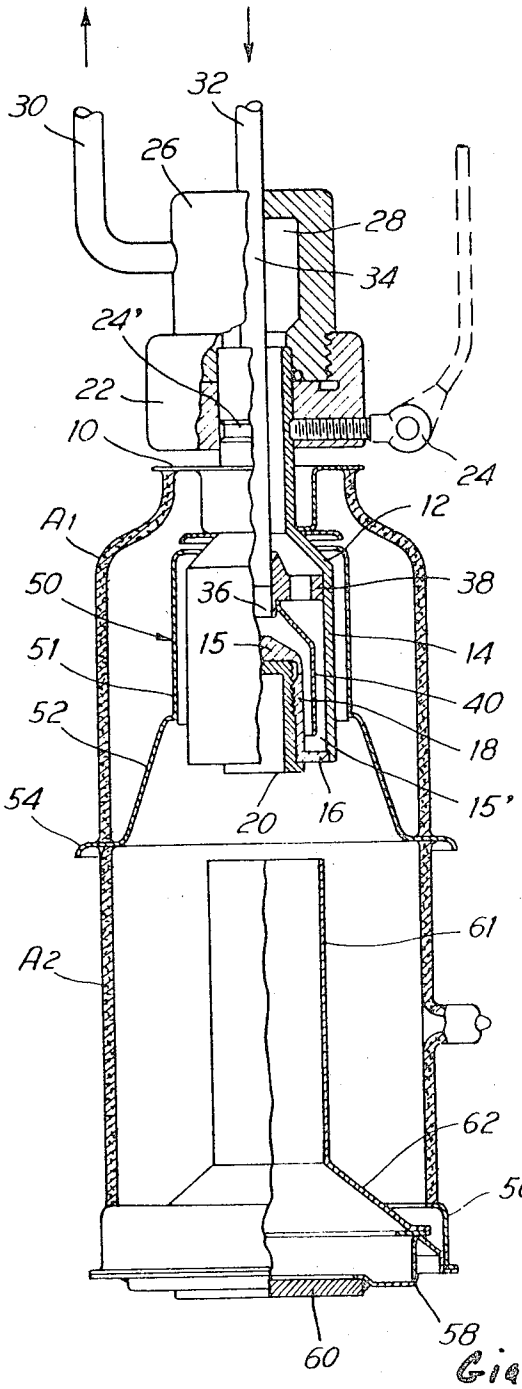
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FIUID COOLED HOLLOW CATHODE DISCHARGE TUBE

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FLUID COOLED HOLLOW CATHODE DISCHARGE TUBE

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ABSTRACT OF THE DISCLOSURE

A cooling means for a hollow cathode tube used in spectrophotometry characterized in that the cathode holder is surrounded by a coaxial body which is spaced therefrom forming a cooling circuit substantially over the entire length of the cathode. An annular baffle is mounted between the cathode holder and the coaxial body to form two separate pathways for the cooling fluid, the pathways being respectively connected to a cooling fluid inlet and outlet.

This invention relates to a hollow cathode tube for application in spectrophotometry.

Tubes of this type, as it is known, may be applied, for example, as wave length reference generators and to determine in conjunction with a burner and photoelectric cell, the contents of certain substances in a given sample material, as, for example, metals.

In applications of the latter type, a light beam emitted by the cathode and directed upon a photocell is absorbed by the flame to a variable degree due to the combustion of the substance to be determined, if this is the same as that of the cathode.

The content of the substance contained in the cathode may be determined by the light variations on the photoelectric cell.

The operating temperature of the tube must be as constant as possible so as to maintain the light emitted by the cathode constant, so that the light variations registered by the photoelectric cell are those due to the presence of a substance in the flame similar to that contained in the cathode of the tube.

From this point of view, it can then be understood, also with reference to other applications, how hollow cathode tubes used in spectrophotometry must be adequately cooled in order to stabilize the operating temperature.

One object of this invention is precisely that of providing a hollow cathode tube with temperature stabilization means and adapted to insure constant and steady emission of light as well as a rapid achievement of a steady operating condition and cathode sputtering control.

A further object of the invention is that of providing a tube of the highest efficiency long life and linear response.

In this invention, the above objectives are achieved by efficient cathode cooling and for this purpose the cathode support or holder is surrounded by a hollow element coaxial to it and the inner part of which is provided with means which help to define the fluid cooling circuit for the cathode.

Said cooling circuit substantially extends over the entire length of the cathode.

According to this invention, one of the ends of the hollow body has a tube extension which receives a tube for circulation of the fluid and which terminates at the top of the cathode with a baffle which divides the interior of the hollow body into intercommunicating chambers in which the cooling fluid circulates.

Another characteristic of the invention is that the anode of the tube conveniently consists of an envelope which surrounds the cathode holder or support, and which extends beyond the cathode to be supported at one end by the bulb of the tube with which it is engaged by a suitable collar which also serves as a terminal clamp for polarity.

According to a further aspect of the invention, a metal tube element is provided between the cathode and the glass bottom or optical window of the tube and which tube element acts both as a second anode and a protection for the optical window.

The invention will now be described in detail in conjunction with the attached drawing, by way of example, and in which the illustration shows the cathode tube according to the invention.

The tube illustrated consists of a glass bulb filled with a rare gas, and having two complementary sections A1 and A2 communicating with each other and sealed air tight, as will be described hereinafter.

The end of section A1 is closed by a metal bottom piece **10**, the rim of which is connected, in air tight relation, for example, by welding, to the rim of said section A1.

A tube shaped spigot **12** is secured air tight, for example, by welding, to said bottom piece and extends to the exterior of section A1 for a certain length. Spigot **12**, in the case illustrated, forms an integral part of a hollow body **14**, the interior of which communicates with the bore of said spigot or tube extension.

Body **14** is closed, air tight, at its other end, by flange **16** of a cathode support **18** extending into said hollow body and which is provided with suitable means, for example, threads, for securing cathode **20** of the tube which, as stated, is hollow.

The end of spigot **12**, extending from section A1 is provided with a groove **24'** which serves to secure a threaded bushing **22** to the spigot itself and which is provided with an eye-bolt **24** to engage said groove. Groove **24'** also serves as an electrical connecting means between the electric power source and cathode of the tube.

A manifold **26** is secured in air tight relationship to the end of spigot **12** by means of a bushing **22** which is screwed to it. The manifold has an inner chamber **28** which is connected to a pipe connection **30** for the cooling fluid outlet. Manifold **26**, in turn, is crossed by a tube **34** which, passing through the inner part of spigot **12**, communicates with the interior of hollow body **14**.

Chamber **28** communicates with the inside of hollow body **14** through a port located between tube **34** and spigot **14**.

The inner end **36** of tube **34** extends into a bored spacer element **38** which is secured to the hollow body **14** which has an annular baffle **40**, which divides the interior of hollow body **14** into two separate chambers.

It should be noted that manifold **26** which carries tubes **30** and **34** and bushing **22** forms a fixed separate unit which is mounted on the hollow cathode tube by introducing tube **34** into the central bore of spacer element **38** and by subsequently securing the bushing to the end of spigot **12** by eye-bolt **24** as previously stated.

Cooling of cathode **20** is obtained by means of the fluid which, after entering tube **34** and discharging at its end **36**, strikes the bottom **15** of cathode support **18** and successively, after being guided in its path by the inner surface of baffle **40**, strikes the external side wall of cathode support **18** to reach the bottom end flange **16** of the latter, after which the fluid reverses its flow direction passing into the chamber formed by baffle **40** and hollow body **14**, the ports in spacer element **38**, the space between tube **34** and spigot **12** and finally to discharge from chamber **28** into pipe **30**.

Consequently, cathode **20**, which is in contact with its support **18**, is constantly and regularly cooled in that the latter entirely surrounds the cathode itself and its entire surface is constantly in contact with the flowing fluid.

The cathode cooling circuit above described ensures uniform and regular circulation of the cooling fluid and thus a stability of temperature in the cathode which thus guarantees a constant emissivity of light.

Insofar as the rapid achievement of a stable operating condition is concerned, it should be noted that this is almost immediately achieved, by virtue of the efficient cathode cooling.

The hollow cathode tubes heretofore known required an average of approximately 20–30 minutes before reaching a stable operating condition and, moreover, were not suitable to provide a light emissivity sufficiently constant to consent the relative measurement in addition to absolute measurement, which it is possible on the other hand to obtain with the tube forming the object of this invention, by virtue of its constant emission of light over a given time.

In order to provide high efficiency and long life, the anode of the tube consists of an envelope or shield **50** having a cylindrical part **51** which surrounds most of hollow body **14** and a conical connecting surface **52** which extends beyond the cathode and is locked by a flange **54** welded air tight between the edges of the two bulb sections **A1** and **A2**.

The arrangement of the anode around the cathode results in a higher efficiency of the working discharge (taking place in the cathode cavity) because the parasite discharges (such as occur outside the cathode hole in the known tubes) are practically eliminated by virtue of the anode coaxial structure which is suitably sized according to the cathode dimension.

Moreover, this arrangement makes its possible to extend the tube's life to hitherto unknown limits as a result of the very great reduction in absorption of the rare gas contained in the tube itself, both because the ionized gases cannot come into contact with the glass parts of the tube and because of the suppression of parasite discharges as well as control of sputtering emitted by the cathode (at constant temperature).

The edge of flange **54** conveniently extends to the exterior of the tube for connection with the anodic supply.

The bulb is then closed air tight at the end of section **A2** by a transparent glass bottom plate **60** representing the optical window and connected to the bulb by metal parts consisting of a ring **58** and flange **56**.

Although the spectrophotometric tube as illustrated and described has provided excellent results, it was noted that this could be further improved by the introduction of suitable changes.

We have noted in fact that under some operating conditions or with certain filling gases or cathode materials, the optical window of the tube may not be sufficiently protected from the cathode sputtering, and that its transparency may consequently be reduced.

To insure the best efficiency of the tube, under any and all operating conditions, with any type of filling gas or cathode material, a hollow metallic element or tube **61** is placed between the cathode and the optical window **60**, said metal element **61** having a cone shaped flange **62** by which it is secured to metal ring **58**. The other end of the tube is free and extends to the neighborhood of the cathode.

The above hollow element **61**, the length and internal diameter of which are suitably proportioned to the dimensions of cathode **20** and function of the filling gas, provides a protection of window **60** from the cathode sputtering and also contributes, if suitably polarized with respect to the cathode and coaxial anode **50–52**, to avoid the formation of parasite discharges, with consequent improvement of the efficiency of the work discharge and life of the tube.

In the latter function it acts as a second anode for the tube, polarization being insured by ring **58** of the bottom plate.

I claim:

1. A hollow cathode tube for spectrophotometry provided with cathode cooling comprising glass bulb means, hollow cathode means, means to support said cathode in said bulb including a hollow body and a tubular portion integral with one end of said body and extending out of said glass bulb, an annular chamber formed by said hollow body being coaxially mounted spaced from said cathode and extending over substantially the entire length thereof, means for mounting said cathode in the free end of said hollow body, annular baffle means coaxially mounted in said chamber forming inner and outer separate fluid pathways, cooling fluid inlet means passing through said tubular portion and integral with said baffle to feed only said inner pathway, cooling fluid exhaust means connected to said tubular portion to receive cooling fluid from said outer pathway, means for supplying power to said cathode, anode means comprising an envelope coaxially mounted about said hollow body, said envelope comprising a cylindrical portion and an integral conical portion the flared end of which extends beyond said cathode so that coolant discharge will not affect the glass bulb, said conical portion extending through said glass bulb thus forming electrical connection means for said anode.

2. A hollow cathode tube according to claim **1** further comprising manifold means, said manifold means being mounted in air-tight relationship on said tubular portion of said cathode support, ring means and locking terminal means sealing said manifold on said tubular portion, electrical connection means for said cathode formed by said ring means, locking terminal means and cathode supporting means.

3. A hollow cathode tube according to claim **1** further comprising an optical window formed in said glass bulb, a hollow metal element fixedly mounted axially between said cathode and said optical window.

4. A hollow cathode tube according to claim **3** further comprising a metal ring secured to the periphery of said optical window, one end of said hollow metal element being secured to said ring and the other end of said hollow metal element terminating in the neighborhood of said hollow cathode.

5. A hollow cathode tube according to claim **3** in which said hollow metal element is a tube.

6. A hollow cathode tube according to claim **4** in which said hollow metal element has a conical flange on one end thereof, said flange being secured to said ring.

7. A hollow cathode tube according to claim **3** in which said hollow metal element forms a second anode which is suitably polarized with respect to said cathode and first anode.

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