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ELECTRIC DISCHARGE SPECTRAL LAMP WITH MEANS IN ADDITION TO THE DISCHARGE ELECTRODES FOR VAPORIZING SOLID SAMPLES

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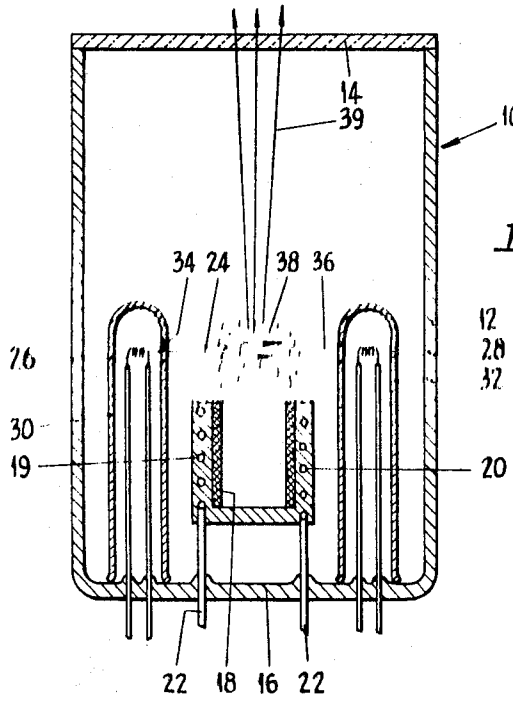


FIG. 1.

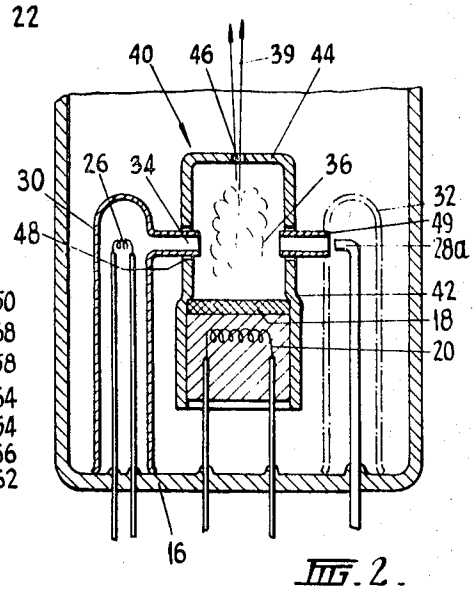


FIG. 2.

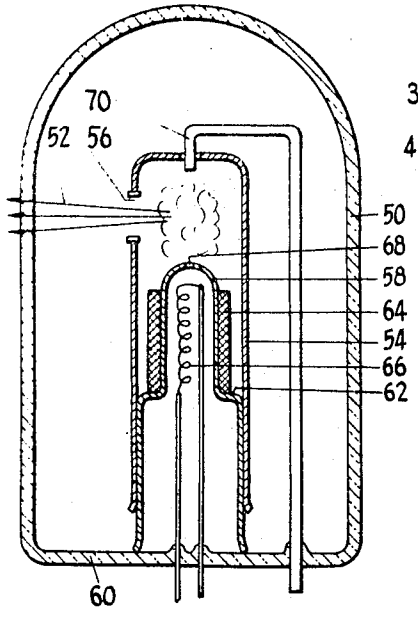


FIG. 3.

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ELECTRIC DISCHARGE SPECTRAL LAMP WITH MEANS IN ADDITION TO THE DISCHARGE ELECTRODES FOR VAPORIZING SOLID SAMPLES

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U.S. Cl. 250—43 11 Claims

ABSTRACT OF THE DISCLOSURE

An electric discharge lamp having an evacuated and hermetically sealed envelope is filled with an inert gas at low pressure and is provided with a window which is transparent to radiation of the desired wavelength. A chamber is mounted within the envelope for holding an element from which the vapor is to be generated. Electrodes are provided within the envelope to provide a discharge through the atomic vapor generated upon heating of the element by separate heating means.

This invention is concerned with improvements in or relating to atomic spectral lamps suitable for use as spectral line sources in spectroscopy, colorimetry or the like.

Practically all atomic spectral lamps involve the excitation of free atoms of a chemical element by means of a gaseous electrical discharge so that said atoms are made to emit their characteristic spectral radition. Such lamps can be divided into two distinct categories according to the nature of the chemical elements employed: those that employ elements which are either gaseous or readily vapourised at ambient temperatures; and those which employ elements that have very low vapour pressures at ambient temperatures.

In the first type of lamp a gaseous discharge may be struck directly in the gas or vapour normally present in the lamp at ambient temperatures or, as with some mercury and sodium lamps, a glow discharge is first struck in an inert gaseous filler and the heat from the discharge serves to vapourise the mercury or sodium so that the initial discharge can excite the vapour atoms. In the second type of lamp an initial discharge is also struck in an inert filler gas but the atomic vapour of the element concerned is generated and excited in the cavity of a hollow cathode by cathodic sputtering.

Since the great majority of chemical elements are solids having low vapour pressures at ambient temperatures, they clearly cannot be employed in the first type of lamp; and, since the majority of the gaseous elements are comparatively inert, lamps of the first type have found very little use in techniques such as atomic absorption spectroscopy.

It will be seen from the above that, in atomic spectral lamps of either type for use with non-gaseous elements, the one and the same discharge serves to generate the atomic vapour and to excite the vapour atoms. Thus, the radiant output of such lamps can only be increased by increasing the exciting discharge current and, at the same time, increasing the vapour generated within the lamp. Where such lamps are employed in atomic absorption spectroscopy, severe limitations are placed on the spectral line width of the so called resonance lines, and since resonance broadening through self-absorption or self-reversal is directly related to the amount of vapour within the lamp and through which the output radiation must pass, the

radiant output of the lamp is strictly limited because vapour generation within the lamp must be kept low. Similarly, in lamps employing gaseous elements, the physical size of the lamp must be kept small to reduce the amount of gas in the lamp and, accordingly, the radiant output from such lamps is similarly limited.

In our prior Australian patent applications Nos. 23,182/62 and 57,944/65, we have described a form of high intensity atomic spectral lamp where the vapour within the lamp is excited by a discharge which is indepedent of the discharge that generates the vapour by cathodic sputtering. In this way, the radiation emitted by the lamp can be increased without a parallel increase in the vapour generated within the lamp, and therefore, without significant line broadening. The exciting discharge is made to occur in a confined region closely adjacent the cathode of the sputtering discharge, so as to excite the cloud of atoms which surround that cathode and, consequently, one limitation of such lamps is that the intense exciting discharge necessary to obtain a highly excited vapour results in the reduction of the voltage effectively available in the sputtering discharge path so that sputtering and vapour generation is actually reduced.

Finally, a disadvantage associated with substantially all of the prior art atomic spectral lamps is that the excited gas in the discharge path occupies a substantial proportion of the tube volume so that the source of radiation appears as a diffuse vapour cloud rather than an intense point source whereas, in many spectroscopic applications, point sources are preferable because narrow entrance slits are employed and much of the radiation from a diffuse source is lost.

The present invention therefore seeks to provide an atomic spectral lamp which can be used with a useful range of chemical elements but which will overcome one or more of the disadvantages associated with the types of lamps discussed above. The present invention is based upon the realisation that, contrary to the implication of the prior art, it is possible to thermally generate sufficient vapour from a wide range of useful solid chemical elemens to permit excitation by an independent gaseous discharge. Preferably, some means for concentrating the vapour generated is employed in conjunction with some means for directing the exciting discharge through the vapour so concentrated.

Thus, the invention may be said to involve a method of generating radiation containing an atomic spectral line characteristic of a given chemical element, which method comprises the steps of: heating a quantity of said chemical element within an evacuated envelope to drive off an atomic vapour from said element; and generating an electrical discharge through said vapour in a region adjacent said chemical element to thereby excite said vapour so as to generate the radiation, characterised in that the heat energy used to drive off said atomic vapour is primarily derived from a source other than the discharge.

From another aspect, the invention includes an atomic spectral lamp for generating radiation containing an atomic spectral line characteristic of a given chemical element, which lamp comprises, an evacuated and hermetically sealed envelope containing an inert gas at low pressure and having a window which is substantially transparent to radiation at the wavelength of said spectral line; means mounted within said envelope for locating or holding a quantity of a normally solid chemical element opposite said window but in spaced relationship with respect thereto; heating means associated with or incorporated in said holding or locating means for heating the said quantity of the chemical element so as to liberate vapour from said element within said envelope; and a pair of opposed exciting electrodes mounted within said envelope for gen-

erating an electrical discharge in the vicinity of the quantity of the chemical element.

As previously indicated, it is preferable to place the elemental material in a chamber which is in turn mounted within the envelope. The vapour generated within the chamber may be substantially confined therein by the shape or configuration of the chamber itself or by the influence of the filler gas within the envelope which has the effect of significantly reducing the mean free path of the vapour atoms. Preferably, however, both methods of confining the vapour are employed and use is also made of the filler gas for facilitating the striking and maintenance of a stable exciting discharge. It is also preferable to shield at least one of the exciting electrodes and to place the electrodes fairly close together so that the exciting discharge is itself confined to a small volume of gas or vapour. Furthermore, it is preferable that the exciting discharge be generated across and within the chamber itself so that the excited vapour is contained by the chamber.

More particularly, but again not essentially, it is preferable for the chamber aperture to have approximately the same shape and area as the entrance slit or objective aperture of the typical spectrographic or colorimetric instruments with which the spectral lamp is to be employed. Similarly, the exciting discharge can, with advantage, be formed transversely across the chamber substantially at right angles to the path of radiation between the aperture and the window of the envelope. Where the exciting discharge is confined by the use of electrode shields, it is also preferable but not essential to make the shields contiguous with the chamber so that the discharge passes through diametrically opposed apertures in the chamber wall.

Various other modifications or alterations of the improved atomic spectral lamp may be employed without departing from the scope of the invention and many of these will be obvious to those skilled in the art. It will be appreciated that it is not essential to form the exciting discharge within the actual chamber—though as indicated above, this is preferable—but, provided the path of discharge is suitably defined, it can be situated at the mouth of an open ended chamber from which the vapour is permitted to emerge. An alternative of particular value is one where the exciting electrode shields extend into the chamber so that only a small portion of the vapour within the chamber is actually excited. The radiation aperture of the chamber will, nevertheless, be kept small in area so that relatively high concentrations of the atomic vapour can build up within the chamber with respect to that in the remainder of the envelope. In this way a comparatively small envelope can be used without fear of window clouding, especially if a filler gas is also employed. It is also possible to use a variety of electrical heating systems for the chamber, although the preferred system involves the use of a heater element which is encapsulated within a separate compartment of the chamber or which is wound around the chamber in any suitable way. Finally, while it is certainly envisaged that the quantity of chemical element concerned can be deposited or secured within a chamber formed from a different material, it is also contemplated that the quantity of the chemical element may form an integral part of the chamber itself (for example, it may constitute the lining of the chamber) rather than a separate addition to the chamber.

It will be appreciated from the above description that the intensity of the exciting discharge is quite independent of vapour generation within the lamp and that large exciting currents of the order of a few amperes can therefore be employed without influencing vapour generation or line width. Moreover, since the atomic vapour and the discharge are strictly confined, a very large proportion of the radiation generated by the intense discharge can be usefully employed even where the lamp is to be used with instruments having narrow entrance slits. As an example of the elements most suited for use in this type of lamp reference can be made to our copending Australian patent application which is concerned with thermal resonance lamps, the most valuable elements being: potassium, sodium, lithium, calcium, cadmium, lead, zinc and magnesium. It also will be appreciated that, apart from sodium, these elements could not have been employed in the atomic spectral lamps of the first category mentioned above and that, hitherto, the most satisfactory sources of the characteristic spectral lines corresponding to these elements have been the high intensity atomic spectral lamps described in our above mentioned copending Australian patent application. However, by contrast with such high intensity lamps employing these elements, atomic spectral lamps formed in accordance with the present invention can provide at least a ten-fold increase in the radiation effectively available from a single lamp.

Having generally indicated the nature of the present invention and some of the variations and modifications envisaged, reference may now be made to the accompanying drawings which illustrate, by way of example only, a number of specific forms of lamp envisaged.

In the drawings:

FIG. 1 is a sectional elevation of an atomic spectral lamp formed in accordance with the present invention.

FIG. 2 is a sectional elevation of portion of a lamp which is similar to that of FIG. 1 except in that the exciting discharge is directed through a chamber.

FIG. 3 is a sectional view of another form of atomic spectral lamp constructed in accordance with the present invention wherein the radiation emerges at right angles to the base of the lamp.

In FIG. 1, the envelope **10** is formed by a sealed tubular vessel **12** having an end window **14** and a base **16**. In this particular case, the chemical element **18** is held within a cup-like container **19** which includes a heater element **20**, the heater cup and element being mounted and supported near the base of the envelope **10** by means of the heater leads **22**. The exciting discharge (indicated by arrows **24**) is struck between an oxide-coated and directly heated exciter cathode **26** and a similar exciter anode **28** which are arranged on either side of the element **18**, tubular shields **30** and **32** enclosing the respective exciter electrodes. The shields **30** and **32** have opposed apertures **34** and **36** which confine and direct the exciting discharge **24** through the cloud of vapour **38** emitted from the container **19** when the lamp is in operation. The excitation of vapour **38** by discharge **24** gives rise to the output radiation indicated diagrammatically by arrows **39**.

FIG. 2 shows a modified electrode and chamber structure and, in this figure, parts which correspond to those of FIG. 1 have been allotted the same reference numerals.

In the arrangement of FIG. 2, the heater element **20** is in the form of a cylindrical plug which is pressed into a tubular chamber **40** so as to retain a disc **18** of the elemental material concerned between itself and a shoulder **42** formed by the chamber wall. The upper end **44** of the chamber **40** is closed except for a narrow slit **46** through which the emergent radiation **39** passes. While the lamp of FIG. 2 employs a cathode **26** and its associated shield **30**, the anode electrode is a bent wire **28***a* sealed in the base **16** of the envelope and, as indicated by the broken lines, the anode shield **32** may be omitted. However, shield **30** (and **32** if included) has a lateral tubular extension **48** formed near its upper end which extends into the chamber **40** through side holes formed therein, defines the aperture **34** and directs the exciting discharge. If shield **32** is omitted a tubular guide **39** is employed as shown to define the aperture **36** and direct the discharge as desired.

FIG. 3 illustrates a different form of lamp constructed in accordance with the principles of the present invention. In this embodiment, the wall **50** of the envelope of the lamp is formed entirely from a glass which is transparent to the emergent radiation **52** so that a separate window is not required. A tubular chamber **54** is employed to confine the elemental vapour and includes a side slit **56**

through which the emergent radiation may pass from within the chamber. Chamber **54** is open at the base and closed at the top and is pressed onto a tubular exciting cathode shield **58** which upstands centrally from the base **60** of the lamp and is stepped at **62** to form a spigot of smaller diameter upon which a sleeve **64** of the element concerned is pressed. An oxide-coated and directly-heated exciting cathode **66** is located within the hollow shield **58** and performs the dual function of generating the exciting discharge and heating the element; an aperture **68** being formed in the top of shield **58** for this discharge. The anode electrode for the exciting discharge is a stiff wire **70** which is sealed in the base of the envelope and bent so that its upper end passes downwardly into the chamber **54** through an aperture formed in its upper end.

We claim:

1. A method of generating radiation containing an atomic spectral line characteristic of a given chemical element, which method comprises the steps of: heating a body of said chemical element within an evacuated envelope to drive off an atomic vapour from said element; and generating an electrical discharge through said vapour in a region adjacent said chemical element to thereby excite said vapour so as to generate the radiation characterized in that the heat energy used to drive off said atomic vapour is primarily derived from a source other than the discharge.

2. A method as claimed in claim **1**, wherein the vapour is substantially confined to a region within the said envelope, and the said electrical discharge is generated across and within the region, whereby the excited vapour is substantially contained within the region.

3. An atomic spectral lamp for generating radiation containing an atomic spectral line characteristic of a given chemical element which lamp comprises an evacuated and hermetically sealed envelope having a window which is substantially transparent to radiation at the wavelength of said spectral line; a body of said chemical element disposed within said envelope; and a pair of opposed exciting electrodes arranged within said envelope so that an electrical discharge can be generated therebetween and heating means arranged to supply heat energy to said body by a path which does not include the discharge so as to drive off from the body an atomic vapour of the element through which vapour the discharge will pass in use of the lamp.

4. An atomic spectral lamp for generating radiation containing an atomic spectral line characteristic of a given chemical element, which lamp comprises an evacuated and hermetically sealed envelope having a window which is substantially transparent to radiation at the wavelength of said spectral line; a chamber mounted within said envelope having an aperture disposed opposite said window so that radiation may pass from within the chamber through said aperture and window; a body of said chemical element disposed within said chamber; and a pair of opposed exciting electrodes arranged within said envelope so that an electrical discharge can be generated therebetween; and heating means arranged to supply heat

energy to the body by a path which does not include the discharge so as to drive off from the body an atomic vapour of the element, through which vapour the discharge will pass in use of the lamp.

5. A lamp as claimed in claim **4**, wherein at least one of the exciting electrodes is provided with a shield having an aperture therein to confine and direct the discharge.

6. A lamp as claimed in claim **5**, wherein at least one tubular guide is provided in association with said aperture to further confine and direct the discharge.

7. A lamp as claimed in claim **4**, wherein the chamber is a tubular chamber arranged with its axis perpendicular to the window; the heater and the body of the chemical element are contained at the end of the chamber remote from the window; and the wall of the chamber is provided with apertures to allow radial passage of the discharge through the chamber.

8. An atomic spectral lamp for generating radiation containing an atomic spectral line characteristic of a given chemical element, which lamp comprises an evacuated and hermetically sealed envelope which is substantially transparent to radiation at the wavelength of said spectral line; a tubular chamber mounted within said envelope having an aperture at one end thereof; a heated cathode electrode enclosed within a tubular shield, which is in turn surrounded by said chamber; an anode electrode projecting into said aperture in the chamber; a body of said chemical element supported on the shield within the chamber and heated by the heating action of the cathode; the shield having an aperture in one end thereof to allow axial pasage of a discharge between said electrodes and through the chamber but spaced from said body; and the chamber having apertures in the walls thereof to allow said radiation to emerge from the chamber.

9. An atomic spectral lamp as claimed in claim **3** wherein at least one of the electrodes is oxide coated.

10. An atomic spectral lamp as claimed in claim **4** wherein at least one oft he electrodes is oxide coated.

11. An atomic spectral lamp as claimed in claim **8** wherein at least one of the electrodes is oxide coated.

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U.S. Cl. X.R.

313—227; 356—86