

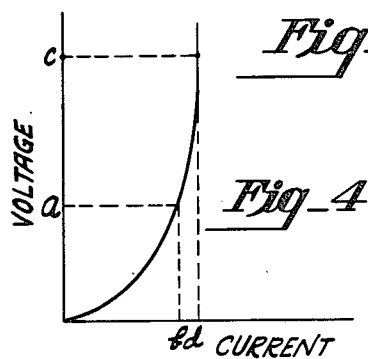
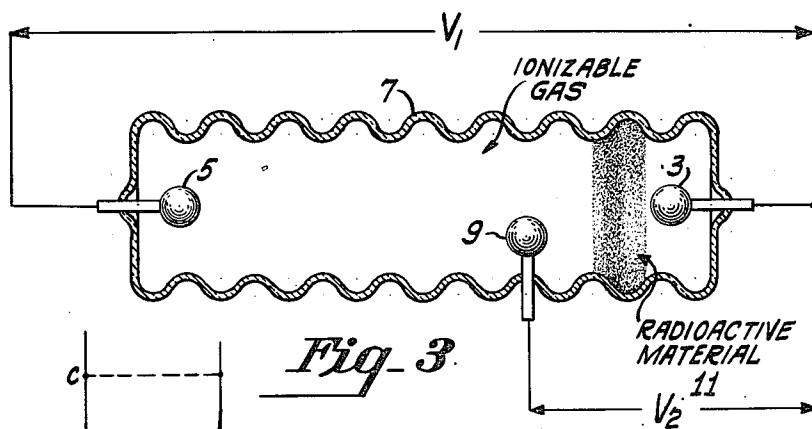
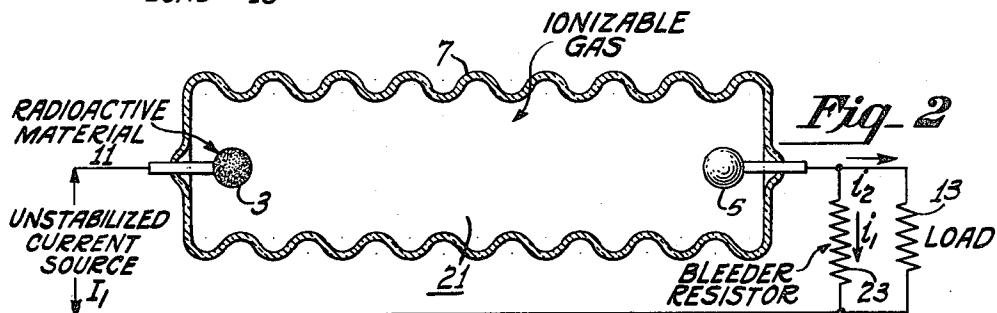
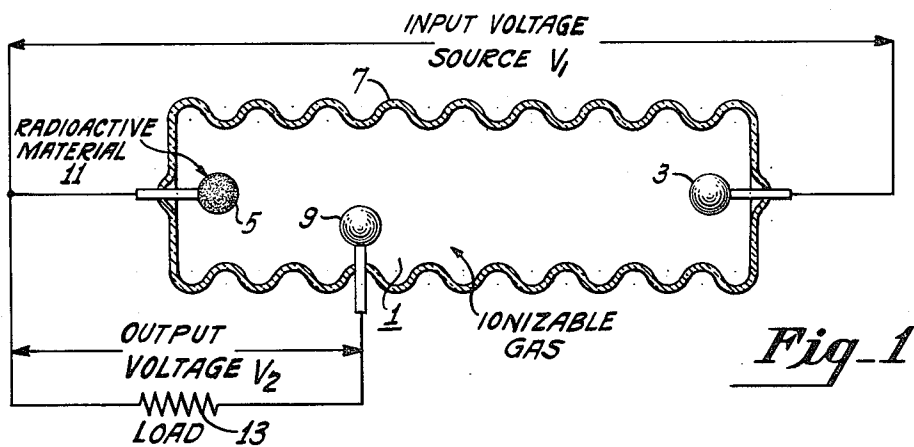
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ELECTRICAL REGULATOR DEVICE AND NETWORK THEREFOR

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ELECTRICAL REGULATOR DEVICE AND NETWORK THEREFOR

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This invention relates generally to electrical voltage dividers and current regulators and more particularly to improved networks and devices employing electrical discharge tubes including radioactive material.

Among the objects of the invention are to provide improved methods of and means for obtaining constant current operation in response to radioactive emission.

Another object is to provide improved methods of and means for utilizing radioactive emission for regulating electrical currents.

A further object is to provide improved voltage divider networks utilizing gas discharge tubes employing radioactive emission.

A still further object is to provide improved gas discharge tube electrical regulating devices utilizing radioactive emission.

Another object is to provide improved voltage dividing and current regulating systems utilizing radioactive emissive gas discharge tubes having substantially constant current characteristics.

Conventional gas discharge tubes employed heretofore as voltage regulators depend for their operation upon the constant voltage drop characteristics of the gas discharge device. The series current through the gas discharge tube therefore varies with the applied voltage to be regulated. Various types of devices employed for constant current or constant voltage regulation also have employed variable conduction tubes or devices wherein the internal resistance of the regulating device is controlled by the voltage or current of the load circuit.

The instant invention comprises improvements upon prior known regulating systems in that a novel gas cold discharge regulator tube is employed which utilizes radioactive emission to provide constant current regulator tube operating characteristics. Such a device may be used as a voltage divider by employing a constant current discharge between a pair of electrodes connected to an unstabilized voltage source. A constant fraction of the applied voltage may thence be derived from across an intermediate portion of the gaseous discharge. The device described is more compact and rugged, and is less sensitive to temperature variations than conventional resistance type voltage dividers.

Similarly, such a cold discharge gas tube including radioactive emissive material may be connected as a constant current series element between an unstabilized current source and a load to provide constant current load operation. All such radioactive discharge tube control de-

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vices of necessity are high impedance elements providing only very minute output currents under practical operating conditions. Such devices have great utility in power supply networks for high impedance, low current devices such as electron microscopes, photo-multipliers, Geiger counters, and the like.

A radioactive emissive source such as polonium, phosphorus P₃₂, and the like, produces in a gaseous medium positive ions and free electrons. These electrons remain free and do not combine with other gas molecules to form negative ions in the case of gases having small electron affinity such as argon, carbon dioxide, nitrogen, etc. In gases readily forming negative ions such as air, oxygen, etc. a stronger radioactive source will be required due to the higher coefficient of recombination and may utilize higher operating voltages under similar conditions. The former type gases will have a wider voltage range of a constant current characteristic. In general, the operating characteristics of such devices will depend only upon the geometrical proportions of the device, the gas pressure, and the type of gas and radioactive emission employed.

The operating gas pressure may range from a small portion of an atmosphere to several atmospheres. The voltage dividing characteristics of the device may range from a few percent to nearly a hundred percent of the applied voltage. In both instances of voltage division or current regulation, the available output current will be determined by the radioactive emission and the type of gas in the device.

The invention will be described in greater detail by reference to the accompanying drawing in which:

Figure 1 is a schematic circuit diagram of a voltage dividing embodiment of the invention;

Figure 2 is a schematic circuit diagram of a current regulating embodiment of the invention;

Figure 3 is a cross-sectional view of a modification of the voltage dividing gas tube shown in Figure 1; and

Figure 4 is a graph illustrative of the operating current versus voltage characteristics of a typical discharge tube according to the invention.

Similar reference characters are applied to similar elements throughout the drawing.

Referring to Figure 1 of the drawing, a typical embodiment of a gas tube according to the invention is shown in a voltage dividing network,

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An input voltage source V_1 is connected to the end terminals 3, 5 of a gas discharge tube 1. The tube 1 has an insulating envelope 7 of sufficient length and insulating properties to provide negligible leakage current for the input voltage V_1 . Preferably, the terminals 3 and 5 have rounded contours to minimize corona effects. The insulating envelope 7 encloses an ionizable gas such as argon, neon, carbon dioxide, nitrogen, etc. at a pressure in the region between a small fraction and several atmospheres. The gas pressure to be utilized will depend on the gas mixture and the range of applied voltages. A voltage dividing electrode 9 also is sealed through the walls 7 of the tube 1 at a point intermediate the input terminals 3, 5. Preferably, the latter electrode 9 also has rounded contours.

A source of radioactive charged-particle-emissive material 11 is coated upon one of the electrodes within the tube, such, for example, as the electrode 5, or is coated upon the inner surface of the envelope 7 as shown in Figure 3. The radioactive coating may be any appropriate material to provide the desired alpha, beta, or gamma radiation which serves to produce ionization of the gas within the envelope. To reduce the health hazard an energetic but short range radiation is preferred. In a typical example, the radioactive source produces an ion saturation current of the order of 10^{-7} amperes per millicurie. In the example selected, argon gas at a pressure of 1 atmosphere is irradiated by 5 m. e. v. alpha particles derived from one millicurie of radioactive polonium Po^{210} . The spacing between the electrodes 3 and 5 was selected to be 10 centimeters while the spacing between the output electrodes 5 and 9 was selected to be one centimeter. For an applied voltage V_1 of the order of 5,000 volts, the output voltage V_2 would be of the order of 500 volts at a current of the order of 10^{-7} amperes. The general operating characteristics of such a device are shown qualitatively in the voltage versus current graph of Figure 4. The output voltage V_2 may be applied to any high impedance low current load 13 such as electron microscopes, photomultipliers, Geiger counters, and the like.

It should be understood that additional voltage dividing electrodes may be sealed into the gas-filled envelope to derive other output voltages as desired.

Figure 2 illustrates the application of the principles of the invention to a current regulating network wherein an unstabilized current source I_1 is serially connected through a two electrode gas tube 21 to a load 13. If desired, a bleeder resistance 23 passing a current i_1 of an order of magnitude greater than the load current i_2 may be provided for maintaining substantially constant load voltage. The ionizable gas tube 21 includes a pair of electrodes 3, 5 sealed into the envelope at the opposite ends thereof. The insulating envelope 7 encloses an ionizable gas as well as a coating of radioactive material 11 applied either to one of the electrodes 3 or distributed over a portion of the inner envelope wall as shown in Figure 3. Since the radioactive material provides a saturation ionization of the ionizable gas within the envelope, the regulator tube 21 becomes a constant current device which regulates the output current applied to the load. As explained heretofore, the radioactive material may comprise any appropriate alpha, beta, or gamma emitter having the desired radioactivity and life characteristics.

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Typical radioactive emitters include the following:

Alpha-ray emitters

Element	Half-life (days)	Energy (equivalent million electron volts)
Polonium (Po^{210})	140	5.25
Actinium (Ac^{223})	11.2	5.66
Thorium X ($Th X^{224}$)	3.64	5.65
Radio actinium ($Rd Ac^{227}$)	18.9	5.92

Beta-ray emitters

Element	Half-life (days)	Energy (equivalent million electron volts)
Phosphorus (P^{32})	14	1.7
Calcium (Ca^{45})	180	0.2
Scandium (Sc^{46})	85	0.9
Iron (Fe^{59})	47	0.26
Arsenic (As^{74})	16	1.5
Strontium (Sr^{90})	55	0.4
Antimony (Sb^{124})	60	0.9
Tungsten (W^{182})	77	1.3
		1.5
		1.53
		0.5

Thus the invention described and claimed herein includes novel and improved voltage dividing and current regulating systems employing saturated ionization of the gas within a discharge tube in response to applied radioactive emission, thereby providing constant current gas tube operating characteristics. The devices disclosed are limited by practical considerations of cost, size and availability of radioactive material to low power, relatively high voltage, applications wherein substantially constant currents are desired.

What is claimed is:

1. A voltage dividing system comprising a tube having an envelope containing an ionizable gas, a plurality of electrodes exposed to said gas, radioactive material enclosed within said envelope for providing a constant current through said gas, means for connecting a source of voltage to two of said electrodes, and means for deriving an output voltage at said constant current from another of said electrodes.

2. A voltage dividing system comprising a tube having an envelope containing an ionizable gas, a plurality of cold discharge electrodes exposed to said gas, one of said electrodes including radioactive material for providing a constant current through said gas, means for connecting a source of voltage to two of said electrodes, and means for deriving an output voltage at said constant current from another of said electrodes.

3. A voltage dividing system comprising a tube having an envelope containing an ionizable gas, a plurality of cold discharge electrodes exposed to said gas, one of said electrodes including radioactive material for providing a constant current through said gas, means for connecting a source of voltage to be divided to two of said electrodes, and means for deriving an output voltage at said constant current from between another of said electrodes and one of said two electrodes.

4. A voltage dividing system comprising a tube having an envelope containing an ionizable gas, at least three cold discharge electrodes exposed to said gas, one of said electrodes including radioactive material for providing a constant current through said gas, means for connecting a source of voltage to be divided to the outer ones of said electrodes, and means for deriving a lower voltage

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than said source voltage at said constant current from an intermediate one of said electrodes and one of said outer electrodes.

5. A current regulating system comprising a tube having an envelope containing an ionizable gas, a plurality of electrodes exposed to said gas, radioactive material enclosed within said envelope for providing a constant current through said gas, means for connecting said tube in series with a load and a source of current to be regulated, and means for connecting a load to said tube.

6. A current regulating system comprising a tube having an envelope containing an ionizable gas, a plurality of cold discharge electrodes exposed to said gas, one of said electrodes including radioactive material for providing a constant current through said gas, means for connecting said tube in series with a load and a source of current to be regulated, and means for connecting a load to said tube.

7. A constant current regulating system comprising a tube having an envelope containing an ionizable gas, a plurality of cold discharge electrodes exposed to said gas, one of said electrodes including radioactive material for providing a constant current through said gas, a high impedance load, and means for connecting said tube in series with said load and a source of current to be regulated.

8. An electrical regulating system comprising a tube having an envelope containing an ionizable gas, a plurality of cold discharge electrodes exposed to said gas, one of said electrodes including radioactive material for providing a constant current through said gas, a shunt connected high im-

pedance bleeder resistance and a load, and means for connecting said tube in series with said shunt connected resistance and said load and a source of current to be regulated.

9. The method of utilizing radioactive emission for dividing an applied voltage comprising providing a constant current through an enclosed body of gas in response to said emission, applying said voltage to be divided to said gas to provide a discharge path therein, and deriving a divided output voltage from said gas discharge path.

10. The method of utilizing radioactive emission for providing a constant current to a load comprising providing a constant current through an enclosed body of gas in response to said emission, applying electric current to be regulated to said gas, and deriving a constant load current from said gas.

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