G. CRISSON.

ELECTRON TUBE REPEATER.

APPLICATION FILED MAY 20, 1919.

1,431,219. Patented Oct. 10, 1922

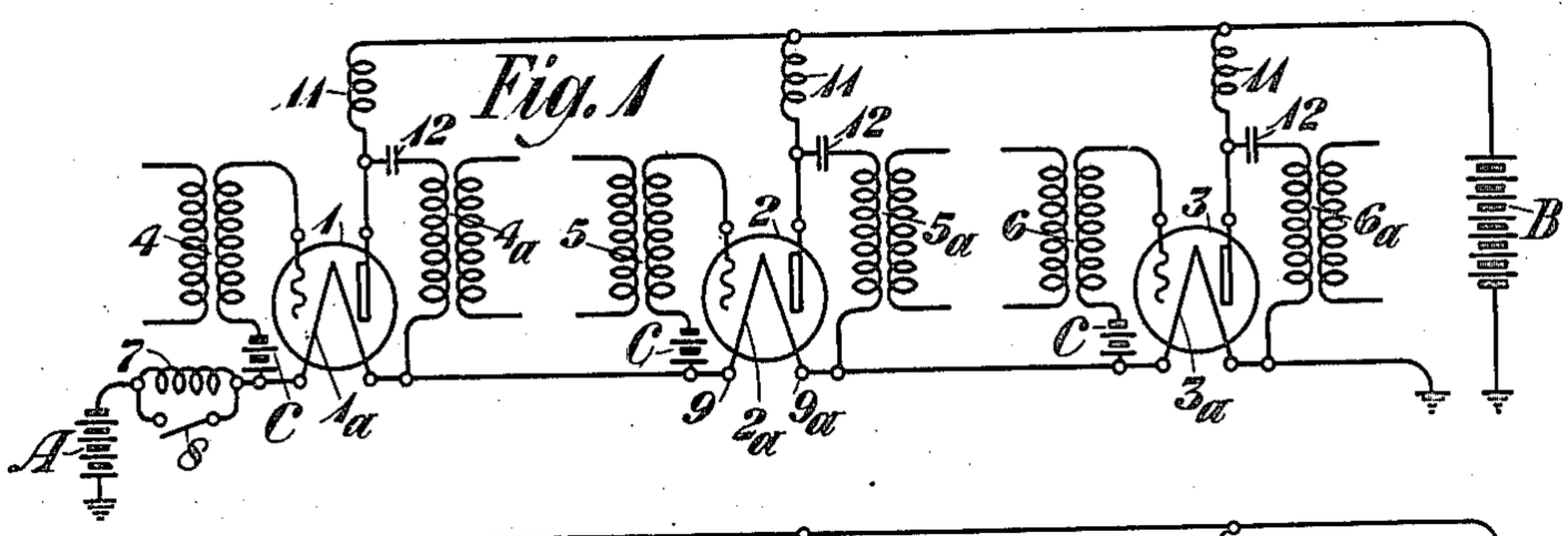

Fig. 1

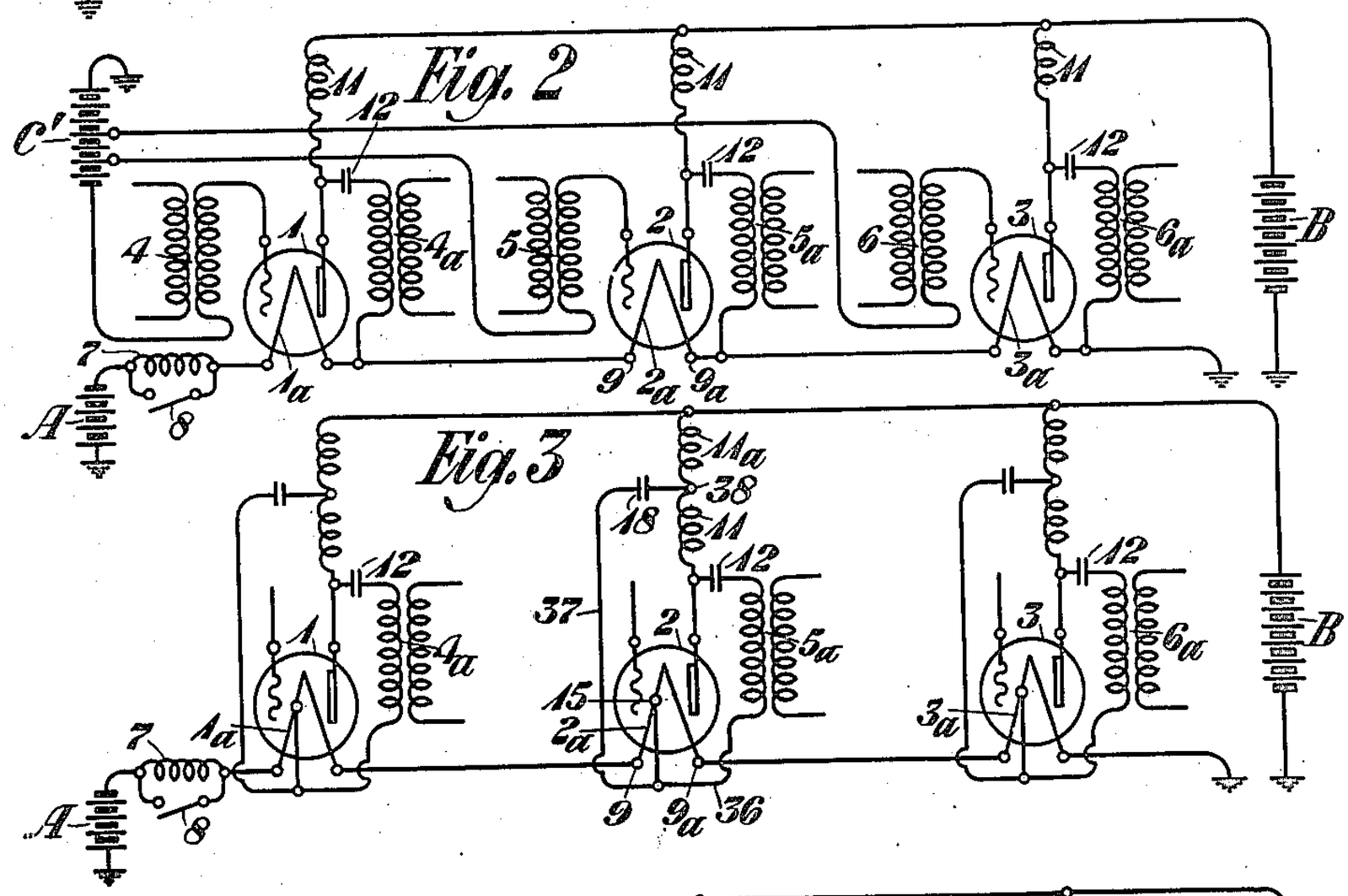

Fig. 2

Fig. 3

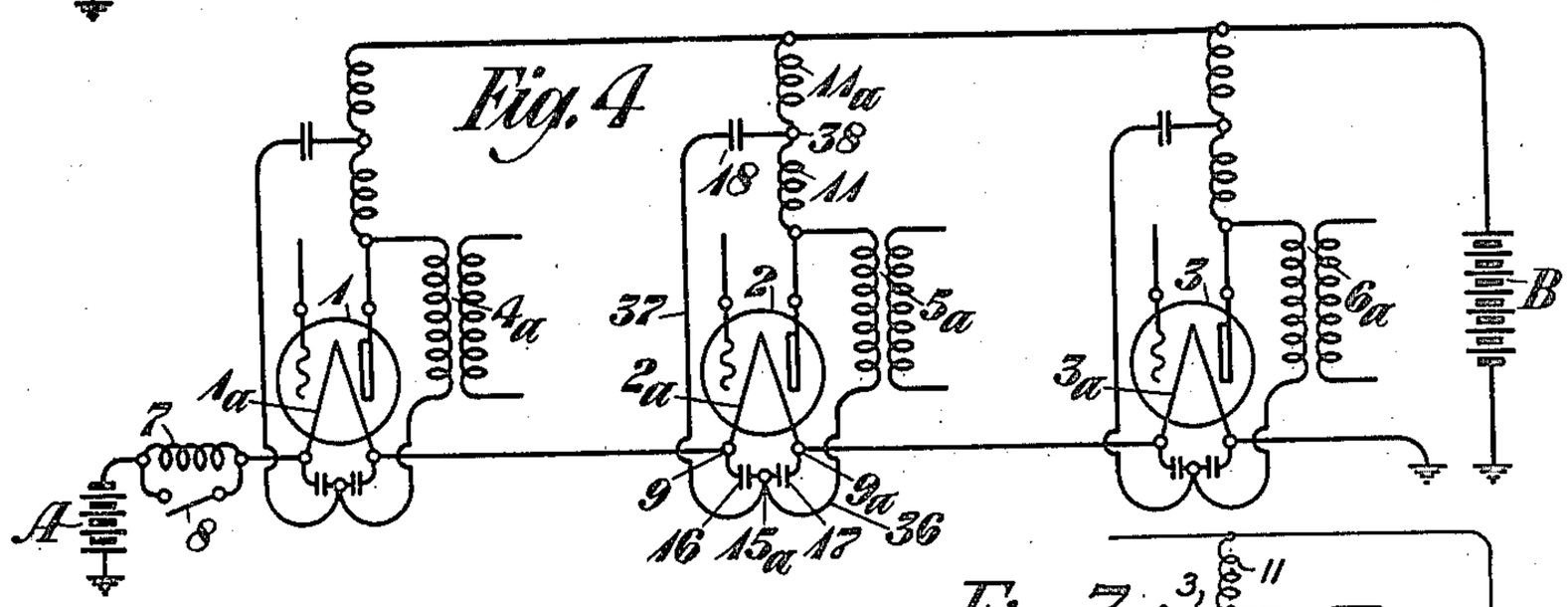

Fig. 4

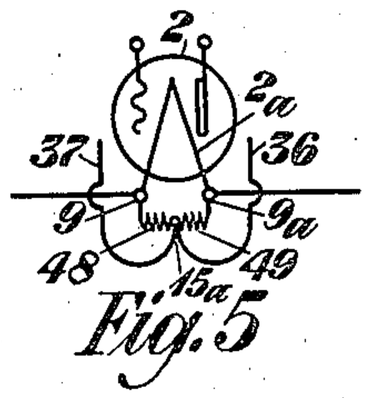

Fig. 5

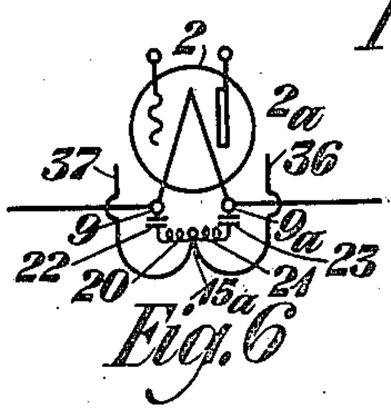

Fig. 6

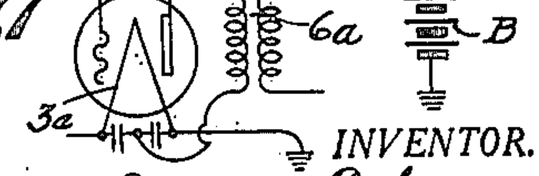

Fig. 7

INVENTOR.

George Crisson

BY

ATTORNEY

Patented Oct. 10, 1922. 1,431,219

UNITED STATES PATENT OFFICE.

GEORGE CRISSON, OF HOBOKEN, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

ELECTRON-TUBE REPEATER.

Application filed May 20, 1919. Serial No. 298,381.

To all whom it may concern:

Be it known that I, GEORGE CRISSON, residing at Hoboken, in the county of Hudson and State of New Jersey, have invented certain Improvements in Electron-Tube Repeaters, of which the following is a specification.

This invention relates to electron tube repeaters; more particularly it concerns apparatus and circuits for preventing cross-talk through the filament circuits of electron tube repeaters.

The electron tubes of a telephone repeater are often connected with their filaments in series with each other to a common source of current, the output circuit of each tube being connected between the plate and one terminal of the filament. When the tubes are so connected each filament effects variations in the potential of its neighbor for reasons set forth hereinafter and if the talking circuits associated with the tubes are independent, these variations in potential cause objectionable cross-talk, particularly when the grid circuits are connected to a common source of constant potential. It is an object of this invention to eliminate or suppress such cross-talk interference, while retaining the series connection of the filaments in the electron tubes.

The manner in which this and other objects of this invention are attained is described below, reference being had to the accompanying drawing in which:

Figure 1 is a diagrammatic view showing a common arrangement of circuits for the electron tubes of telephone repeaters.

Figure 2 is a diagrammatic view of a modification of the circuits shown in Fig. 1.

Fig. 3 is a diagrammatic view showing one form of this invention associated with the repeaters of Figs. 1 and 2.

Fig. 4 is a diagrammatic view showing a modification of Fig. 3.

Figs. 5 and 6 are diagrammatic views showing modifications in certain parts of the circuits in Fig. 4.

Fig. 7 is a diagrammatic view showing a simplified form of the arrangement of Fig. 4.

Similar reference characters refer to similar parts in each of the several views.

For a complete understanding of this invention it is necessary, first, to understand the cause of cross-talk in the usual arrangements of the repeater circuits, as shown in Figs. 1 and 2. With this in view, reference is first had to Fig. 1, wherein reference characters 1, 2 and 3 designate electron tubes having their filaments 1^a, 2^a, and 3^a, connected in series in a circuit supplied with current from the battery A, through a retardation coil 7, which, when desired, may be short-circuited by a contact 8. Each electron tube is associated with a talking circuit not shown in its entirety but indicated merely by input and output transformers designated 4, 4^a; 5, 5^a; 6 and 6^a respectively. The plates of the tubes are connected through retardation coils 11 to a battery B, condensers 12 being connected between the plates and primary windings of the output transformers to prevent the B battery current from flowing through the transformers. The grids of the tubes are held at negative potential with respect to the filaments by means of individual C batteries inserted between the filaments and grids.

The circuit arrangement in Fig. 2 differs from that in Fig. 1 merely in that the potentials for the various grids are derived from a common battery C′, each grid being connected to a different terminal on this battery so that each grid bears the desired negative potential with respect to its filament.

In each electron tube of Figs. 1 and 2, the B battery impresses a substantially constant potential between the filament and the plate so that a current flows across the tube space, which current is continuous and constant in value as long as the potential on the grid with respect to the filament remains undisturbed. As soon, however, as there is a disturbance of this potential, caused, for example, by incoming voice currents, the current between the plate and the filament varies in accordance with these potential variations. The total space current

of each tube, that is, the current flowing between the plate and the filament, may be considered as made up of two components, the first of which is the continuous and constant B battery current and the second of which is the alternating voice current. The first component being constant cannot produce disturbances and may, therefore, for the present description be disregarded. The second component, the voice current, flows through two parallel paths outside the tube. By far the greater part of this current flows from the filament of the tube to the plate thereof through the primary winding of the corresponding output transformer, and this current is herein termed the output current. A small portion of the voice current of each tube, however, flows from the filament to the plate through the filament circuit, ground, battery B, and the retardation coil 11 adjacent to the tube, and this current is herein termed the leakage current.

The manner in which tube 2 disturbs the adjacent tubes will now be described:

The voice current of tube 2 in traversing filament 2^a causes a drop of potential therein, and thus brings about a difference of potential between the filament terminals 9 and 9^a, which difference in potential alternates in accordance with the alternations of the voice currents. This has the following effect on the neighboring tubes. In case contact 8 is closed so that retardation coil 7 is short circuited, the above described alternating potential difference between the terminals of the filament causes a current to flow through the filament circuit, which current alternates in accordance with the voice current, and as this current traverses filaments 1^a and 3^a, it causes therein corresponding alternating drops in voltage. The grid of each tube, when connected to one terminal of the filament, as shown in Fig. 1, normally bears a definite potential difference to the filament, which difference is affected by the drop of voltage in the filament due to the voice current. Cross-talk is thus caused in tubes 1 and 3 by tube 2. This is caused to an even greater extent when the grids are connected to a separate, constant source of potential, as shown in Fig. 2, for in this case the grid potential remains undisturbed in tubes 1 and 3 whereas the potential of the filament varies.

When contact 8 is opened and coil 7 is thus included in the filament circuit, the alternating difference in potential between the terminals of filament 2^a caused by the voice current cannot set up a corresponding alternating current in the filament circuit because of the choking action of the retardation coil 7. It does cause fluctuations in the potential of the filament 1^a with respect to ground, which fluctuations, however, are of no effect when the grid, as in Fig. 1, is connected directly to one terminal of the filament 1^a, because with such connection the grid rises and falls in potential together with the filament. However, where the common battery C′ is used, the grid potential remains stationary while the filament potential fluctuates and in this case cross-talk from tube 2 is produced in tube 1. The potential of the filament 3^a being undisturbed, when coil 7 is in circuit, tube 2 causes no cross-talk to tube 3.

To determine, now, the effect of that portion of the voice current of tube 2 which leaks through retardation coil 11, it is first considered that retardation coil 7 is again short circuited by contact 8 so that the leakage current defined hereinbefore flows in substantially equal parts through filaments 1^a and 3^a, respectively, to battery B and retardation coil 11. This current causes drop in potential in filaments 1^a and 3^a and thus produces cross-talk in tubes 1 and 3.

In case contact 8 is open so that retardation coil 7 is included in the filament circuit, the leakage current is substantially confined to flow through that portion of the filament circuit not including coil 7, i. e. through the filaments 2^a and 3^a, thus causing a drop of potential in these filaments and cross-talk to tubes 1 and 3.

While the above description is limited to an explanation of the manner in which tube 2 causes cross-talk to its neighbors it is readily understood that tubes 1 and 3 produce cross-talk in like manner to the tubes at their right and left respectively.

The cause of cross-talk having thus been explained, it is now in order to show how it is avoided by the present invention, one embodiment of which is shown in Fig. 3. The primary winding of output transformer 5^a is connected to an intermediate point 15 on the filament 2^a, so that the voice current now flows from both parts of the filament to point 15, increasing in strength progressively until it reaches this point and from there it flows through the output circuit similarly as in Figs. 1 and 2. If now point 15 is so located on filament 2^a that the drop in potential due to the voice current is the same from each terminal to point 15, the resultant difference in potential between the terminals is zero and its effect on the other tubes is nullified. The proper location for point 15 depends on the construction of the tube, and is ordinarily not at the middle point of the filament for the reason that one terminal thereof is at a lower potential with respect to the plate than the other, according to the direction of the filament heating current. Since the electron discharge from any point in the filament depends on its potential with reference to the plate, the voice current in one half of the filament is not equal to the current in the other half. For equal and

opposite drops in voltage, therefore, the location of point 15 is a short distance off center. Thus in one type of tube, the lengths of the portions of the filament from point 15 to terminals 9 and 9ª, respectively, are in the ratio of 1 to 1.23. The effect of the drop in potential in the filament due to the voice current is thus nullified, but the effect of the leakage current still remains.

By this invention, the latter current is diverted from the filament circuit by a low impedance shunt, which comprises a condenser 18, one terminal of which is connected by a wire 37 to the point 15, and the other terminal of which is associated with terminal 38 of retardation coil 11. A second retardation coil 11ª is connected in series with coil 11 as shown. The alternating current which leaks through coil 11 is thus provided with two parallel paths. One leads from point 15 of the filament through wire 37 and condenser 18 to terminal 38, and the other leads from the terminals of the filament through the filament circuit, battery B, and retardation coil 11ª. The former of these is of such low impedance compared to the second that it takes practically all of the alternating current which leaks through coil 11 and thus prevents this current from flowing through the filament circuit and causing cross-talk in the other tubes.

The invention thus completely eliminates cross-talk from tube 2 and by like apparatus from tubes 1 and 3. It should here be noted that the grid circuits have not been shown in Fig. 3 to prevent unnecessary complications. It is understood that these circuits may be as shown in Fig. 1 or Fig. 2 or of any other suitable type.

It is ordinarily difficult for reasons of tube construction, to make a connection to an intermediate point of the filament, and in the preferred form of the invention shown in Fig. 4 a like result is accomplished by connecting the lead 36 of the output transformer to a neutral point 15ª formed by a pair of condensers 16 and 17 connected across the filament terminals. For perfect balance in the case of one type of tube the condensers are in the ratio of 1.23 to 1, the larger condenser being connected to the terminal 9. The condensers 12 of Figs. 1, 2 and 3 may be omitted because their function is now performed incidentally by condensers 16 and 17.

Neutral point 15ª may also be obtained by bridging the filament terminals with other impedances, such as resistances 48 and 49, Fig. 5, or an autotransformer having windings 20 and 21, Fig. 6, the ratios of which are inversely to the ratio of the condenser capacities, in order that the corresponding impedance ratios may remain the same. When an autotransformer is used it is generally necessary to insert a pair of condensers 22 and 23 in series therewith to prevent flow of the filament heating current through the windings.

In commercial installations a small amount of cross-talk between the tubes is not objectionable and it has been found that under ordinary circumstances the condenser 18 and the auxiliary retardation coil 11ª may be omitted, the cross-talk caused by the small amount of leakage current being negligible. This arrangement is illustrated for the electron tube 3 in Fig. 7, it being understood that similar circuits are provided for tubes 1 and 2. For like reasons it is not necessary to secure perfect balance of voltage drop in the filament and the impedances connected across the filament may be made equal to each other without giving rise to a serious or important amount of cross-talk.

Although only a few forms of the invention are shown and described herein, it is understood that various changes and modifications may be made therein within the scope of the following claims without departing from the spirit and scope of the invention.

What is claimed is:

1. The method of preventing interference between electron tube translating devices whose filaments are connected in series in a heating circuit, which consists in substantially preventing the flow of the variable component of the plate current of each tube in parts of the filament heating circuit other than the filament of the tube.

2. The method of preventing the variable component of the plate current of an electron tube having a filament heated by direct current from causing potential variations across the terminals of the filament, which consists in causing the said current to so divide and flow through the filament in opposite directions, that the drop in potential in the filament caused by the current in one direction is substantially equal and opposite to the drop in potential caused by the current in the other direction.

3. The method of rendering an electron tube translating device substantially ineffective to cause interference in another electron tube device when the output circuits thereof are independent of each other and the filaments thereof are connected in the same heating circuit, which consists in rendering the variable component of the plate current of the one tube substantially ineffective to cause potential disturbances in the filament of the other.

4. The method of rendering an electron tube translating device substantially ineffective to cause interference in another electron tube device when the filaments thereof are connected in series circuit, which consists in causing the variable component of the plate current thereof to so traverse the fila-

ment that it causes substantially no effect on the potential of the other filament.

5. The method of rendering an electron tube translating device substantially ineffective to cause interference in another electron tube device when the filaments thereof are connected in series circuit, which consists in causing the variable component of the plate current thereof to divide and traverse the filament in opposite directions, so that substantially no effect is produced on the potential of the other filament.

6. In combination, an electron tube, a filament in said tube heated by direct current and traversed by the output current, and means associated with said filament for preventing a variable difference of potential across the filament terminals due to said output current.

7. In combination, an electron tube comprising a filament and a plate, a pair of impedances connected across the filament, an output circuit connected between the plate and a point intermediate said impedances, said impedances being chosen of such relative magnitude that the flow of the output current through said filament produces substantially no potential difference between the filament terminals.

8. In combination, a plurality of electron tubes, a filament heating circuit connecting said filaments in series, an impedance connected across each filament, said impedance being substantially impassable to the filament heating current, and an output circuit for each tube connected between the plate of the tube and an intermediate point on said impedance, said point being so located on said impedance that the potential drop due to the output current is substantially the same from this point to each terminal of the filament.

9. In combination, an electron tube comprising a filament and a plate, a circuit for supplying direct current to said plate and comprising a pair of inductances for impeding the flow of alternating current therethrough and a connection of low impedance to alternating current between said filament and an intermediate point of said inductances.

10. In combination, an electron tube, a first circuit for supplying the space current thereof, an output circuit connected in parallel to said first circuit, an inductance in said first circuit, a pair of impedances associating said output circuit with the filament of said tube, and a connection of low impedance to alternating current between said inductance and said impedances.

11. In combination, an electron tube, a pair of impedances connected across the filament of the tube, an output circuit connected between the plate and a point intermediate said impedances, said point being so chosen that the flow of the output current through said filament produces substantially no potential difference between the filament terminals, a plate current supply circuit in parallel with said output circuit, and comprising a pair of inductance coils and a connection comprising a condenser between a point intermediate said inductance coils and said point intermediate said impedances.

12. In combination, a plurality of electron tubes comprising filaments and plates, a filament circuit connecting said filaments in series, an output circuit for each tube associated with the filament and plate thereof, a retardation coil associated with the plate of each tube, a direct current supply circuit for each tube associated with the retardation coil thereof and comprising part of said filament circuit, and a shunt for each supply circuit, each shunt being of low impedance to alternating current but substantially impassable to direct current.

13. In combination, an electron tube comprising a filament and a plate, a direct current filament heating circuit and a plate circuit for said tube, and means for so associating the said plate circuit with said filament that the current in said plate circuit causes substantially no variable potential difference across the filament terminals.

14. In combination, a plurality of electron tubes, independent output circuits therefor, a circuit for supplying heating current to the filaments thereof, and means for rendering the plate current of one ineffective to cause potential disturbances in the filament of another.

15. In combination, a plurality of electron tubes having their filaments connected in series, and means for rendering the plate circuit current of one tube substantially ineffective to cause variations in the plate circuit current in the other tubes.

16. In combination, a plurality of electron tube repeating elements having their filaments associated in common heating circuit, independent signal transmission circuits associated with said repeating elements, and means for preventing interference between said signal circuits, comprising pairs of substantially like impedances connected between the terminals of the filaments of said tubes and output circuits for said tubes connected between the midpoints of said pairs and the plates of the tubes.

17. In combination, a plurality of electron tubes, a circuit for connecting the filaments thereof in series with each other, a source of potential common to the grids of said tubes, pairs of condensers connected between the terminals of the filaments thereof, and independent output circuits for said tubes connected between the plates of the tubes and the midpoints of said pairs of condensers.

18. A plurality of vacuum tube repeaters in independent lines, having their filaments connected in series in a heating circuit, each of said filaments having a region emitting a proportionally greater number of space current carriers, each of said repeaters having an output circuit so connected that the greater portion of the space current is conducted by the end of the filament nearest said region.

In testimony whereof, I have signed my name to this specification this 19th day of May, 1919.

GEORGE CRISSON.