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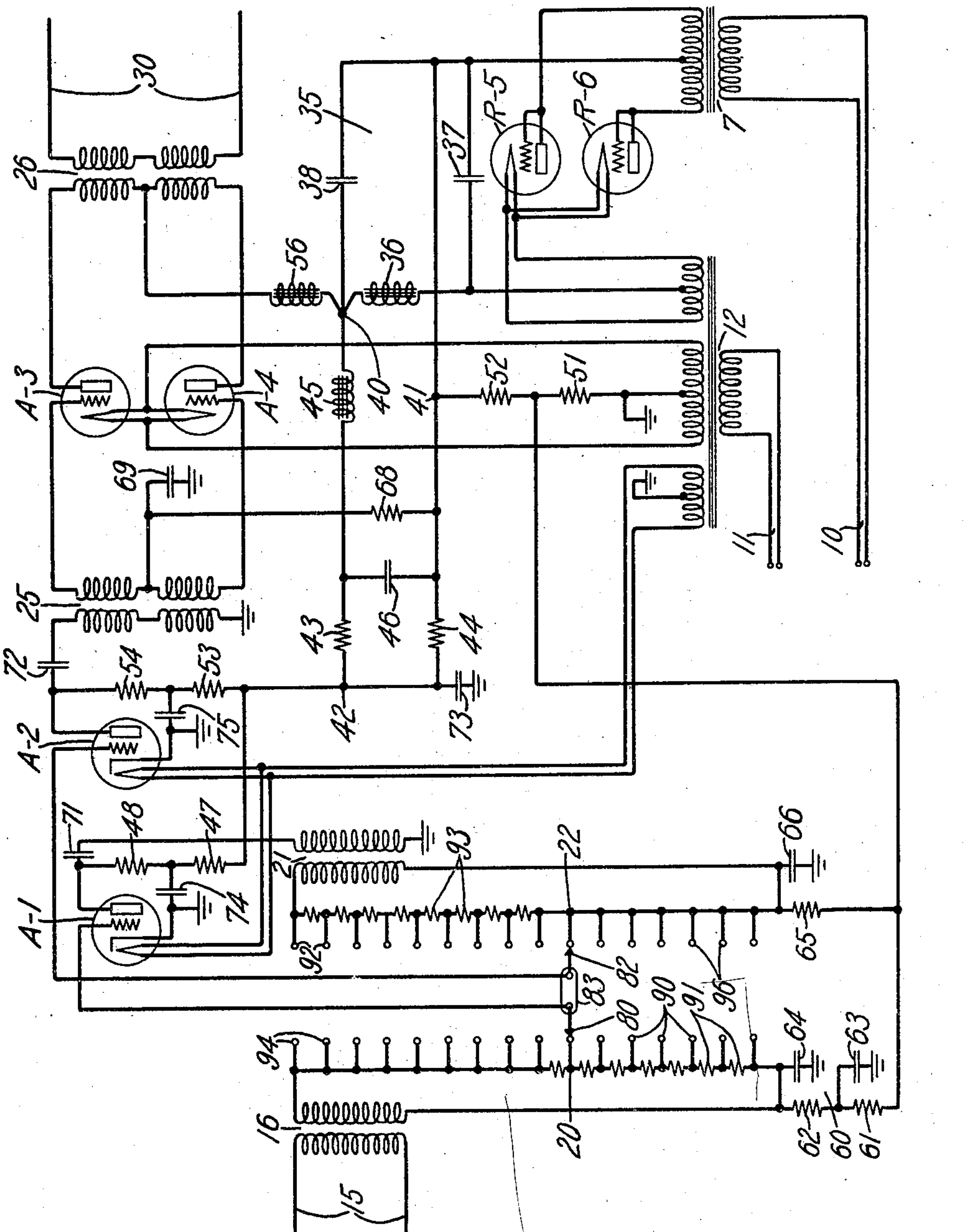

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WAVE TRANSMISSION SYSTEM

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This invention relates to wave transmission systems and especially to electric wave transmission systems employing amplifiers or electric space discharge devices.

Objects of the invention are to reduce deleterious noise effects in such systems and, specifically, to so control their gain or transmission efficiency as to reduce the noise effects and avoid overloading the discharge devices or amplifiers.

In one specific aspect the invention is a vacuum tube amplifier with two amplifying stages in tandem relation, and with an input, gain adjusting potentiometer and an interstage, gain adjusting potentiometer, and to insure that as far as practicable without danger of overloading the first stage any transmission loss produced by the potentiometers will occur in the second or interstage potentiometer so that effects of tube noise or other disturbance originating in or entering the system between the two potentiometers will be reduced, the potentiometers are so constructed and so mechanically connected that the first potentiometer has substantially its minimum loss setting or adjustment except when the second potentiometer has some adjustment in which it gives a voltage reduction approximately equal to or at least comparable to the difference between the voltage applied to the second potentiometer as a consequence of the voltage applied to the grid of the first tube and the latter voltage, and the load capacity of the first tube is made sufficiently great to avoid likelihood of the amplitudes of the waves impressed on the grid of that tube being so great as to cause wave distortion in the tube. As indicated in C. W. Green Patent 1,607,980, November 23, 1926, in amplifiers with input and interstage potentiometers or gain adjusting devices, as far as merely avoiding possibility of overloading the first stage is concerned, the first potentiometer rather than the second ordinarily is the preferable potentiometer for introducing transmission loss, in systems where the waves fed to the amplifier may at times have such amplitudes as to cause overloading of the first stage unless the first potentiometer is set to introduce sufficient loss at those times. However, where tube noise becomes objectionable, as for example because of the type of tubes or tube energization employed or conditions of acoustic feed back or mechanical vibration under which the tubes are operated, it may become advisable to provide for the reduction of the tube noise, and this can be done as indicated above without producing likelihood of overloading. In order that the portion of the total potentiometer loss that occurs in the second potentiometer before substantial loss occurs in the first potentiometer may be large without danger of overloading, the load capacity of the first stage may be made comparable to or even substantially greater than that of the succeeding or second stage. This high load capacity may be attained in any suitable way or ways, such as by employing a tube or tubes of inherently high load capacity in the first stage, or operating the tube or tubes of the first stage at high plate potentials and high negative grid potentials. The expression "load capacity" as used in the specification and claims, refers to the amplitude of the input waves that can be applied to the tube without causing the tube to produce substantial distortion in the waves that it transmits.

The noise reduction in accordance with the principles of the invention is of special utility in rendering practicable amplifiers of high gain for waves of very low energy level where the amplifiers require a wide range of volume control or gain variation and have in the first stage a heater type or uni-potential cathode type of tube that employs alternating current for heating its cathode.

For simplicity in explaining the principles of the invention, particular reference has been made to two stages of amplification and an input potentiometer and an interstage potentiometer. However, the application of the invention and the scope of the claims are not restricted to the control of two potentiometers or gain adjusting devices in the manner described but extend to control in such manenr of any desired number of potentiometers or gain adjusting devices in any desired positions with respect to the amplifiers or space discharge tubes of a circuit.

For example, three like potentiometers may be operated by a single shaft and may be respectively connected in the input circuits of the first three stages of a vacuum tube amplifier and may respectively control the voltages applied to the grids of the vacuum tubes in those stages, the movement of the shaft to reduce the amplifier gain first causing the potentiometer in the input circuit of the vacuum tube in the third stage to attenuate the voltage to be applied to the grid of that tube until the setting of substantially maximum attenuation for that potentiometer has been reached, and then causing the potentiometer in the input circuit of the vacuum tube of the second stage to attenuate the voltage to be applied to the grid of that tube until the setting of substantially maximum attenuation for that potentiometer has been reached, and then causing the potentiometer in the input circuit of the vacuum tube of the first stage to attenuate the voltage to be applied to the grid of that tube until the setting of maximum attenuation for that potentiometer has been reached. The claims are intended to apply to such a system.

Other objects and features of the invention will be apparent from the following description and claims.

The single figure of the drawing is a diagram of a vacuum tube amplifier embodying the invention.

The amplifier shown is a three stage amplifier, suitable for use in, for example, public address systems or sound reproducing systems employed for producing synchronized or non-synchronized sound pictures. The first two stages comprise uni-potential cathode tubes A—1 and A—2 respectively and the third stage comprises two tubes A—3 and A—4 in push-pull connection. Two tubes R—5 and R—6 are used for rectifying current obtained through a voltage step up transformer 7 from a 110 volt, 60 cycle power supply circuit 10. The rectified current is used to supply the grid and plate potentials for all stages. The currents for heating the filaments of all five of the tubes are alternating currents obtained from a power supply circuit 11 through voltage step down transformer 12. The tubes A—1 and A—2 may be for example of the heater type disclosed in Freeman and Wade British Patent 209,415 assigned to the Westinghouse Electric and Manufacturing Co., or the type disclosed in French Patent 593,321, May 22, 1925 or the type disclosed in U. S. Patent to M. J. Kelly, 1,678,145, July 24, 1928.

Waves to be amplified are impressed on input transformer 16 from amplifier input circuit 15. They may be, for example, waves corresponding to sounds to accompany motion pictures either synchronized or not synchronized with said sounds. The waves are transmitted through that transformer to an amplifier input potentiometer or adjustable gain controlling attenuator 20 in the input circuit of tube A—1, thence through that tube and an interstage transformer 21 to an interstage potentiometer 22, and thence through tube A—2 interstage transformer 25, tubes A—3 and A—4, and output transformer 26 to amplifier output circuit 30.

The currents rectified by tubes R—5 and R—6 pass through a filter 35, comprising inductance coil 36 as a series arm and condensers 37 and 38 as shunt arms, for suppressing voltage and current fluctuations. Points 40 and 41 may be regarded as the positive and negative output terminals respectively of the filter 35.

A potential from which plate potential for tubes A—1 and A—2 is obtained is derived from the junction point 42 of voltage dividing resistances 43 and 44, which are connected across points 40 and 41 by a filter consisting of an inductance coil 45 as a series arm and a condenser 46 as a shunt arm. This filter assists the filter 35 in suppressing voltage and current fluctuations. The steady plate current for tube A—1 passes from point 42 through resistances 47 and 48 to the plate of the tube, thence to the grounded cathode of the tube, and thence through resistances 51 and 52 to point 41. The steady plate current for tube A—2 passes from point 42 through resistances 53 and 54 to the plate of the tube, thence to the grounded cathode, and thence through the resistances 51 and 52 to the point 41.

The steady plate current for tubes A—3 and A—4 passes from the point 40 through a choke coil 56 for suppressing current fluctuations, the primary windings of transformer 26, the tubes A—3 and A—4, the middle pair of secondary windings of the transformer 12, and resistances 51 and 52, to the point 41.

Negative grid biasing potential for the tubes A—1 and A—2 is obtained from the voltage drop in resistance 51. The biasing potential for the grid of tube A—1 is applied from the junction of resistances 51 and 52 through a resistance and condenser filter 60 and the secondary winding of transformer 16 and the potentiometer 20. The filter 60 consists of resistances 61 and 62 as series arms and condensers 63 and 64 as shunt arms.

The biasing potential for the grid of tube A—2 is applied from the junction of resistances 51 and 52 through a filtering series resistance and shunt condenser 65 and 66 and the secondary winding of transformer 21 and the potentiometer 22.

Negative grid biasing potential for the tubes A—3 and A—4 is obtained from the voltage drop in resistances 51 and 52. The biasing potential is applied from point 41 through a filtering series resistance 68 and shunt condenser 69 and the secondary windings of transformer 25.

Condensers 71 and 72 are the usual stopping condensers, of negligibly low reactance for the frequencies of the wave to be amplified, for blocking passage of direct current.

Fluctuations of the plate current supply for tube A—1 are further prevented by a filter consisting of the resistances 47 and 48 as series arms and condensers 73 and 74 as shunt arms. Fluctuations of the plate current supply for tube A—2 are further prevented by a filter consisting of the resistances 53 and 54 as series arms and condensers 73 and 75 as shunt arms.

The volume control potentiometers 20 and 22 that control the amplitudes of the waves to be applied to the grids of the first two tubes have their movable contacts 80 and 82 mounted on the same shaft or movable element 83. The potentiometer 20 has fixed contacts 90 which the contact 80 successively engages in its movement and which are connected by resistances 91. The potentiometer 22 has fixed contacts 92 which the contact 82 successively engages in its movement and which are connected by resistances 93. The contacts 90 are so located relatively to the contacts 92 in the direction of motion of the contacts 80 and 82, that as the shaft 83 is rotated or moved to move the contacts 80 and 82 from their position of minimum loss in the potentiometers in order to reduce the gain of the amplifier, during the first part of the travel of contacts 80 and 82, the contact 82 engages contacts 92 successively and causes the loss introduced by potentiometer 22 to increase step by step to its maximum value while the loss introduced by potentiometer 20 remains at its minimum value, and during the remainder of the travel of contacts 80 and 82 to decrease the amplifier gain, the contact 80 engages the contact 90 and causes the loss introduced by potentiometer 20 to increase step by step to its maximum value while the loss introduced by potentiometer 22 remains at its maximum value. When the contacts 80 and 82 are moved in the opposite sense, to increase the amplifier gain, the loss in potentiometer 20 is reduced to its minimum value before the loss in potentiometer 22 is changed from its maximum value. Attenuation occurring in potentiometer 22, at any time, is not only attenuation of the signal and noise waves applied to the amplifier from circuit 15, but is also attenuation of any noise entering or generated in the system at any portion of the system preceding the potentiometer 22, notably the noise introduced by tube A—1. Thus, the attenuation which takes place in the grid circuit of the second tube affects equally the signal and the noise generated or picked up in the first stage. Such additional attenuation as may be necessary over and above that obtainable in the second potentiometer is obtained in the first potentiometer.

If desired, potentiometer 20 can include stationary contacts 94 all at the same potential, one positioned opposite each of the contacts 92, and potentiometer 22 can include stationary contacts 96 all at the same potential, one positioned opposite each of the contacts 90, so that contacts 80 and 82 can each bear on a fixed contact in each setting of the potentiometer.

The voltage reduction introduced by potentiometer 22 before potentiometer 20 is moved from its minimum attenuation setting can be made sufficiently great to prevent overloading tube A—2 by operation of tube A—1 at its maximum load capacity. When these tubes have the same load capacity, this voltage reduction can be made substantially equal to or at least comparable to the difference between the voltage applied to the potentiometer 22 as a consequence of the voltage applied to the grid of tube A—1 and the latter voltage. In other words, when these tubes have the same load capacity, the voltage attenuation inserted by potentiometer 22 before potentiometer 20 is moved from its minimum attenuation setting can be made substantially equal to or at least comparable to the voltage gain that the circuit gives between the grid of tube A—1 and the input side of the potentiometer 22. In order that the attenuation introduced by potentiometer 22 before the potentiometer 20 is moved from its minimum loss setting may be made large without overloading tube A—1, the load capacity of that tube may be made comparable to or even substantially greater than that of the succeeding tube. Then the voltage attenuation inserted by potentiometer 22 before potentiometer 20 is moved from its minimum attenuation setting can be made substantially greater than the voltage gain that the circuit gives between the grid of tube A—1 and the input side of the potentiometer 22.

If desired, the first stage can be a push-pull stage (having tubes of the uni-potential cathode type, or other type) in order to reduce (in the general manner indicated in D. G. Blattner Patent 1,483,273, Feb. 12, 1924) noise resulting for example from the use of alternating current to energize the heater elements or the filaments of the tubes of that stage. Then if the tubes used in the first two stages are of the same kind or of equal load capacity, the load capacity of the first stage (i. e. the magnitude of the voltage that can be applied between its girds without causing it to distort the signal) will be larger than the load capacity of the second stage; and the voltage attenuation inserted by potentiometer 22 before potentiometer 20 is moved from its minimum attenuation setting can be made substantially greater than the voltage gain that the circuit will give between the grids of the first stage and the input side of the potentiometer 22, or in other words, can be made sufficiently great to prevent overloading tube A—2 by operation of the preceding push-pull stage at its maximum load capacity.

In one system embdoying the invention and having the circuit configuration given in the drawing, the tubes A—1 and A—2 are Western Electric Company, Inc., Type 247—A vacuum tubes operated with the same plate potential (90 volts) and with substantially the same negative grid biasing potential (3 volts), the tubes A—3 and A—4 being Type 205—D tubes of the same company. The gain of the amplifier is about 84 decibels, the gains of the first, second and third stages being approximately 30 db., 30 db. and 35 db. respectively. In that particular amplifier the maximum attenuation of potentiometer 22 is 30 db. and the maximum attenuation of potentiometer 20 is 36 db. These numerical values are given merely by way of example, and the invention is not to be regarded as limited thereby.

Attention is directed especially to the following desirable features of the system of the invention:

1. A constant ratio of signal strength to noise generated in the stages preceding that in which the attenuation is being obtained is maintained over the attenuation range obtainable in that stage.

2. Use is made of the large load carrying capacity of the initial tubes to keep the ratio of signal to noise constant. This excess load carrying capacity in the initial stages results from the fact that in an amplifier it is, in general, advantageous to use as many vacuum tubes as possible of the given kind, and to operate these tubes at like "B" and "C" potentials. After advantage has been taken of any excess load carrying capacity of a given stage or stages preceding a given potentiometer, any further attenuation desired is obtained in the stages preceding the given potentiometer.

3. A high gain amplifier may be given a high range volume control and so be used at low gain without increase in the ratio of noise to signal. This is because the gain in each stage is approximately counteracted by the attenuation in the succeeding stage.

What is claimed is:

1. A circuit comprising two adjustable transmission efficiency controllers, and means connecting them in successive relation and introducing disturbing waves in the circuit between them, and means interlocking said controllers for insuring that the first controller is set for substantially its maximum transmission efficiency except when the second controller is in a setting in which it renders its output voltage at least substantially as low as the output voltage of the first controller.

2. A signal transmitting circuit comprising an electric space discharge device, an adjustable transmission efficiency controller feeding signaling waves to said device, a translating device, a second transmission efficiency controller for transmitting signaling waves from said first device to said translating device, and means interlocking said controllers for insuring that the first controller is set for substantially its maximum transmission efficiency except when the second controller is in a setting in which it prevents the transmission level of the waves that it feeds to said translating device from being so great as to cause the latter device to produce distortion of the signal when the transmission level of the waves fed to said first device from said first controller is substantially as high as the maximum transmission level that said first device can receive from said first controller without producing distortion of the signal in said first device.

3. A signal transmitting circuit comprising an electric space discharge device, an adjustable transmission efficiency controller feeding signaling waves to said device, a translating device, a second transmission efficiency controller for transmitting signaling waves from said first device to said translating device, and means interlocking said controllers for insuring that the first controller is set for substantially its maximum transmission efficiency except when the second controller is in a setting in which it prevents the transmission level of the waves that it feeds to said translating device from being so great as to cause the latter device to produce distortion of the signal when the transmission level of the waves fed to said first device from said first controller is at least substantially as high as the maximum transmission level that the second device can receive from said second controller without producing distortion of the signal in said translating device.

4. A circuit comprising an electric space discharge amplifying device having an anode, a cathode and a discharge control element, an input circuit for said device, an adjustable voltage attenuator in said input circuit, an adjustable voltage attenuator having input terminals fed from said device, and means interlocking said attenuators for insuring that the first attenuator is set for substantially its minimum attenuation except when the second controller is set to give a voltage attenuation at least of the order of magnitude of the voltage amplification from said discharge control element and cathode of said first tube to the input terminals of said second voltage attenuator.

5. A circuit comprising two adjustable transmission efficiency controllers and means connecting them in tandem relation and introducing disturbing waves in the circuit between them, and means interlocking said

controllers for insuring that, as far as practicable without overloading said first means, any decrease in transmission efficiency produced by said controllers occurs in the controller fed from said first means, said first means comprising a vacuum tube having a uni-potential cathode and a heater element for heating said cathode, and means for supplying alternating heating current to said element.

6. A vacuum tube amplifier comprising amplifying stages, an adjustable input potentiometer for the first of said stages, an adjustable interstage potentiometer connected between said first stage and the next stage, said potentiometers being so constructed and related that the first potentiometer has substantially its minimum loss setting or adjustment except when the second potentiometer has substantially its maximum loss adjustment, the maximum loss of the second potentiometer being as great as practicable without overloading the first stage prior to overloading succeeding stages, and the load capacity of the first stage being at least substantially as great as that of the second stage.

7. A circuit comprising two tandem connected stages of electric space discharge amplifying devices each having an input circuit and a discharge control element, the load capacity of the first of said devices being at least as great as that of the second, adjustable transmission efficiency controllers, one in the input circuit of each of said devices, and means interlocking said controllers for insuring that the first controller is set for substantially its maximum transmission efficiency except when the second controller is set to give a voltage reduction substantially equal to the difference between the voltage applied to the second controller when the first device works at the maximum voltage its discharge control element can stand without causing distortion in the first device and the maximum voltage that the discharge control element of the second device can stand without causing distortion in the second device.

In witness whereof, I hereunto subscribe my name this 6th day of September, 1929.

ROBERT A. MILLER.