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GLOW DISCHARGE DEVICE

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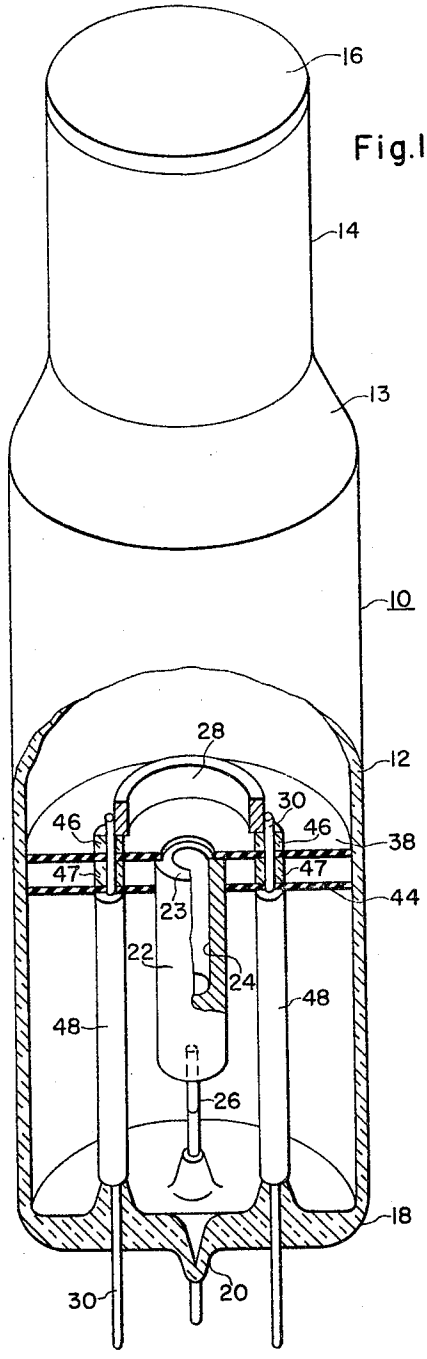


Fig.1.

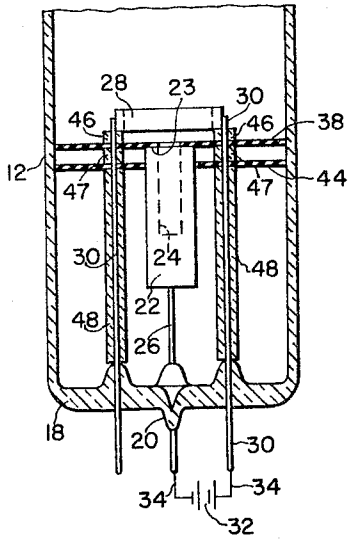


Fig.2.

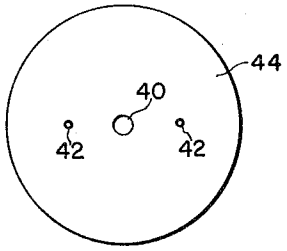


Fig.3.

WITNESSES

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GLOW DISCHARGE DEVICE

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The present invention relates to discharge devices and more particularly to hollow-cathode light sources for use in atomic absorption spectroscopy equipment.

The use of hollow-cathode devices light sources in spectroscopic investigations has long been known and devices of this nature have been widely used in applications requiring sharp spectral lines. The most common form of such a device includes a cathode which is substantially cup-shaped and a ring-shaped anode which is substantially coaxial with and spaced from the cup portion of the cathode. The cup-shaped portion of the cathode is commonly referred to as the hollow. In these prior art devices, a large portion of the discharge current has occurred between the outside of the cathode, and its supporting structure, and the anode, and its supporting structure. Since only the discharge inside the hollow contributes to the spectral output, such devices have lacked in efficiency and, because of practical potential considerations, have been limited in their intensity output. It has been known in the prior art to supply an outer cup-shaped member, of insulating material such as glass, which substantially surrounds the cathode in all areas except the hollow. However, such an insulating member is extremely difficult to manufacture, as well as being costly, and the problem of shielding the cathode support structure must still be considered.

It is, therefore, an object of this invention to provide an improved discharge device.

Another object is to provide an improved hollow-cathode device for use in atomic absorption spectroscopy.

A further object is to provide improved means for increasing the efficiency of hollow-cathode devices.

A still further object is to provide a light source for spectroscopic use in which substantially all of the discharge occurs inside the hollow of the cathode.

Basically, the present invention provides a gaseous discharge device for the production of spectral lines in which the anode structure is substantially shielded from all except the hollow of the cathode. Additionally, means are provided whereby any sputtered cathode material from the outside of the cathode is substantially prevented from forming leakage paths to the anode.

Further objects and advantages of the invention will become apparent as the following description proceeds and features of novelty which characterize the invention will be pointed out in particularity in the claims annexed to and forming a part of this specification.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIGURE 1 is a perspective view, partially broken away and partially in section of a discharge device embodying the present invention;

FIG. 2 is a side elevational view partially in section showing in greater detail the electrode and shielding structure of the present invention; and,

FIG. 3 is a top plan view of the insulating disks utilized in the present invention.

With reference now to FIGS. 1 and 2, there is shown a discharge device in accordance with the present invention. This device includes an envelope **10**, the suitable material such as glass, having an enlarged tubular portion **12** and a smaller tubular portion **14** which are interconnected by a transition portion **13**. The tubular portion **14** is sealed off at one end by a window **16** which is of a suitable

material efficiently transmissive of light wavelengths produced by the device in a manner well known in the art. For example, if the device is designed to produce wavelengths of approximately 2850 angstrom units, quartz may be used for the window **16**. The portion **12** is sealed off by a button stem header **18** having a suitable tipped off exhaust tube **20** in a manner well known in the art.

Supported by the header **18** and disposed within the portion **12**, there is positioned a cathode **22** which is of any desired electrically conductive material. For example, if it is desired to have spectral lines of a single element such as iron, the cathode **22** may be made of iron. Or, if desired, the cathode **22** may be made of a multi-element composition such as the calcium, magnesium, and aluminum cathode set forth in the copending application, Serial No. 189,088, "Discharge Device" by James E. Patterson, filed April 20, 1962, now issued as U.S. Patent No. 3,183,393, and assigned to the assignee of the present invention. The cathode **22** is substantially cylindrical in shape and has a centrally extending bore **24** extending from the end of the cathode **22** most closely adjacent the window **16** into the cathode **22** for a considerable distance. The bore **24**, or more correctly the side walls defining the bore, is commonly referred to as the hollow. Although other configurations may be utilized to support the cathode **22** within the portion **12**, the most expedient method of providing this support is by a conductive lead member **26**, of suitable conducting material such as nickel which is affixed to the cathode **22** and extends through the header **18** to the exterior of the envelope **10**. The lead **26** not only serves to support the cathode within the envelope portion **12** but also serves to provide it with an electrical potential as will be explained in greater detail later.

An anode **28**, which is shown to be in the form of a ring, is positioned in close proximity to the cathode near its upper edge **23**. The anode is of a suitable electrically conductive material such as tantalum, nickel, or tungsten and is supported, in the illustrated embodiment, from the header **18** by means of two support rods **30**. At least one of the support rods **30** is of an electrically conductive material, for example the same material as that of the anode. This support extends through the header **18** to the exterior of the tube and serves as a means by which a potential may be applied to the anode. This method of supporting and supplying the anode with an electrical potential is that which is most expeditious and it is evident that other means of achieving these same end results are readily applicable.

A suitable potential means **32** (FIG. 2) is connected by suitable leads **34** to the leads **26** and **30** to provide a potential difference between the cathode and anode.

The structure which has been thus far described is substantially that which is well known in the art and without the inclusion of the present invention would suffer from the same defect, namely, that part of the discharge current would be passed between the anode supporting structure (leads **30**) and the outside of the cathode **22** or to its lead member **26**.

In accordance with the present invention, the discharge within the device is limited to the hollow **24** of the cathode **22** and the ring anode **28** through the utilizing of insulating shielding means which substantially isolates all but the hollow of the cathode from the anode. Included within this shielding means is an insulating disk **38** which is positioned atop the cathode **22**.

The disk **38** is made of a suitable insulating material such as mica or ceramic and is provided with three apertures (FIG. 3). The central aperture **40** has a diameter which is not smaller than that of the hollow **24** and not larger than the outer diameter of the cathode **22**. In the illustrated embodiment, the central aperture **40** has a

diameter intermediate the above two cathode dimensions. The two outer apertures **42** are of sufficient size to just slip over the two anode supports **30**. A second insulating disk **44**, which may be of the same material as the disk **38**, is also provided. The disk **44** is substantially identical to the disk **38** and has a central aperture **40***a* whose diameter is substantially equal to the outside diameter of the cathode **22**. The disk **44** is displaced from the disk **38** a small distance in the direction away from the anode **28** and extends from the exterior of the cathode **22** to the inside wall of the envelope portion **12**. The rest of the insulating structure is comprised of a first pair of insulating ring members **46** which are fitted around the anode support members **30** between the bottom of the anode **28** and the top of the disk **38**, a second pair of insulating rings **47** which are fitted around the anode support member **30** between the two disks **38** and **44**, and two elongated insulating sleeves **48** which surround the anode support members **30** between the lower surface of the insulating disk **44** and the top of the button stem header **18**. The rings **46** and **47** and the sleeve **48** are of any suitable material, for example high dielectric ceramic. Thus, it is readily apparent that by this structure, that high dielectric strength material is positioned in all paths between the anode and cathode excepting that extending between the anode **28** and the cathode hollow **24**.

While the device is illustrated with two insulating disk members **38** and **44**, it is obvious that a greater or lesser number could be used. The advantage of using two as opposed to one is that manufacturing tolerances are somewhat lessened by such an arrangement. That is, if the disk **44** were omitted and the disk **38** were made to fit very tightly against the envelope wall the device would function just as well as will two disks. However, if a small gap were to exist at any place between the disk **38** and the wall of the envelope portion **12**, any cathode material which is sputtered during the use of the device may find its way to that gap and create a leakage path around the edge of the disk. The use of two disks as is illustrated substantially prevents this from occurring and yet does not require rigid manufacturing tolerances. As two disks have been found to operate quite satisfactorily, the addition of another disk similar to that of **44** would appear to be only an unnecessary redundancy.

A further modification which readily presents itself, but which has not been illustrated, is to provide that the side apertures **42** of the disks **38** and **44** be made of a diameter equal approximately to the outer diameter of the ceramic or insulating sleeve **48**. This sleeve may now be made of sufficient length to extend from the bottom edge of the anode **28** to the button stem header **18**. While this modification is a little simpler in that a fewer number of individual pieces are utilized, it has for a disadvantage the fact that the apertures within the disk are larger and that there is no overlapping insulating structure around these apertures. With this structure there is a possibility that leakage paths along the outside of the insulating sleeve could develop.

After the above assembly has been made, the device is evacuated, filled with an inert atmosphere, for example argon or neon, and sealed off by means of the exhaust tube **20** in the manner well known in the art of discharge devices. While the pressure of the fill may vary, it is normally in the range of from about 0.5 to 10 millimeters of mercury.

In operation, a direct current potential of appropriate value from the source **32** is applied between cathode **22** and the anode **28** to provide that the cathode **22** is negative with respect to the anode **28**. This direct current potential causes the gas within the envelope to ionize and a glow discharge is established between these two electrodes. The discharge is concentrated between the interior surface of the bore or the hollow **24** and the anode **28**. The bombardment of this surface by ions causes the cathode to sputter and emit radiation in accordance with

the material of which the cathode **22** is composed. This emitted radiation is transmitted to the length of the envelope **10** and passes through the window **16** where it may be utilized by methods well known in the art to analyze or inspect a desired sample material.

As is shown, the total volume of the envelope **10** is large compared with that occupied by the electrode structures. This large ratio of volumes is for the purpose of including a relatively large amount of gas as it has been found that in operation, metal vapor emanating from the cathode tends to deposit on the walls of the envelope **10**. In so doing, it entraps some of the gas fill. Thus, by providing a large volume of gas, the useful operational life of the device is appreciably increased.

It is thus seen that by the present invention, there has been provided a hollow cathode type discharge device, which through the expediency of relatively inexpensive insulating means, confines the discharge between the desired portions of the anode and cathode. In practice, tubes made in accordance with the present invention displayed a spectral output increase of up to 10 times over the old design (without the insulating means). This increase was achieved at the same operating currents for both types of devices. At output levels corresponding to those of prior design, tube life will be greatly increased as the amount of current necessary to achieve this output level is considerably less than that of the prior designs. A further advantage resulting from the present design resides in the fact that the insulating disks **38** and **40** serve to help center the cathode and to support it against mechanical shock.

While there have been shown and described what are at present considered to be the preferred embodiments of the invention, modifications thereto will readily occur to those skilled in the art. It is not desired, therefore, that the invention be limited to the specific arrangements shown and described and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

I claim as my invention:

1. A spectral light source comprising an envelope; an anode and a cathode disposed in a spaced relationship within said envelope for maintaining an electron discharge therebetween, said cathode having a hollow portion therein and made of a material having the property of establishing a beam of light in response to said electron discharge, said envelope having a portion transmissive to said beam of light through which said beam of light is directed; first and second electrically conductive members connected respectively to said anode and said cathode and extending through said envelope at a place remote from said transmissive portion; and electrically insulating means including a disk having an aperture therein and disposed between said cathode and anode for confining said electron discharge to said hollow portion, and a member disposed to prevent a further electron discharge between said first electrically conductive member, and said cathode and said second electrically conductive member.

2. A glow discharge device comprising an envelope having a gaseous atmosphere therein; an anode and a cathode disposed in a spaced relationship within said envelope for establishing an electron discharge therebetween, said cathode comprising a member of a material capable of emitting a beam of spectral light and having a hollow portion therein; said envelope having a transmissive portion through which said beam of spectral light may pass; first and second electrically conductive means connected respectively to said anode and said cathode; and insulating means including at least one insulating disk member positioned between said anode and said cathode and extending to said envelope, said first and second electrically conductive means extending through said envelope at a place disposed on the opposite side of said insulating disk member with respect to said transmissive

portion, said insulating disk member having an aperture the peripheral edge of which is so dimensioned and so aligned with respect to said hollow portion to confine said electron discharge to said hollow portion, and an insulating member disposed to prevent further electron discharge between said first electrically conductive means, and said cathode and second electrically conductive means.

3. An electron discharge device comprising an envelope, a gaseous atmosphere within said envelope, a cathode having a surface with a hollow portion therein and made of a material capable of establishing a light beam of a defined spectral line characteristic of said material in response to electron bombardment, first electrically conductive means in contact with said cathode, an anode comprising a ring-shaped member of electrically conductive material spaced from said surface of said cathode for establishing an electron discharge therewith and disposed about said beam light, second electrically conductive means in contact with said anode, said envelope having a portion transmissive to said beam of light through which said beam of light is directed, an insulating disk having a first aperture through which said beam of light passes and being positioned between said anode and said cathode, said second electrically conductive means extending through a second aperture within said insulating disk and through said envelop at a first point disposed upon the opposite side of said insulating disk with respect to said transmissive portion, said first electrically conductive means extending through said envelope at a second point disposed upon the opposite side of said insulating disk with respect to said transmissive portion, said first aperture being so dimensioned and said insulating disk being disposed to abut said surface of said cathode that said electron discharge is confined to said hollow portion, and an insulating member disposed about that portion of said second electrically conductive means extending between said second aperture and said first point to prevent a further electron discharge between said second electrically conductive means, and said cathode and first electrically conductive means.

4. A spectral light source comprising an envelope, an inert gaseous atmosphere within said envelope, a cathode having a surface with a hollow portion therein and made of a material capable of establishing a light beam of a defined spectral line characteristic of said material, first electrically conductive means electrically connected to said cathode, an anode comprising an annular member of

electrically conductive material spaced from said surface of said cathode for establishing an electron discharge therebetween, said anode disposed about said beam of light, second electrically conductive means electrically secured to said anode, said envelope having a portion transmissive to said beam of light through which said beam of light is directed, a first insulating disk having a first aperture through which said beam of light passes and being positioned between said anode and said cathode, said first insulating disk extending to the inner periphery of said envelope, said second electrically conductive means extending through a second aperture within said first insulating disk and through said envelope at a first point disposed upon the opposite side of said first insulating disk with respect to said transmissive portion, said first electrical conductive means extending through said envelope at a second point disposed upon the opposite side of said first insulation disk with respect to said transmissive portion, said first aperture having a diameter not less than that of said hollow portion nor greater than that of said cathode, said first insulating disk being disposed to abut said surface of said cathode so that said electron discharge is confined to said hollow portion, a second insulating disk having a third aperture therein and disposed about said cathode between said first disk and said first and second points, said third aperture having a diameter substantially that of said cathode, said second insulating disk having a fourth aperture through which said second electrically conductive means extends, and a cylindrically shaped insulating member disposed about that portion of said second electrically conductive means extending between said fourth aperture of said second insulating disk and said first point to prevent a further electron discharge between said electrically conductive means, and said cathode and first electrically conductive means.

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