

Dec. 24, 1935.

H. N. KOZANOWSKI ET AL

2,025,595

MODULATION CIRCUIT

Filed Jan. 23, 1934

2 Sheets-Sheet 1

Fig. 1.

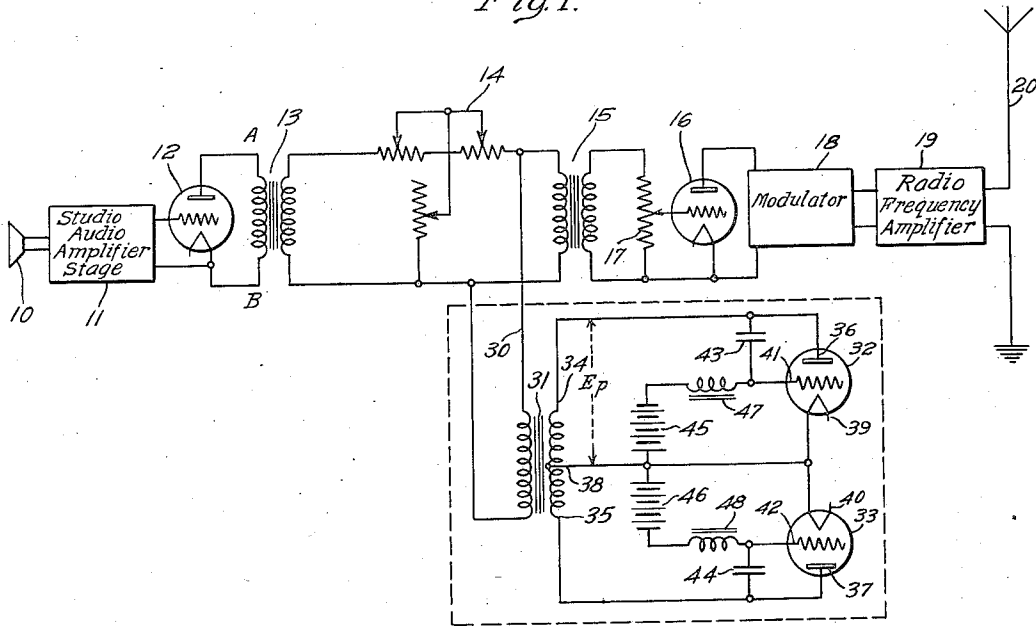
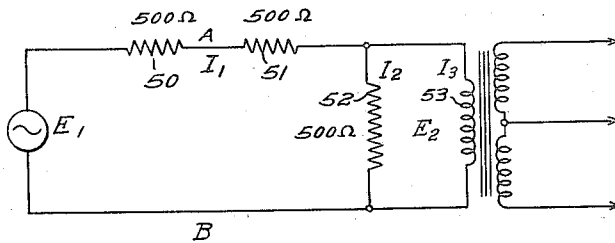


Fig. 2.



WITNESSES:

C. J. Weller.
R. W. Bailey

INVENTORS.

Henry N. Kozanowski &
Harrell V. Noble.

BY

F. W. Lyle.
ATTORNEY

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Fig. 3.

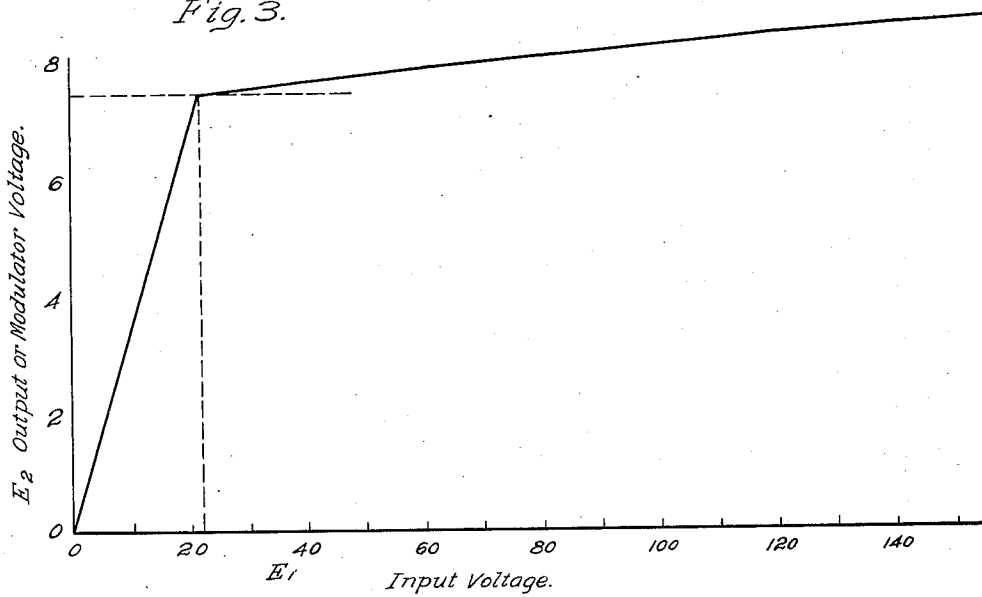
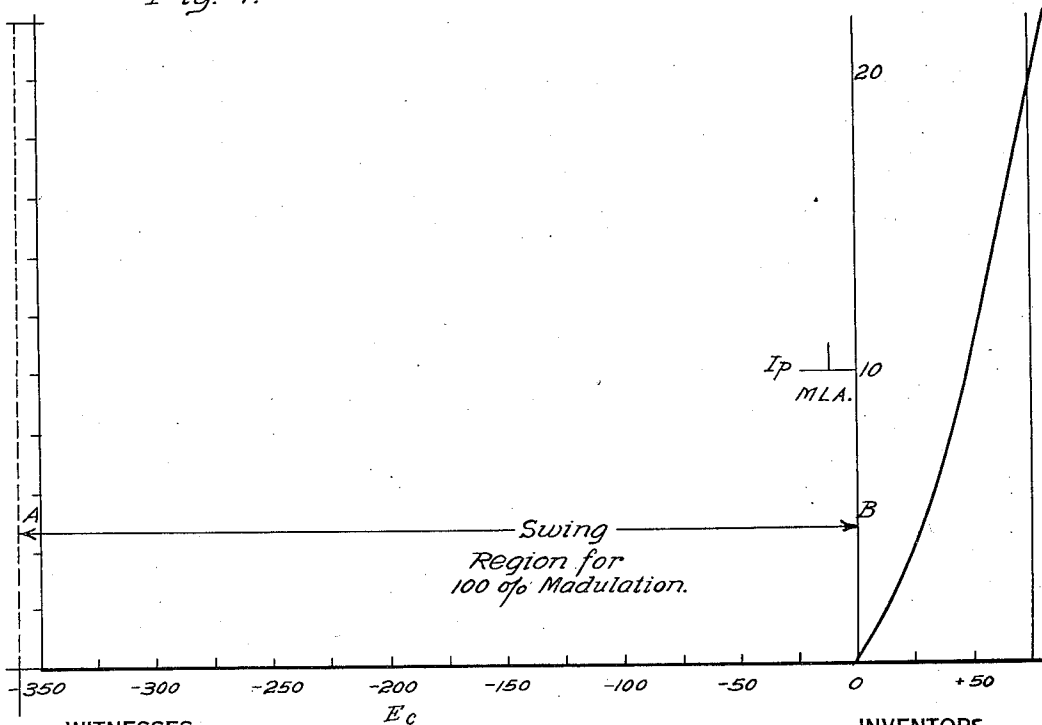


Fig. 4.



WITNESSES:

C. J. Weller.
R. W. Bailey

INVENTORS.

Henry N. Kozanowski &
Harrell V. Noble.

BY

F. W. Lyle.
ATTORNEY

UNITED STATES PATENT OFFICE

2,025,595

MODULATION CIRCUIT

Henry N. Kozanowski, Wilkinsburg, and Harrell V. Noble, Forest Hills, Pa., assignors to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application January 23, 1934, Serial No. 707,912

3 Claims. (Cl. 179-171)

Our invention relates to modulation circuits and it has particular relation to means for preventing over modulation in transmitting circuits.

5 An object of our invention is to provide means that will automatically limit the modulation voltage in radio transmitting circuits to a predetermined value.

10 Another object of our invention is to eliminate the interruptions that occur in the circuits of broadcasting stations, due to an abnormal increase in the grid and plate voltages and currents in the modulator and power amplifier stages.

15 Other objects of our invention will become evident from the following detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a diagrammatic view of a system including a preferred form of our invention;

20 Fig. 2 is a diagrammatic view of an equivalent circuit illustrating effect of the various components of the circuit of Fig. 1;

25 Fig. 3 is a graph disclosing the region in which the modulation suppressor of Fig. 1 operates; and,

Fig. 4 is a graph disclosing the permissible voltage in the modulator circuit.

30 The records of broadcasting stations disclose that a frequent cause of interruptions of programs is due to over modulation. This condition of over modulation causes abnormal grid and plate voltages and currents in the modulator and power amplifier stages, with the result that there may be flash-backs that damage the tubes of the circuit. To prevent damage to the tubes of the circuit, an overload relay is provided that will interrupt the circuit and prevent damage to the tubes. While the tubes of the circuit are thus protected by the overload relay, yet the interruption is highly undesirable generally and particularly if each interruption causes a financial loss. It is practically impossible to foresee when any performer or performers before the microphone may cause an increase of sound volume to produce an excessive voltage in the audio stage and cause over modulation in the power amplifier stage. Manual means cannot, of course, act quickly enough to prevent damage or interruption in case the sound volume at the microphone is suddenly increased. Accordingly, it is an object of our invention to provide means for automatically limiting the voltage of the modulation circuit when the audio frequency voltage exceeds a prescribed value, as for instance,

the one corresponding to 100% modulation in the output stage.

In Fig. 1 is diagrammatically illustrated the circuit of a broadcasting transmitter circuit and a preferred form of over modulation suppressor 5 applied to the audio section of this circuit.

The sound to be reproduced in the receivers tuned to the station is picked up by the microphone 10 and the electrical circuit therethrough passes through the studio audio amplifier stage 11 to the tube 12 which may be of the UX-210 type. This tube is connected to the transformer 13 at the primary points labeled A and B. The transformer is connected to the standard telephone line which at present has a resistance 15 value of 500 ohms. The portion of the circuit up to this point we shall call the studio audio input. An attenuator 14 maintains the proper resistance in the line and across it, and it is well-known in the art. A transformer 15 connects this to the conventional amplifier tube 16 through a resistance 17. The output of this audio circuit is then connected to a suitable modulator 18 and radio frequency power amplifier 19, wherein a radio carrier frequency is provided and this carrier frequency is modulated by the audio frequency produced in the circuit just described. The signal is then broadcast from the antenna 20.

30 While the above description concerns a radio broadcasting station circuit, it is apparent that the invention might be applied to similar forms of circuits involved in the modulation of one circuit by another, but which are not broadcast from an antenna.

A preferred form of our invention includes a 35 shunt circuit across the audio stage or line and preferably between the attenuator and the transformer 15. This shunt connection 30 is connected preferably to the primary winding of a transformer 31 having its secondary connected to 40 two tubes 32 and 33. The ends 34 and 35 of the secondary are preferably connected to the anode 36 of the tube 32 and the anode 37 of the tube 33 respectively. The midpoint 38 of the secondary of this transformer 31 is connected to the 45 cathode 39 of the tube 32 and the cathode 40 of the tube 33. The grid 41 of the tube 32 and the grid 42 of the tube 33 are connected to their respective anodes through condensers 43 and 44. 50 A negative bias is placed upon each of the grids by the respective batteries 45 and 46 or other source of voltage. These batteries are connected between the midpoint 38 of the transformer 31 and the connections to the grids of both of the 55

tubes. Chokes 47 and 48 isolate the grids at audio frequency from ground.

The tubes 32 and 33 may be of any suitable form having suitable static characteristics.

5 While one of these tubes would act to prevent over modulation during one-half cycle, it is preferred to have the two tubes connected in this push-pull arrangement so that the suppressor would be effective for all portions of the sine wave voltage.

10 It is preferred to use the tubes of the type known as UX-250 in this over modulation suppressor. In further describing the effect of the suppressor upon the audio stage, certain static characteristics of these tubes will be considered and also the parameters of the standard circuit will be mentioned. It will be recognized, of course, that the invention is not limited to the specific tube used nor to the specific values of the standard circuit, nor to the particular values of current, voltage, transformer ratios, etc., mentioned in the following description.

It is preferred to use a highly negative bias on the grids 41 and 42 of the tubes of the over modulator suppressor circuit. In our specific example, we have taken this voltage on these tubes as -95 volts. The plate voltage on these tubes will, of course, depend upon the voltage across the audio line, and this will, in turn, depend upon the input voltage of the audio stage. Reference is made to the electrical equivalent circuit in Fig. 2 where E_1 is the voltage from the circuit including the audio amplifier studio stage and the tube 12. The transformer 13 has a reflected impedance of 500 ohms into the circuit, illustrated at 50 in Fig. 2. This reflected impedance, of course, comes from the prior parts of the circuit. The attenuator resistance of 500 ohms is illustrated at 51. The current through these two is labeled I_1 . There are then two branch circuits 52 and 53 and the voltage across these two branch circuits is E_2 .

This voltage E_2 is the output voltage of the circuit and we are primarily interested in the effect on this output voltage E_2 of an increase in the input voltage E_1 . The various values given below have been calculated from equations and from the ordinary vacuum tube static curves, in this case for the UX-250 tube.

For 100% modulation we will assume that E_2 equal 7.5 volts peak and that the transformer 31 of the overmodulation suppressor has a one to twenty ratio. The values of the tube are taken as

E_p =peak plate voltage;
 I_p =peak plate current; and
 E_g =peak grid voltage.

The μ of the tube is taken as 3.8.

$E_2 = \frac{1}{10}$ of E_p since the coupling ratio is 20 to 1, or 10 to 1, considering the central tap connection. I_2 is equal to E_2 divided by 500 since the resistance of the attenuator is 500 ohms. I_3 equals 10 I_p from the transformer ratio of 10 to 1. $I_1 = I_2 + I_3$ which follows from the sum of the branch currents. $E_1 = E_2 + 1000 I_1$. The thousand comes from the reflected impedance 50 of 500 ohms and the line resistance 51 of 500 ohms.

It will be noted that the plates of the two suppressor tubes are connected across a high ratio transformer 31 and have no direct current supply voltage. The grids are coupled to the plates by the condensers 43 and 44 so that any change of plate voltage is also impressed on the grids. The grids of the tubes are biased highly negative by a battery 45 or 46 and influence of negative bias on grid will be counterbalanced by the positive voltage on the plate due to 100% mod-

ulation. Higher values of plate voltage corresponding to over modulation will cause a flow of plate current. The combined control voltage E_c of any triode tube is equal to $E_p + \mu E_g$. Then from the constants on this particular circuit and the static characteristics of the tubes used, the following values are obtained. Note $\mu = 3.8$.

E_p	E_g	I_p	I_3	I_2	I_1	$1000I_1$	E_2	E_1	μE_g	E_c
0-----	-95	.000	.000	0	.000	0	0	0	-360	-360
25-----	-70	.000	.000	.005	.005	5	2.5	7.5	-270	-235
50-----	-45	.000	.000	.010	.010	10	5.0	15.0	-170	-120
75-----	-20	.000	.000	.015	.015	15	7.5	22.5	-76	-1
80-----	-15	.004	.040	.016	.056	56	8.0	64.0	-57	+23
85-----	-10	.010	.100	.017	.117	117	8.5	125.5	-38	+47
90-----	-5	.018	.180	.018	.198	198	9.0	207.0	-19	+71

It will be noted from the above that the control voltage E_c is negative for values up to 7.5 volts of E_2 . Above this point, the control voltage becomes positive and the tubes will function by initiating an electronic current that will make the over modulation suppressor circuit operate and introduce a variable resistance that will prevent an over modulation of the voltage in the audio stage. This is illustrated by the curve in Fig. 3 in which the values of E_1 are plotted against the values of E_2 . It will be noted that the output voltage rises linearly until the 100% modulation voltage is reached and then the curve levels off very sharply. The control voltage of the tube against the current in the plate circuit of the tube of the over modulation suppressor is also plotted in Fig. 4. It will be noted, from the values illustrated by the points from A to B, that the control voltage permits of no current in the plate circuit of the tube, but the moment that the control voltage is positive the value of the plate current in the tube rises very sharply.

Between the limits A and B on the curve in Fig. 4 the audio amplitudes are entirely unaffected. In other words, the output voltage will be directly proportional to the input voltage up to the 100% modulation, as disclosed in the curve in Fig. 3. However, the moment over modulation occurs, the current through the tubes will be automatically started and the modulator and oscillation voltage will be kept below the value at which there is danger of interruption of performance. Other tubes with different characteristics can, of course, be used and the various constants of the circuit changed to suit particular conditions.

Although we have shown and described certain specific embodiments of our invention, we are fully aware that many modifications thereof are possible. Our invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

We claim as our invention:

1. A transmitting arrangement having in combination a circuit for providing a carrier frequency, a circuit modulating the carrier frequency of said first-mentioned circuit and a circuit connected in shunt to said second mentioned circuit and comprising a grid controlled electron discharge tube having an anode electrode, a negative bias on the grid of said tube, means for coupling said grid and anode whereby the voltage of said second circuit will be simultaneously impressed upon said grid and anode electrodes.

2. In combination, a source of variable potential, a load circuit connected thereto for operation at potentials below a predetermined maximum, a pair of electron discharge devices con-

5 nected 180 degrees out of phase with each other
and effectively in shunt to said load circuit, each
of said devices comprising a cathode and at least
two cold electrodes one of which cold electrodes
5 is disposed between said cathode and the other
cold electrode, a biasing potential on at least
one of the cold electrodes of each of said devices,
said biasing potential being of such a value as
to preclude operation of said electron discharge
10 devices at impressed potentials below the value
of said above referred to maximum potential, and
means for applying potentials derived from said
variable source to both of said cold electrodes of
each device simultaneously.

15 3. In combination, a source of variable potential, a load circuit connected thereto for operation at potentials below a predetermined maxi-

mum, a pair of electron discharge devices connected 180 degrees out of phase with each other
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cathode and the other cold electrode, a biasing
potential on each of said intermediate electrodes,
said biasing potential being of such a value as
to preclude operation of said electron discharge 10
devices at impressed potentials below the value
of said above referred to maximum potential, and
means for applying potentials derived from said
variable source to both of said cold electrodes of
each device simultaneously.

HENRY N. KOZANOWSKI.
HARRELL V. NOBLE.

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