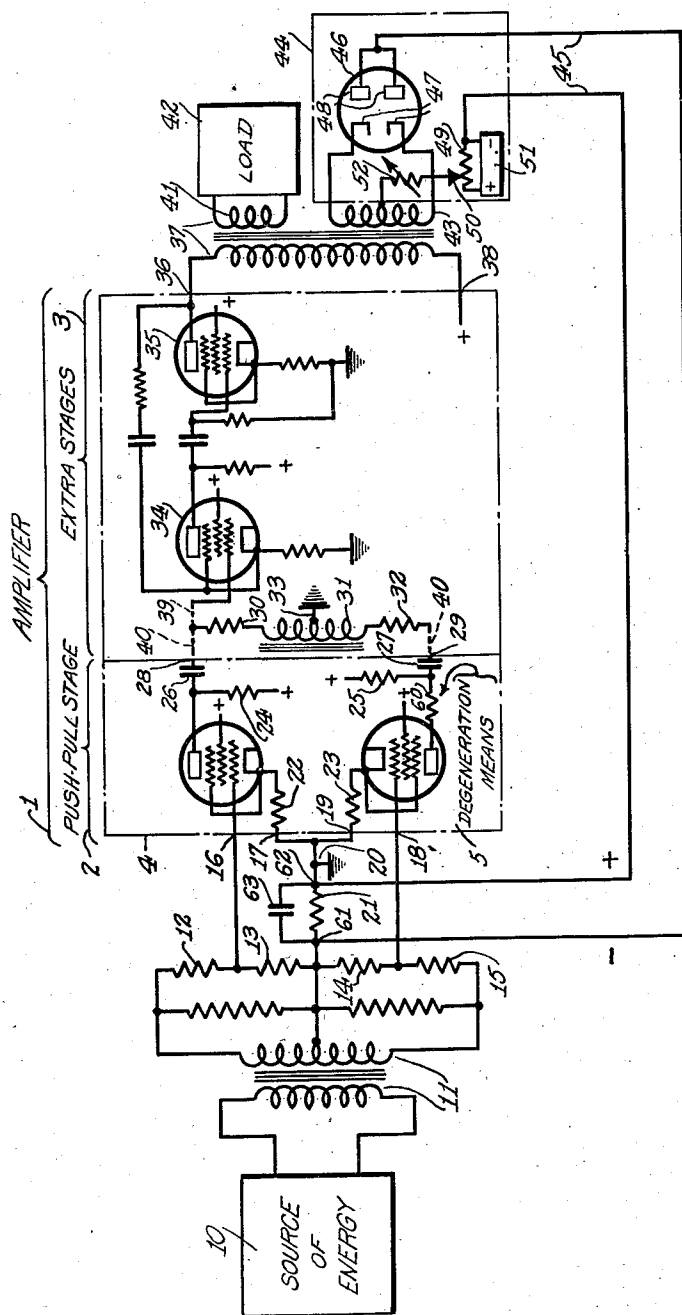


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L. P. TUCKERMAN
PEAK LIMITING AMPLIFIER

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INVENTOR.
LUCIEN P. TUCKERMAN
BY *J. L. Fearing*
ATTORNEY

UNITED STATES PATENT OFFICE

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PEAK LIMITING AMPLIFIER

Lucien P. Tuckerman, Washington, D. C., assign-
or to Federal Telephone and Radio Corpora-
tion, a corporation of Delaware

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This invention relates to amplifiers of the automatic volume control type, and more particularly to such amplifiers including a push-pull stage of amplification.

While automatic volume control circuits in combination with amplifiers of the kind referred to, are in general very old, the available forms of such circuits appear to be subject to quite rigid limitations which cannot be overcome by ordinary means without undesirably affecting the stability of operation of the circuits. Difficulties have been found in cases where the gain of the amplifier is very high, or where a very high quality of wave transmission is required over a wide frequency range, or where the speed of operation of the automatic volume control is high, and more particularly where two or more of the preceding conditions are to be met, the problem being to obtain a steady and satisfactory operation of the amplifier free from the tendency to develop self-oscillations, distortion, or interruption of transmission. For example, in the case of a relatively high gain amplifier employing a push-pull amplifying stage and having the usual volume control circuit for transmitting a rectified impulse from the output of the amplifier to an input coupling common to the two input circuits of the push-pull stage, it has been found that a sudden large increase of amplitude of the signal wave, may entirely paralyze the operation of the amplifier for a brief period at least, or may cause self-oscillation of the amplifier, or may otherwise interfere with the normal intended operation of the amplifier.

Some of the objects of the present invention are to counteract one or more of the above difficulties, to provide an improved wide frequency range amplifier, capable of relatively high amplification, and having an automatic volume control circuit adapted to operate with suitable improved stability while permitting of relatively quick and efficient volume control without objectionably disturbing the normal desired operation of the amplifier.

When installing amplifier tubes and making replacements of tubes in push-pull amplifiers of the automatic volume control type referred to above, where any two tubes generally differ somewhat in their characteristics and thus interfere with the production of a perfect balance in the push-pull stage, I have found that it is important to position the tubes in the push-pull stage in such relation to each other that the resulting unbalance of the circuit has an effect whose phase is in degenerative relation with the auto-

matic volume control circuit. Since the effective amplification or output of the two tubes, as purchased in the open market, or as obtained within the limits of commercial tolerances for such tubes, is generally unequal when the tubes are new, or may be subject to temporary or permanent change within predetermined limits during operation, an undesirable amount of experimentation, extra skill, effort, or time may be required in trying to make the amplifier operate with suitable stability under the conditions referred to.

In accordance with the present invention, these difficulties may be counteracted effectively and the range of stable operation of the amplifier extended by providing an auxiliary unbalance of suitable amount and suitable phase in the transmission circuit which includes the push-pull amplifier and extends from the volume control input terminals of the amplifier to the rectifier in the automatic volume control circuit. This unbalancing means may, for example, consist of a difference of resistance of corresponding parts of the opposite sides of the push-pull circuit or of some other usually or nominally balanced portion of said transmission circuit. For example, an unbalancing resistance may be included in the cathode-anode circuit of one amplifying tube in the push-pull stage, to reduce the effective amplification of one side of the push-pull amplifier, so that the resulting unbalanced characteristic is greater than the unbalanced transmission produced by the inherent predetermined difference in the tubes themselves, and the phase relation of the unbalanced transmission characteristic is such as to produce degeneration with respect to the feedback path formed by the automatic volume control circuit. The resulting amplifier is adapted to quickly and efficiently limit peak amplitudes in the amplified signal wave.

These and other objects and features of the invention will be understood more clearly from the following detailed description in connection with the accompanying drawing and the appended claims.

The drawing shows a schematic circuit diagram of an amplifier illustrative of one form of the present invention.

In the drawing, the amplifier 1, includes a push-pull amplifying stage 2, and the extra stages 3, the push-pull stage including amplifying units 4 and 5 which are shown, by way of example, as being of the electron discharge type, although it will be understood that the invention is applicable to amplifying units of other types.

Each electron discharge device includes an anode, an electron emitting cathode, and an electron control element.

The source of waves 10 impresses signal waves to be amplified on the primary of transformer 11, the secondary of which has a circuit in shunt therewith, including resistance elements 12, 13, 14 and 15 in series, the resistance 13 being made equal to resistance 14, and resistance 12 being made equal to resistance 15 for the purpose of symmetry and circuit balance. The input signal voltage across resistance 13, is transmitted to the input terminals 16, 17 of amplifying unit 4, and input signal voltage across resistance 14, is transmitted to input terminals 18 and 19 of amplifying unit 5, terminals 17 and 19 being connected together at ground 20. Terminal 16 connects directly with the control grid of unit 4, and terminal 18 connects directly with the control grid of unit 5, the terminals 16 and 18 constituting push-pull input terminals for the push-pull amplifier stage 2. The grid-cathode circuit for each unit 4 and 5 has a portion in common including the resistance coupling 21 having the automatic volume control terminals 61 and 62, the condenser 63 being in shunt therewith for opposing too sudden changes in the automatic volume control grid bias.

The resistance 22 is connected between the cathode of unit 4 and ground 20, and the corresponding resistance 23 is connected between the cathode of unit 5 and ground 20, resistances 22 and 23 serving in well known manner to provide a normal negative biasing potential for the respective control grids of units 4 and 5. Space current is supplied to the anodes of units 4 and 5, through the coupling resistances 24 and 25. Output current from the anodes of units 4 and 5 is transmitted through the respective direct current blocking condensers 26, 27 to the output terminals 28, 29 across which is connected in series, the resistor 30, auto-transformer coil 31, and the resistance 32, the mid-point 33 of the coil 31 being grounded. Amplified output current passing through circuit 30, 31, 32 transmits impulses to the control grid amplifier 34 of the electron discharge type having a capacity-resistance coupling between its anode and the control grid of amplifier 35 of the electron discharge type, the anode of which connects with output terminal 36, to which is connected one terminal of the primary of transformer 37, the other terminal of said primary being connected with the output terminal 38 for amplifier 35.

It will be seen that terminals 36 and 38 serve as output terminals for the amplifier 1. The number of extra amplifier stages 3 may obviously be varied to suit requirements as indicated by the dotted line 39, at which point additional stages of amplification not shown may be introduced, and similarly it will be apparent that additional push-pull stages of amplification similar to push-pull stage 2, may be introduced immediately following stage 2 at the points indicated by the dotted lines 40. The output transformer 37, may obviously have its terminals 36, 38, connected directly with terminals 28, 29, when the number of extra stages 3 are reduced to zero. The secondary winding 41, of transformer 37, is connected with the load 42, which may be any desired form of utilization circuit for the amplified signal waves. The secondary winding 43 of transformer 37, is coupled with rectifier 44, the direct current output conductors 45 of the rectifier being connected directly with the terminals

61, 62 of the coupling resistance 21, constituting the automatic volume control input terminals for the amplifier.

Rectifier 44, preferably includes a full-wave rectifier tube 46 having two cathodes 47 connected respectively with opposite terminals of coil 43. The anodes 48 being connected together with one of the conductors 45, the other conductor 45 being connected through potentiometer resistances 49, by way of the adjustable tap 50 with the mid-point of coil 43. Potentiometer 49 is connected across the direct current source of potential 51, poled in a direction to oppose the output potential of the rectifier. Adjustment of potentiometer 49, permits of adjustment of the threshold amplitude of amplified output signals below which no rectification takes place in automatic volume control circuit extending from coil 43 to coupling 21, and below which no volume control impulses are transmitted to the input of the amplifier, this operation being in accordance with the well-known practice for limiting the operation of the automatic volume control to apply to only those amplified output signal amplitudes which exceed a predetermined value. The capacity 63 is made small enough to permit of a relatively quick application of the automatic volume control biasing potential to the grids of amplifying units 4 and 5, when the amplitude of the output signal waves tend to exceed the desired value. The variable resistance 52 may be included in one of the conductors 45 for damping the volume control impulses.

When the requirements of the amplifier are such that a very high gain of amplification is to be obtained, or where a very wide range of signal frequencies are to be amplified, or where a relatively quick response is to be made by the automatic volume control circuit and especially where two or more of these conditions are to be met in a given amplifier, I have found that small unbalances in the push-pull stage 2 tend to cause serious difficulties. These difficulties are apparently due in part to inherent differences between the characteristics of available amplifier tubes for substitution in units 4 and 5. These tube differences produce an unbalance which tends to cause instability of operation of the amplifier and may momentarily paralyze operation of the amplifier or cause it to produce self-oscillations, or cause the production of peak amplitudes momentarily far in excess of the limit set by the automatic volume control circuit, or may otherwise interfere with the stable operation of the amplifier when there is a sudden increase in the amplitude of signal waves from the source 10, and the amplitude reaches a value sufficient to cause operation of the automatic control circuit.

In order to counteract this difficulty, I have found that the circuit may be suitably stabilized by introducing a definite unbalance at some place in the transmission circuit including the push-pull amplifier and extending from the terminals of coupling 21 to the rectifier 44, as for example, by placing the resistor 60, in the anode-cathode circuit of that one of the units 4 or 5, which causes the amplifier to operate in a degenerative sense with respect to the automatic volume control or feedback circuit 45. The resulting stabilization of operation serves to limit peak amplitudes satisfactorily to the maximum set by the automatic volume control circuit 45.

It will be apparent that when the number of stages of amplification is changed from that shown in the drawing, or when the phase of any

of the couplings in said transmission circuit, is reversed from that utilized in the circuit of the drawing, it may be necessary to change the position of the unbalancing means, as for example by changing the position of the resistor 60, to the other side of the circuit so that the unbalance of the circuit is reversed 180° in phase, in order to produce degeneration around the closed path formed by the amplifier in combination with the automatic volume control circuit 45.

The value of the resistance 60, or other unbalancing means introduced in one side of the transmission circuit, referred to above is preferably not less than that necessary to compensate for any undesired unbalance due to inherent differences between amplifying units of the same type utilized in the push-pull stage 2, and is preferably of sufficient value to produce a safe margin of unbalance in excess of that necessary to compensate for said tube or amplifying unit differences, so that the desired stability is achieved irrespective of the relative positions of the unequal amplifying units or tubes in the push-pull stage 2.

The invention is not limited to the use of amplifiers of the space current type in the push-pull stage 2, but is applicable to various other types of amplifiers, and the form of the unbalancing means and its position in the transmission circuit may have any of a wide range of variations without departing from the invention as set forth in the appended claims.

What is claimed is:

1. In an amplifying system having a push-pull amplifying stage, wherein two amplifying units have individual input circuits providing push-pull input terminals for signals to be amplified, a portion of each said input circuit being in common and including a coupling having automatic volume control input terminals, and a feedback circuit including rectifying means responsive to an amplified wave derived from the output of said push-pull stage and connected with said volume control input terminals for transmitting volume control impulses thereto, the combination wherein there is provided a transmission circuit including said push-pull stage and extending from said volume control input terminals to said rectifying means, said transmission circuit including predetermined circuit unbalancing means for producing a circuit unbalance not less than any circuit unbalance due to inherent differences between amplifying units of the same type in said push-pull stage, said unbalancing means being in degenerative phase relation with said feedback circuit.

2. In an amplifying system according to claim 1, the combination wherein said transmission circuit includes two conducting elements positioned respectively in corresponding positions in opposite sides of said transmission circuit, the resistances of said elements being substantially different from each other, the difference between said resistances constituting said circuit unbalancing means.

3. In an amplifying system according to claim 1, the combination wherein each of said amplifying units includes an electron discharge device having an anode, a cathode, an electron control element, and an anode-cathode circuit external to said device, said anode-cathode circuits having a difference of resistance constituting said circuit unbalancing means.

4. In an amplifying system according to claim 1, the combination wherein said rectifying means includes a rectifier of the full-wave type for transmitting rectified impulses to said volume control input terminals.

5. In an amplifying system according to claim 1, the combination wherein said rectifying means includes a rectifier of the full-wave type for transmitting rectified impulses to said volume control input terminals, a source of potential being provided in said feedback circuit between said rectifier and said volume control input terminals in opposition to the output of said rectifier.

6. An amplifier having a push-pull amplifying stage including two amplifying units having individual input circuits providing push-pull input terminals for signals to be amplified, a portion of each said input circuit being in common and including a coupling having input terminals for automatic volume control impulses, a rectifier coupled with the output of said amplifier and having a direct current output connection with said volume control input terminals, said amplifying units being of the same nominal type but having an inherent predetermined difference in characteristics whereby there is produced an unbalanced transmission characteristic for impulses applied to said volume control terminals, and auxiliary transmission unbalancing means responsive to waves transmitted to said amplifier, said auxiliary unbalancing means having an unbalanced characteristic greater than that produced by said inherent difference in said amplifying units, said auxiliary unbalancing means being in degenerative phase relation with respect to the feedback path formed by said rectifier connection with said volume control terminals.

7. An amplifier according to claim 6, wherein said auxiliary unbalancing means includes a partially balanced circuit having a conductor of given resistance in one side of said circuit and a corresponding conductor of greater resistance in the other side of said circuit.

8. An amplifier according to claim 6, wherein said amplifier includes a cathode, an anode, and electron control means, and said auxiliary unbalancing means includes means for making the normal resistance of the anode-cathode circuit of one of said amplifying units greater in value than that of the anode-cathode circuit of the other of said amplifying units.

9. An amplifier according to claim 6, wherein the said auxiliary unbalancing means includes a partially balanced circuit having a conductor of given resistance in one side of said circuit and a corresponding conductor of greater resistance in the other side thereof, said rectifier being of the full-wave type for transmitting rectified current to said volume control terminals.

10. An amplifier according to claim 6, wherein said auxiliary unbalancing means includes a partially balanced circuit having a conductor of given resistance in one side of said circuit and a corresponding conductor of different resistance in the other side thereof, said rectifier being of the full-wave type for transmitting rectified current to said volume control terminals, said direct current connection including a source of direct current potential opposed to the output of said rectifier.

LUCIEN P. TUCKERMAN,