May 21, 1929. R. S. OHL 1,713,615

THERMIONIC VACUUM TUBE

Filed Oct. 10, 1925 2 Sheets-Sheet 1

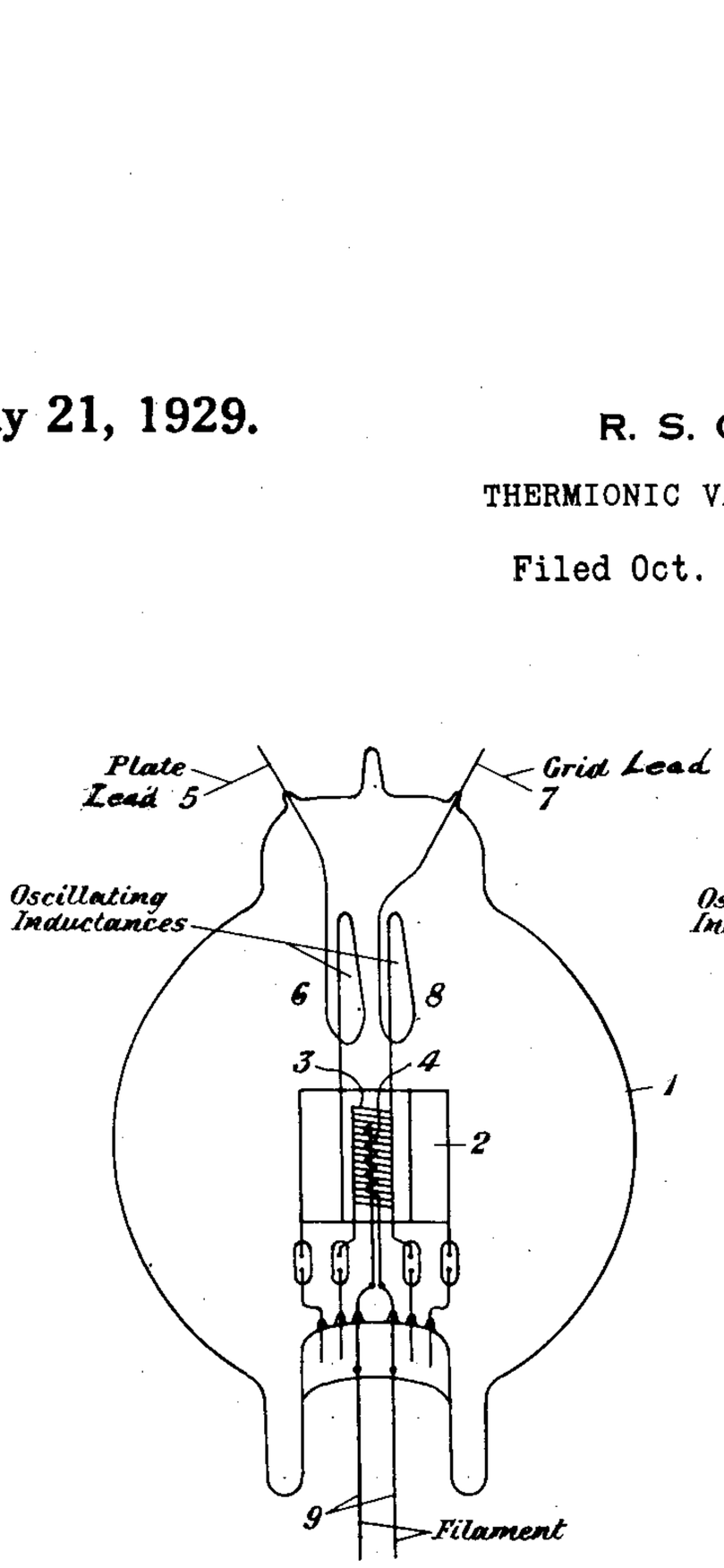

Fig. 1

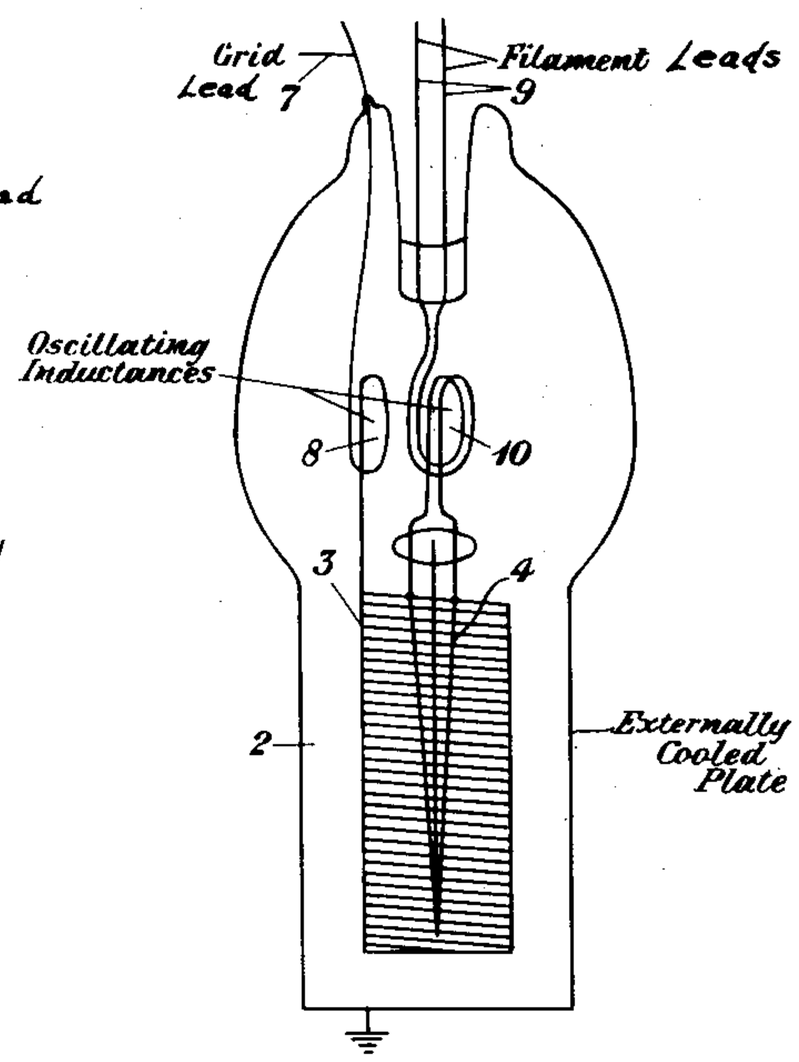

Fig. 2

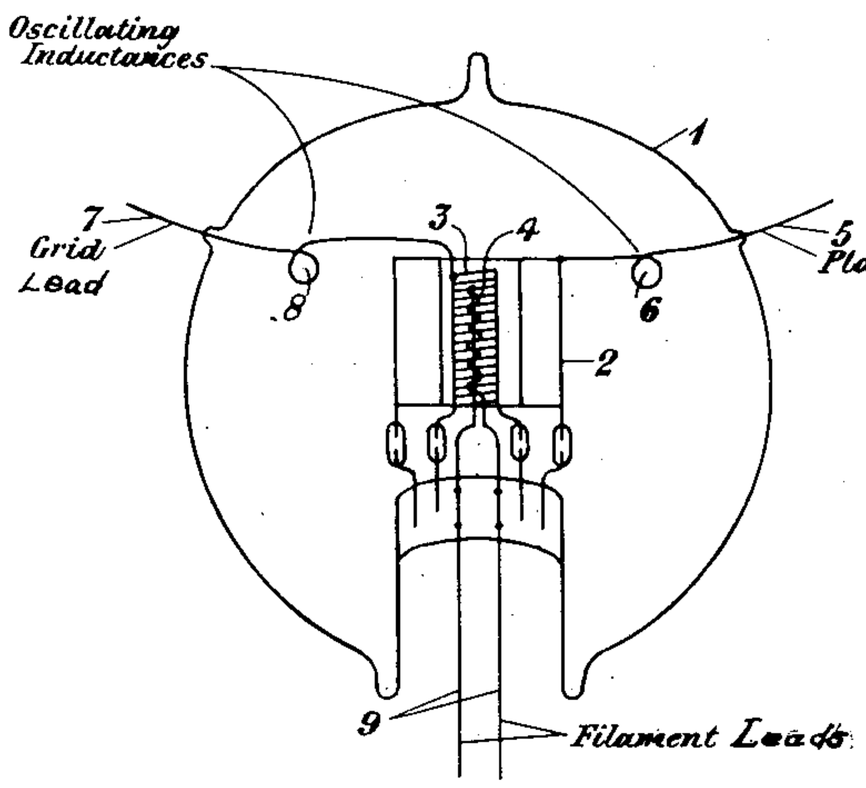

Fig. 3

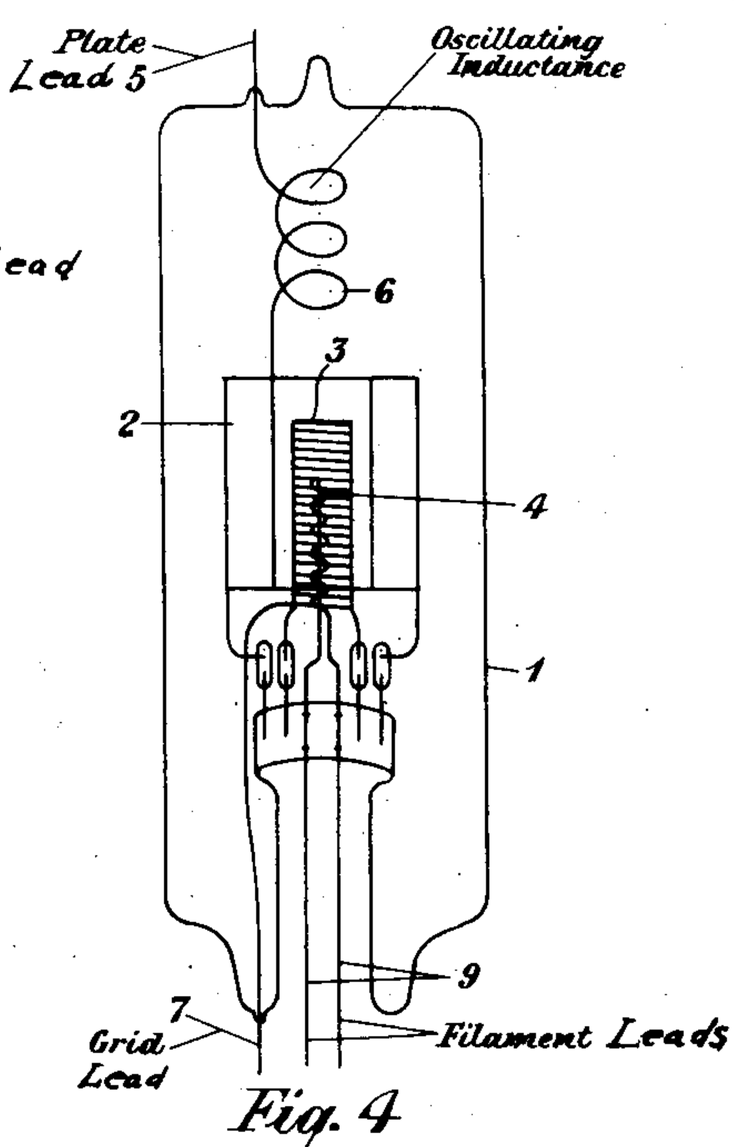

Fig. 4

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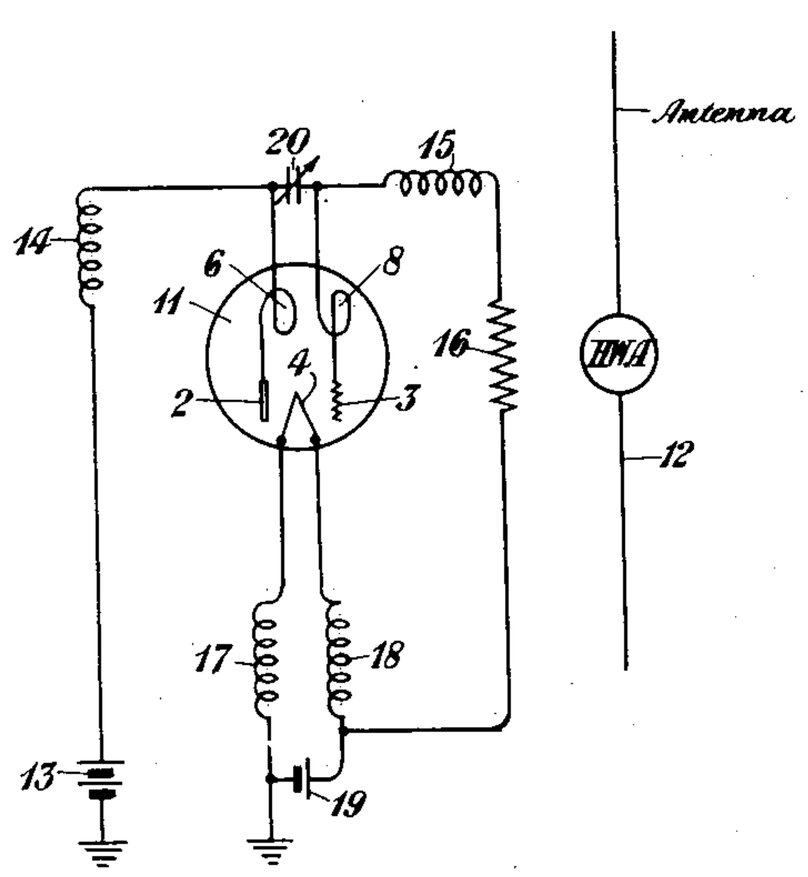

Fig. 5

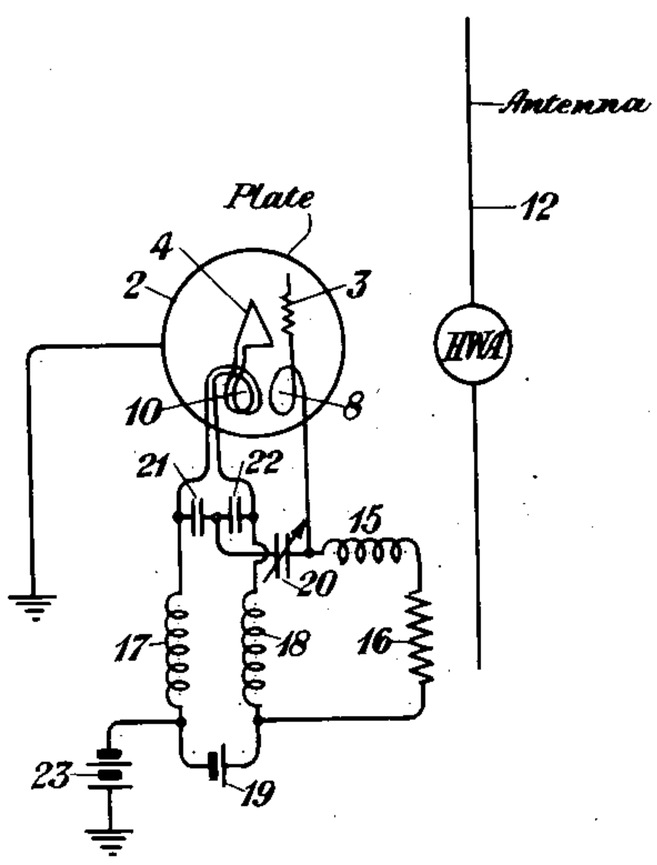

Fig. 6

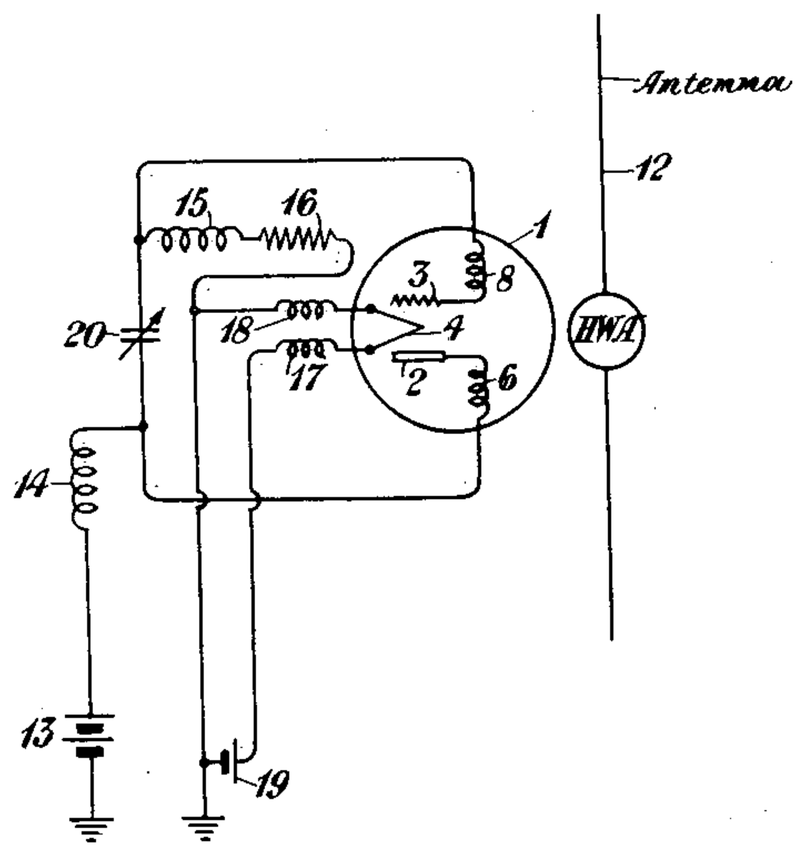

Fig. 7

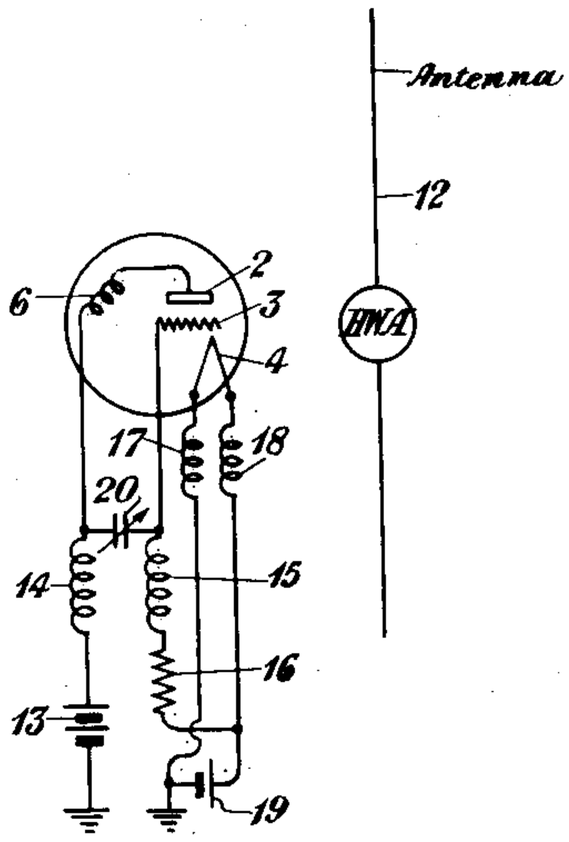

Fig. 8

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UNITED STATES PATENT OFFICE.

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THERMIONIC VACUUM TUBE.

Application filed October 10, 1925. Serial No. 61,782.

This invention relates to thermionic vacuum tubes and particularly to tubes employed in generating short waves of the order of two meters.

When vacuum tubes of the well known types are employed in the generation of frequencies of the order of 150,000 kilocycles a difficulty arises from the length of wire extending from the grid and the plate of a tube to the inductance coils external to the tube, which inductance coils are intended to constitute the coupling between the grid and the plate circuits for the production of sustained oscillations. The effect of the normal inductance and capacity between the conductors connecting the said inductance coils with the grid and the plate of the tube is to establish another coupling between the grid and the plate circuits in shunt with the coupling established by the inductance coils which modifies the effect of the coupling produced by the said coils.

My invention resides, in part, in a thermionic vacuum tube having in addition to the elements usually found in such tubes an inductive coupling enclosed within the envelope of the tube, by virtue of which the tuning of the grid plate circuit may be effected.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing, of which Figures 1 to 4, inclusive, represent various forms of thermionic vacuum tubes embodying the invention, and Figs. 5 to 8, inclusive, represent schematically circuits employing tubes of the types shown in Figs. 1 to 4, inclusive, for the generation of short waves, for example, of the order of two meters in length.

The form of tube shown in Fig. 1 comprises an envelope 1 which preferably should be of hard glass, with tungsten vacuum-seals where the conductors extend through the envelope. The tube comprises a plate 2, a grid 3, and a filament 4 (represented by the wavy line within the grid). These elements may be supported in any well known manner within the envelope. The plate 2 is connected with the external circuit by the conductor 5, the connection including the coil 6 which may be of one or more turns enclosed within the envelope 1. In like manner the grid 3 is connected with the external circuit by means of the conductor 7, the connection including the coil 8, which likewise may be of one or more turns enclosed within the said envelope. The coils 6 and 8 are inductively related to couple the plate and the grid circuits for the production of oscillations, the manner of doing which will be apparent from the description of Fig. 5. The filament 4 is connected with the conductors 9, by means of which current is applied to the filament for its energization.

Fig. 2 represents a vacuum tube of the externally cooled plate type, having oscillation inductance coils contained within the envelope of the said tube. In this figure, the plate 2, which constitutes the metallic envelope of the vacuum tube, is preferably grounded. Connected between the grid 3 and the grid lead 7 is an inductance coil 8, which may be of one or more turns. Likewise, connected between the filament 4 and the leads 9 by means of which current is supplied to the filament, is a coil 10 which is inductively related to the coil 8 to form a coupling between the filament and the grid circuits for the production of oscillations. The coil 10 comprises two parts, one connected between each of the conductors 9 and a terminal of the filament 4, the two parts being so connected as to aid each other. The manner of using the device shown in Fig. 2 will be apparent from the subsequent description of Fig. 6.

In the form of the invention shown in Fig. 3 the coupling inductances 6 and 8 are upon opposite sides of the tube. In this respect it differs from the form shown in Fig. 1. The manner in which the tube shown in Fig. 3 may best be used is shown in Fig. 7 which will be described later.

Fig. 4 shows a form of tube having the inductance coil 6 between the plate 2 and the lead 5. This coil serves in part to control the tuning of the plate circuit. The coupling is effected by the capacity between the plate 2 and the grid 3. The manner in which the tube shown in Fig. 4 may best be used is shown in Fig. 8, which will be presently described.

Fig. 5 shows a form of circuit by means of which a tube of the type shown in Fig. 1 may be used for the production of sustained oscillations. In this figure the tube 11 is positioned so that oscillations created by virtue of the coupling between the grid and the plate of the tube will be impressed upon the antenna 12, which preferably is of the type best suited for the transmission of short waves; that is to say, an antenna insulated from the ground. The plate 2 is connected with a

source of plate potential 13, the connection including an inductance 14 and also the coil 6 enclosed within the envelope of the tube and constituting one of the oscillation inductances. The grid 3 is connected with the filament circuit of the tube 11, the connection including the inductance 15, the grid leak resistance 16 and the coupling inductance 8 within the envelope of the tube. The inductances 14 and 15 are choke coils acting upon the high frequencies and tending to prevent the dissipation of the high frequency energy to ground. Similar choke coils 17 and 18 are included within the filament circuit. A suitable source of current 19 for energizing the filament is connected therewith.

The manner in which this circuit operates for the production of sustained oscillations of an ultra high frequency of the order of 150,000 kilocycles is described in the copending application of Ohl, Serial No. 757,926, filed December 24, 1924. In the arrangements shown in that application the oscillation inductances are outside the envelope of the tube, being connected with the elements in the tube by lead-in wires. The efficiency of operation of a circuit of the type therein described is limited by the inductive and the capacity effects between the lead-in wires. This effect is eliminated in the present invention by placing the inductive coupling within the envelope in close proximity to the elements of the tube. Oscillations produced by the interconnection between the plate and the grid circuits, the frequency of which will be governed by the inductances 6 and 8 and by the capacity introduced by the variable condenser 20, will be impressed upon the antenna 12 and radiated therefrom.

The arrangements shown in Fig. 6 illustrate the mode of use of the type of vacuum tube shown in Fig. 2 in which the envelope of the tube is metallic and forms the plate element of the tube. In Fig. 6 the plate 2 is grounded. The grid 3 is connected through the oscillation inductance 8 with the filament circuit, the connection including a higher frequency choke oil 15 and a grid leak resistance 16. The filament 4 is connected with a source of current 19, the connection including the high frequency choke coils 17 and 18 and also the oscillation inductance coils 10. Bridged across the conductors between the source 19 and the filament 4 are condensers 21 and 22. The junction point of these condensers is connected with one plate or group of plates of the variable condenser 20, the other plate or group of plates thereof being connected with the grid circuit. A grounded source of potential 23 has its negative pole connected with the filament circuit. This of course has the effect of making the plate of the tube, namely, the metallic envelope, positive with respect to the other elements of the tube.

The manner in which this circuit operates to produce oscillations is substantially the same as the circuit shown in Fig. 5. The variations of the plate filament current will produce variations in the charge upon the condenser 20, which in turn will produce variations of potential upon the grid 3. This will in turn react upon the plate filament current to produce further variations. The frequency of these variations or oscillations will be determined by the magnitude of the capacity represented by the setting of condenser 20, and by the inductance represented by the coils 8 and 10. The oscillations thus created will be impressed by the inductances 8 and 10 upon the antenna 12.

The arrangement shown in Fig. 7 illustrates the mode of use of the tube shown in Fig. 3. The difference between the circuits of Fig. 7 and Fig. 5 resides largely in the position of the coils 6 and 8 with respect to each other and with respect to the antenna 12. In Fig. 7 the axis of these coils is substantially parallel to the axis of the antenna 12, whereas in Fig. 5 the axis of the coils is substantially perpendicular to the antenna.

Fig. 8 represents a circuit for utilizing a tube of the type shown in Fig. 4, in which a single coil 6 enclosed within the envelope of the tube and connected with the plate thereof coacts with the capacity between the grid 3 and the plate 2 and of the condenser 20 to determine the oscillating frequency.

It will be seen that by means of tubes of the type herein described and shown, one of the principal difficulties in the production of sustained oscillations of ultra high frequencies may be eliminated. A further advantage to be derived from tubes of this type arises from having the intense electro-magnetic field at these very high frequencies within a vacuum because the dielectric loss is lower under such condition than is possible in any other medium.

While this invention has been disclosed as embodied in particular forms it is to be understood that these are purely schematic and illustrative and that the invention is capable of embodiment in other forms within the spirit and scope of the appended claims.

What is claimed is:

1. A thermionic vacuum tube for the production of oscillations comprising an evacuated envelope constituting one electrode of the said tube, a plurality of other electrodes enclosed in the said envelope, and means also enclosed in the said envelope and connected with the said electrodes enclosed therein to inductively connect these electrodes.

2. A thermionic vacuum tube for the production of oscillations having an evacuated metallic envelope, constituting one electrode of the said tube, a plurality of other electrodes within the said envelope, and a plurality of leading-in conductors, each individual to and connected with an electrode,

certain of said conductors being formed to constitute an inductive coupling between the said conductors.

3. A thermionic vacuum tube for the production of oscillations, having an evacuated metallic envelope, constituting one electrode of the said tube, a filament and a grid electrode within the said envelope, and a plurality of leading-in conductors, each individual and connected with one of said enclosed electrodes, the said conductors having loops formed therein to inductively couple the electrodes connected therewith.

4. A thermionic vacuum tube for the production of oscillations, having an evacuated envelope consisting in part of a metallic portion, constituting the plate of the said tube and in part of an insulating portion, the junction of the said parts being hermetically sealed, a filament and a grid electrode within said envelope, a conductor connected with each of said electrodes and extending through the insulating portion of the said envelope and coupling means connected with the conductors extending to the enclosed electrodes to inductively connect those electrodes.

In testimony whereof, I have signed my name to this specification this 9th day of October, 1925.

RUSSELL S. OHL.