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AUTOMATIC ATTENUATION CIRCUIT

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Fig. 1.

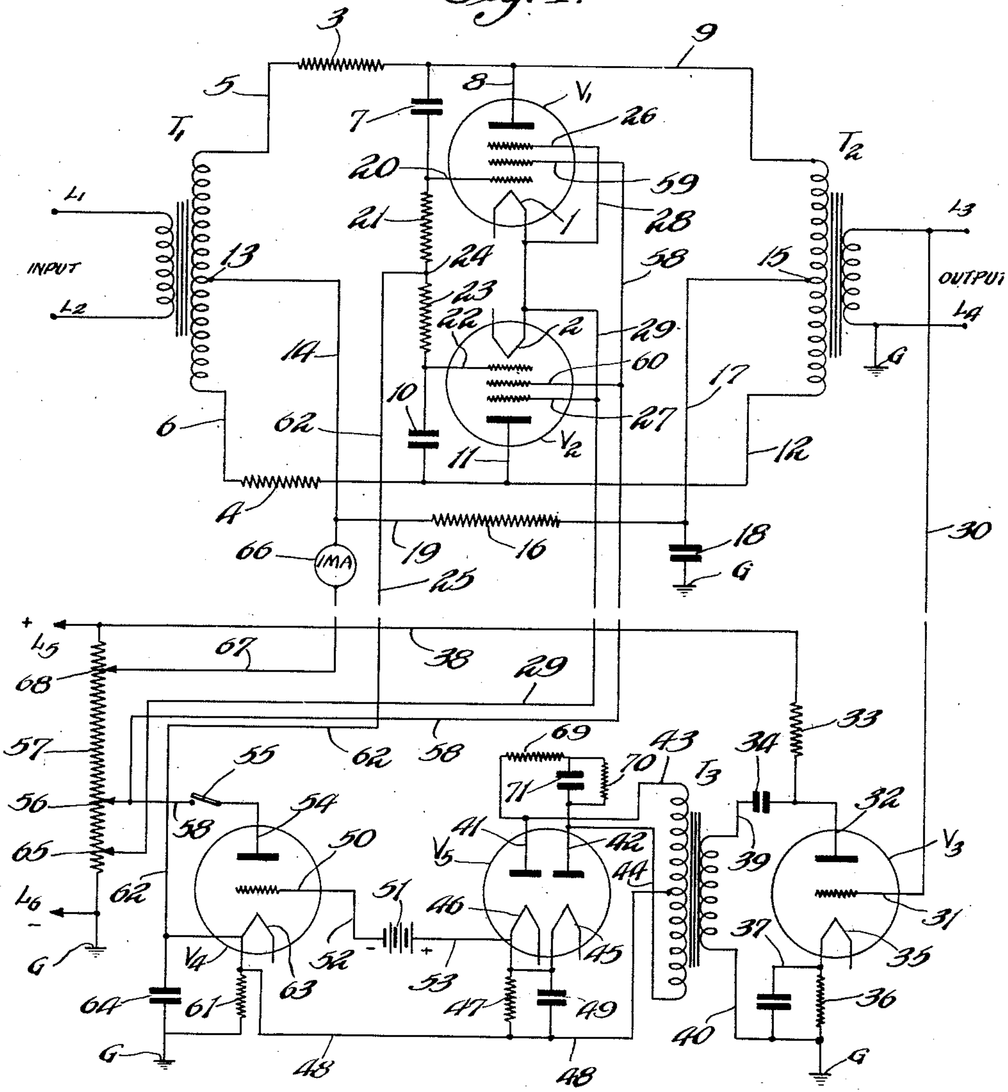

Fig. 2.

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AUTOMATIC ATTENUATION CIRCUIT

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5 Claims. (Cl. 178—44)

This invention relates in general to communication circuits and more particularly to a vacuum tube circuit for the automatic attenuation of audio frequency transmission in a communication line.

A long felt need for a simple automatic means for controlling the level of audio frequency transmission where transmitted signals must not exceed predetermined limited values in order to maintain proper quality of reproduction in given output circuits is fulfilled by this invention.

Amplified audio frequency transmission originating from microphones or recordings often exceeds normal transmission limits. Prior to this invention several means were employed to regulate and govern the transmission of audio frequency transmission, including a manual attenuation control and automatic vacuum tube control circuits. The manual method of control is unsatisfactory inasmuch as the attenuation is dependent entirely upon the human element and the heretofore used automatic vacuum tube circuits introduced undesirable amplitude distortion in the transmitted signals.

In the present invention the means employed is entirely automatic in its operation and may be adjusted to accurately limit transmission to predetermined maximum levels and the automatic attenuation is effected without the introduction of amplitude distortion.

The principal object of the invention is the provision of vacuum tube and circuit means for automatically limiting the maximum level of audio frequency transmission in a communication circuit.

A further object of the invention is the provision of an automatically variable resistance network for controlling the levels of audio frequency transmission in transmission lines.

A further object of the invention is the inclusion of vacuum tube plate circuits as the control elements in a transmission line.

A further object of the invention is the provision of vacuum tubes included in a circuit network in a transmission line under the controlling influence of a secondary vacuum tube network.

Referring to the drawing:

Fig. 1 is a schematic diagram of the attenuation network in a transmission line.

Fig. 2 is a schematic diagram of a secondary network adapted to control the attenuation network shown in Fig. 1.

L1, L2, L3, and L4 represent the input and the output of a section of a transmission line. L1 and L2 are connected to the primary of a conventional audio input transformer T1. L3 and L4 are connected to the secondary of a conventional audio output transformer T2.

Conventional five element vacuum tubes V1 and V2 comprise the active elements in the attenuation or compression circuit for controlling the power level in the transmission line.

Although pentode tubes are used in this preferred form, it is understood that other types of vacuum tubes may be used for the same purpose in the present circuit. For purposes of simplicity it is assumed that electric power is supplied to the cathodes 1 and 2 of the tubes.

The secondary of the input transformer T1 is connected to one side of the limiting resistors 3 and 4 by conductors 5 and 6 respectively. The remaining side of the limiting resistor 3 is connected to a coupling condenser 7 and the plate 8 of vacuum tube V1 and to one side of the primary of output transformer T2 by conductor 9. The remaining side of limiting resistor 4 is connected to one side of the coupling condenser 10, the plate 11 of the vacuum tube V2 and to the remaining side of the primary of the output transformer T2 by conductor 12.

The center tap 13 of the secondary of the transformer T1 is supplied with B power by conductor 14, to be hereinafter described.

The center tap 15 in the primary of the output transformer T2 is connected to resistor 16 by conductor 17. One side of by-pass condenser 18 is connected to conductor 17 and the remaining side of the condenser connected to ground at G. The remaining side of resistor 16 is connected to conductor 14 by conductor 19.

The control grid 20 of the vacuum tube V1 is connected to a common junction of one side of the bias resistor 21 at its junction with the coupling condenser 7. The control grid 22 of vacuum tube V2 is connected to the common junction of the bias resistor 23 at its junction with one side of condenser 10. The two grid bias resistors 21 and 23 are connected together at 24 with conductor 25, which conductor runs to control apparatus to be hereinafter described.

The suppressor grids 26 and 27 of tubes V1 and V2 are connected to one side of their respective cathodes 1 and 2 by conductors 28 and 29 respectively. Conductor 29, which is common to cathode 2 and suppressor grid 27, is connected to control apparatus to be hereinafter described.

One side of the output line L4 is connected to ground at G and the other side of the output line L3 is connected by conductor 30 to the control circuit, to be hereinafter described.

It is apparent from the foregoing that the circuit included between the input transformer T1 and the output transformer T2 in effect is a continuation of the transmission line having two branches, the upper branch—conductor 5, resistor 3 and conductor 9, and the lower branch—conductor 6, resistor 4 and conductor 12. The central or common leg of the branch circuit is completed through the center tap 13 of the input transformer and the center tap 15 of the output transformer through conductor 17, resistor 16 and conductor 14.

It is common practice in such circuits to control the transmission level by means of an L pad resistance network in each branch, which usually consists of a series and parallel resistance. In this case the L pad network of the upper transmission line branch is represented by resistor 3 in series with the line and a shunting or parallel resistance effected by the plate circuit of the vacuum tube V1 between its cathode 1 and the plate 8 to the conductor 9. The same is true for the lower branch in that the resistor 4 represents the series resistance and the shunt or parallel resistance is effected by the plate circuit of the tube V2 between the cathode 2, plate 11 and conductor 12. The means employed for automatically varying the plate impedance or resistance of the tubes V1 and V2 will be hereinafter described.

Three vacuum tubes are utilized in a secondary circuit which is adapted to control the foregoing attenuation circuit. Vacuum tubes V3 and V4 are conventional triodes and vacuum tube V5 is a full wave rectifier. For the purpose of simplicity, the cathode heating circuit to all tubes has been omitted. Line L5 is connected to the positive side of a source of high voltage direct current. Line L6 is connected to the negative side of the same source of high voltage direct current and is also connected to ground at G. A voltage dividing resistor 57 is connected therebetween.

Grid 31 of vacuum tube V3, Fig. 2, is connected to output line L3, Fig. 1, by conductor 30. The plate 32 of vacuum tube V3 is connected to one side of plate resistor 33 and blocking condenser 34. One side of the cathode is connected through bias resistor 36 and by-pass condenser 37 to ground at G. Plate voltage is supplied to the remaining side of the plate resistor 33 from the direct current source L5 through conductor 38.

Transformer T3 is used for coupling the vacuum tube V3 to the rectifier tube V5. One primary lead of the transformer is connected to blocking condenser 34 by conductor 39. The remaining side of the primary is connected to ground by conductor 40.

The outside terminals of the secondary of transformer T3 are connected to the anodes 41 and 42 of rectifier tube V5 by conductors 43 and 44 respectively. The resistors 69 and 70 and the condenser 71, which constitute a network connected across the anodes 41 and 42 of the vacuum tube V5, are for the purpose of regulation only and are not important in the general operation of the circuit. One side of the cathodes 45 and 46 are connected through bias resistor 47 and its by-pass condenser 49 to conductor 48, which conductor is connected to the center tap of the secondary of the transformer T3 and also to the cathode of the vacuum tube V4. The grid 50 of the regulator vacuum tube V4 is connected to the negative side of a bias battery 51 by conductor 52. The positive side of the bias battery is connected to one side of both cathodes of the vacuum tube V5 by conductor 53. The plate 54 of vacuum tube V4 connects through an "on-off" switch 55 to a variable point 56 of the voltage divider 57 by conductor 58.

Conductor 58 is also connected to the screen grids 59 and 60 of the vacuum tubes V1 and V2, Fig. 1, which is conventional practice in pentode type tubes. One side of the cathode 63 of vacuum tube V4 is connected through control resistor 61 and a parallel connected by-pass condenser 64 to ground at G. The same side of the cathode of tube V4 is connected to the bias resistors 21 and 23 at their junction 24, Fig. 1, through conductor 62.

Conductor 28, running from the common connections to the cathodes 1 and 2 of the tubes V1 and V2, Fig. 1, is connected to a variable point 65 of the voltage divider 57.

One side of milliammeter 66 is connected to conductor 14, Fig. 1, and the remaining side of the milliammeter is connected through conductor 67, Fig. 2, to a point 68 of the voltage divider 57.

For the purpose of describing the operation of the entire circuit, it will be assumed that the cathodes of all tubes are supplied with proper operating current and that a variable audio frequency signal is impressed upon transformer T1 through the input lines L1 and L2. It is apparent that the signal will be induced in the secondary of transformer T1 and transmitted through the upper and lower legs of the control circuit and the common center tap circuit of the transformer to the output transformer T2 and thence to the continuation of the transmission line L3 and L4. The electron emission from the cathodes 1 and 2 of the vacuum tubes V1 and V2 to their respective plates 8 and 11 will comprise a shunt resistance across the two legs 9 and 12 of the transmission line in addition to the relatively small additional shunt circuit through the coupling condensers 7 and 10 and the grid resistors 21 and 23.

In order to provide a non-inductive L pad network, the resistors 3 and 4 are fixed at a nominal predetermined value to provide a given attenuation in connection with the shunt path provided by the plate impedance of the vacuum tubes V1 and V2. The signal is transmitted through the upper and lower legs of the control circuit to the plates 8 and 11 of the vacuum tubes V1 and V2 and through coupling condensers 7 and 10 to their respective control grids simultaneously. Since the applied signal is impressed simultaneously to the control grids and the plates of the vacuum tubes V1 and V2 respectively, the shunt resistance is provided in the path of the signal between the points 8 and 11, and instead of being equal to the sum of the alternating current plate resistances, it is equal to the sum of the A. C. plate resistances divided by the amplification constant of the tubes V1 and V2. The milliammeter 66 indicates the plate current of the vacuum tubes V1 and V2 and normally remains at zero. It will follow that the normally attenuated signal will be impressed by conductors 9 and 12 upon the output transformer T2 and thence transmitted to the lines L3 and L4.

Since the vacuum tubes V1 and V2 and their associated network control the transmission line, the following will describe the vacuum tube network which controls the action of the tubes V1 and V2 and thus provides the compression or attenuation to the transmitted signal when normal levels are exceeded.

The output audio frequency signals in the lines L3 and L4, Fig. 1, are impressed upon the grid of the vacuum tube V3, Fig. 2, by conductor 30 connecting the output line L3 and the ground connection common to line L4 and the vacuum tube V3. Plate current is supplied to vacuum tube V3 from line L5, Fig. 2, conductor 38 and plate resistor 33. Thus it will be seen that the high impedance grid circuit of vacuum tube V3 will not seriously affect the output in the lines L3 and L4 but the signal transmitted therethrough will be amplified by vacuum tube V3 and impressed upon the primary of the coupling transformer T3 through the condenser 34 and conductor 39, and condenser 37 and conductor 40.

The amplified output signal in transformer T3 is impressed upon the rectifier tube V5 through the conductors 43 and 44 connected to the anodes 41 and 42 of the tube respectively and the mid-tap, completing a circuit to the cathodes of the tube through conductor 48, condenser 49 and the resistor 47.

The rectified components of the signal impressed upon the vacuum tube V5 are carried to the amplifier tube V4 through conductor 53, bias battery 51, grid conductor 52 and the cathode conductor 46.

Under normal operating conditions where signals passing through the transmission line, shown in Fig. 1, are not in excess of a predetermined nominal value, the battery 51 biases the grid of tube V4 sufficiently to normally reduce the plate current to zero value, hence, under normal conditions, no current will flow through resistor 61 Plate voltage is supplied from a point 56 of the voltage divider 57 through conductor 58 through the closed "on-off" switch 55 to the plate 54 of the tube V4.

The voltage drop across the resistor 61 between the cathode and ground of the tube V4, when plate current is caused to flow, is impressed through conductor 62 to both grids of the vacuum tubes V1 and V2, Fig. 1, by virtue of the common junction 24 of both the grid bias resistors 21 and 23 of the vacuum tubes V1 and V2 and the return through the cathodes of the tubes V1 and V2 through conductor 29 to point 65 of voltage divider 57 and thence to the common ground G.

Condenser 64 is provided to by-pass audio frequency currents and to permit only uni-directional currents to flow in conductor 62 and to regulate the time period associated with the limiting action of the circuit. The condenser 49 and resistor 47 also are arranged to regulate the time period of the limiting action of the circuit. Thus it will be seen that the plate currents in vacuum tubes V1 and V2 will be zero so long as the voltage of the bias battery 51 is not exceeded by the rectified output potential of the vacuum tube V5. When an audio frequency current is transmitted through the network and impressed upon the output lines L3 and L4 of a value greater than a predetermined normal level the rectified potential in the vacuum tube V5 will overcome the normal bias on the grid 50 produced by the battery 51 and reduce the normal bias to a point where plate current will flow in the tube V4 and through the control resistor 61. The increases in plate current flow for excessive signals will be in proportion to the level of the original transmitted signal. Thus a lesser negative bias will be applied to the grids of the vacuum tubes V1 and V2 which will inherently permit a larger plate current to flow in both tubes by virtue of the conductor 62 which will apply the voltage drop across the control resistor 61 to the common junction of the grid bias resistors 21 and 23 of the vacuum tubes V1 and V2. As a result of the increase in the positive bias of the tubes V1 and V2 the resultant larger plate current will provide a lower impedance path through each tube and hence act as a lower value shunt resistance across the lines 9 and 12, which will automatically reduce the transmitted signal to a predetermined value in the output lines L3 and L4. The milliammeter 66 will automatically indicate the attenuation or suppression by indicating the plate currents in vacuum tubes V1 and V2 in excess of normal.

Having described our invention, we claim:

1. An automatic attenuation circuit for an audio frequency transmission line comprising input and output means, a circuit network included between said input and output means, a vacuum tube means included in said circuit network, the plate and grid circuits of said vacuum tube means connected as a shunt path across the said circuit network, including an additional vacuum tube circuit connected and responsive to audio frequency signals in the said transmission line, said additional circuit adapted to control and automatically decrease the normal impedance of the aforesaid vacuum tube means when signals in excess of predetermined values are impressed upon said transmission line to limit the amplitude of signals in the said output means of the said transmission line to a predetermined level.

2. In an automatic attenuation circuit for an audio frequency transmission line, an input transformer, an output transformer, a control circuit connecting said input and output transformer having two branches, said circuit comprising series and parallel resistance elements, a vacuum tube means connected in each said branch of said control circuit, the plate and grid circuits of said vacuum tube means shunt connected in each said branch in said control circuit, an auxiliary regulation circuit network including vacuum tubes responsive to audio frequency signals in the aforesaid output transformer and connected with and adapted to control the impedance of the aforesaid vacuum tube means to govern and limit to a predetermined level audio frequency signals transmitted in the aforesaid transmission line.

3. In an automatic attenuation circuit for an audio frequency transmission line, an input transformer, an output transformer, a circuit network having two branches connecting said input transformer with said output transformer, fixed resistance in series with each branch of said circuit, a pair of vacuum tubes connected in said circuit having a common grid terminus, regulation means for applying voltage variations to the said common grid terminus in proportion to the value of signals in the said transmission line, the plate of each said vacuum tube connected to each of the aforesaid branches, the grid of each said vacuum tube connected through condenser means to each of the aforesaid branches, the plate and grid circuits of said vacuum tubes adapted to vary the shunt impedance path across each of the aforesaid branches in proportion to voltage variations impressed by the said regulation means upon the said common grid terminus of said vacuum tubes to govern and limit to a predetermined level audio frequency signals transmitted in the aforesaid transmission line.

4. In an automatic attenuation network for an audio frequency transmission line, a control circuit means including controlling vacuum tubes interposed in said transmission line, the plate and grid circuits of said controlling vacuum tubes comprising a shunt impedance path across the said transmission line when said tubes are activated, the said vacuum tubes including a common grid circuit responsive to applied voltages, a vacuum tube regulating means responsive to audio frequency signals in the said transmission line, said regulating means having a fixed bias voltage applied to its output tube, said output tube adapted to control the aforesaid common grid circuit when audio frequency signals in the said transmission line exceed a predetermined value to govern and limit to a predetermined level audio frequency signals transmitted in said transmission line.

5. An automatic attenuation circuit for an audio frequency transmission line comprising input and output means, a circuit network having two branches connecting said input means with said output means, a pair of vacuum tubes having grid and plate elements connected in said network, said tubes having a common grid terminus, the value of the internal impedance of said tubes dependent upon the value of voltage applied to the said common grid terminus, the plate of each said vacuum tube connected to each of the aforesaid branches, a condenser connecting the grid and plate of each of the aforesaid vacuum tubes, a regulation means responsive to audio frequency signals transmitted in said transmission line connected to said grid terminus, said vacuum tubes adapted to vary the shunt impedance path across each of the aforesaid branches in proportion to voltage variations impressed upon the said grid terminus by the said regulation means to control and limit to a predetermined level audio frequency signals transmitted in the said output means.

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