

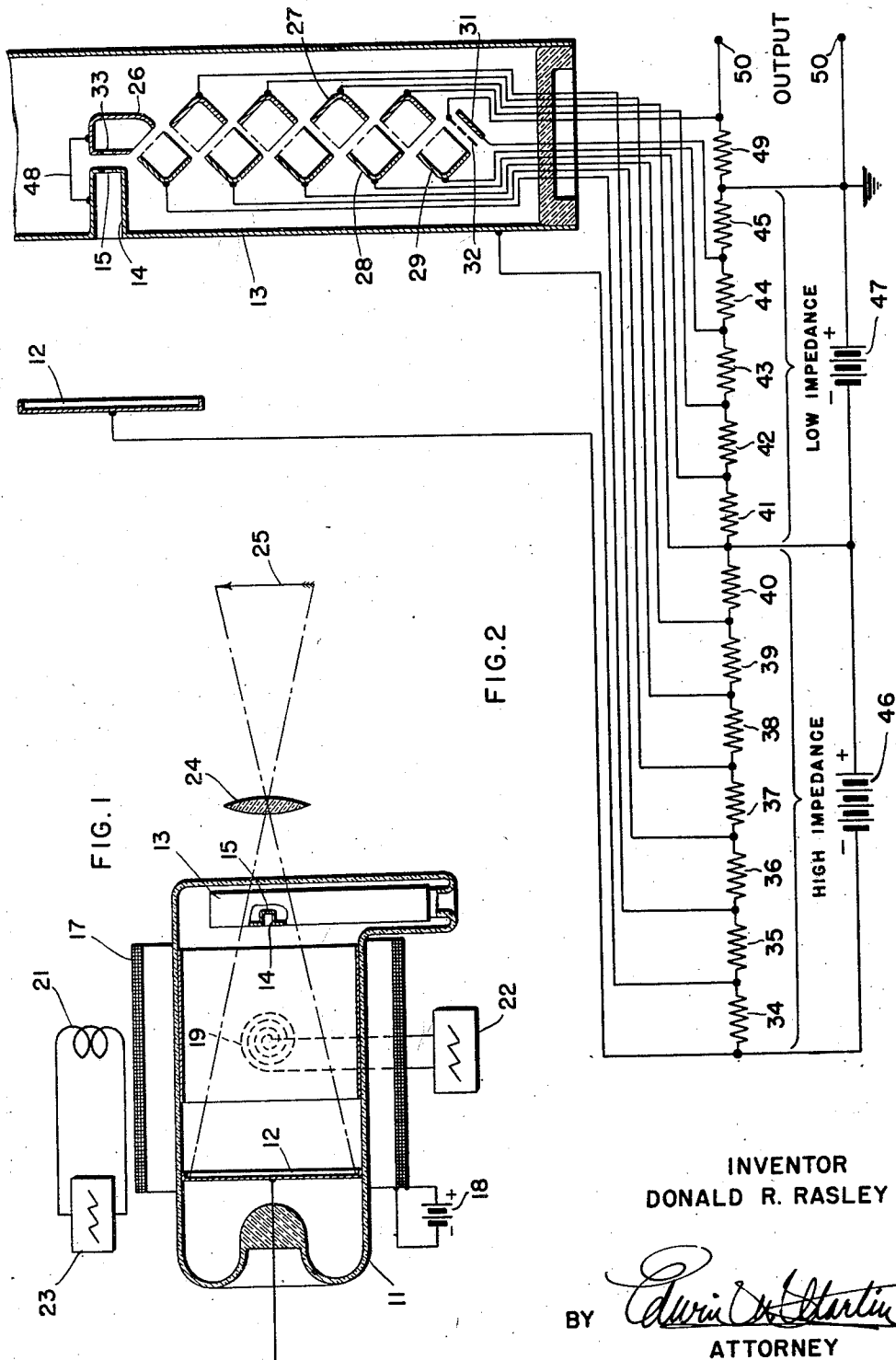
Dec. 16, 1947.

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2,432,681

ELECTRON MULTIPLIER VOLTAGE SUPPLY

Filed Dec. 2, 1943



UNITED STATES PATENT OFFICE

2,432,681

ELECTRON MULTIPLIER VOLTAGE SUPPLY

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Application December 2, 1943, Serial No. 512,541

5 Claims. (Cl. 250—27)

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This invention relates to signal amplifiers and particularly to voltage supplies for an electron multiplier type of amplifier.

It is customary to employ multistage static electron multipliers to amplify many different types of signals. A multistage multiplier is essentially a device which is operated by impressing positive potentials of increasing values to successive ones of the secondary emissive multiplier electrodes. In many cases it is desirable to maintain a substantially uniform potential difference between successive multiplier electrodes. One way in which this type of operation may be achieved is by use of independent sources of potentials for each pair of electrodes. Each of these sources may be chosen to impress the desired voltage upon the electrodes to which it is connected and to deliver power in the amount required by the relative magnitude of the electron current flowing between the electrodes. In this manner the source of potential between any two electrodes is not affected materially by the electron current flow between these two electrodes. Thus, the multiplication ratio of each multiplier stage and, consequently, the overall multiplication ratio of the entire device remain substantially constant throughout a considerable range of variation of the primary electron concentration at the multiplier input. The voltages developed in the output circuit of the multiplier then are substantially directly proportional to the primary electron concentrations at the multiplier input. Such a device is said to have a linear operating characteristic.

Ordinarily, however, it is more convenient to provide the electron accelerating potentials for the multiplier electrodes from taps on a voltage divider to which is connected a single source of relatively high unidirectional voltage. Where substantial linearity of response by the multiplier is required over a relatively wide range of variation in the primary electron concentrations, it is the usual practice to employ relatively low impedance components in the voltage divider. In this manner the electron current flow in the voltage divider components constitutes but a relatively small proportion of the total current flowing in the divider. Thus, the voltage for impression upon the multiplier electrodes developed in a given voltage divider component is not affected materially by variations in the electron current flow through the component and consequently remains substantially constant.

However, the achievement of relatively good regulation of the individual voltage sources pro-

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vided by such a voltage divider requires the use of a unidirectional source which is capable of delivering a substantial amount of power. One expedient which has been tried to reduce the power consumption by a voltage divider source of multiplier accelerating potentials is the use of relatively high impedance components for the divider. While the power requirements of a unidirectional voltage source are substantially reduced by such an arrangement, the performance of the multiplier is affected in a manner which is not always desirable. In such a case the electron current flow in a given divider component constitutes a substantial proportion of the total current flow through the component. Therefore, the voltage developed at the terminals of the component is subject to an appreciable variation in accordance with the magnitude of the electron current flow. The overall multiplication ratio of the multiplier varies as a consequence in accordance with variations in the magnitude of the primary electron concentrations. In such a case the operating characteristic of the multiplier no longer is linear throughout the entire operating range.

In some cases such a performance is desirable for the purpose of effecting an automatic gain control of the multiplier. However, the range within which substantial linearity of response is obtained is materially reduced with respect to the linear response range of a multiplier supplied with accelerating potentials from a relatively low impedance voltage divider.

It is an object of the present invention, therefore, to provide an accelerating voltage supply for an electron multiplier in which the power consumption is relatively low and which, at the same time, will enable the multiplier to operate in a substantially linear manner throughout a relatively wide range.

In accordance with the invention there is provided an electron multiplier having a plurality of secondary electron emissive electrodes between which there is produced a secondary electron current flow. The electron accelerating potentials impressed upon the multiplier electrodes are derived from a voltage divider which consists of a plurality of impedance components, one group of which is of a relatively high order of magnitude and the other group of which is of a relatively low order of magnitude. Individual sources of unidirectional voltages are provided for each group of the multiplier impedance components.

For a better understanding of the invention,

together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing:

Fig. 1 is a diagrammatic representation of a dissector tube embodiment of the invention; and

Fig. 2 is a schematic wiring diagram showing the electrical characteristics of the pertinent components of a dissector tube drawn to an enlarged scale.

Having reference now to Fig. 1 of the drawing, there is illustrated a sectional view of a dissector tube provided with an evacuated envelope 11. Mounted within and adjacent to one end of the envelope is a photoelectric cathode 12. Also, within the envelope and adjacent to the end opposite the cathode, there is mounted a multistage electron multiplier housed within a metallic shielding anode 13. The anode is provided with a recessed portion 14 at the end of which is formed a primary scanning aperture 15 which is disposed substantially centrally with respect to the cathode 12 and faces the cathode. An accelerating anode is provided in the form of an interior wall coating 16 between the cathode 12 and the anode 13.

A focusing coil 17 is disposed on the outside of the tube envelope 11 in a manner to surround substantially completely the space within the tube between the cathode and the anode. A battery 18 or other suitable source of electrical energy is connected to the focusing coil for the energization thereof to establish the desired focusing field within the tube envelope whereby an electron image is formed substantially in the plane of the anode 13. The tube also is provided with horizontal and vertical scanning coils 19 and 21, respectively. Each of these coils is energized by respective sources 22 and 23 of appropriate saw-toothed wave form voltages.

In conjunction with the dissector tube there also is provided an optical system represented by a lens 24, whereby an optical image of a subject 25 is focused into the plane of the photoelectric cathode 12.

Referring now to Fig. 2 of the drawing, a more detailed description of the electrical connections to the photoelectric cathode 12 and the electron multiplier will be given. The multiplier which is housed within the anode shield 13 comprises a plurality of box-like electrodes such as 26, 27, 28 and 29. In the case of a so-called eleven-stage multiplier the device includes ten of such box-like electrodes, the eleventh stage ordinarily being in the form of a plate such as 31. A collecting electrode of suitable form such as a grid 32 is located between the tenth stage electrode 29 and the eleventh stage electrode 31. The first stage electrode 26 is provided with a secondary scanning aperture 33 in alignment with the primary scanning aperture 15 formed in the anode shield 13. The secondary aperture ordinarily is smaller than the primary aperture, being of substantially the same size as the desired elemental scanning area.

Suitable accelerating potentials are impressed upon the multiplier electrodes and the photoelectric cathode by appropriate connections to taps on a voltage divider which, as illustrated, comprises the series connection of resistors 34 to 45, inclusive. The resistors 34 to 40 are of a relatively high order of magnitude and are connected across a source of unidirectional voltage such as

a battery 46. The requirements of this battery are that it be capable of producing a voltage of the order of 1500 volts and of delivering but a relatively small amount of power. The resistors

41 to 45 are of a relatively low order of magnitude and are connected across the terminals of a source of unidirectional voltage such as a battery 47. The requirements of the battery 47 are that it be capable of producing a voltage of the order of 1000 volts and of delivering relatively large amounts of power. The batteries 46 and 47 are connected in series, as shown, with the highest positive potential terminal connected to ground.

The negative terminal of the battery 46 is connected to the photoelectric cathode 12. The junction point between resistors 34 and 35 is connected to the shielding anode 13, and also by means of an internal connection such as represented by a conductor 48 to the first stage multiplier electrode 26. Thus, the anode shield and the first stage electrode are operated at the same positive potential with respect to the cathode 12. The electrodes comprising multiplier stages 2 to 7 inclusive, the latter of which is the electrode 27, are connected respectively, to other taps on the high impedance portion of the voltage divider in a manner to impress increasingly higher positive potentials on succeeding ones of these multiplier electrodes. The eighth stage multiplier electrode 28 is connected to the junction point between the low impedance resistances 41 and 42. Similarly, the multiplier stages 9 to 11 are connected, respectively, to other taps on the low impedance portion of the voltage divider. For example, the tenth stage electrode 29 is connected to the junction point between resistors 43 and 44 and the eleventh stage electrode 31 to the junction point between resistors 44 and 45. The other terminal of the resistor 45 is connected to the grounded positive terminal of the battery 47 and also to one terminal of an output resistor 49. The other terminal of the output resistor is connected to the collecting electrode 32 of the multiplier and also to one of a pair of output circuit terminals 50, of which the other terminal is connected to ground.

Referring now to the operation of the illustrated embodiment of the invention, it is believed that a consideration of a concrete example will serve best to demonstrate the manner in which the useful and beneficial result is obtained. In prior art power supplies of this general character for electron multipliers where substantial linearity of response is desired, it has been customary to utilize for resistors similar to 35 to 45 inclusive voltage divider components having values of approximately 20,000 ohms each. The component similar to resistor 34 usually has a value of the order of 30,000 ohms. The unidirectional voltage source connected across such a prior art divider is approximately 2,500 volts, which is the combined voltage of the present sources 46 and 47, the former being 1,500 volts and the latter 1,000 volts.

For the present consideration the current flow through the various voltage divider components resulting from the supply of electrons to the multiplier electrodes will be neglected for the reason that where a low impedance divider is used, the electron currents will be small as compared with the current circulated through the divider by the unidirectional voltage source. Accordingly, the current flow through a prior art type of low impedance voltage divider is approximately 10 milliamperes, which requires that the unidirectional

power source be capable of furnishing approximately 25 watts of power.

The voltage supply arrangement in accordance with this invention contemplates that the resistor 34 have a value of approximately 390,000 ohms, the resistors 35 to 40 inclusive, have values of approximately 220,000 ohms each and resistors 41 to 45 have values of approximately 20,000 ohms each. In such a case the current supplied by the battery 46 to the high impedance portion of the divider is approximately 0.9 milliampere, thus requiring the battery to furnish approximately 1.35 watts of power. Even as in the present case where the voltage divider is of a relatively high impedance, it is not inaccurate to omit consideration of the electron current flow for the reason that it is relatively small in the lower multiplier stages.

The current flow (exclusive of the electron current flow) in the low impedance portion of the divider is approximately 10 milliamperes, requiring that the battery 47 furnish approximately 10 watts of power. It is seen that the combined power output of the batteries 46 and 47 will be approximately 11.35 watts, as compared with the 25 watt output required of a prior art unidirectional power source. The power saving which results from the use of a power supply in accordance with the present invention is approximately 55%, based on the power output requirements of a prior art device of this character.

It must not be overlooked that this material saving in power consumption is realized without the loss of linearity of response by the multiplier. Extensive tests have shown that a multiplier provided with either of two power supplies, one in accordance with the prior art practice as specified hereinbefore and the other in accordance with the previously specified embodiment of the present invention, produces signal voltages in either case which correspond in a substantially linear manner to the primary electron concentrations at the multiplier input.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In an electron multiplier, a plurality of secondary electron emissive electrodes, a first source of unidirectional voltage, relatively high impedance means connected to said first source of voltage for developing a first series of voltages, means for impressing said first series of voltages upon respective ones of one group of said electrodes, a second source of unidirectional voltage, relatively low impedance means connected to said second source of voltage for developing a second series of voltages, and means for impressing said second series of voltages upon respective ones of another group of said electrodes.

2. In an electron multiplier, a plurality of secondary electron emissive electrodes, a first source of unidirectional voltage having a relatively low power output capacity, relatively high impedance means connected to said first source of voltage for developing a first series of voltages, means for

impressing said first series of voltages upon respective lower-numbered ones of said electrodes, a second source of unidirectional voltage having a relatively high power output capacity, relatively low impedance means connected to said second source of voltage for developing a second series of voltages, and means for impressing said second series of voltages upon respective higher-numbered ones of said electrodes.

3. In an electron multiplier, a plurality of secondary electron emissive electrodes, a first source of unidirectional voltage having a relatively low power output capacity, a relatively high impedance voltage divider connected across said first source of voltage, connections from individual points on said high impedance voltage divider to respective lower-numbered ones of said electrodes, a second source of unidirectional voltage having a relatively high power output capacity, a relatively low impedance voltage divider connected across said second source of voltage, and connections from individual points on said low impedance voltage divider to respective higher-numbered ones of said electrodes.

4. In an electron multiplier, a plurality of secondary electron emissive electrodes, a first source of unidirectional voltage having a relatively low power output capacity, a relatively high impedance voltage divider comprising a plurality of components of a relatively high order of magnitude connected in series across said first source of voltage, connections from individual ones of said high impedance voltage divider components to respective lower-numbered ones of said electrodes, a second source of unidirectional voltage having a relatively high power output capacity, a relatively low impedance voltage divider comprising a plurality of components of a relatively low order of magnitude connected in series across said second source of voltage, and connections from individual ones of said low impedance voltage divider components to respective higher-numbered ones of said electrodes.

5. In an electron multiplier, a plurality of secondary electron emissive electrodes, a first source of unidirectional voltage having a relatively low power output capacity, a relatively high impedance voltage divider comprising a plurality of resistors of a relatively high order of magnitude connected in series across said first source of voltage, connections from individual ones of said high impedance voltage divider resistors to respective lower-numbered ones of said electrodes, a second source of unidirectional voltage having a relatively high power output capacity, a relatively low impedance voltage divider comprising a plurality of resistors of a relatively low order of magnitude connected in series across said second source of voltage, and connections from individual ones of said low impedance voltage divider resistors to respective higher-numbered ones of said electrodes.

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