

## [54] MICROWAVE-EXCITED LIGHT EMITTING DEVICE

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[22] Filed: Apr. 28, 1972

[21] Appl. No.: 248,477

[52] U.S. Cl. .... 315/248, 315/267

[51] Int. Cl. .... H05b 41/24

[58] Field of Search .. 331/66, 97, 98, 177; 315/267,  
315/150, 155, 248; 313/110, 63

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## [57] ABSTRACT

A microwave-excited light emitting device is provided comprising an electrodeless evacuated discharge lamp containing ionizable elements mounted in the frequency determining resonator of a microwave oscillator. The oscillator resonator is tuned to provide a microwave energy at a frequency sufficiently high to provide ionization and excitation of the elements within the electrodeless discharge lamp while mitigating deleterious ion bombardment of the walls of the electrodeless discharge lamp. By placing the lamp in the oscillator resonator any changes in the electrical characteristics of the lamp after firing will cause a frequency shift in the oscillator allowing the lamp and oscillator to remain in tuned relationship.

4 Claims, 2 Drawing Figures

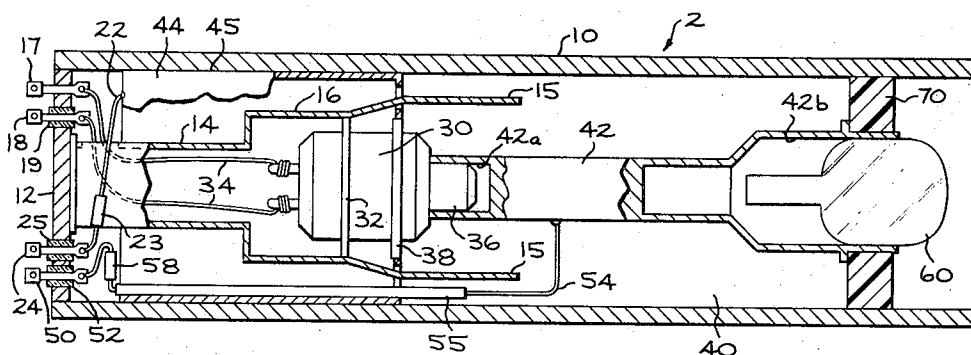


FIG. 1

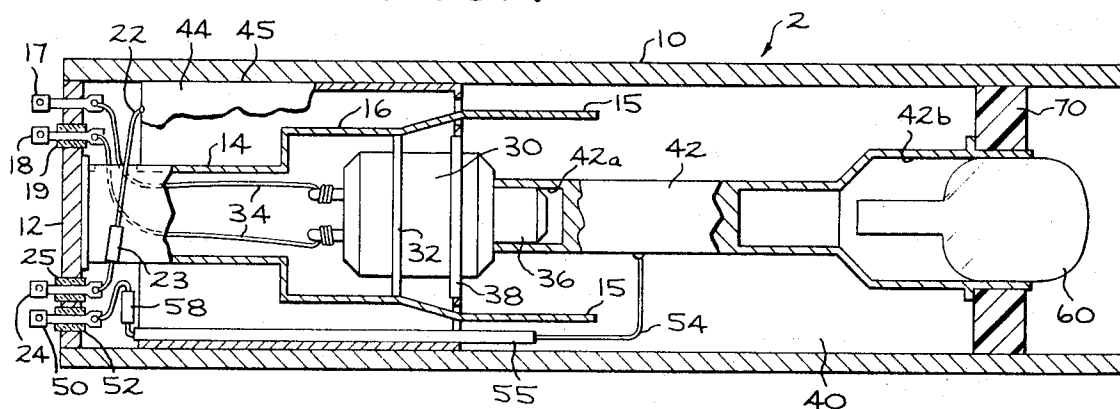
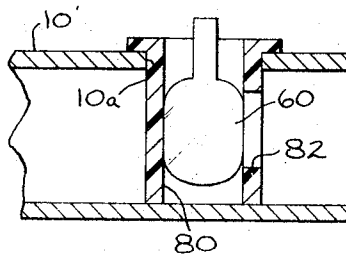


FIG. 2



## MICROWAVE-EXCITED LIGHT EMITTING DEVICE

### CROSS-REFERENCE TO RELATED APPLICATION

This application is related to U.S. Pat. application, Ser. No. 248,478 filed concurrently in the names of L. R. Bolin, C. Hopper, Jr., and S. A. Jolly.

### BACKGROUND OF THE INVENTION

This invention relates to light-emitting devices excited to emit light by electromagnetic energy of microwave wavelength. More particularly, this invention relates to a microwave device comprising a microwave cavity oscillator having a light emitting electrodeless lamp integrally mounted therein.

In certain types of apparatus, such as, for example, spectroscopic analysis equipment for identification of the presence of certain elements in samples, a modulated beam of the light spectrum of the element in question is produced to excite the sample. This modulated light source has been produced using hollow cathode electron discharge devices. However, for certain elements this has proved unsatisfactory because the presence of the particular element shortens the life of the hollow cathode.

It has therefore been proposed to produce the desired light spectrum by exciting such elements using microwaves. The element is encapsulated, together with an inert gas, in an electrodeless lamp comprising a sealed envelope which is transparent to the desired wavelengths such as, for example, quartz or other glasses. The lamp is placed in a microwave cavity resonator in the particular location desired for light emission and coupled to a microwave cavity oscillator resonator to provide the power source for the excitation.

However, it has been found that at low frequencies, i.e., lower than about 500 mHz, the excited ions within the lamp bombard the glass envelope of the lamp with resultant undesirable shortening of lamp life. At higher frequencies this problem is mitigated or eliminated but other problems are encountered which are thought to be due to an untuned condition between the two cavity resonators housing, respectively, the oscillator and the lamp. It has been found that the lamp cavity resonator apparently resonates at a different frequency when the lamp is in an unexcited or unfired state than when the elements are excited. As a result the oscillator cavity resonator, if tuned to the excited resonance frequency of the lamp resonator, will not commence the excitation (fire the lamp) while conversely, if the oscillator resonator is tuned to the unexcited frequency, it will not deliver power efficiently to the lamp cavity resonator during sustained excitation resulting in loss of light output.

It is therefore an object of this invention to provide an integral, microwave stimulated, light-emitting device comprising a microwave oscillator cavity resonator containing an electrodeless light-emitting lamp. It is another object of the invention to provide means for improving the operating efficiency of such a device.

These and other objects of the invention will be apparent from the following description and accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially cutaway cross-sectional view of a preferred embodiment.

FIG. 2 is a fragmentary sectional view of another embodiment of the invention.

### DESCRIPTION OF THE INVENTION

The invention generally comprises a light-emitting device comprising a microwave oscillator generally indicated at 2 having an outer electrically conductive shell 10 and containing an electrodeless discharge lamp 60 adjacent one end thereof, an active device 30 adjacent an opposite end of the shell 10, and means therebetween defining a resonant cavity generally indicated at numeral 40 which cooperates with the active device 30 to provide an oscillator to provide a sustained emission of microwave energy at the resonant frequency of the device as determined by the parameters of the associated circuit.

The shell 10 comprises a hollow metal shell which may be provided with a cylindrical bore therein. A metal end cap 12 is fitted into the central bore in shell 10 to provide an end wall 12 therefor. End wall 12, in turn, communicates with a hollow metal tube 14 and a larger-diameter metal tube 16 within shell 10 to electrically couple end wall 12 with the cathode terminal 32 of active device 30 which, in the illustrated embodiment, comprises a triode electron discharge device having the usual cathode, grid and anode electrodes (not shown). Heater wires for the cathode are connected by leads 34 connected to terminals 17 and 18 on end wall 12. Terminal 17 is grounded to the end wall 12 while terminal 18 is brought out through an insulator 19.

Device 30 has an anode stud 36 which is coupled to an anode line 42 via a first hollowed out bore 42a in anode line 42. Anode line 42 is also provided with an enlarged-diameter counter bore 42b at the opposite end of the line for a purpose which will be explained below.

Device 30 is also provided with a grid terminal ring 38 which is connected to a metallic grid cylinder 44 having a dielectric coating 45 thereon to insulate it from shell 10. The grid at device 30 is connected to a terminal 24 via a lead 22 and grid resistor 23 leading from the grid cylinder 44. Terminal 24 is mounted in end wall 12 and insulated therefrom by an insulator 25.

Power is supplied to anode stud 36 through a terminal 50 mounted in end wall 12 and insulated therefrom by an insulator 52. A lead wire 54 connected to anode line 42 passes through a shield 55 to terminal 50 through an RF choke 58.

Feedback fingers 15 electrically connected to the cathode 32 pass through openings in the end wall of grid cylinder 44 to feed energy from the plate circuit back to the cathode circuit to sustain oscillation of the device.

The oscillator provides microwave energy in a manner well known to those skilled in the art and described, for example, in Chapter 6 of "Electronic Designers' Handbook"; by R. W. Landee, D. C. Davis, and A. P. Albrecht; McGraw-Hill Book Company, Inc.; 1957.

Electrodeless discharge lamp 60 comprises a sealed, hollow ampule comprising silica or glass or the like and containing gas of the particular elements, for example, mercury vapor and an inert gas such as argon. The

lamp 60 is mounted, in the illustrated embodiment, as the load of the oscillator 2 and to this end is in accordance with a feature of our invention disposed in the counter bore 42b in anode line 42. The anode line, having the lamp mounted therein, is mechanically supported within shell 10 by a dielectric material 70 which may comprise a washer of teflon or other suitable dielectric materials.

The anode line is designed to be, electrically, one-half wavelength long, taking into account the foreshortening of the transmission line section. Thus the electrodeless discharge lamp 60 is placed approximately in a position of maximum electrical field strength. This is desirable to provide maximum intensity of the field and therefore maximum intensity of the emitted light resulting from the excitation of the ions within the lamp by the microwaves. It has been found, however, that the most efficient operation can be obtained by making slight adjustments in the length to provide the maximum impedance matching of the lamp to the anode line.

The microwave energy generated in the oscillator is transmitted to the electrodeless discharge lamp whereby the gas and vapor therein are excited to emit light therefrom. The sustained emission of light based on excitation of the gas or vapor therein can result in frequency shift of the oscillator. While this effect is not fully understood, it is believed to be the result of a change in the effective impedance of the load resulting from the change of the reactance of the lamp under excitation conditions as opposed to the unexcited state. These changes in capacitance change the resonant frequency of the cavity which, in turn, results in a shift in the frequency of the oscillator. This frequency shift, however, affects both the oscillator and the lamp equally and the two therefore remain on the same resonant frequency. Hence, the oscillator and the lamp remain in a tuned condition resulting in the maximum efficiency of the operation.

Turning now to FIG. 2, an alternate embodiment is shown in which counter bore 42b is omitted in anode line 42 of FIG. 1. A side bore 10a is placed in shell 10' and a dielectric cylinder 80 comprising teflon is placed in the bore 10a. The electrodeless discharge lamp 60 is placed within cylinder 80. A window 82 is provided to allow emission of light from lamp 60 to pass out the open end of oscillator 2'. It has been found that the placing of dielectric cylinder 80 around lamp 60 causes a foreshortening of the plate line and a change in the loading on the oscillator resulting in better impedance matching for the electrodeless discharge lamp load.

While the invention has been described with regard to a particular microwave oscillator, it should be pointed out that other oscillators may be used and should be deemed to be within the scope of the invention. For example, instead of the grounded-grid oscillator illustrated, other microwave power generating devices such as a grounded-cathode oscillator or a grounded-anode oscillator, could be used. Similarly, active device 30 illustrated in FIG. 1 as a triode vacuum tube may be any charge control device, including a solid state device.

Thus, the invention provides a device comprising a light emitting lamp stimulated by microwave energy and contained in a common cavity resonator with a microwave oscillator thereby allowing the oscillator and

lamp to remain in tuned relationship to one another both during initiation of the excitation and during the sustenance of the excitation of the ions within the lamp. While the invention has been described with regard to particular configurations, it should be readily apparent that minor modifications may be made without departing from the scope of the invention which is to be limited only by the appended claims.

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

1. A light-emitting device comprising:
  - a. a microwave oscillator including:
    1. a conductive shell;
    2. an active means disposed within said shell for providing a sustained emission of microwave energy;
    3. an elongated electrode disposed within said shell, said electrode having one end coupled to said active means, said electrode forming with said conductive shell a resonant cavity, said electrode dimensioned to be electrically at least one-half the operating frequency wave length of said cavity and adapted to create at least two positions of maximum electric field intensity, one of said positions being adjacent said one end of the electrode; and
  - b. an electrodeless discharge lamp disposed within said shell and spaced from said active means a distance, electrically, of at least one-half the operating frequency wave length of said cavity so as to be disposed at another position of maximum electric field intensity in said cavity, said microwave oscillator being operable to transmit microwave energy to said lamp such that the gas therein provides a sustained emission of light.
2. The light-emitting device of claim 1 further comprising a dielectric member disposed in said shell and having an opening therethrough, the other end of said electrode being supported and substantially surrounded by said dielectric member, said other end having an opening supporting said lamp therein at said another position of maximum electric field intensity.
3. A light-emitting device comprising:
  - a. microwave oscillator including:
    1. a conductive shell defining a resonant cavity, said shell being dimensioned to be electrically at least one-half the operating frequency wave-length of said cavity and thereby adapted to create at least two positions of maximum electric field intensity;
    2. an active means disposed within said cavity at a location adjacent one of said positions for providing a sustained emission of microwave energy at a predetermined operating frequency;
  - b. an electrodeless discharge lamp disposed within said cavity and spaced from said active means a distance at least one-half the operating frequency wave length of said cavity and thereby being disposed at another position of maximum electric field intensity in said cavity.
4. The device of claim 3 further comprising a dielectric member disposed in said shell, said member having an opening therein mounting said lamp at said another position of maximum electric field intensity.

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