

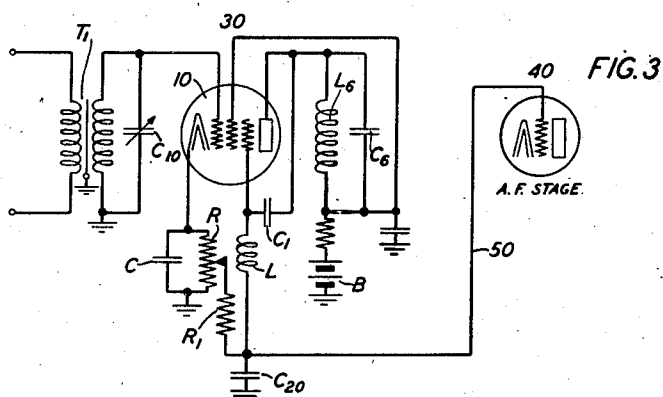
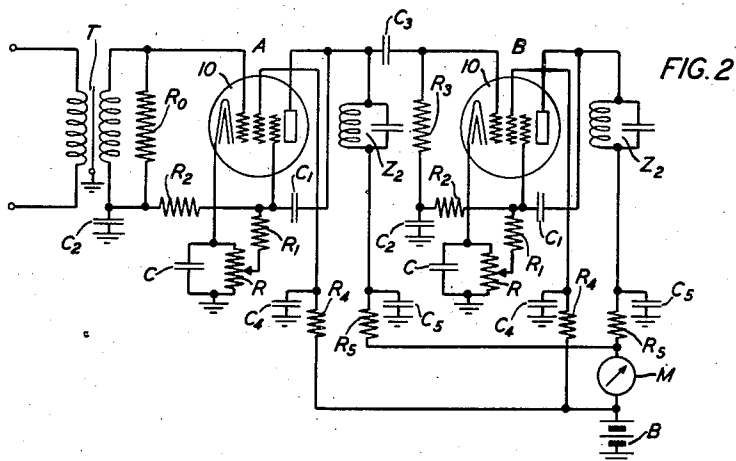
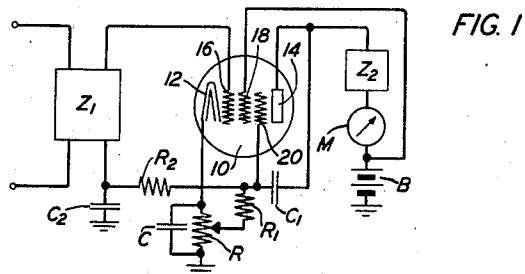
April 11, 1944.

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2,346,545

ELECTRON DISCHARGE DEVICE CIRCUIT

Original Filed Aug. 10, 1940 2 Sheets-Sheet 1



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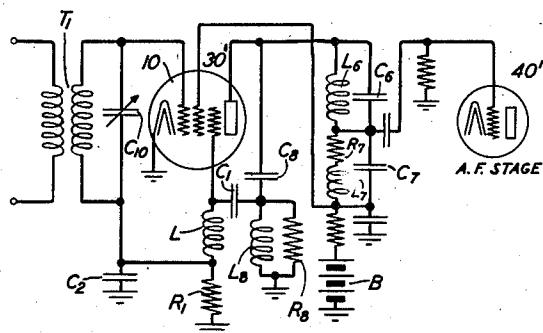


FIG. 4

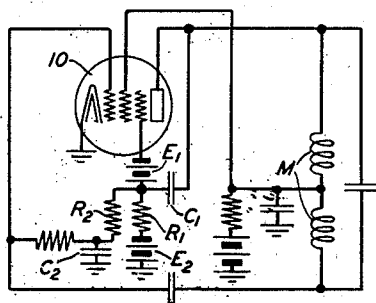


FIG. 5

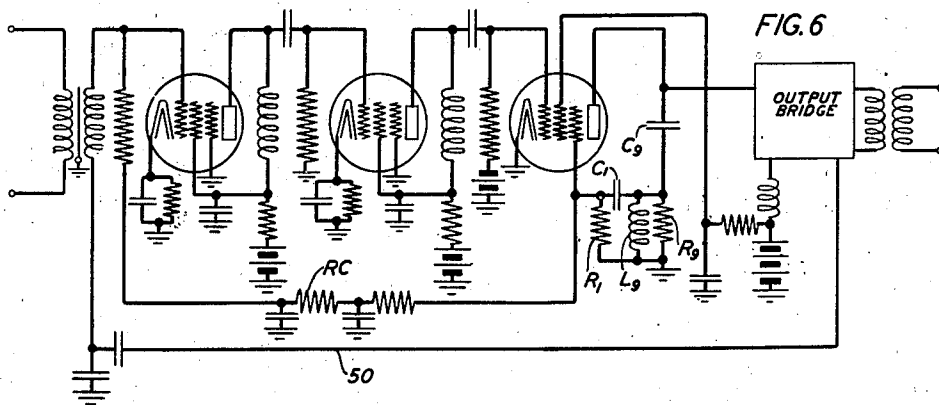


FIG. 6

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ELECTRON DISCHARGE DEVICE CIRCUIT

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Original application August 10, 1940, Serial No.
352,051. Divided and this application Septem-
ber 12, 1942, Serial No. 458,153. In Great
Britain August 1, 1941

4 Claims. (Cl. 179—171)

This application is a division of my application
Serial No. 352,051, filed August 10, 1940, for Elec-
tron discharge device circuits, now Patent No.
2,311,807, Feb. 23, 1943.

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

An object of this invention is to combine a plu-
rality of circuit functions in a single electron dis-
charge device.

Another object is to utilize the suppressor grid
and another electrode of a pentode or other multi-
grid 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, prefer-
ably a device one of whose grids is a suppressor
grid, are so associated through appropriate cir-
cuit 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 de-
tected 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 inven-
tion will be derived from the detailed description
which follows, read with reference to the append-
ed 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 amplifier-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 pen-
tode having a cathode, an anode, an input con-
trol grid, a screen grid and a suppressor grid, the
suppressor grid should be maintained at a po-
tential below that of the anode to insure the re-
turn 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 re-
action only upon the alternating current in the
cathode-anode circuit. Applicant's investiga-
tions 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 sup-
pressor grid can be established well into nega-
tive regions without impairing the characteristics
of the tube to any great degree. These proper-
ties of the suppressor grid may be used to com-
bine diode action in pentode and other multi-
electrode tubes along with other functions.

Fig. 1 shows the general circuit of a wave meas-
uring or amplitude indicating meter. It em-
bodies 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 net-
work Z_1 to a suitable source of electric wave en-
ergy. The cathode is connected to ground
through a grid biasing resistor R , by-passed 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 pro-
vided with a slide for adjustment along resistor
 R to provide a variable or adjustable direct cur-
rent bias for the suppressor grid. The input grid
is connected through the network Z_1 and con-
denser C_2 to ground, a resistance R_2 being con-
nected 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. Con-
nection 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 at-
tained.

The alternating current input, which may

comprise a modulated or an unmodulated electric 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 in 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 operat-

ing 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_2 and condenser C_2 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_2 and condenser C_2 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 condenser-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_0 , inductance L_0 and resistance R_0 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. In combination, an electron discharge device comprising a cathode, an anode and a discharge controlling grid, an input circuit and an output circuit for said device, a second electron discharge device comprising a cathode, an anode and a plurality of grids one of which is a suppressor grid, an input circuit and an output circuit for said second device, means for coupling the output circuit of said first device and the input circuit of said second device, feedback means coupling the output circuit of said second device and the input circuit of said first device and producing both negative feedback and sustained oscillation around the feedback loop comprising said devices and said coupling means, a diode rectifier comprising the cathode and the suppressor grid of said second device, means for impressing a preassigned portion of the alternating current in the output circuit of said second device on said suppressor grid whereby such alternating current is rectified, and means for impressing said rectified alternating current upon said discharge controlling grid of said first tube.

2. A multistage electric wave discharge device circuit comprising a gain reducing negative feedback connection around the stages, said circuit having a tendency to oscillate at a frequency outside of the frequency band to be transmitted by said circuit and being allowed to oscillate, one stage of said circuit comprising a discharge device having a discharge controlling electrode, a later stage of said circuit comprising a discharge device having a cathode, an anode and a plurality of grids one of which is a suppressor grid, means for causing said suppressor grid and said cathode to serve as a diode to rectify said oscillation, and means for feeding the detected energy to said controlling electrode of said one stage to limit the circuit gain at the frequency of oscillation.

3. An electric wave discharge device circuit comprising an amplifying device and a gain-reducing negative feedback connection therefor, said circuit having a tendency to and being allowed to oscillate, said device comprising an anode, a cathode, a discharge controlling grid and a suppressor grid, means to derive energy from said oscillation and to feed the derived energy to said suppressor grid for rectification by diode action of said suppressor grid and said cathode, and means for supplying the rectified voltage to said discharge controlling grid to regulate the gain of said device with respect to such oscillation so that the amplitude of the oscillation is maintained below a level that would be objectionable.

4. An electric wave discharge device circuit comprising an amplifying device and a feedback connection therefore, said circuit having a tendency to and being allowed to oscillate, said device comprising an anode, a cathode, a discharge controlling grid and a suppressor grid, means for causing said suppressor grid and said cathode to serve as a diode to rectify said oscillation, and means for feeding the detected energy to said discharge controlling grid to reduce the gain of said device and thereby control the feedback of the circuit at the frequency of oscillation.

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