United States Patent

[11] 3,633,990

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[21] Appl. No. 834,264
[22] Filed June 18, 1969
[45] Patented Jan. 11, 1972

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[54] **DEMOUNTABLE CATHODE GLOW DISCHARGE TUBE, PARTICULARLY FOR SELF-ALIGNING SPECTROSCOPIC DEVICES**
10 Claims, 3 Drawing Figs.

[52] U.S. Cl. 356/80, 313/210, 313/231, 313/237, 356/86, 356/98
[51] Int. Cl. G01j 3/10, H01j 17/04, H01j 17/26
[50] Field of Search 356/80, 85, 86; 313/209, 210, 231, 237

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ABSTRACT: In a self-aligning spectroscopic device of the glow discharge type, the cathode of a glow discharge tube is formed with a hollow beryllium copper cylinder which is removably seated within the cathode cavity about the tubular beryllium copper anode of the glow discharge tube. The exterior wall of the anode and the interior wall of the cylinder forms a cavity which contains a gaseous discharge medium.

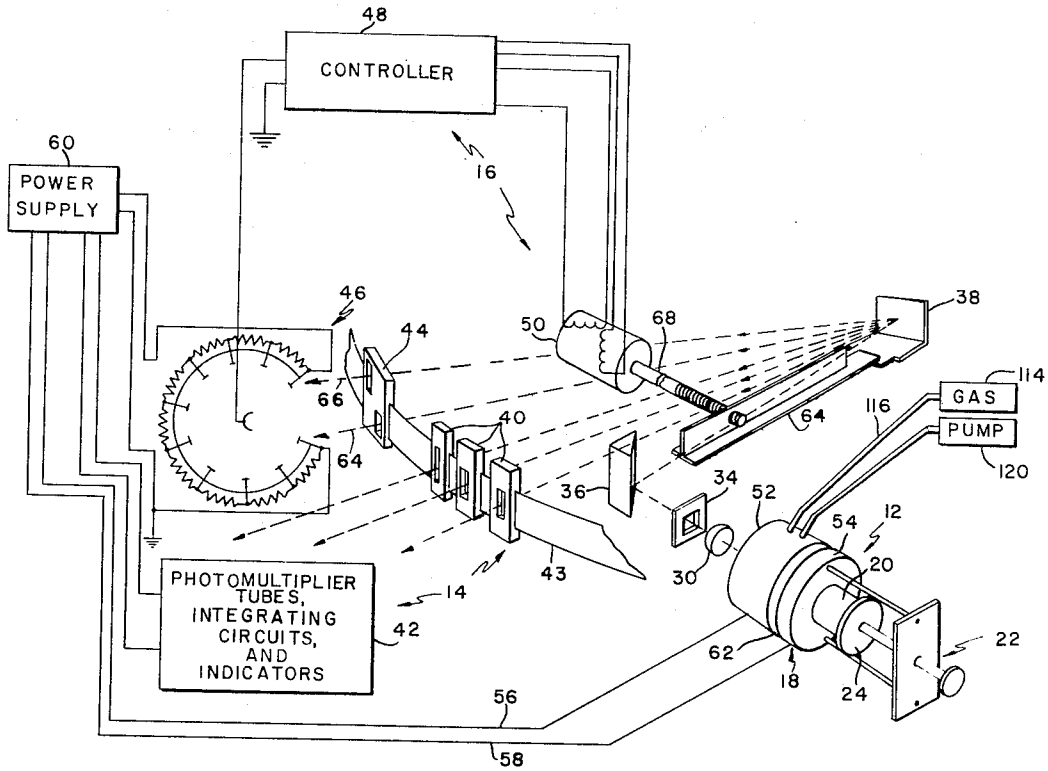
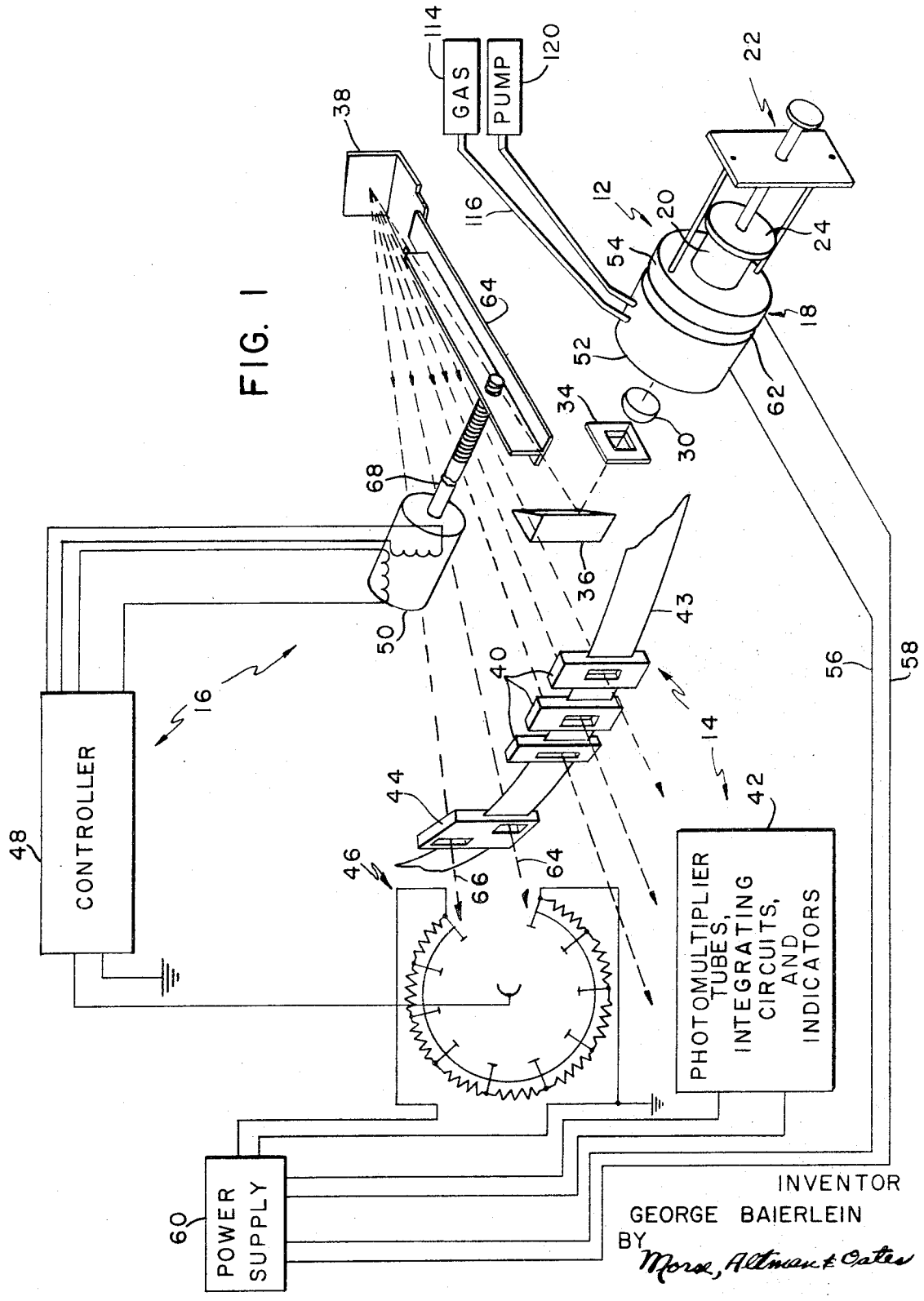
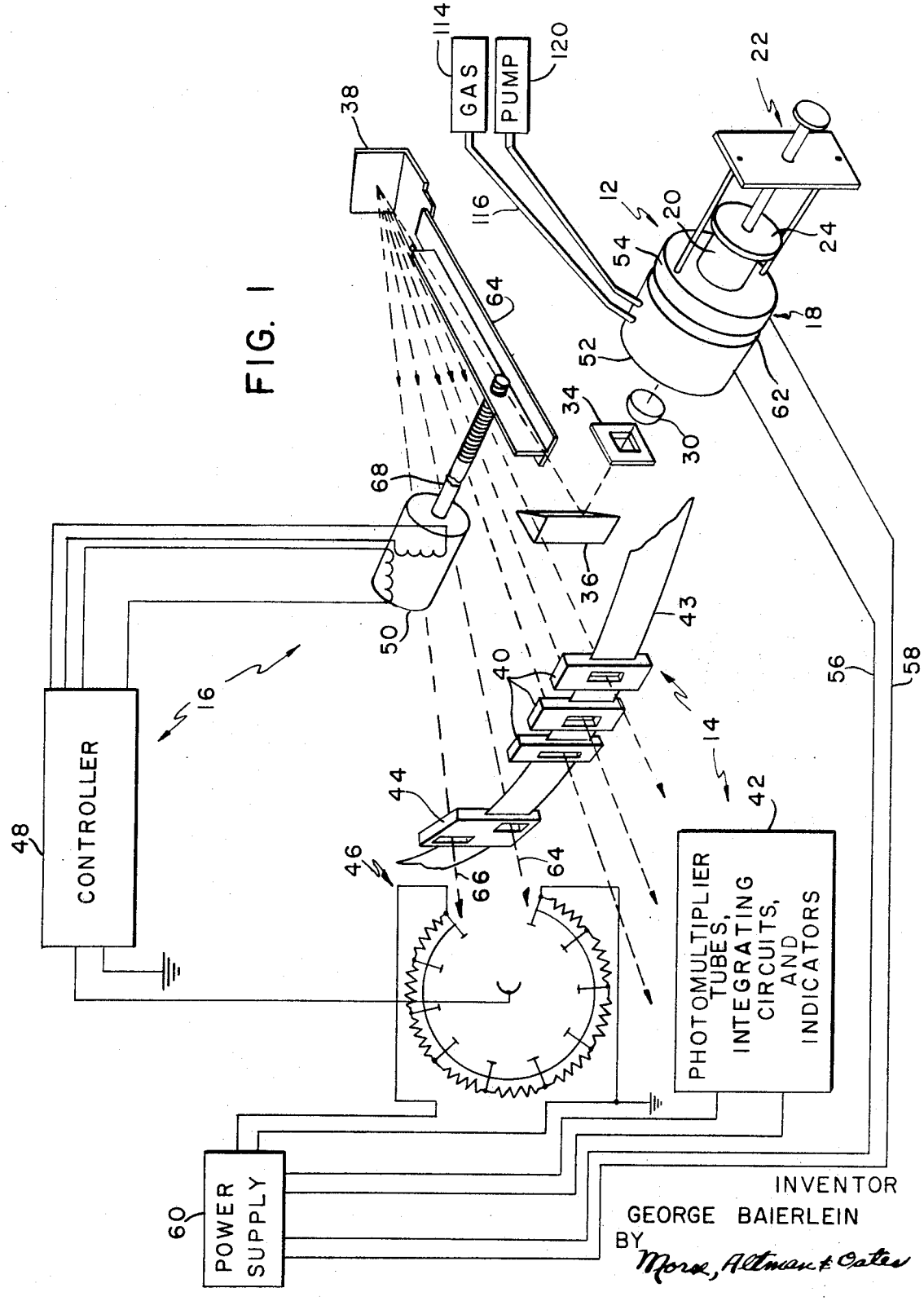


FIG. 1



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FIG. 1



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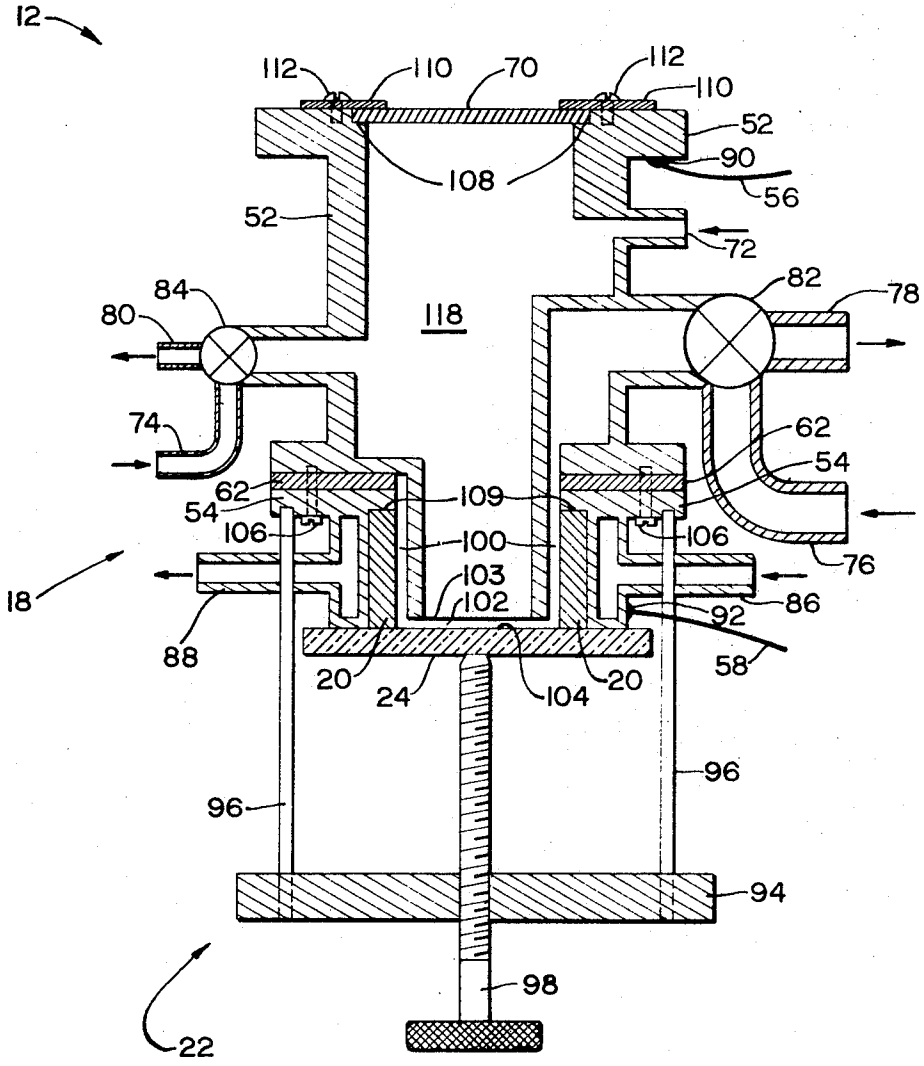


FIG. 2

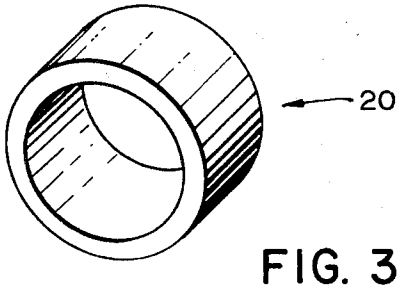


FIG. 3

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DEMOUNTABLE CATHODE GLOW DISCHARGE TUBE, PARTICULARLY FOR SELF-ALIGNING SPECTROSCOPIC DEVICES

BACKGROUND AND SUMMARY OF THE INVENTION

The present invention relates to spectrum analysis, and particularly, to self-aligning spectrometers of the so-called "direct reading" type which automatically indicate the composition of a specimen by determining the intensity distribution of radiation of characteristic wavelengths emitted by the specimen under excitation. More particularly, the present invention relates to spectrometers of the glow discharge type.

By way of example, a typical direct reading spectrometer comprises an entrance slit that transmits radiation from an electrically excited specimen, a diffraction grating that forms a spectrum from radiation so transmitted, and a plurality of exit slits that transmit components of specimen radiation of preselected wavelengths to photocells in order to determine the differing intensities at these wavelengths. In a self-aligning spectrometer, the spatial relationships among the entrance slit, the diffraction grating, and the exit slits are controlled by a servosystem, whereby errors caused by a spectrum shift are minimal. In one type of the aforementioned spectrometers, a glow discharge tube is utilized for exciting the specimen. As the specimen is excited, specimen particles enter the cavity formed by the exterior wall of the anode and the interior wall of the cathode and in consequence, specimen radiation is inhibited. Such a spectrometer has suffered from low efficiency, which has resulted from the necessity of dismantling the entire cathode cavity when specimen particles built up between the anode and cathode has inhibited specimen radiation.

The primary object of the present invention is to provide a self-aligning spectrometer of the glow discharge type characterized by a servosystem for maintaining the proper spatial relationships among the entrance slits, the diffraction grating, and the exits slits and a glow discharge tube, having a demountable cathode, for exciting the specimen being analyzed. The glow discharge tube is formed with a hollow cylinder which is removably seated within the cathode cavity about the tubular anode, the cylinder forming a part of the cathode. The exterior wall of the anode and the interior wall of the cylinder forms a cavity which contains a gaseous discharge medium. The combination of servosystem and demountable cathode is such as to provide a precise and efficient spectrometer.

Other objects of the present invention will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements, and arrangement of parts that are exemplified in the foregoing detailed disclosure, the scope of which will be indicated in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the present invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a block and schematic diagram of a spectroscopic system embodying the present invention;

FIG. 2 is a sectional of the glow discharge tube of FIG. 1; and

FIG. 3 is a perspective view of the demountable cathode of FIG. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Generally, the spectroscopic system of FIG. 1 comprises an excitation apparatus 12 for exciting a specimen to be analyzed, a spectrometer 14 for indicating the chemical composition of the specimen, and a servosystem 16 for maintaining proper alignment of the spectrometer. Excitation apparatus 12 includes a glow discharge tube 18 having a

demountable cathode 20 and a clamping device 22 for firmly positioning a specimen 24 against the excitation apparatus. Spectrometer 14 includes a lens 30, and entrance slit 34 and a mirror 36 for imaging the radiation from specimen 24 toward a diffraction grating 38 in order to produce a spectrum, exit slits 40 for directing this spectrum toward respective photomultiplier tubes in association with appropriate integrating circuits and indicators at 42, exits slits 44 and photomultiplier 46 for providing alignment signals to a controller 48. Servosystem 16 includes controller 48 which is responsive to signals from photomultiplier 48 and a servomotor 50 for controlling the spatial relationship between diffraction grating 38 and exit slits 40 and 42 which are mounted on a bar 43.

In the spectroscopic system of FIG. 1, excitation voltage is applied to the anode 52 and cathode 54 of glow discharge tube 18 via conductors 56 and 58, respectively, which are connected to a power supply 60, whereby specimen 24 is excited. The radiation from specimen 24 is directed via lens 30, slit 34, and mirror 36 to diffraction grating 38 which is mounted on a frame 64. The spectrum produced by diffraction grating 38 is directed toward the respective photomultiplier tube in 42 via exit slits 40. The servosystem is photoelectrically controlled by monitor radiation in the form of that component of specimen radiation by which the diffraction grating forms the so-called "central image" of entrance slit 34. It is known that the central image is formed by the grating in such a way that the angle of deflection is equal to the angle of incidence. Accordingly, servosystem 16 is positioned to receive from diffraction grating 38 via exit slits 44 a beam having an angle of deflection that is equal to the angle of incidence on diffraction grating 38 of the beam of specimen radiation from entrance slit 24. Normally, the servosystem is adjusted so that when the diffraction grating is properly oriented, beams 64 and 66 are transmitted in equal intensity to photomultiplier 46. But when the grating becomes improperly oriented, more of one of the beams and less of the other is transmitted to photomultiplier 46. Here a resulting imbalance signal is transmitted to servomotor 50 via controller 48, in consequence lead screw 68, which is affixed to a frame 64, is rotated in a direction such as to reorient the diffraction grating. Servomotor continues to rotate until beams 64 and 66 are transmitted in equal intensity. The chemical composition of specimen 24, specified by the intensity distribution of characteristic wavelengths emitted by the specimen under excitation which is directed through respective exit slits 30 toward respective photomultiplier tubes in association with appropriate integrating circuits in 42, are presented by indicators in 42. The details of excitation apparatus 12, hereinafter described, are shown in FIG. 2.

Generally, excitation apparatus 12 comprises a glow discharge tube 18 for exciting specimen 24 and clamping device 22 for fastening specimen 24 to the body of glow discharge tube 18. Anode 52 is manifolded and includes a gaseous discharge inlet 72, flush system inlets 74 and 76, evacuation outlets 78 and 80, and control valves 82 and 84. A window 70, for example quartz, is seated in groove 108 of anode 52 and is firmly held therein by clamp 110 and screws 112. Cathode 54 is manifolded and includes coolant inlet 86 and coolant outlet 88. Demountable cathode, a hollow cylinder as shown in FIG. 3, is seated within groove 109 of cathode 54. Anode 52 is provided with a terminal 90 whereat conductor 56 is connected and cathode 54 is provided with a terminal 92 whereat conductor 58 is connected. Clamping device 22 includes a solid member 94 which is held away from glow discharge tube 18 via rods 96, and thumbscrew 98 which is threaded into member 94. As thumbscrew 98 is threaded further into member 94, specimen 24 is firmly pressed against cathode 54 and demountable cathode 20 of glow discharge tube 18. A cavity 100 is formed between the exterior wall of anode 52 and the interior wall of demountable cathode 20 and a cavity 102 is formed between a forward wall 103 of anode 52 and a rearward facet 104 of specimen 24. Typically, the spacing between the anode and cathode is eight-thousandths of an inch. Anode 52 and cathode 54 are separated by dielectric an-

nulus 62, for example, a teflon gasket, the anode and cathode being held together by dielectric fasteners 106, for example, nylon screws. Glow discharge tube 18 is provided with sealing means (not shown) such as O-rings and the like, whereby all internal cavities are hermetically sealed. In the preferred embodiment of the present invention, anode 52, cathode 54, and demountable cathode 20 are highly conductive, particularly high-temperature, high-strength copper base metal such as beryllium copper and the gaseous discharge medium is an inert gas, particularly a noble gas such as argon.

In the apparatus of FIG. 2, argon as at a source 114 (FIG. 1) is made available at inlet 72 via a conductor 116. Anode cavity 118 is charged with argon, in consequence of the evacuating action of vacuum pump 120, which is connected to evacuation outlets 78 and 80. In this instance, valves 82 and 84 are in the evacuating position, i.e., outlets 78 and 80 are open to the anode cavity and inlets 74 and 76 are closed to the anode cavity. In the preferred embodiment of the present invention outlet 78 has a larger orifice than outlet 80, in consequence thereof, the pressure in the rearward portion of anode cavity 118 is greater than in the forward portion thereof. This resulting imbalance in pressure causes cavities 100 and 102 to be charged with argon. The anode and cathode are excited from power supply 60 via conductors 56 and 58, respectively. The potential difference between the voltage as at terminal 90 and terminal 92 is greater than the breakdown voltage of the argon, whereby a spark is produced between the anode and cathode. Specimen 24, which is in electrical contact with cathode 54 and demountable cathode 20 is excited, in consequence thereof, specimen radiation is emitted from that portion of the specimen which is opposite anode 52. The specimen radiation is transmitted through window 70 to lens 30. The chemical composition of the specimen is analyzed in accordance with the delineation of FIG. 1. During the excitation phase, particles (not shown) from the specimen are deposited on the forward inner and exterior walls of the anode. If these particles are not removed, excitation of the next specimen to be analyzed is inhibited.

Upon completion of the excitation phase, specimen 24 is released by unscrewing thumbscrew 98 out of member 94 and valves 82 and 84 are activated to the flush position, i.e., inlets 74 and 76 are open to the anode cavity and outlets 78 and 80 are closed to the anode cavity. Preferably an inert gas at high pressure, particularly a noble gas such as argon, is provided from a source (not shown) at inlets 74 and 76. The inrush of argon causes specimen 24 to be pushed away from cathode 54 and demountable cathode 20, and also causes demountable cathode 20 to be ejected from groove 109. Once the specimen and demountable cathode are removed, the anode is purged of specimen particles which are deposited during the excitation phase. It will be appreciated that the ejection of the demountable cathode allows the anode to be purged of all specimen particles with relative ease. If the cathode is a unitized body, the eight-thousandths clearance between the anode and cathode hinders purging of the anode and in some instances the glow discharge tube must be completely disassembled for cleansing of the specimen particles deposited during the excitation phase.

Since certain changes may be made in the foregoing disclosure without departing from the scope of the invention herein involved, it is intended that, all matter contained in the above description and shown in the accompanying drawings, be construed in an illustrative and not in a limiting sense.

What is claimed is:

1. A spectroscopic apparatus comprising excitation means, including a glow discharge tube, having demountable cathode means, for causing a chemical specimen to emit characteristic radiation, said glow discharge tube having anode and cathode means, said anode means formed with a tubular portion and said cathode means formed with a bore, the diameter of said cathode bore being larger than the diameter of said tubular portion of said anode means, said cathode bore receiving said tubular portion of said anode means, said tubular portion of said anode means concentrically mounted within said cathode bore, said cathode means also formed with a groove operating to slidably receive said demountable cathode means, said demountable cathode means interposed between said anode and cathode means, a cavity being formed between an exterior surface of said tubular portion of said anode means and an interior surface of said demountable cathode means, entrance slit means for passing said radiation from said excitation means, diffraction grating means for diffracting said radiation from said entrance slit means into a distribution of spectrum lines of which a plurality of spectrum lines indicate the composition of the specimen and a selected spectrum line serves as a reference, a plurality of exit slit means for passing said plurality of said spectrum lines, a plurality of indicator photodetecting means for receiving said plurality of spectrum lines, a selected exit slit means for passing said selected spectrum line, a reference photodetecting means for receiving said selected spectrum line in order to produce a signal, said entrance slit means, said diffraction grating means, said plurality of exit slit means and said selected exit slit means being geometrically related and oriented with respect to each other to provide coincidence of said plurality of spectrum lines with said plurality of exit slit means and said selected spectrum line with said selected exit slit means, and servo means responsive to said signal for controlling the relations among and orientations of said entrance slit means, said diffraction grating means, said plurality of exit slit means and said selected slit means.

2. The spectroscopic apparatus of claim 1 wherein said selected spectrum line is the central image from said diffraction grating means.

3. The spectroscopic apparatus of claim 1 wherein said demountable cathode means is a hollow cylinder, said hollow cylinder being slidably received within said groove, said cavity being formed between said exterior surface of said tubular portion of said anode means and an interior surface of said hollow cylinder.

4. A spectroscopic specimen exciting apparatus comprising glow discharge tube means having demountable cathode means for causing a chemical sample to emit characteristic radiation, said glow discharge means including anode and cathode means, said anode means formed with a tubular portion and said cathode means formed with a bore, the diameter of said cathode bore being larger than the diameter of said tubular portion of said anode means, said cathode bore receiving said tubular portion of said anode means, said tubular portion of said anode means concentrically mounted within said cathode bore, said cathode means having demountable cathode means, said cathode means also formed with a groove operating to slidably receive said demountable cathode means about said anode, a cavity being formed between an exterior surface of said tubular portion of said anode means and an interior surface of said demountable cathode means.

5. The spectroscopic specimen-exciting apparatus of claim 4 wherein said apparatus includes clamping means for fastening a specimen to said glow discharge tube means.

6. The spectroscopic specimen-exciting apparatus of claim 4 wherein said demountable cathode means is a hollow cylinder removably seated within said groove about said anode means, said cavity being formed between said exterior surface of said tubular portion of said anode means an an interior surface of said cylinder, first inlet means whereat a gaseous discharge medium is provided, second inlet means whereat a coolant is provided for said cathode means outlet means for evacuating the internal cavity of said glow discharge tube means, flush inlet means for purging said glow discharge tube means, window means at a rearward wall of said anode means, said window hermetically sealed to said anode means, said sample being hermetically sealed at a forward wall of said cathode means and demountable cathode means, anode terminal means connected to said anode means and cathode terminal means connected to said cathode means, said glow discharge tube means being charged with a gaseous discharge medium via said first inlet means, said gaseous discharge

medium being contained within said cavity formed between said anode means and demountable cathode means, said sample being excited via a potential applied to said anode and cathode terminal means, whereby said sample emits characteristic radiation.

7. The glow discharge tube means of claim 6 wherein said outlet means includes valve means operatively connected to a source of inert gas at high pressure and said flush inlet means, said inert gas operating to push said hollow cylinder out of said groove and eject said hollow cylinder from said cathode means when said valve means are in the flush position.

8. The spectroscopic specimen exciting apparatus of claim 6 wherein said anode means is beryllium copper.

9. The spectroscopic specimen-exciting apparatus of claim 6 wherein said cathode means and hollow cylinder is beryllium copper.

10. The spectroscopic specimen-exciting apparatus of claim 6 wherein said outlet means includes first outlet means and second outlet means, said first outlet means having a larger orifice than said second outlet means, whereby the pressure of said gaseous discharge medium is greater at the rearward portion of said glow discharge tube means than the pressure at the forward portion of said glow discharge tube means, said sample being at the forward portion of said glow discharge tube.

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