PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in or relating to Electron Multipliers

We, FRANCOIS JOSEPH GERARD VAN DEN BOSCH, of Belgian Nationality, HAROLD SEFTON MOLYNEUX-FFENNELL, a British Subject, and VACUUM-SCIENCE PRODUCTS LIMITED, a British Company, all of the Company's address, 166, Weir Road, London, S.W. 12, do hereby declare the nature of this invention to be as follows:—

This invention relates to electron multipliers of the kind in which there is provided within an envelope a primary cathode for producing a stream of electrons, one or more secondary electron-emitting electrodes arranged in said stream and adapted to release secondary electrons by the impact of said stream thereon and a collector electrode or anode for collecting the augmented stream of electrons. Considerable high-frequency losses are involved as a rule in the external circuit associated with such multipliers, owing, *inter alia*, to the length of the leads between the electrodes of the electron multiplier and the components of the circuit such as condensers and inductances with which the electrodes are to be associated.

According to this invention an electron multiplier of the kind referred to above is characterised in that one or more of said electrodes is or are so formed as to constitute the required component or components of the circuit with which the multiplier is to be associated, or said electrode or electrodes is or are connected directly with the component or components which is or are disposed within the envelope of the multiplier. For example, adjacent electrodes may be arranged to form a condenser of a value required for the circuit. It is usually necessary to provide de-coupling condensers between adjacent secondary cathodes. Thus, in carrying the present invention into effect the surface areas of adjacent secondary electron-emitting cathodes are selected to provide the necessary capacity for said de-coupling condensers.

It is also desirable to provide a de-coupling condenser between the primary cathode and the adjacent secondary cathode, and in the case where an accelerator is provided the de-coupling condenser may be constituted by the accelerator and a closely spaced plate having a sufficiently large aperture as not to restrict the flow of the electron stream. The two plates may be separated by air or by any suitable insulating material if a higher capacity is required. This material would be perforated in the same way as the additional plate. The extra plate has the further advantage of improving the electrostatic screening between the control grid and the succeeding electrodes.

It is often required to associate with the output electrode of an electron multiplier, a tuned component, and according to this invention the tuned component is arranged within the envelope. For example, this component may comprise an impedance in the form of two nested metal tubes spaced apart, and connected together at one end, the other end of the inner tube being closed. The last secondary cathode is spaced away from the closed end of the inner tube to provide a condenser and is also spaced away from the output electrode to provide a second condenser. Suitable leads extend from the nested tubes and last secondary cathode and from the output electrode and the last secondary cathode respectively, which leads pass through pinches in the envelope. These latter two leads are arranged for connection with a tuning condenser and constitute the means for the removal of power to high-impedance circuits.

A small loop of wire may be provided at the other end of the nested tubes and is provided with output leads spaced apart so as to form a low impedance output of the required characteristics. Instead of providing an external tuning condenser between the high-frequency output leads means may be provided for varying the gap between the last secondary cathode and the output electrode. This may be effected by moving the last secondary cathode by external pressure applied through a suitable

[*Price* 1/-]

flexible field in the glass. Other methods of moving this electrode may comprise an external magnet or by a system of gravity-controlled levers so that the electrode could be moved by tilting the envelope. Yet a further method of moving the electrode would be by over-expansion of a suitable rod caused by the passage of electric current through it.

The conductors between any of the electrodes referred to above and the lead-in wires through the pinches may be constituted by comparatively broad strips of metal, whereby high-frequency losses are reduced.

The various electrodes of tuned components may be carried by rods formed from refractory insulating material as described in specification No. 547,971.

The elements of the aforesaid tuned components are preferably formed from metal suitable for use in high-vacuum apparatus, such as nickel or Swedish iron and should be plated with a metal of low specific resistance such as silver, copper or chromium.

The following is a more detailed description of an electron multiplier according to this invention.

The various electrodes of the multiplier are carried on four ceramic rods having inset at their lower ends metal legs which are sealed into the envelope by the usual pinches. The lower end of each ceramic rod is shaped to provide a shoulder, while the upper ends are screw-threaded and receive clamping nuts also formed of ceramic material. Certain of the electrodes are separated by collars encircling the rods. Thus, the electrodes and the collars may be clamped between the nuts and shoulders. The primary cathode is mounted in a housing between two ceramic plates and is tubular in form. A heater extends through the cathode and is fed with power through suitable leads and pinches in the envelope. A grid is mounted between the cathode and the lower plate. Both plates are carried by said rods. The primary cathode and grid are also connected to suitable lead-in wires. Separated from the grid by one of the aforesaid collars is a metal plate having an aperture therein sufficiently large as not to restrict the flow of the electron stream from the cathode. Disposed a short distance beneath the apertured plate is the usual accelerator having a funnel-shaped opening in its centre. Disposed at a substantial distance beneath the accelerator is the first of a number of secondary cathodes constructed in the manner set out in Specification No. 531,541 and having associated therewith subsidiary electrodes. The apertured plate and accelerator are connected between the primary cathode and the first secondary cathode by branch leads respectively. The accelerator has also attached to it a downwardly extending rod connected through a supporting strip to one of the legs. The last of the secondary cathodes is in the form of a disc which is supported by radially extending wires from an annulus of mica which is mounted on said ceramic rods. This disc constitutes the output electrode and is connected by a comparatively wide metal strip with one of the aforesaid legs. The collector or anode is in the form of a perforated plate and is connected by a lead with another leg passing through the envelope. The secondary cathodes are provided with similar connections. A tuned component may also be associated with the output anode which is disposed within the envelope of the multiplier, in which case the lower part of the structure above described is modified. For this purpose, the output anode has secured to its underside two nested metal tubes connected together at their lower ends, and the inner tube being closed at its upper end. The last secondary cathode is disposed between the output anode and the closed end of the inner tube, the latter parts being separated by an air-gap or some other dielectric, such as mica or ceramic. A lead from the last secondary cathode extends through a hole in the outer tube and, together with a lead from the output electrode, pass through pinches in the surrounding envelope, and constitute a high-impedance output which may be tuned externally by a variable condenser. Alternatively, the tuning may be effected internally by varying the gap between the output electrode and the last secondary cathode, by any of the means outlined above. Another lead from the last secondary cathode extends through a hole in the closed end of the inner tube, out through the open end thereof and thence through a pinch in the envelope. Yet a further lead extends from the junction between the two tubes and out through the envelope, thus providing yet another tube output. A loop comprising one or more turns is threaded through a hole in the outer tube and through a hole in the junction between the two tubes so that a part of the coil is outside the outer tube and another part in the space between the two tubes. The plane of the coil is arranged parallel with the axis of the tubes. Leads from this coil constitute a low-impedance output.

Dated this 13th day of February, 1942.

BOULT, WADE & TENNANT,
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London, E.C.1,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in or relating to Electron Multipliers

We, FRANCOIS JOSEPH GERARD VAN DEN BOSCH, of Belgian Nationality, HAROLD SEFTON MOLYNEUX-FFENNELL, a British Subject, and VACUUM-SCIENCE PRODUCTS LIMITED, a British Company, all of the Company's address, 166, Weir Road, London, S.W. 12, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to electron multipliers of the kind in which there is provided within an envelope a primary cathode for producing a stream of electrons, one or more secondary electron-emitting electrodes arranged in said stream and adapted to release secondary electrons by the impact of said stream thereon and a collector electrode or anode for collecting the augmented stream of electrons which electrodes are of plate-like form arranged face to face in axial alignment. In electrical circuits in which said electron multipliers are employed, it is necessary that predetermined electrical conditions or characteristics shall be afforded between certain electrodes. For example, it may be necessary for decoupling condensers to be provided between certain of the secondary cathodes; or again, it may be necessary to provide predetermined impedance conditions between the primary cathode and a succeeding electrode. These conditions are usually satisfied by the provision of condensers or impedances in an external circuit connected to the appropriate electrodes.

According to this invention an electron multiplier of the kind referred to above is characterised in that a required capacity effect between any two electrodes of the multiplier is obtained by the employment within the multiplier of a plate-like component, arranged face to face and in axial alignment with and connected to one or other of said electrodes. Thus, the capacity effect between the primary cathode and a succeeding electrode may be increased by connecting a plate to said cathode and by disposing it between said cathode and the succeeding electrode. Assuming the electron multiplier is provided with an accelerator between the primary cathode and an adjacent secondary cathode a decoupling condenser may be provided between the primary cathode and the first secondary cathode by arranging a plate to be closely spaced in relation to the accelerator, which plate is provided with a sufficiently large aperture as not to restrict the flow of the electron stream.

The various electrodes and the additional plate-like electrode may be carried by rods formed from refractory insulating material as described in the specification No. 547,971.

The plate-like component is preferably formed from metal suitable for use in high-vacuum apparatus, such as nickel or Swedish iron and should be plated with a metal of low specific resistance such as silver, copper or chromium.

The following is a more detailed description of an electron multiplier according to this invention reference being made to the accompanying drawing which is a side elevation of an electron multiplier showing certain parts in section.

The various electrodes of the multiplier are carried on four ceramic rods 10 having inset at their lower ends metal legs 11 which are sealed into the envelope 12 by the usual pinches 13. The lower end of each ceramic rod is shaped to provide a shoulder 14, while the upper ends are screwthreaded at 15 and receive clamping nuts 16 also formed of ceramic material. Certain of the electrodes are separated by collars 17 encircling the rods. Thus, the electrodes and the collars may be clamped between the nuts and the shoulders. The primary cathode 18 is mounted in a housing between two ceramic plates 19 and 27 as described in the Specification of Application No. 547,945, and is tubular in form. A heater 20 extends through the cathode 18 and is fed with power through suitable leads 28 and 29 extending through pinches in the envelope. A grid 26 is mounted between the cathode and the lower plate 27. Both plates are carried by said rods. The primary cathode and grid are also connected to suitable lead-in wires 22 and 23. Separated from the grid by one of the aforesaid collars is a metal plate-like electrode 34 having an aperture therein sufficiently large as not to restrict the flow of the electron stream

from the cathode. Disposed a short distance beneath the apertured plate is the usual accelerator 38 having a funnel-shaped opening 39 in its centre. A predetermined capacity effect is thus provided between the primary cathode and accelerator resulting in the additional de-coupling which smooths out any unwanted A.C. components and stabilizing the multiplier.

The accelerator and additional plate may be separated by air or by any suitable insulating material if a higher capacity is required. This material would be perforated in the same way as the additional plate. The extra plate has the further advantage of improving the electrostatic screening between the control grid and the succeeding electrodes.

Disposed at a substantial distance beneath the accelerator is the first of a number of secondary cathodes 40 constructed in the manner set out in Specification No. 531,541 and having associated therewith subsidiary electrodes 41. The apertured plate 34 and accelerator 38 are connected between the primary cathode 18 and the first secondary cathode 40 by branch leads 42 and 43 respectively. The accelerator has also attached to it a downwardly extending rod 44 connected through a supporting strip 65 to one of the legs 11. The last of the secondary cathodes is in the form of a disc 45, which is supported by radially extending wires 46 from an annulus 47 of mica which is mounted on said ceramic rods 10. This disc constitutes the output electrode and is connected by a comparatively wide metal strip 48 with one of the aforesaid legs. The collector electrode is in the form of a perforated plate 49 and is connected by a lead 50 with another leg 51 passing through the envelope. The secondary cathodes are provided with similar connections.

The conductors between any of the electrodes referred to above and the lead-in wires through the pinches may be constituted by comparatively broad strips of metal, as shown in Figure 1, whereby high-frequency losses are reduced.

The specification of application No. 15317/43 (Serial No. 558.109) describes and claims an electron multiplier having the additional plate-like component in combination with a nested tubular impedance, and no claim is made to this combination herein.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, and subject to the above disclaimer, we declare that what we claim is:—

1. An electron multiplier of the kind referred to, wherein a required capacity effect between any two electrodes is obtained by the employment within the multiplier of a plate-like component, arranged face to face and in axial alignment with and connected to one or other of said electrodes.

2. An electron multiplier according to Claim 1, wherein the capacity effect between a primary cathode and a succeeding electrode is increased by connecting a plate to said cathode and disposing it between said cathode and the succeeding electrode.

3. An electron multiplier according to Claim 2 and having an accelerator between the primary cathode and an adjacent secondary cathode wherein a decoupling condenser is provided between the primary cathode and first secondary cathode by arranging a plate to be closely spaced in relation to the accelerator, which plate is provided with a sufficiently large aperture as not to restrict the flow of the electron stream.

4. An electron multiplier according to any of the preceding claims wherein the various electrodes and the additional plate-like component are carried by rods formed from refractory insulating material as described in Specification No. 547,971.

5. An electron multiplier having a plate-like component arranged to provide a required capacity effect between two of the multipliers electrodes substantially as described with reference to the accompanying drawings.

Dated this 15th day of March, 1943.
BOULT, WADE & TENNANT,
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Chartered Patent Agents.

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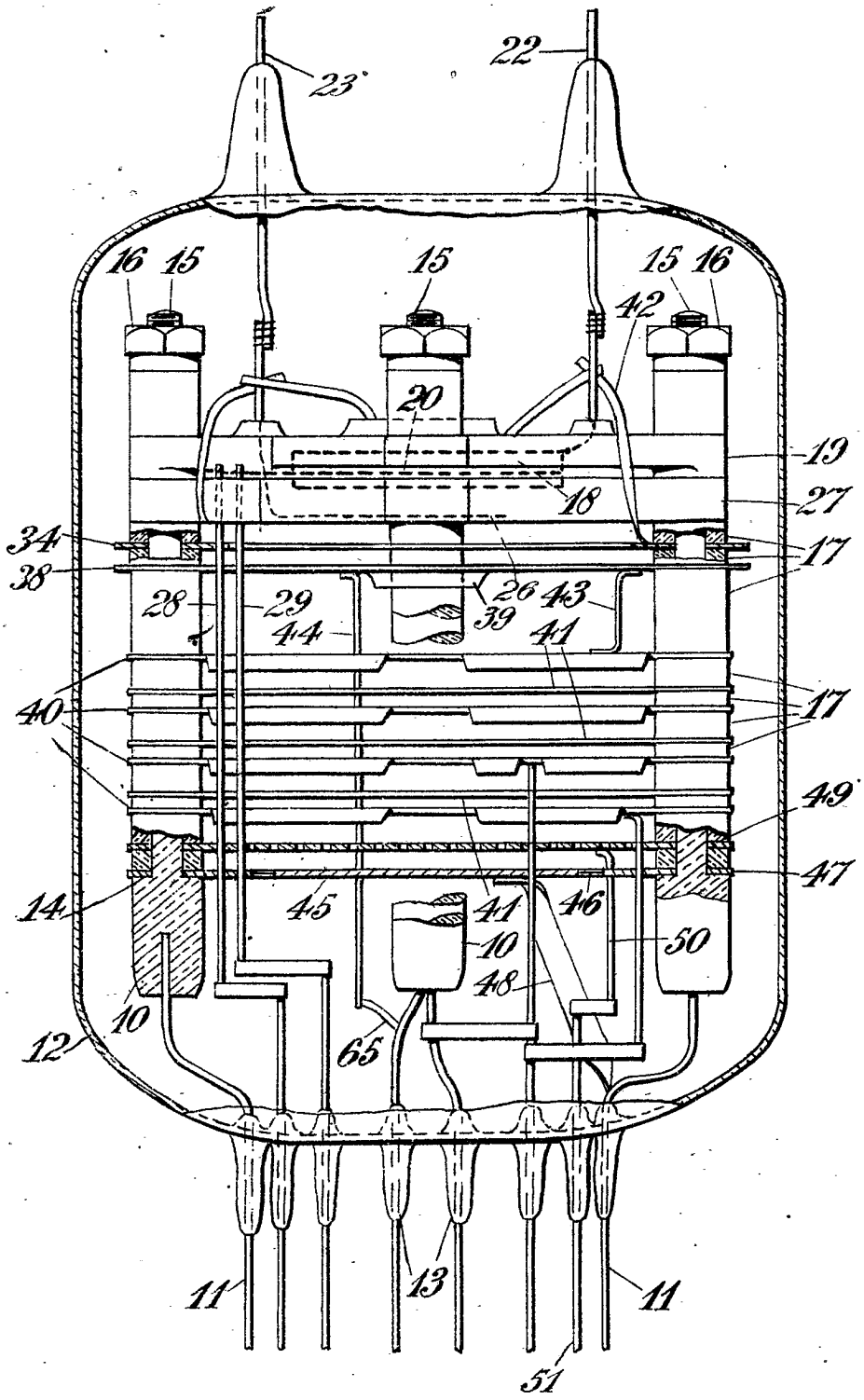

[This Drawing is a reproduction of the Original on a reduced scale.]

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