

Feb. 23, 1943.

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2,311,807

ELECTRON DISCHARGE DEVICE CIRCUIT

Filed Aug. 10, 1940

2 Sheets-Sheet 1

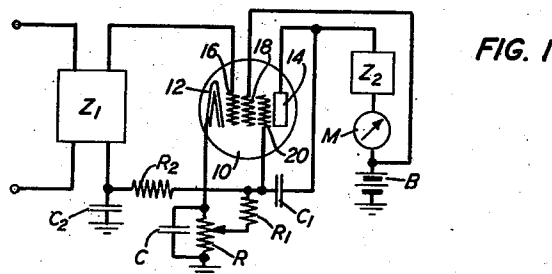


FIG. 1

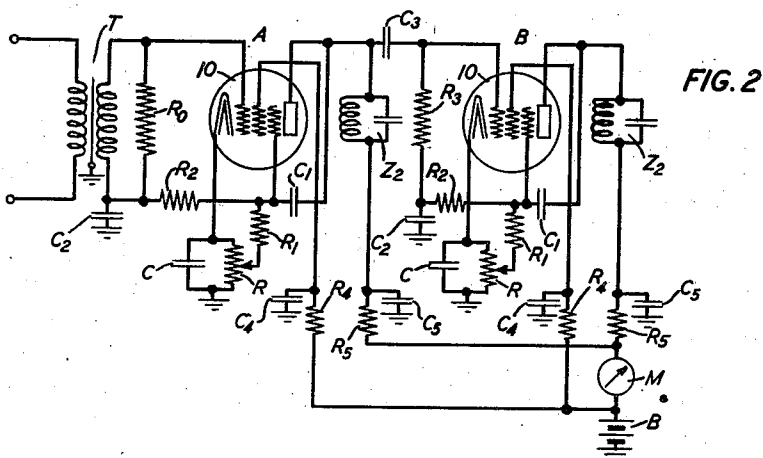


FIG. 2

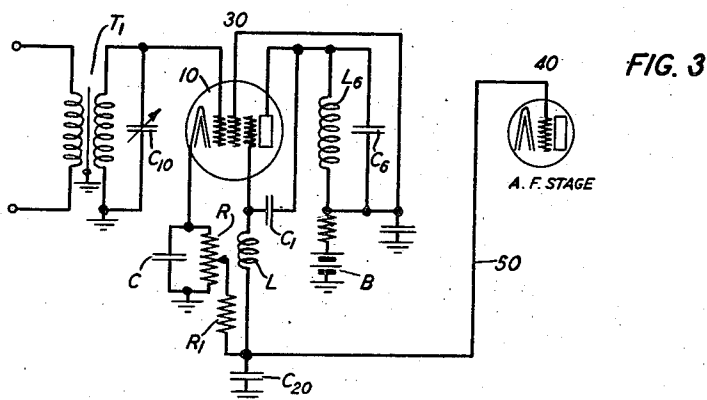


FIG. 3

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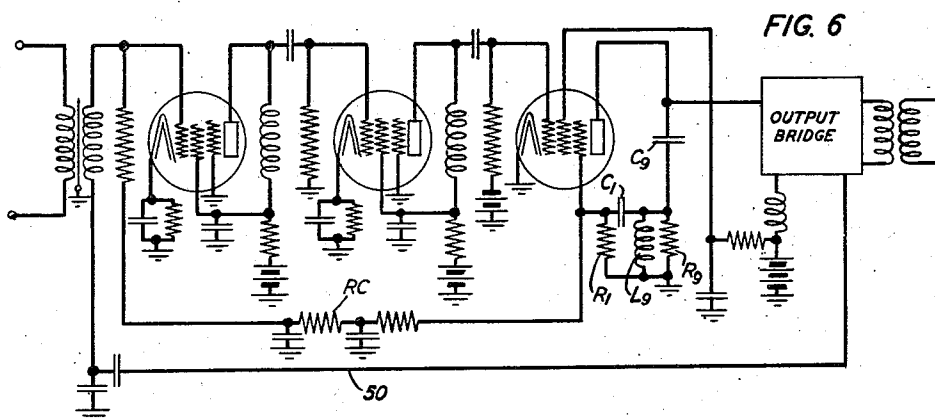
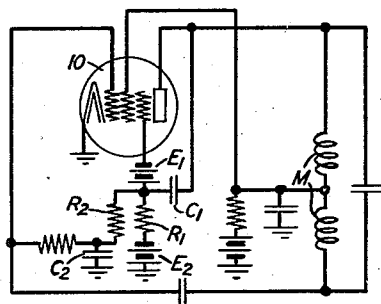
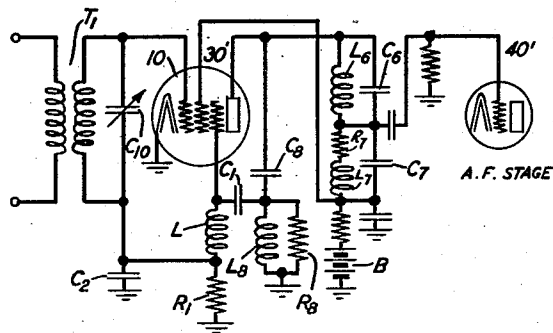
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2 Sheets-Sheet 2



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ELECTRON DISCHARGE DEVICE CIRCUIT

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Application August 10, 1940, Serial No. 352,051

5 Claims. (Cl. 171—95)

This invention relates to electric wave circuits and more particularly to circuits employing electron discharge devices embodying a plurality of grid electrodes.

An object of this invention is to combine a plurality of circuit functions in a single electron discharge device.

Another object is to utilize the suppressor grid and another electrode of a pentode or other multigrid discharge device as a detector or rectifier to alter the mode of operation of the device in preassigned manners.

In accordance with the invention, the electrodes of a multigrid electron discharge device, preferably a device one of whose grids is a suppressor grid, are so associated through appropriate circuit elements that a portion or all of the output of the cathode-input grid-anode structure of the device is caused to flow to the suppressor grid and to be rectified or detected by the cathode-suppressor grid structure of the device. The detected energy is developed across an appropriate circuit element or elements, and is caused to be impressed across the cathode-input grid circuit of the device, to be amplified, or to constitute a control potential on the input grid to regulate the gain or other characteristic of the device.

A more complete understanding of the invention will be derived from the detailed description which follows, read with reference to the appended drawings, wherein each of the circuits shown embodies the invention, and, specifically:

Fig. 1 shows a general circuit arrangement for a wave measuring or amplitude indicating means or meter;

Fig. 2 shows a circuit or wave measuring means comprising a plurality of stages in cascade;

Figs. 3 and 4 show amplified-detector circuits;

Fig. 5 shows an oscillator circuit; and

Fig. 6 shows a multistage amplifier circuit of the stabilized negative feedback type.

In a multielectrode tube, for example a pentode having a cathode, an anode, an input control grid, a screen grid and a suppressor grid, the suppressor grid should be maintained at a potential below that of the anode to insure the return of secondary emission electrons from the anode to their source, and, in general practice, the suppressor grid is usually maintained at cathode potential. The effect of the suppressor grid potential on the space current is relatively small compared with that of the control grid so that alternating current derived from the

anode may be fed to the suppressor grid with small reaction only upon the alternating current in the cathode-anode circuit. Applicant's investigations show the suppressor grid to be usable, with the cathode of the tube, as an element of a diode rectifier, and that the average voltage of the suppressor grid can be established well into negative regions without impairing the characteristics of the tube to any great degree. These properties of the suppressor grid may be used to combine diode action in pentode and other multielectrode tubes along with other functions.

Fig. 1 shows the general circuit of a wave measuring or amplitude indicating meter. It embodies a pentode 10 comprising indirectly-heated cathode 12, anode 14, input control grid 16, screen grid 18 and suppressor grid 20. The input grid-cathode circuit is coupled through an input network Z_1 to a suitable source of electric wave energy. The cathode is connected to ground through a grid biasing resistor R , bypassed by condenser C . The anode is connected to the positive terminal of source B of anode potential through a suitable load impedance Z_2 and the visual indicating device or meter M , the screen grid being connected directly to the battery B . The suppressor grid is coupled to the anode through condenser C_1 , and is connected to the cathode bias resistor through resistance R_1 provided with a slide for adjustment along resistor R to provide a variable or adjustable direct current bias for the suppressor grid. The input grid is connected through the network Z_1 and condenser C_2 to ground, a resistance R_2 being connected between the junction of network Z_1 and condenser C_2 and the junction of the resistance R_1 and condenser C_1 .

The load impedance Z_2 may be tuned to a single fixed or variable frequency, or it may be designed to provide a desired impedance over a band of frequencies. The input network Z_1 likewise may be tuned or flat as a function of frequency. The resistance condenser network R_1-C_1 forms a grid leak-condenser combination and the resistance-condenser network R_2-C_2 constitutes a filter to suppress alternating current and to limit gain reducing feedback from the output circuit. Connection of the resistance R_1 to the bias resistor R permits the suppressor grid to be biased so as to delay the action of the grid detector until a preassigned input signal amplitude has been attained.

The alternating current input, which may comprise a modulated or an unmodulated elec-

tric wave, appears across the cathode-input grid circuit and is amplified by the cathode-input grid-anode structure. The amplified alternating current is applied to the suppressor grid through the condenser C_1 and is rectified by the cathode-suppressor grid acting as a diode. The direct current potential developed across the resistance R_1 is fed back to the control grid through the resistance R_2 . The resultant increased negative potential on the input grid relative to the cathode causes reduction in the space or cathode-anode current which is indicated by the meter M .

A feature of such a circuit arrangement is that the incoming signal is amplified before detection and so presents a greater amplitude than would be presented to a control grid leak rectifier, resulting in more satisfactory rectification for low input signal levels. Another feature is that the rectification is associated with the anode circuit and is removed from the input grid circuit which, therefore, may be designed for a higher input impedance and lower damping. Two sets of tuned circuits, furthermore, one on the input grid side and the other on the anode side may be used to precede the detector. This permits additional selectivity to be obtained. Although anode current has been shown as the controlled medium in the circuit of Fig. 1, screen current or suppressor grid current could be the controlled medium variation which would be indicated by an indicating device or meter.

The circuit of Fig. 1 being an amplifying circuit, several stages may be used in cascade. A two-stage circuit for a cramped-scale indicating meter for operation with an input wave of, for example, 50 kilocycles, is shown in Fig. 2. Additional stages, of course, may be provided but two stages illustrate the principle involved. Elements in the circuit corresponding to those of Fig. 1 bear corresponding identifying characters. The input network is shown in Fig. 2 as comprising a transformer T with an impedance matching resistance R_0 connected across its secondary winding. The stages A and B are condenser resistance-coupled by condenser C_3 and resistance R_3 . Current-limiting resistances R_4 , R_5 with suitable by-pass condensers C_4 , C_5 , are connected in the anode and in the screen grid connections from battery B .

For the lowest effective signal input, the initial stage operates as an amplifier and drives the second stage. As the signal amplitude increases, the second stage becomes saturated and the indicating action takes place in the initial stage. In a circuit employing more than two stages, the initial stages would operate as amplifiers driving the last stage for the lowest effective signal input. As the signal inputs increased, the last stage would become saturated, and the indicating action would take place in the preceding stage. This action would continue until the anode current range of all of the tubes in the circuit had been taken up.

A number of advantages are derived from a circuit arrangement such as is shown in Fig. 2. The feedback to the input control grid is localized to each individual stage. This results in smaller attenuation to be required and in simpler filtering networks. With low time constants, the variations of signal input may be followed with great speed, and singing difficulties which might be encountered in a circuit involving feedback around several stages are avoided. The operating characteristics of the individual tubes of the various stages may be overlapped to provide a continuous

variation of anode current or other indicating medium over the entire range of signal amplitude to be observed.

As the amplitude of the input signal is reduced to very low values, the initial stages of the multi-tube circuit become amplifiers and very little rectification occurs. The signal passes through a maximum number of interstage coupling networks. If these are tuned for the signal frequency or band of frequencies, maximum discrimination against frequencies outside the tuned band is realized for the lowest signal level for which it would be most necessary. If the suppressor grid were biased slightly negative to eliminate rectification at these levels, the loading effect which develops when suppressor grid current is drawn is removed from the tuned anode circuit so that an increase in selectivity results.

Suppressor grid rectification in accordance with this invention may be provided in an amplifier-detector circuit for modulated carrier or radio frequency waves. Fig. 3 shows a circuit comprising a combined amplifier-detector stage 30 preceding an audio frequency stage 40, for example, in a radio broadcast receiver. The modulated carrier or radio frequency wave is impressed on the input grid-cathode circuit through transformer T_1 , a tuning condenser C_{10} being connected across the transformer secondary winding to tune it to the carrier frequency. Inductance L , connected between condenser C_1 and resistance R_1 , offers a high impedance to the carrier frequency and aids in maintaining the two-terminal impedance of the LR_1C_1 combination over the audio frequency band. Condenser C_{20} is a radio frequency by-pass condenser. The anode circuit network comprising inductance L_s and condenser C_s is tuned to the carrier frequency, with condenser C_1 and inductance L being proportioned to be resonant at the upper end of the audio frequency band comprising the modulating wave. The amplified received signal flows to the suppressor grid through the condenser C_1 , and is rectified by the diode structure comprising the cathode and the suppressor grid, the detected modulating wave appearing across R_1 being delivered to the input control grid of the audio frequency stage 40 through the connection 50.

The circuit arrangement of Fig. 4 comprises a reflex amplifier-detector stage 30', and an audio frequency amplifying stage 40'. A tuning condenser C_{10} is connected across the secondary winding of the input transformer T_1 . The cathode of tube 10 is shown connected directly to ground, although the conventional grid biasing resistor and by-pass condenser may be included in the cathode lead, and the suppressor grid is connected to ground through the radio frequency choke L and resistance R_1 . Condenser C_2 is a radio frequency by-pass condenser. The input grid is connected through the transformer secondary winding to the suppressor grid termination of resistance R_1 . The network comprising inductance L_s and condenser C_s is tuned to the radio frequency; the network comprising resistance R_7 , inductance L_7 and condenser C_7 is tuned to the audio frequency band by which the radio frequency has been modulated, and provides a low radio frequency impedance; and the network comprising condenser C_8 , inductance L_8 and resistance R_8 constitutes a high-pass filter, that is, it passes the amplified modulated radio frequency wave but offers high impedance to the feedback of audio frequencies in the output circuit of tube 10. The audio frequency stage 40' may be con-

denser-resistance coupled to the preceding stage 30'.

In operation, the modulated radio frequency input is amplified and fed back to the suppressor grid for demodulation by the cathode-suppressor grid diode. The audio frequency potentials appearing across resistance R_1 are impressed across the input control grid and cathode and are amplified by the tube 10. The amplified audio frequency output is transmitted to the succeeding stage 40' for further amplification.

Fig. 5 shows an oscillator circuit of known type in which suppressor grid rectification is provided to stabilize the amplitude of the oscillator output to a definite value determined by the fixed input control and suppressor grid biases furnished by the sources E_1 and E_2 . As the alternating current anode potential of the oscillator exceeds that of the sources E_1 and E_2 , the rectification action of the suppressor grid develops an additional biasing potential across the resistance R_1 to render the input grid more negative. The transconductance of the tube 10 is reduced until the output stabilizes at a value which will just maintain the gain necessary for oscillations. Of course, where a greater control is required, additional direct current amplification may be provided.

Fig. 6 shows a multistage stabilized negative feedback amplifier designed, for example, for use in carrier telephony to transmit and to amplify a band of frequencies between twelve kilocycles and 60 kilocycles, and comprising a gain-reducing negative feedback connection 50 to the input control grid of the amplifier's initial stage from the output circuit of the last stage of the amplifier through a suitable output bridge. The conventional practice would be so to design the amplifier that at the frequency at which high frequency oscillations might be generated, the $\mu\beta$ gain and the $\mu\beta$ phase would be so related that there would be a safe margin against singing. By employing suppressor grid rectification in accordance with this invention, the amplifier could be constructed without regard for this singing possibility, the high frequency oscillations being detected in the last stage of the amplifier and the resultant potential being applied to the input grid of the amplifier's initial stage to control the amplifier gain with respect to such oscillations so that the amplitude of the oscillations is maintained below a level that would be objectionable. The network comprising condenser C_3 , inductance L_3 and resistance R_3 is a high frequency filter of high impedance to the frequency band being amplified. The high frequency oscillations generated would flow to the suppressor grid through the condenser C_1 and be rectified by the diode constituted by the cathode and the suppressor grid, the potential developed across the resistance R_1 being fed back through the input grid of the first tube through a resistance-condenser network RC of appropriate time constant.

Although this invention has been described with reference to a number of specific embodiments, its scope is not limited thereto, but is to be determined in the light of the prior art and the appended claims.

What is claimed is:

1. An electric wave measuring circuit comprising an electron discharge device having a cathode, an input control grid, a second grid, a suppressor grid and an anode, an input circuit connected to said cathode and input grid for applying the electric wave thereto, an output circuit

connected to said cathode and anode, an impedance connected between said anode and said suppressor grid to enable flow to the suppressor grid of alternating current in the cathode-anode circuit, a second impedance connected between said suppressor grid and said cathode, said second impedance being adapted to have potentials developed thereacross by diode action of said cathode and suppressor grid on said alternately current flow to said suppressor grid, a connection from said second impedance to said input grid to transfer the potentials developed across said second impedance to said input grid, and an indicating device in said output circuit for evidencing the change in space current in said cathode-anode circuit when said potentials are transferred to said input grid.

2. An electric wave measuring circuit comprising an electron discharge device having a cathode, an input control grid, a second grid, a suppressor grid and an anode, an input circuit connected to said cathode and said input grid for applying the electric wave thereto, an output circuit connected to said cathode and anode, means to bias said suppressor grid to a preassigned negative potential with respect to said cathode, an impedance connected between said anode and said suppressor grid to enable cathode-anode circuit alternating current to flow to the suppressor grid, a second impedance connected between said suppressor grid and said cathode on said alternating current flow to said suppressor grid when the alternating current is of a magnitude sufficient to overcome the bias on said suppressor grid, said second impedance being adapted to have potentials developed thereacross by diode action of said cathode and suppressor grid, a connection from said second impedance to said input grid to transfer the developed potentials to said input grid, and an indicating device in said output circuit for evidencing the change in space current in said cathode-anode circuit when said potentials are transferred to said input circuit.

3. An electric wave measuring circuit comprising a plurality of electron discharge devices connected in cascade, each device comprising a cathode, an anode and a plurality of grids including an input control grid and a suppressor grid, an input circuit connected to the cathode and input grid of each device, an output circuit connected to the cathode and anode of each device, a rectifier circuit connected to the cathode and suppressor grid of each device, a connection from the rectifier circuit of each device to its respective input grid and an indicating device common to the output circuit of each device.

4. The method of measuring the amplitude of an electric wave that comprises establishing a space current flow in an electron discharge device of the multigrid type, applying the electric wave to the cathode and one of said grids for amplification by said device, the amplified wave appearing in the cathode-anode circuit of the device, feeding back the amplified wave to a second of said grids for rectification between said cathode and said second grid, and feeding back the rectified wave to said first grid in such phase as to reduce the space current, the variation in the amplitude of the electric wave input to the cathode-first grid circuit being evidenced by the resulting variation in the reduced space current.

5. An electric wave measuring circuit comprising a plurality of electron discharge devices connected in cascade, each device comprising a

cathode, an anode and a plurality of grids including an input control grid and a suppressor grid, an input circuit connected to the cathode and input grid of each device, an output circuit connected to the cathode and anode of each device, means individual to each device for feeding back alternating current to its respective

suppressor grid for rectification between the latter and its respective associated cathode, means individual to each device for applying said rectified alternating current to its respective input grid, and indicating means common to the output circuits of said devices.

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