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TRANSMISSION SYSTEM

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FIG. 1

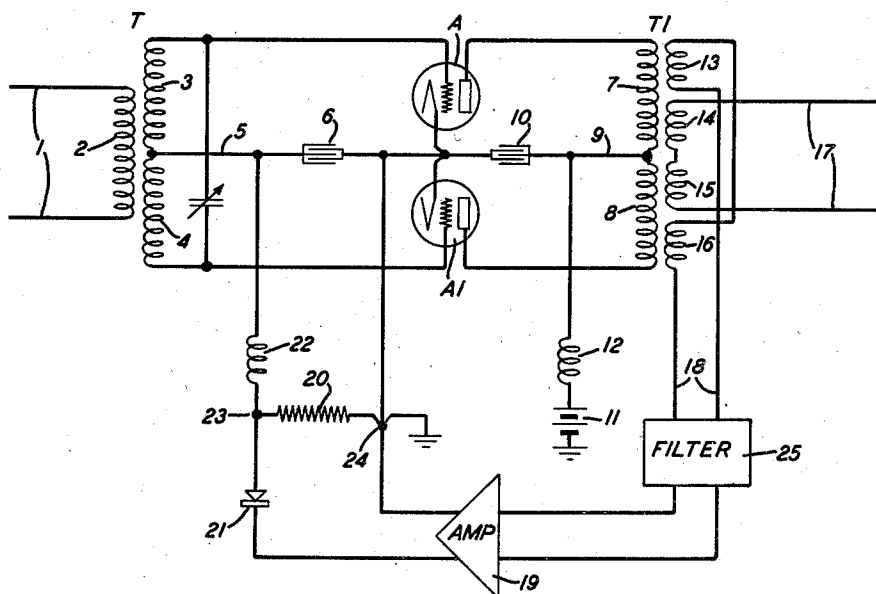
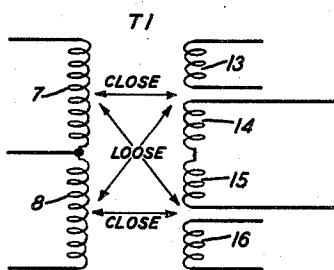


FIG. 2



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TRANSMISSION SYSTEM

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13 Claims. (Cl. 178-44)

This invention relates to transmission systems and particularly to arrangements for controlling and regulating the gain in these systems.

The objects of the invention are to regulate the gain in a transmission system in such a manner as to obtain the most satisfactory transmission levels consistent with good quality; to utilize the undesirable signal components present in the system to regulate and control the transmission level; and otherwise to effect improvements in systems of this character.

Systems have been devised in the past for utilizing the signal currents in the output circuit of an amplifier for the purpose of controlling the gain of the amplifier. And in some cases it has been suggested to make use of the noise currents, which frequently accompany the useful signal currents in a transmission system, to regulate and maintain the energy level in the system at certain desired values.

According to the present invention advantages are secured over these prior systems by means of a gain control arrangement in which the noise currents are selectively separated from the signal currents in the output circuit of an amplifier and then applied to the input control circuit of the amplifier to control the gain of the amplifier and maintain the energy level in the output circuit within certain desired limits. The separation of the noise currents is effected by providing the output transformer with aiding windings in which the useful signal energy flows to the work circuit and also with neutralizing windings in which the signal currents are balanced out but which do not fully neutralize the noise currents because of the coupling of the winding and because of the random nature of said currents. These unneutralized noise currents are then delivered by the neutralizing windings of the transformer to a gain control circuit, in which they are utilized to control the input potential of the amplifier.

The foregoing and other advantages of the invention will be explained more fully in the following detailed specification and will also be set forth in the appended claims.

In the drawing, which accompanies the specification and forms a part thereof, Fig. 1 represents any stage of translation, such as a detector or amplifier, in a wave transmission system. More specifically it shows two vacuum tubes connected in push-pull relationship for amplifying signal waves delivered to them from an incoming circuit and for delivering the amplified waves to an outgoing work circuit. And Fig. 2 is a dia-

gram showing the coupling of one of the transformers.

In wave transmission systems and particularly where vacuum tube circuits are used for translation purposes, as to obtain amplification of the signal energy, the noise currents present in the system have a detrimental effect on the quality of the transmission and must be taken definitely into account if the best results are to be had. These noise currents are a phenomenon resulting largely from thermal conditions in the physical parts of the system; they are of a random nature and occur to a large extent in accordance with laws that are not readily ascertainable. They are, however, known to be proportional to the absolute temperature of the physical elements of the system, to the resistance values of the circuit elements, and to the width of the frequency band being transmitted. Reference may be had to an article by J. B. Johnson entitled "Thermal agitation of electricity in conductors" published in Physical Review, volume 32, pages 97 to 109, for a discussion of the nature and magnitude of thermal noise currents. These noise currents mingle with the useful signal currents, and it is their presence that determines and limits the amount of amplification that can be effected at any given stage. As the gain of the amplifier is raised, the amplified noise energy becomes more and more disturbing until a point is reached beyond which it is inadvisable to increase the gain. And it is because of this relation between the intensity of the harmful noise currents and the gain applied to the useful signals that it is possible to utilize the noise currents as a measure of the permissible gain for the signal currents and to maintain the transmission level at the best values consistent with the quality required.

Referring now particularly to the drawing, there is here shown a single translating and amplifying stage in a transmission system. The amplifying stage is shown as comprising a pair of translating devices, each of which may be a space-discharge tube of any well-known type. While an amplifying stage is illustrated and described herein, it should be understood that the invention may be applied to a stage where demodulation occurs or to any other translation stage in a transmission system. Likewise, it will be obvious that the specific construction of the amplifying or translating devices may vary.

The incoming circuit 1 shown in the drawing is connected to the primary winding 2 of the input transformer T. The two secondary wind-

ings 3 and 4 of the transformer T are connected in series, the free terminals being connected respectively to the grid control elements of the space discharge amplifiers A and A—1. The mid-point of the connected windings 3 and 4 is joined by conductor 5 to a common point between the cathode elements of the amplifiers A and A—1. A condenser 6 is included in the conductor 5. The plate or anode element of the device A is connected to one terminal of the primary winding 7 of the input transformer T—1, and the anode of the other device A—1 is connected to one terminal of a second primary winding 8 of said transformer. The other terminals of the windings 7 and 8 are connected to form a mid-point, and this mid-point is joined by a conductor 9 to the common point of the cathodes of the devices A and A—1. A condenser 10 is included in the conductor 9. A battery 11 is connected through a choke coil 12 or any other suitable impedance to the conductor 9 for the purpose of furnishing plate current to the tubes A and A—1. With the circuit arrangement thus described the amplifiers A and A—1 are connected in the well-known push-pull relationship. The transformer T—1 is provided with four secondary windings 13, 14, 15 and 16. The windings 14 and 15 are connected to each other in series aiding and to the outgoing transmission circuit 17. The other two coils 13 and 16 are connected to each other in series opposing and to the auxiliary or control circuit 18. The primary winding 7 is preferably coupled closely to windings 13 and 14 and loosely to windings 15 and 16, and the primary winding 8 in like manner is coupled closely to windings 15 and 16 and loosely to windings 13 and 14. This coupling arrangement between the primary and secondary windings is illustrated schematically in Fig. 2, and its purpose will be discussed more fully later.

The control circuit 18, which includes the opposing windings 13 and 16, is connected to the input side of any suitable amplifier 19. A frequency selective device 25 of any suitable kind, such as a filter, is included in the control circuit 18. The output circuit of the amplifier 19 includes a resistance 20 and a rectifying device 21. The poling of the rectifier 21 is such that the amplified current in the output circuit of the amplifier 19 always flows in the same direction, namely, the direction in which the right-hand grounded terminal 24 of the resistance 20 is positive with respect to the other terminal 23 of the resistance. The terminals of the resistance 20 are also connected across the condenser 6, and a choke coil 22 or other suitable impedance is included in the connection as shown.

The operation of the system will now be described. Assume that signal currents are flowing over the transmission line 1. These currents pass through the primary winding 2 of the transformer T and induce potentials in the secondary windings 3 and 4. These induced potentials cause in the well-known manner changes of potential on the grid elements of the tubes A and A—1, resulting in turn in the flow of signal currents through the windings 7 and 8 in the output circuits of said tubes. The signal current flowing in the winding 7 bears a definite phase relation to the signal current flowing in the winding 8, and these currents cause equal potentials to be induced in those secondary windings of the transformer which have the same degree of coupling with respect to said primary windings 7

and 8. For example, the potential induced in the winding 14 from the closely coupled winding 7 is equal to the potential induced simultaneously in the winding 15 from the closely coupled winding 8. Similarly, the signal current induced in the winding 15 from the loosely coupled primary winding 7 is equal to the signal current induced in the winding 14 from the loosely coupled primary winding 8. These induced potentials in windings 14 and 15 add to cause a resultant signal current flow in the outgoing transmission line 17. Also, since equal currents are flowing in windings 7 and 8, the potential induced in the winding 13 from the closely coupled winding 7 is equal to the potential induced in the winding 16 from the closely coupled winding 8, and the potential induced in the winding 13 from the loosely coupled winding 8 is equal to the potential induced in the winding 16 from the loosely coupled winding 7. These equal potentials in the windings 13 and 16 being of opposite phase completely neutralize each other and no signal current flows in the auxiliary circuit 18. There are also present in the output circuit of the amplifier tubes, as was explained hereinbefore, disturbing currents which result from different causes and which are usually referred to as noise currents. Because of their random nature, the noise currents flowing in the primary winding 7 of the transformer are not in phase with the noise currents flowing in the other primary winding 8. Since the winding 7 is coupled closely to winding 13 and loosely to winding 16, the potential induced in the winding 13 as a result of the noise current in winding 7 is greater than the opposing potential induced in the winding 16 from the winding 7. Accordingly, there is as a result of the noise currents flowing in winding 7, a certain voltage across windings 13 and 16 which is obtained by subtracting from the greater potential in the winding 13 the lesser potential in the winding 16. In a similar manner the noise currents flowing in the winding 8 at the same instant induce a greater potential in the winding 16 and a lesser potential in the winding 13, and the resultant of these two last-mentioned potentials is a voltage which is out of phase with the voltage resulting from the primary winding 7. Therefore, there appears across the conductors of the control circuit 18 a resultant voltage which causes a corresponding current to flow toward the input circuit of the amplifier 19. This current is amplified by the device 19 to produce a voltage across the resistance 20 which varies in magnitude with the intensity of the noise current flowing in circuit 18. As the noise currents in the system increase in intensity, the terminal 23 of the resistance 20 becomes more and more negative with respect to the other terminal 24 of said resistance. This increases the negative potential on the grid elements of the tubes with respect to their cathodes and correspondingly reduces the gain of the amplifiers.

Since even harmonic currents, should they appear in the output circuits of the amplifiers, bear a phase relationship for the two amplifiers, operating in a push-pull manner, opposite the phase relation of the fundamentals and odd-order currents for the two amplifiers, these even-order currents may appear in the circuit 18. That is, if the odd-order terms are in opposing phase in the common circuit 9 and coils 13 and 16 are wound to exclude these components from circuit 18, the even-order components are in phase in circuit 9 and would then appear in circuit 18.

These even-order currents may be effectively eliminated from circuit 18 by means of the filter 25. The filter 25 may be designed to exclude the first even-order component and all higher frequency components, leaving in the circuit 18 all noise currents having frequencies under that of the second harmonic. Or, to obtain a greater range of noise currents, the filter may be of the well-known multi-peak type so designed that it eliminates the successive even-order components, allowing all noise currents having frequencies between these successive components to flow to the amplifier 19.

What is claimed is:

1. The combination in a transmission system of a transmission line having a translating device therein, input and output circuits for said device, a coupling transformer in the output circuit having its windings arranged to selectively separate the thermally produced noise currents and signal currents in said output circuit, and means for utilizing said selected noise currents to control the voltage in the input circuit of said translating device.
2. The combination in a transmission system of an amplifier having input and output circuits, an incoming transmission line coupled to said input circuit, an outgoing transmission line, a coupling transformer between said output circuit and outgoing line and having its windings arranged to separate the thermally produced noise currents from the signal currents in said output circuit, a control circuit for receiving the separated noise currents from said transformer, and means responsive to the noise currents in said control circuit for applying control potentials to the input circuit of said amplifier.
3. The combination in a transmission system of an amplifier having input and output circuits, an incoming transmission line coupled to said input circuit, an outgoing transmission line, a control circuit, a transformer having a primary winding in said output circuit, a secondary winding for said transformer connected in said outgoing transmission line, other secondary windings for said transformer connected in said control circuit, said other secondary windings arranged to deliver to said control circuit the noise currents induced therein from said output circuit and to effectively neutralize all signal currents induced therein, and means for amplifying the noise currents in said control circuit and utilizing them to control the gain of said amplifier.
4. The combination in a transmission system of an amplifier having input and output circuits, an incoming transmission line coupled to said input circuit, an outgoing transmission line, a control circuit, a transformer having a primary winding in said output circuit, a secondary winding for said transformer for delivering to said outgoing transmission line currents induced therein from said primary winding, a pair of opposing secondary windings for said transformer connected to said control circuit, said latter windings serving to neutralize all signal currents induced therein from said primary winding and to deliver to said control circuit the unneutralized components of the random noise currents induced therein from said primary winding, and means in said control circuit for utilizing said noise currents to control the output signal level of said amplifier.
5. In combination an amplifier having input and output circuits, a coupling transformer con-

nected in said output circuit, a work circuit, a control circuit, a pair of windings for said transformer connected in aiding relation for delivering to said work circuit currents induced from said output circuit, a second pair of windings for said transformer connected in opposition for neutralizing all currents induced with equal intensities in both windings and for partially neutralizing currents induced in said windings in unequal intensities, said second pair of windings serving to deliver to said control circuit all unneutralized currents induced therein, and means for utilizing the currents in said control circuit to control the operation of said amplifier.

6. In combination an amplifier comprising two space-discharge devices, a combined output circuit for said devices having signal currents and random noise currents therein, a transformer having its primary windings connected in said output circuit, a control circuit, secondary windings for said transformer arranged to deliver to said control circuit a portion of the noise currents induced therein from said primary windings and to fully neutralize all signal currents induced therein from said primary windings, and means responsive to said noise currents in said control circuit for controlling the gain of said amplifier.

7. The combination in a transmission system of means for transferring energy from one part of the system to another comprising a transformer having a plurality of secondary windings, two of which are connected in opposition, a primary winding coupled closely to one and loosely to the other of said opposing secondary windings and a second primary winding likewise coupled closely to one and loosely to the other of said opposing secondary windings, and circuit means for delivering the currents in said system to said primary windings.

8. The combination in a transmission system of an incoming circuit, two outgoing circuits, means for transferring energy from said incoming circuit to said outgoing circuits comprising a transformer having a pair of secondary windings connected in the first outgoing circuit, a second pair of secondary windings connected to the second outgoing circuit, a primary winding closely coupled to one of the windings connected to said first outgoing circuit and to one of the windings connected to said second outgoing circuit and loosely coupled to the remaining two secondary windings, and a second primary winding closely coupled to said remaining two secondary windings and loosely coupled to the other two secondary windings.

9. The combination in a transmission system, an incoming circuit, an outgoing circuit, a coupling transformer between said circuits comprising a pair of secondary windings wound in opposing relation, a primary winding closely coupled to the first and loosely coupled to the second of said secondary windings, a second primary winding closely coupled to the second and loosely coupled to the first of said secondary windings, an amplifier serving to deliver to said primary windings currents having both useful and harmful components, the useful currents appearing in phase in said primary windings and the harmful currents appearing out of phase in said primary windings, and means for utilizing the unneutralized currents induced in said secondary windings for controlling the operation of said amplifier.

10. The combination in a transmission system of a transmission line having a translating de-

vice therein, input and output circuits for said device, a coupling transformer in the output circuit having its windings arranged to select thermally produced noise currents and means for utilizing said selected noise currents for controlling the voltage in said input circuit.

11. The combination in a signal transmission of a transmission line having a translating device therein, input and output circuits for said device, a transformer having a primary winding connected in said output circuit, and a control circuit for controlling the voltage in said input circuit, the primary and secondary windings of said transformer being so arranged that noise currents existing in said output circuit as a result of noise currents thermally produced in said input circuit are impressed on said control circuit while signaling currents have no effect on said control circuit.

12. In a transmission system, a transformer having two primary windings and a plurality of secondary windings, said primary windings being energized by currents some components of which are at all times of substantially equal intensity in both windings and some components of which

windings, one of the secondary windings being closely coupled to one of the primary windings and loosely coupled to the other of the primary windings, and another secondary winding being closely coupled to said other primary winding and loosely coupled to said one primary winding, said secondary windings being connected in opposition.

13. In a transmission system, a transformer having two primary windings and a plurality of secondary windings, said primary windings being energized by currents, some components of which are at all times of substantially equal intensity in both windings and some components of which are of random intensity and occurrence in the two windings, one of the secondary windings being closely coupled to both of said primary windings, another secondary winding being closely coupled to one of the primary windings and loosely coupled to the other of the primary windings, and another secondary winding being closely coupled to said other primary winding and loosely coupled to said one primary winding, said other secondary windings being connected in opposition.

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