March 5, 1929. A. G. THOMAS 1,704,155

VACUUM TUBE

Filed July 27, 1923

Fig. 1.

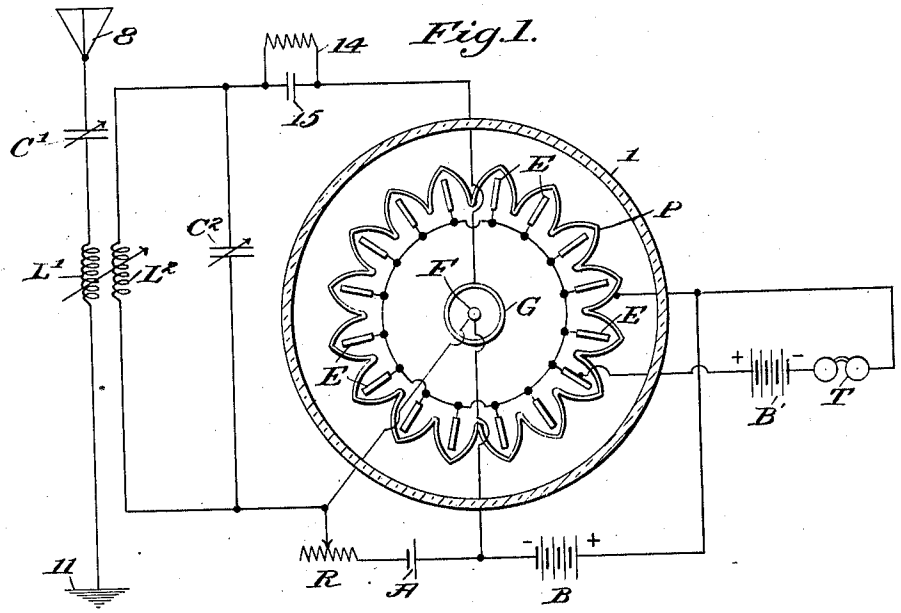


Fig. 1a.

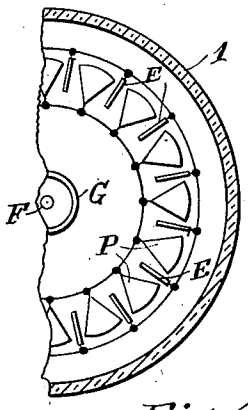


Fig. 2.

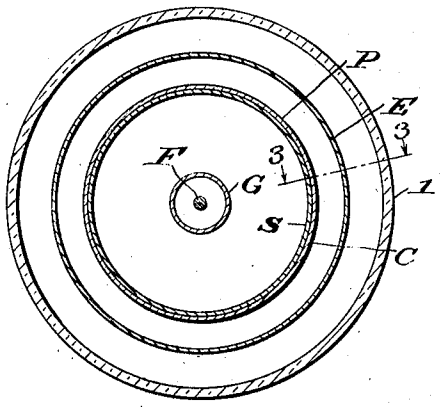


Fig. 3.

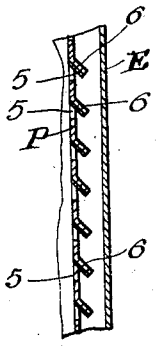
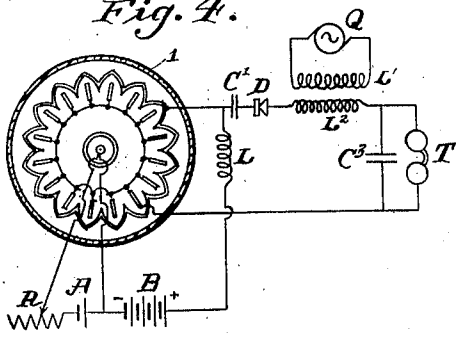


Fig. 4.



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UNITED STATES PATENT OFFICE.

ALBERT G. THOMAS, OF LYNCHBURG, VIRGINIA.

VACUUM TUBE.

Application filed July 27, 1923. Serial No. 654,238.

This invention relates to improvements in vacuum tubes and systems for use especially in the detection and amplification of high frequency fluctuating currents such as are used in radio telephony and telegraphy.

Among the objects of this invention is the provision of a tube depending upon secondary emission of low-speed electrons for the delivery of a signal current. Another object is to provide a tube requiring no filament-plate connection for the telephone receiver. A further object is to provide circuit systems which permit the use of these improved tubes.

The drawings show two circuits and several modifications of construction of such tubes. Fig. 1 is diagrammatic, showing a vacuum tube of my improved type with its elements in relative position. Fig. 1ª is a tube having a structure somewhat modified from that of Fig. 1. Fig. 2 is a further modification showing a section through the entire tube. Fig. 3 is a section on 3—3 of Fig. 2, showing a detail of the construction of the further modified tube. Fig. 4 is a modified circuit with only sufficient disclosure of the tube of Fig. 1 to illustrate the association of the tube with the circuit.

In these drawings, 1 represents an evacuated glass vessel. F is the filament; and G is the grid. In each case, the filament is represented in end view; and the grid may be constructed of a spiral of wire, a cylinder of wire mesh, or a cylinder of perforated sheet metal, disposed coaxially with the filament and at a suitable distance from it; these elements form no part of the present invention, except as they are necessary to the function of the tube. P is the plate to receive the electrons emitted from the filament F: it is composed of a plane or corrugated cylinder coaxial with the filament F, and is composed of or coated with an easily ionizable substance such as thorium: it preferably has a series of recesses or bays. E is the auxiliary plate element or elements, and in Fig. 1 comprises metal strips connected together electrically and disposed parallel and radial to the filament F, to present the least obstruction to the electronic stream: in Fig. 1 they are located in the recesses or bays of the plate P. In Fig. 1ª, the plate is formed as small triangles in spaced relation, and the auxiliary elements E are disposed between them.

In Fig. 1, the tube is shown connected in a circuit of an appropriate type for use with this tube. 8 is the receiving antenna, C′ a series condenser, L′ an inductance, and 11 the ground. Electromagnetically coupled with the inductance L′ is a secondary inductance L^2 which may be tuned by a variable condenser C^2. One terminal of the inductance L^2 is connected through the usual grid leak 14 and grid condenser 15 to the grid G of the tube. The other terminal of the inductance L^2 is connected to the filament F as usual. All this constitutes the ordinary receiving circuit.

The filament F is heated by the battery A through the regulating rheostat R, and is thereby caused to emit a discharge of high speed electrons. A positive potential is applied to the plate P with regard to the filament F by means of a high voltage battery B or other source. The receiving indicator such as the telephone T is connected in series with another high voltage battery B′ or other source, and to the plate P and the auxiliary plate E: the battery B′ thus impresses a positive potential on the element E with regard to the plate P.

The operation of the circuit of Fig. 1 is as follows: The incoming wave in the usual manner controls the high-speed electronic stream from the filament F by means of the grid G. This controlled stream bombards the plate P and releases a secondary emission of a relatively large number of low-speed electrons. These low-speed electrons in turn bombard the auxiliary plate E and establish a current between P and E, thus completing the circuit of the battery B′ through the telephone T. Ordinarily, this circuit has a practically infinite resistance across the gap between P and E, with practically no current flowing. The number of low-speed electrons will vary proportionately to the exciting high-speed stream, which in turn is varied by the charge impressed on the grid G by the incoming wave. The flow from battery B′ across the gap between P and E will therefore vary proportionately with the incoming wave.

The modified form of Fig. 1ª shows the plate elements P forming triangles and disposed nearer the filament F than elements E. The high-speed electronic stream will strike the elements P and give rise to the secondary emission which will be attracted to the elements E by the electrostatic field between these elements.

In Fig. 2, the plate P is shown as a thin-walled cylinder S coaxial with the filament F and the grid G, preferably formed of or coated with an easily ionizable material at C such as thorium or sodium. The base or support S shown may be of any material and preferably affords free passage to electrons, such as an aluminum or mica cylinder. If the coating itself is conductive, the support need not be. The auxiliary plate E is a similar cylinder of conductive material disposed outside and coaxial with the plate P. Fig. 3 shows a section of the elements P and E, with the element P having apertures 5 formed therein by stamping the tongues 6 out of plane. The lower surfaces of these tongues may be covered with an easily ionizable material.

The operation of this tube is the same as that of Fig. 1, and it may be used with the same circuit. No special description of such circuit is therefore needed. When the electronic stream from the filament F, as controlled by the grid G, strikes the plate P, the high-speed electrons bombard it and dislodge from it or its coating C a relatively large number of low-speed electrons, which are drawn towards the auxiliary element E by the positive potential created by a battery similar to B′ of Fig. 1.

The circuit of Fig. 4 shows a means of impressing a potential between P and E which is independent of that between F and P. The battery B′ is omitted, and a transformer L', L^2 is inserted, which is fed by an oscillating tube or other source Q of high frequency current, preferably super-audible. The induced currents flowing in the secondary L^2 are rectified by a crystal or other detector D, and thus feed the plate E with rectified high-frequency current through a condenser C'. The other terminal of L^2 is connected to the telephones T, which are shunted by a condenser C^2 adapted to by-pass the high frequency current. An iron or air core choke coil L keeps the high frequency currents out of the circuit of battery B. By this arrangement, E will not be made positive with respect to the filament F, but will be positive with respect to plate P.

Inasmuch as the operation of the tube depends on the secondary emission of electrons, it is essential that the material of the plate P be such as to facilitate the release of as large a number of these electrons as possible. For this purpose, I may have recourse to coating or otherwise treating this plate, in manners well-known in the art.

What I claim is:

1. In a vacuum tube, a cathode adapted to emit electrons, a grid surrounding said cathode, a plate surrounding said grid and presenting a plurality of surfaces at substantial angles to the direction of the electron stream from the cathode to the plate, said surfaces being mounted in pairs divergent towards said cathode, and a plurality of auxiliary plates each arranged radially to the cathode and between a pair of said surfaces to receive the secondary radiation from said surfaces.

2. In an electron discharge tube, a cathode adapted to emit electrons at high velocity, a plate to receive the impact of the stream of primary electrons from said cathode and comprising a plurality of surfaces, a grid to control the primary electron stream and disposed between the cathode and plate, a conductor connected to the grid so that the electrical charge on said grid may be varied at radio frequencies whereby to vary said stream, so that said high velocity stream of electrons may project a proportionate secondary electron discharge of low velocity from said plate by impact from the cathode-directed surface thereof, an auxiliary plate in the path of said low velocity discharge from said surface, and conductors connected to said plates and cathode whereby steady electrostatic fields may be imposed between said cathode and plate and between said plate and said auxiliary plate.

3. In an electron discharge tube, a cathode adapted to emit electrons, a grid surrounding said cathode, a conductor leading from said grid whereby a fluctuating potential may be impressed upon said grid, an anode comprising a plurality of reflecting and re-radiating surfaces, and an auxiliary anode comprising plates disposed in the effective trajectory of the reflected and secondary emission from said anode.

In testimony whereof I affix my signature.

ALBERT G. THOMAS