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Hruda et al.

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[54] **ELECTRODELESS LAMP IGNITER SYSTEM**

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[52] **U.S. Cl.** **315/267,** 315/344

[51] **Int. Cl.** **H05h 41/24**

[58] **Field of Search** 315/150, 248, 267, 344, 315/348; 313/160

[56] **References Cited**

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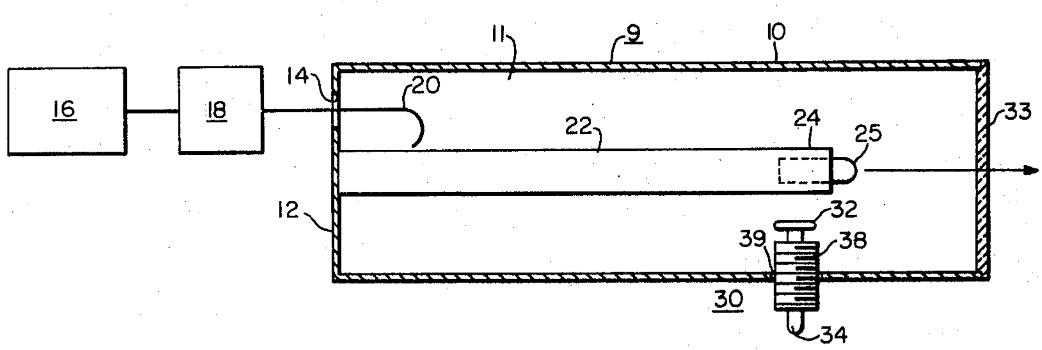
[57] **ABSTRACT**

An electrodeless lamp resonant cavity apparatus for use as a spectral source in atomic absorption spectroscopy. The apparatus utilizes a cavity resonator to excite the lamp. A tuning means is utilized to ignite the lamp by momentarily sweeping the tuning of the cavity with the unexcited lamp through the most favorable condition for ignition. Upon release the tuning means returns the tuning of the cavity to that condition most favorable to maintaining the lamp discharge.

5 Claims, 3 Drawing Figures



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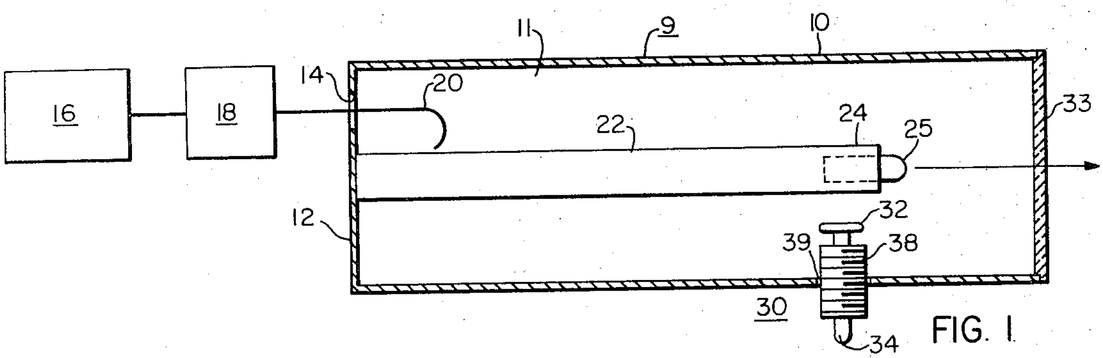

FIG. 1

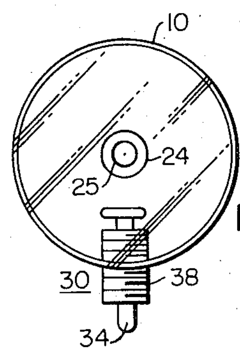

FIG. 2

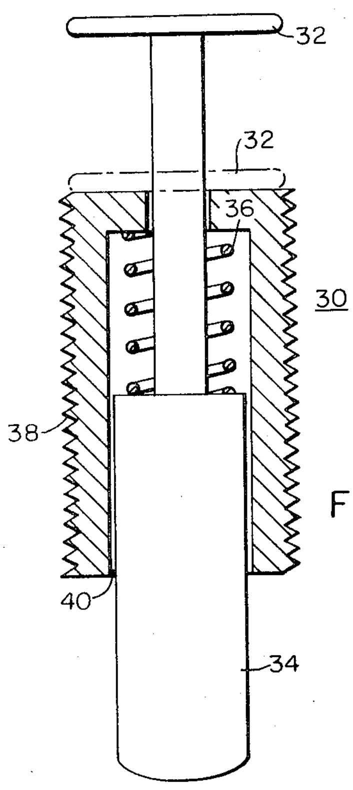

FIG. 3

ELECTRODELESS LAMP IGNITER SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a radio frequency excited light source, and more particularly, to a source capable of emission of light of a wavelength characteristic of a material within a lamp member, and primarily for utilization in atomic absorption spectroscopy. In this type of source, it is necessary to use a gaseous type discharge lamp wherein an arc or plasma is created in a vapor which will, when electrically excited to optical emission, produce one or more spectral lines characteristic of the vapor material. The material may be a gas, metal or a metallic salt. One type of light source utilized in this area is the hollow cathode type, such as described in U.S. Pat. No. 3,264,511 issued Aug. 2, 1966 to G. K. Yamasaki and assigned to the same assignee as this invention. The hollow cathode lamp is the most common type of spectral source.

There also has been a considerable amount of work on electrodeless discharge lamps as spectral sources. The term "electrodeless" means that the lamps are provided without electrodes within the envelope, and the discharge is initiated and maintained by radio frequency electric fields. The radio frequency may be in range of 300 to 3,000 megahertz. These types of lamps provide higher intensity as compared to the hollow cathode lamps and freedom from contamination due to the presence of electrodes and other elements within the envelope. The electrodeless lamp generally comprises a cylindrical quartz envelope whose length is normally greater than its diameter. The volume within the envelope in most applications is filled to a few torrs with a suitable gas such as argon or neon plus a vaporizable salt of the desired element. The lamp is then mounted in a suitable radio frequency field region such as that generated by the cavity resonator, an antenna or some other means. Upon application of a radio frequency field to the lamp proper, the gas, such as argon, is ionized. This discharge tends to heat the quartz envelope and the salt such as lead iodide, until enough of the lead is vaporized, at which time the lamp switches over from running on argon to running on vaporized salt. The result is the desired spectral emission due to lead. These sputtered atomic particles of the lead are bombarded and a portion are excited from a ground state to a higher energy level. When these excited sputtered atoms return to their lower ground state level, energy originally absorbed from the bombarding particles is released in the form of radiation having spectral lines characteristic of the lead in the envelope. This beam of spectral radiation is then directed through a vaporized sample of a solution or material to be analyzed. If the wavelength of radiation from the spectral source corresponds to that required to excite the vaporized atoms in the sample which are at ground state, a portion of the intensity of the spectral radiation will be absorbed by the atoms of the vaporized sample solution. The normal practice is then to direct the radiation after transmission through the unknown sample to a monochromator which is adjusted to the wavelength of the initial radiation from the source. A suitable detector is associated therewith which measures the amount of absorption of that passing through the sample and that not passing through the sample, so as to arrive at a determination of the amount of spectral radiation absorbed within the

unknown sample. This atomic absorption technique is well known in the art.

In the radio frequency discharge type light source, the lamp proper or envelope is mounted within the high electric field region of a cavity. The purpose of the cavity is to transfer power from a radio frequency source to the gas within the lamp proper. The resonant cavity structure is utilized to increase the electric field found within the cavity. It is, of course, desirable to match the impedance of the cavity to that of the coaxial line of the radio frequency power supply. When the resonant frequency of the cavity is tuned to that of the radio frequency source and the impedance is matched, then power reflected from the cavity is at a minimum.

It is found that the design of such a resonant cavity for excitation of electrodeless lamps is complicated because the lamp represents two distinct radio frequency loads. When extinguished, the lamp is a simple capacitance, while when ignited, the lamp is equivalent to a complex reactance including inductance, resistance and capacitance. If the cavity is tuned to the best operating frequency of the lamp, serious detuning occurs if the lamp is extinguished and reignition is attempted. The disadvantage of a resonant cavity is that the reactive characteristics of the discharge varies with the state of the discharge in the lamp. The spectral radiation of the discharge is extremely sensitive either to changes in incident radio frequency power or to changes in the coupling efficiency between the radio frequency source and the discharge. One solution is to provide a triggering voltage in the form of a radio frequency field to produce the initial discharge which is thereafter sustained by the radio frequency energy introduced in the cavity. Such a solution, of course, results in additional circuitry and voltage supplies.

SUMMARY OF THE INVENTION

This invention is directed to a radio frequency excited light source utilizing a cavity resonator in which apparatus is provided for tuning of the cavity to the most favorable condition for maintaining a discharge within the light source and providing additional tuning apparatus to momentarily sweep the tuning of the cavity through the most favorable condition for igniting the discharge within the light source.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** is a longitudinal sectional diagram of a radio frequency excited lamp apparatus incorporating the teachings of this invention;

FIG. **2** is an end view of the cavity apparatus illustrated in FIG. **1**; and

FIG. **3** is an enlarged sectional view of the tuning means embodied in FIGS. **1** and **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, there is illustrated a cavity resonator **9** comprised of a cylindrical member **10** which may be of a suitable electrical conductive material or at least having an electrical conductive coating on the inner surface thereof of a material such as silver. The length of the cylindrical member **10** may be about 10 cm. The diameter of the cylindrical member **10** may be about 4 cm. Positioned at one end of the cylindrical member **10** is an end plate **12** with an opening **14** therein through which radio frequency energy is coupled into cavity **11** defined by the member **10** from a radio frequency source **16.** A window **33** such as glass may be provided on the opposite end of the member **10.** The window **33** is transmissive to radiation from the lamp **24.** An opening may be also provided in the window **33** or the window **33** may be omitted. A matching network **18** may be provided between the source **16** and the cavity **11** to provide optimum transfer of energy between the source **16** and the cavity **11.** A loop **20** may be provided within the cavity **11** to couple the energy into the cavity **11.** A tubular member **22** is secured at one end to the end plate **12** and extends for a distance of about 6 cm. therefrom. The diameter of the member **22** may be about 1.5 cm. Positioned near the end of the member **22** is an envelope or lamp **24** which contains a gas and an element whose characteristic emission is desired. The lamp **24** may have a diameter of about 10 millimeters and a length of from less than 1 centimeter to a few centimeters. The volume within the envelope **24** may be a few cubic centimeters. The envelope **24** may have a specially defined window **25** for transmission of the spectral radiation.

A graphite sleeve may be provided about the envelope **24** and the envelope is located within the opening in the tubular member **22.** The envelope may project out of the member **22** for a short distance about ½ centimeter. The electric field in the cavity **11** is concentrated at the nose of the member **22.**

A tuning means **30** is associated with the cavity resonator **10.** The tuning means **30** includes a main tuning screw or sleeve **38** which is inserted into the cavity **11,** and its extension into the cavity **11** may be adjusted by means of the thread on the outer surface engaged a threaded opening **39** in the wall **10.** The tuning means **30** also includes a capacitor plate **32** within the cavity **10** which is mounted on a push-button shaft **34.** The plate **32** as well as sleeve **38** should be of electrically conductive material or coated therewith. The shaft **34** is positioned within a central region **40** of the tuning sleeve **38** and a spring member **36** is positioned therein to bias the shaft **34** outwardly in a relaxed or stationary condition as indicated by the dotted lines for the plate member **32.** Pushing the shaft **34** inwardly moves the capacitor plate **32** inwardly, as indicated in FIG. **3,** to a temporary position such as illustrated.

Tuning means **30** is adjusted in the relaxed or stationary condition by adjusting the sleeve **38** such that the cavity **10** is tuned to near the resonant frequency with the electric discharge lamp **24** ignited to provide high stability of light output. This will provide a large amount of electric field in the discharge portion of the envelope **24.** In the unexcited condition, the cavity resonator **9** will not be tuned to near resonance; but by pushing the push-button shaft **34** inwardly, the capacitor plate is thrust into the cavity **11,** thereby passing the cavity resonator **9** through a condition of resonance with regard to the unexcited condition. As a result, a high electric field is generated in the electric discharge region of lamp **24** and the lamp **24** is ignited by the high field produced. The shaft **24** is then released, and the cavity reverts to its condition of maximum efficiency with the activated lamp.

It is, of course, obvious that there may be other modifications to the invention, such as different tuning means associated with the cavity and also, if desired, the ignition system could be distinct from the main tuning member.

We claim as our invention:

1. A radio frequency light source comprising means defining a cavity resonator, an electrodeless discharge lamp envelope positioned within said cavity resonator, said cavity resonator having an opening through which the light generated by said discharge lamp may pass to the exterior of the cavity, means for introducing radio frequency power into said cavity resonator for producing an electric field in the region of said discharge lamp, a first tuning means for said cavity resonator for tuning said cavity resonator to a frequency to provide a stable spectral output from said lamp in an excited condition and a second tuning means for momentarily tuning said cavity resonant through a favorable condition for ignition of said discharge lamp.

2. The light source set forth in claim **1,** in which said first tuning means is adjustable to establish a substantially stationary position to maintain a favorable tuning for a stable light output from said lamp in the excited condition and said second tuning means is movable to momentarily sweep through a plurality of positions to substantially maximize tuning for favorable ignition of said lamp.

3. The device as set forth in claim **2,** in which said first and second tuning means have a common tuner member and said second tuning means is a spring loaded shaft member, such that said spring biases said tuning member in said stationary position and said shaft member position is manually operable to move said tuning member through a plurality of temporary positions to thereby sweep the tuning of said cavity through a favorable temporary position for excitation of said lamp and then return to said stationary position favorable to maintaining said discharge.

4. A radio frequency light source comprising a cavity resonator, an electrodeless discharge lamp containing a material of which its characteristic spectral radiation is desired, said cavity resonator having a transmissive portion through which said characteristic radiation may pass, means for establishing an electric field within said cavity with said lamp positioned within a region of high electric field, tuning means provided within said cavity resonator to momentarily sweep the tuning of said cavity resonator to maximize tuning of said cavity resonator for favorable ignition of said lamp.

5. The light source set forth in claim **4** in which said tuning means is returned to a stationary position after said sweep, said stationary position providing a favorable electric field for maintaining a stable emission from said lamp.

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