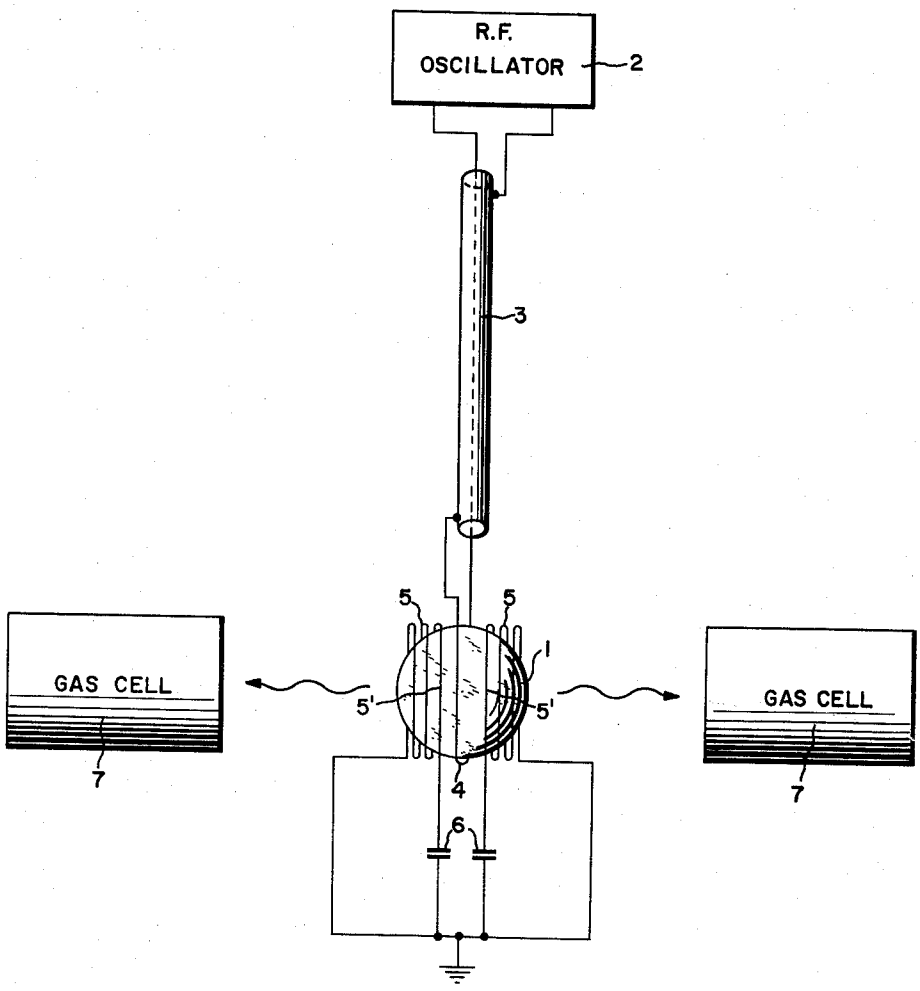
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ELECTRODELESS DISCHARGE LAMP APPARATUS

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# ELECTRODELESS DISCHARGE LAMP APPARATUS

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The present invention relates in general to electrodeless discharge lamps, and more particularly to a novel circuit arrangement which permits an electrodeless discharge to be initiated and maintained by a remote power source.

High frequency electrodeless discharge lamps have recently been developed for use as efficient and stable sources of highly resolved optical spectral line radiation. Such lamps are disclosed in an article appearing in Review of Scientific Instruments 32,688 (June 1961), and also in copending U.S. Patent application Serial No. 56,412, filed September 16, 1960, now U.S. Patent 3,109,960, assigned to the same assignee.

The discharge in such lamps is initiated and maintained through the high frequency fields of an external radio frequency coil which encircles a bulb containing an optically radiating gas or vapor. The impedance presented by such a coil to excitation power depends strongly on the condition of the discharge and hence varies considerably during operation. This presents a difficult problem when, for purposes such as electrical or thermal isolation, it is desired to excite the coil from a remote power source via a transmission line. For example, when the lamp is used to optically pump and monitor a gas cell (containing, for example, an alkali vapor such as rubidium) which senses and measures weak magnetic fields, it is desired to remove the magnetic influence of materials and currents in the power source.

It is an object of the present invention to provide electrodeless discharge lamp apparatus adapted for efficient and stable operation when excited from a remote power source. Generally, this is accomplished by the provision of a novel transmission line termination utilizing magnetic coupling to a tuned circuit which is at least partially decoupled after the lamp discharge is initiated by the interposition of the then conducting ionized gas of the discharge.

Various features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawing which illustrates an embodiment of the present invention adapted for use in an instrument employing optically pumped gas cells.

Excitation power for lamp bulb **1** is provided by a remote R.F. oscillator **2**, via a coaxial transmission line **3**. The line **3** is terminated by a single turn, low impedance, untuned loop **4** encircling the bulb **1**. Loop **4** is magnetically coupled to the tank coil **5** of a floating, high Q, parallel resonant circuit. Coil **5** is preferably wound in two sections with the end turns **5'** adjacent each other to aid in the establishment of a high field strength for rapidly initiating the discharge, a feature claimed in U.S. Patent 3,109,960. The capacitive reactance of the resonant circuit is preferably provided by a pair of capacitors **6** symmetrically located relative to ground in order to minimize leakage radiation. These capacitors may be variable to provide a tuning adjustment or alternatively they may be fixed and provision for tuning made in the R.F. oscillator **2**.

In a typical embodiment, the diameter of bulb **1** is one centimeter; the excitation frequency of oscillator **2** is 140 mc./sec.; the characteristic impedance of line **3** is 50 ohms; coil **5** consists of six turns of No. 24 wire; and capacitors **6** each have a nominal capacitance value of 10 $\mu\mu$f.



In operation, the single loop **4** coupled to the tuned circuit **5**, **6** presents a good impedance match to the transmission line **3** so that a high intensity alternating magnetic field is developed with minimum power by the high Q circuit **5**, **6** and initiates a discharge inside the bulb **1**. Thereafter the conductivity of the discharge serves to partially decouple the tuned circuit **5**, **6** and the discharge is maintained by the loop **4** which now provides a good match to the load despite variations in lamp impedance, the power being absorbed by the conducting ionized gas instead of the tuned circuit. The length of line **3** is preferably an integral number of half-wavelengths at the operating frequency to avoid undesired impedance transformation to the oscillator of small residual reactances which may be present at the bulb end of the line. Thus, stable, high efficiency operation is achieved for all operating conditions. For example, in the above described typical embodiment, the desired operation was obtained at an excitation power level of 1–2 watts with a standing wave ratio on the transmission line of between 1:1 and 1:3.

In the illustrative embodiment, the lamp bulb **1** radiates optical resonance radiation of the gas or vapor contained therein through a suitable optical system (including lenses, filters, polarizers, etc., not shown, as desired) to optically excite or "pump" a pair of gas cells **7** which contain the same gas or vapor. This arrangement which conveniently provides oppositely directed light beams through the separate gas cells may be used, for example, in a magnetometer of the type described and claimed in U.S. patent application Serial No. 62,480, filed October 13, 1960, abandoned in favor of Serial No. 250,460, filed January 7, 1963, and assigned to the same assignee, in which the intensity modulation of the optical radiation passing through each gas cell **7** is detected and fed back to the opposite cell in the form of an alternating magnetic field which maintains the device in self-oscillation at a frequency determined by the intensity of the environmental magnetic field at the cells.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 426; 42 U.S.C. 2451), as amended.

What is claimed is:

1. An electrodeless discharge lamp apparatus comprising: a bulb containing a discharge substance sealed therein, said substance being in the gaseous state at glow discharge pressure in operation, said bulb having at least a light transmissive portion for transmission of light out of said bulb; exciting means at least partially disposed externally to said bulb for exciting an optically radiating discharge therein; said exciting means including a source of R.F. energy, a first termination circuit means portion disposed inductively adjacent said bulb and coupled to said source for generating an alternating R.F. magnetic field in said bulb which dissipates sufficient power in the discharge when excited to maintain said discharge, and a tuned second termination circuit means portion tuned to a frequency having a peaked response at substantially a frequency of R.F. energy supplied from said source and disposed inductively adjacent said bulb and initially inductively coupled to said first termination

circuit means portion for building up a high intensity alternating field in said bulb which initiates said discharge, and thereafter being at least partially decoupled from said first termination circuit means portion by the conductivity of the discharge.

2. The apparatus according to claim 1 including an R.F. transmission line connected in circuit between said source of R.F. energy and said first termination circuit means portion for supplying R.F. energy to said first termination circuit means portion.

3. Apparatus according to claim 2 wherein said first termination circuit means portion consists of single turn coil.



4. Apparatus according to claim 2 wherein said transmission line is substantially an integral number of half-wavelengths long at said excitation frequency connecting said source to said first termination circuit means portion.

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