a single core may be utilized, with or without additional cores in parallel, to energize a single fluorescent lamp which has a "Figure 8" shape with a common central leg, or wherein a pair of loops may pass through the same core or cores to be energized thereby simultaneously. In FIG. 5, envelopes **25** and **26** having energized legs **27** and **28**, respectively, pass through 3 ferrite cores **29**, **30** and **31**, each of which is wound, either in series circuit or series-parallel relationship, depending upon the impedance match desired for the energizing circuit, with primary windings to cause the coupling of an appropriate voltage to the portions **27** and **28** of envelopes **25** and **26** constituting single turn secondaries of the effective transformer to cause the initiation of breakdown therein. In order that both envelopes **25** and **26** break down, auxiliary cores **32** and **33** are used and, are similarly energized in order to make sure that ionization occurs in both envelopes. In their absence, ionization in one core, would cause a lower voltage gradient therein thus effectually short-circuiting the unionized envelope so that only one would be energized. With the presence of cores **32** and **33**, however, both envelopes are energized, ionized, and both emit visible radiation.

FIG. 6 of the drawing illustrates yet another embodiment of the invention, wherein the structure of a core utilized is such as to allow for removal of the lamp envelope in case of failure thereof by breakage, or by extended life and burnout of the phosphor, or any other contingency which may occur. In FIG. 6 a primary winding **17** wraps around a portion of core **15** and couples electromagnetic energy into envelope **12**. As is also illustrated in FIG. 3, a second secondary **22**, having a large number of windings as compared with primary winding **17**, is connected with a pair of probes **23** and **24** which are connected with, and abutting against, the outer edges of envelope **12** to cause a high voltage to be induced therein to cause initial breakdown of the ionizable vapors therein. A portion **35** of core **17** is hinged at **36** and fastened at **37** to permit opening of the closed core to remove the envelope **12** and replace with a new one. Although the particular shape of core **17** illustrated in FIG. 6 is square, it should be appreciated that any configuration of core may be hinged to permit removal thereof, and that the fact that there is an interface between respective portions of the core is of no real significance in utilizing the core to couple electromagnetic energy from primary **17** to the vapors within envelope **12**.

FIG. 7 of the drawing illustrates schematically a radio frequency oscillator which is utilized, in accord with the the fluorescent lamp embodiment of the present invention, to provide a radio frequency signal of approximately 400 kilocycles per second for operation of lamp envelope **12** containing an ionizable mixture of argon and mercury, as described above. In FIG. 7, envelope **12** is electromagnetically coupled by four ferrite cores, each of which is represened by a single dotted line, paired for purposes of simplicity of representation, in core groupings **40** and **41**. Core groupings **40** and **41** are coupled in a primary winding arrangement constituting first coil members **42** and **43** and second coil members **44** and **45**. Coil members **42** and **43** are each wound in series circuit relationship around the core members constituting core grouping **40**, on one hand, and the cores of core grouping **41**, on the other hand, and are connected in parallel relationship with a 0.03 microfarad capacitor to provide a resonant circuit. Coil members **44** and **45** are each wound in series circuit relationship around both of the cores within either core grouping **40** or core grouping **41** and are then connected in parallel circuit relationship with one another. Coils **44** and **45** are connected in the emitter circuit of the transistor **46**, utilized as the active circuit element in the oscillator of FIG. 7. In the specific embodiment constructed and illustrated in FIG. 7, an MJ423 transistor was utilized as transistor **46**, which is connected in a modified Hartley oscillator configuration, connected in the grounded-collector, emitter-fed circuit configuration. A similar, collector fed configuration could also be used.

The emitter circuit of transistor **46** also includes an MR1337–3 diode to protect the transistor emitter circuit. The input to the transistor circuit is approximately 160 volts D.C. and is provided by a rectifying and filter network represented generally as **50** which is connected with a 117 volts A.C. RMS voltage source. This filter and rectification network includes a 2.5 ohm, 5 watt input resistor and a bridge network comprising 4 symmetrical IR10DB3A germanium diodes shunted with a 200 microfarad capacitor. In operation, coil members **42** and **43** are connected in series circuit relationship across all of the cores in core groupings **40** and **41** to keep the voltage induced thereby in phase. Each of coils **42** and **43** may conveniently consist of a single turn about each core. The actual driving power for each core is supplied by coil members **44** and **45** which effectively constitute the primary windings for the cores and may conveniently be from 3 to 6 windings about each core member connected as illustrated in FIG. 7. Alternatively, a modified circuit may be utilized wherein a similar oscillator utilizes a pair of transistors connected in a modified push-pull oscillator circuit for added power and stability.

In accord with the present invention, it is necessary that the cores utilized be of such material and configuration that the core losses are no greater than 50% in order that effective coupling of electromagnetic energy into the light source may be effected. Similarly, low core losses reduce heating of the core and minimize the possibility of failure and maximize its efficiency. Preferably, as in the described specific embodiment of the invention hereinbefore, core losses are maintained to less than 25% of total input power. The amount of core utilized varies with the degree of excitation required. In general, however, in order that a voltage gradient of 2 volts RMS per inch be induced in an envelope having an arc length of approximately 36 inches, I find that it is necessary to use approximately 4 square inches in cross section of core, the exact configuration of the closed loop of the core being immaterial. In general, any high performance, low loss ferrite core material may be utilized. As is well known to the art, a ferrite is a ceramic-like material showing ferri-magnetic properties and usually exhibits a spinel structure having a cubic crystal lattice and has the generalized formula $Me \cdot Fe_2O_4$ wherein Me represents any metal. A suitable core material may be obtained from Ferrox Cube Company of Saugerties, N.Y., and may bear the identification Type 3B7 or Type 3H1. Such cores, having an annular configuration with an outside diameter of 3½ inches and an inner diameter of 1½ inches, have been utilized in accord with the present invention. To drive a 1¼ inch outside-diameter fluorescent lamp having a partial pressure of 7 microns of mercury and a partial pressure of argon of 2½ mm. of mercury, four such cores have been utilized, each core having a thickness dimension of approximately ½ inch. Accordingly, two square inches cross section of total core utilized, resulting in a 55 volt arc drop at 0.5 ampere and a core loss of totalling approximately 10 watts at a total input power of 42 watts and a 25% core loss.

By the foregoing it may readily be seen that I have discovered a new and improved method of providing electrodeless arc lamps and, more specifically, fluorescent arc lamps wherein the light emitted thereby is emit-

ted by a fluorescent phosphor coating the interior surface of a light-transmissive, non-conducting hermetically sealed envelope containing a partial pressure of mercury and an inert starting gas. In accord with my invention, I provide an electromagnetic coupling between a radio frequency oscillator oscillating in a frequency range of from 100 kilocycles per second to 500 kilocycles per second utilizing ferrite cores having a power efficiency such as to keep the core losses below 50% and preferably below 25%. In further accord with my invention I provide a solid state oscillator producing radio frequency oscillations in the range of 100 kilocycles to 500 kilocycles per second and delivering an output power that is relatively low.

In further accord with the present invention I am able to cause a lamp constructed in accord with the present invention to be instantaneously startable, by providing a second secondary winding upon the ferrite core, which winding is a step-up winding and is connected with a pair of probes upon the exterior surface of the lamp envelope, causing the induction of a high voltage therein which is sufficient to cause instantaneous starting of the lamp.

While the invention has been set forth hereinbefore with respect to certain specific embodiments thereof many modifications and changes will readily occur to those skilled in the art. Accordingly by the appended claims I intend to cover all such modifications and changes as fall within the true spirit and scope of the present invention.

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

1. An electric light producing apparatus including

(a) a hollow tubular light transmissive envelope in the form of a closed loop containing an ionizable vapor,

(b) coupling means encircling a portion of said loop and comprising a high frequency high ferrimagnetic permeability ferrite core adapted to couple energy from an input winding to said ionizable vapor at a radio frequency in excess of approximately 50 kc. with less than 50% loss of energy.

(c) an input winding encircling a portion of said coupling means for supplying an alternatnig radio frequency voltage of in excess of approximately 50 kc. thereto,

(d) means connected to said input winding for generating a radio frequency voltage at a frequency in excess of approximately 50 kc.

2. The apparatus of claim **1** wherein the radio frequency is in the range of approximately 100 kc. to 500 kc.

3. The apparatus of claim **2** wherein said envelope is coated on the inside thereof with a luminescent phosphor adapted to emit light in the visible spectrum when excited by radiation of a mercury arc and said envelope further includes sufficient mercury to supply an excess of unvaporized mercury under operating conditions and a partial pressure thereof of approximately 5 to 10 microns and a partial pressure therein of an inert gas of approximately 1 to 5 torr.

4. The apparatus of claim **3** wherein the coupling coefficient and the efficiency of the transformer comprising said ferrite core, said ionizable vapor, and said primary winding is effective to produce a voltage within said ionizable vapor from 50 to 100 volts RMS A.C. at a current of 0.25 to 1.0 ampere and a radio frequency of 100 to —500 kilocycles per second.

5. The apparatus of claim **3** wherein the voltage gradient within said ionized vapors within said envelope is approximately 0.5 to 5.0 volts per inch.

6. The apparatus of claim **3** wherein said radio frequency generating means is a modified Hartley oscillator in the grounded collector circuit configuration with output feed to said core.

7. The apparatus of claim **5** wherein a first primary winding for supplying power to a plurality of cores is wound in series parallel circuit relationship about said plurality of cores and a second control and feedback primary winding is wound around each of said plurality of cores in series circuit relationship to maintain phase synchronization between said cores.

8. The apparatus of claim **2** wherein a second secondary winding encircles said ferrite core with a greater number of turns than said primary winding and the ends thereof are connected to probes attached adjacent the exterior of said envelope for inducing therein a high voltage to cause instantaneous energization of said ionizable vapors therein upon energization of said primary winding.

9. The apparatus of claim **7** wherein said starting voltage is approximately 500 to 1000 volts RMS.

References Cited

UNITED STATES PATENTS

1,534,251	4/1925	Smith	315—248 X
1,813,580	7/1931	Morrison	315—248 X
2,030,957	2/1936	Bethenod et al.	315—248
2,770,734	11/1956	Reek	331—117 X

JAMES W. LAWRENCE, Primary Examiner

C. R. CAMPBELL Assistant Examiner

U.S. Cl. X.R.

315—248

ted by a fluorescent phosphor coating the interior surface of a light-transmissive, non-conducting hermetically sealed envelope containing a partial pressure of mercury and an inert starting gas. In accord with my invention, I provide an electromagnetic coupling between a radio frequency oscillator oscillating in a frequency range of from 100 kilocycles per second to 500 kilocycles per second utilizing ferrite cores having a power efficiency such as to keep the core losses below 50% and preferably below 25%. In further accord with my invention I provide a solid state oscillator producing radio frequency oscillations in the range of 100 kilocycles to 500 kilocycles per second and delivering an output power that is relatively low.

In further accord with the present invention I am able to cause a lamp constructed in accord with the present invention to be instantaneously startable, by providing a second secondary winding upon the ferrite core, which winding is a step-up winding and is connected with a pair of probes upon the exterior surface of the lamp envelope, causing the induction of a high voltage therein which is sufficient to cause instantaneous starting of the lamp.

While the invention has been set forth hereinbefore with respect to certain specific embodiments thereof many modifications and changes will readily occur to those skilled in the art. Accordingly by the appended claims I intend to cover all such modifications and changes as fall within the true spirit and scope of the present invention.

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(c) an input winding encircling a portion of said coupling means for supplying an alternatnig radio frequency voltage of in excess of approximately 50 kc. thereto,

(d) means connected to said input winding for generating a radio frequency voltage at a frequency in excess of approximately 50 kc.

2. The apparatus of claim **1** wherein the radio frequency is in the range of approximately 100 kc. to 500 kc.

3. The apparatus of claim **2** wherein said envelope is coated on the inside thereof with a luminescent phosphor adapted to emit light in the visible spectrum when excited by radiation of a mercury arc and said envelope further includes sufficient mercury to supply an excess of unvaporized mercury under operating conditions and a partial pressure thereof of approximately 5 to 10 microns and a partial pressure therein of an inert gas of approximately 1 to 5 torr.

4. The apparatus of claim **3** wherein the coupling coefficient and the efficiency of the transformer comprising said ferrite core, said ionizable vapor, and said primary winding is effective to produce a voltage within said ionizable vapor from 50 to 100 volts RMS A.C. at a current of 0.25 to 1.0 ampere and a radio frequency of 100 to —500 kilocycles per second.

5. The apparatus of claim **3** wherein the voltage gradient within said ionized vapors within said envelope is approximately 0.5 to 5.0 volts per inch.

6. The apparatus of claim **3** wherein said radio frequency generating means is a modified Hartley oscillator in the grounded collector circuit configuration with output feed to said core.

7. The apparatus of claim **5** wherein a first primary winding for supplying power to a plurality of cores is wound in series parallel circuit relationship about said plurality of cores and a second control and feedback primary winding is wound around each of said plurality of cores in series circuit relationship to maintain phase synchronization between said cores.

8. The apparatus of claim **2** wherein a second secondary winding encircles said ferrite core with a greater number of turns than said primary winding and the ends thereof are connected to probes attached adjacent the exterior of said envelope for inducing therein a high voltage to cause instantaneous energization of said ionizable vapors therein upon energization of said primary winding.

9. The apparatus of claim **7** wherein said starting voltage is approximately 500 to 1000 volts RMS.

References Cited

UNITED STATES PATENTS

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1,813,580	7/1931	Morrison	315—248 X
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2,770,734	11/1956	Reek	331—117 X

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Filed July 17, 1967 2 Sheets-Sheet 1

Fig. 1.

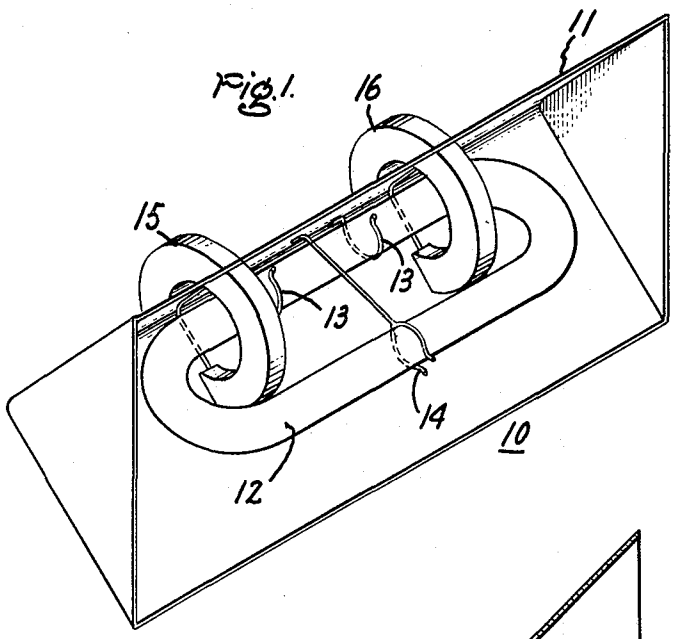
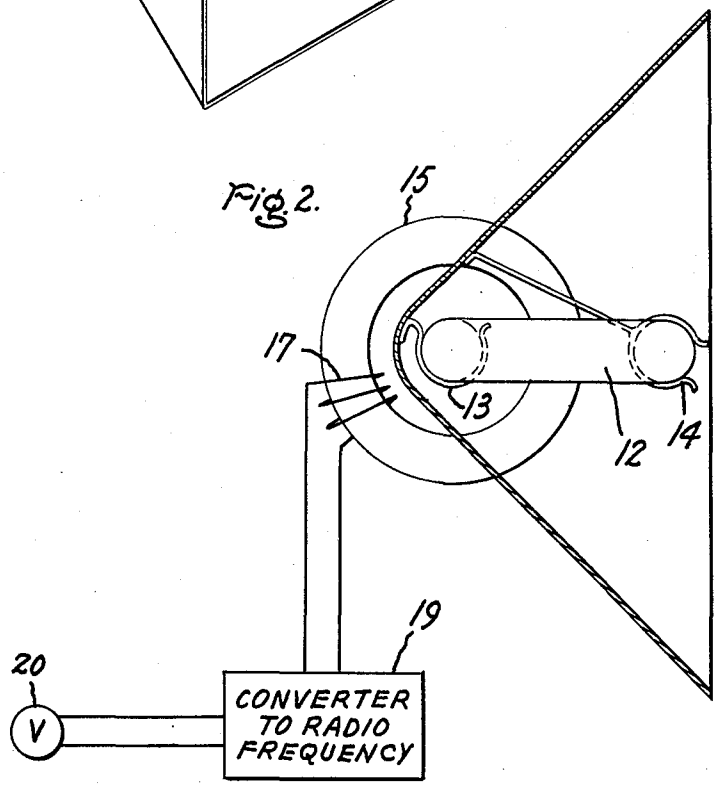


Fig. 2.



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ELECTRODELESS GASEOUS ELECTRIC DISCHARGE DEVICES UTILIZING FERRITE CORES

Filed July 17, 1967 2 Sheets-Sheet 2

Fig. 3.

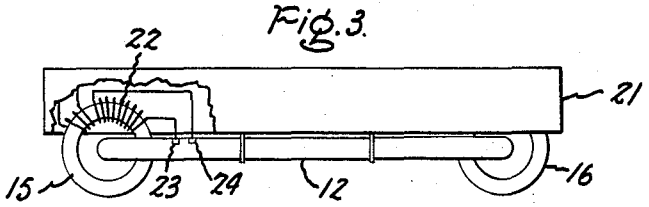


Fig. 4.

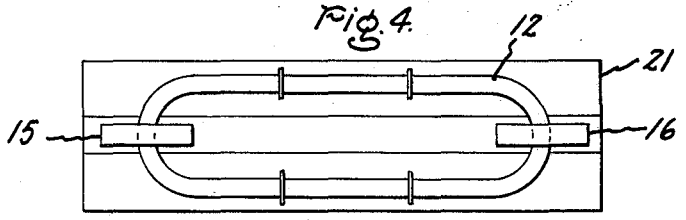


Fig. 5.

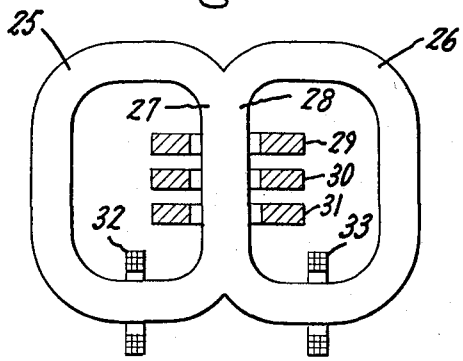


Fig. 6.

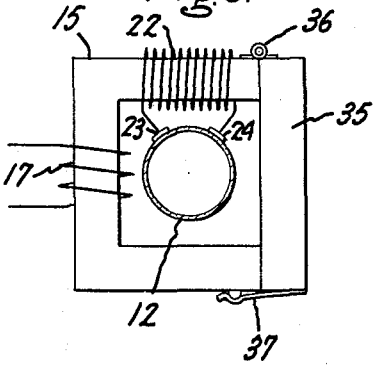
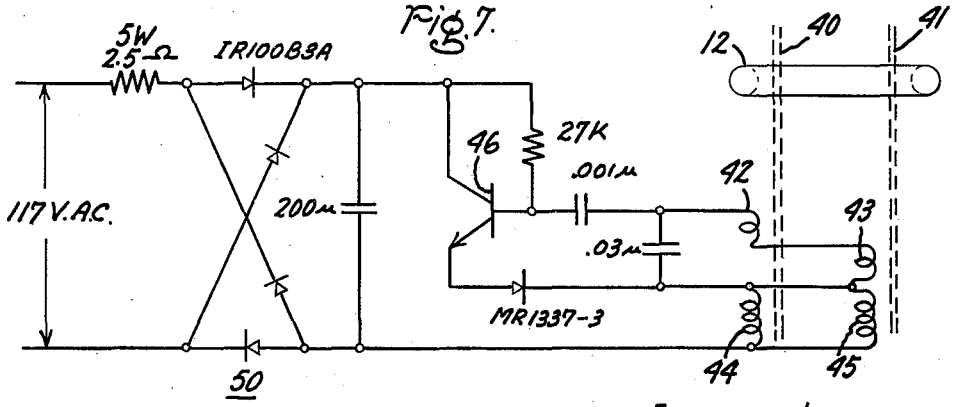


Fig. 7.



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