Nov. 5, 1929. G. T. LORANCE 1,734,219

TRANSMISSION REGULATION

Filed Feb. 27, 1925

Fig. 1

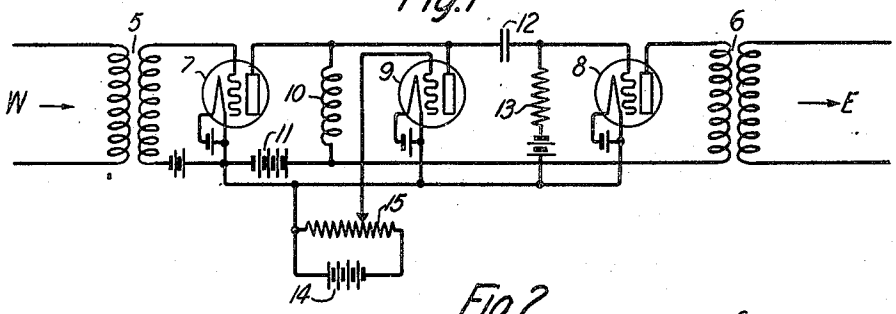


Fig. 2

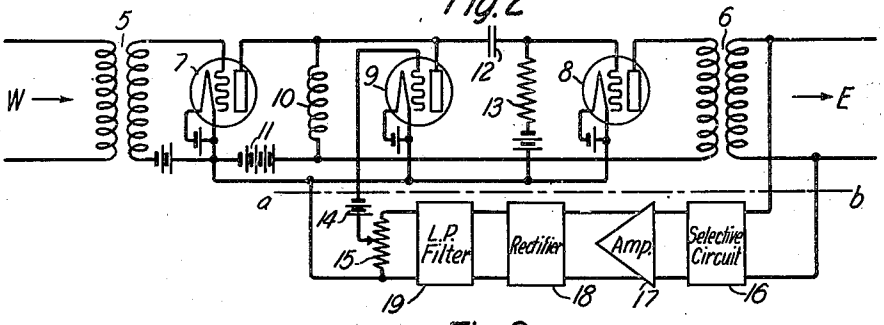


Fig. 3

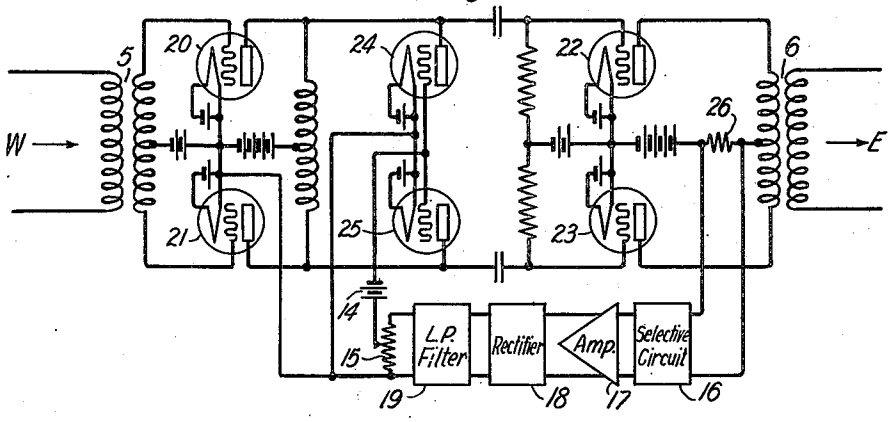
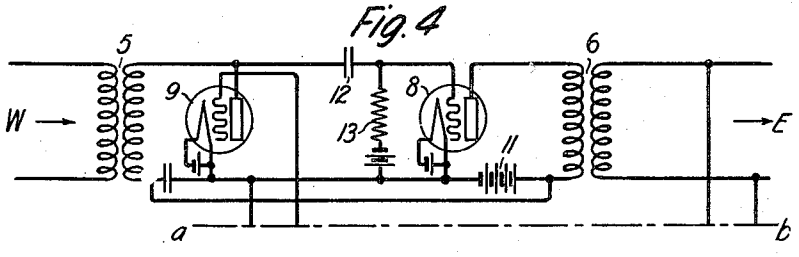


Fig. 4



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UNITED STATES PATENT OFFICE

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TRANSMISSION REGULATION

Application filed February 27, 1925. Serial No. 11,977.

This invention relates to transmission regulation, and particularly to amplifier circuits.

An object of the invention is to adjust the transmission characteristics of a translating device or circuit.

A related object of the invention is to regulate the gain of a vacuum tube amplifier.

Another object of the invention is to maintain the transmission efficiency of a carrier wave signaling system invariable or variable only within narrow limits, under wide variations in transmission conditions.

The invention provides means for regulating the gain of a vacuum tube amplifier by manually or automatically controlling the coupling impedance thereof.

In a particular embodiment of the invention, one or more three-electrode vacuum tubes are employed as coupling impedances between the stages of a vacuum tube amplifier.

The gain of the amplifier is a function of the filament to plate impedance of the coupling tube which, in turn, is a function of its grid potential, and the gain of the amplifier is controlled, in accordance with the invention, by regulating the grid potential of the coupling tube.

The invention is particularly adapted for stabilizing the transmission characteristics of a repeater circuit, such as is employed for example in a carrier wave signaling system. In systems of this type, employing fairly high frequencies, changes in the attenuation of the transmission medium produce corresponding variations in the overall transmission equivalent of the system, and result in large fluctuations in the volume of a telephone or other message being transmitted.

In order to overcome the effects of transmission variations in such systems, it is common practice to subject a pilot current to the same conditions as those affecting the signaling currents, and to utilize the pilot current so transmitted to adjust the transmission at repeaters or other points in the system. Such a system is shown, for example, in Patent No. 1,511,013 to H. A. Affel, issued October 7, 1924.

In accordance with a feature of the present invention, a pilot current is transmitted between the terminals of a carrier signaling system, and is utilized to control the grid potential of a vacuum tube which is employed as the coupling impedance of an amplifier located at some point in the transmission line.

The pilot current is selected from the line at the repeater point, rectified and applied to the grid of the coupling tube. The polarity of the direct current potential impressed on the grid of the coupling tube is such that for an increase in the level of the pilot current, the gain of the amplifier is decreased, and for a decrease in the level of the pilot current the gain of the amplifier is increased.

In the drawing, Figs. 1 to 4, inclusive, are circuit diagrams illustrating different applications of the invention, like reference characters indicating corresponding parts in the several figures.

In Fig. 1, an incoming transmission line section W terminates in the primary winding of an input transformer 5, and an outgoing line section E terminates in the secondary winding of an output transformer 6.

The two-stage amplifier connecting line sections W and E includes a pair of three-electrode vacuum tube amplifiers 7 and 8 connected in tandem. The input circuit of the tube 7 is connected to the secondary winding of transformer 5, and the output circuit of the tube 8 is connected to the primary winding of transformer 6.

The output circuit of the amplifier tube 7 is coupled to the input circuit of the amplifier tube 8 through a shunt impedance controlling tube 9. A constant space current is supplied to the tubes 7 and 9 through choke coil 10 from batery 11, which may also supply space current to the tube 8.

The alternating voltage in the output circuit of tube 7 is impressed upon the grid of the amplifier tube 8, through condenser 12 and resistance 13. In an impedance coupled amplifier the voltage supplied to the grid of the second stage tube depends upon the value of the coupling impedance, being large when the coupling impedance is large compared to the impedance of the first tube,

and decreasing as the ratio between these impedances becomes smaller. Since the impedance of the choke coil 10 and of the resistance 13 may be made very high, the filament to plate impedance of the coupling tube 9, being comparable to the filament to plate impedance of tube 7, will be the controlling factor in the ratio of impedances upon which the voltage impressed upon the grid of tube 8 depends. Hence the gain of the amplifier is a function of the filament to plate impedance of the coupling tube.

Since the gain of the amplifier is a function of the filament to plate impedance of the coupling tube 9, which in turn is a function of its grid potential, it is evident that the gain of the amplifier may be controlled by regulating the grid potential of the coupling tube. The grid circuit of the coupling tube 9 includes the negative polarizing battery 14 and the variable potentiometer 15. The potentiometer 15 may, therefore, be adjusted to vary the grid potential supplied to the coupling tube 9 to increase or decrease the gain of the amplifier.

Fig. 2 shows a one-way repeater for carrier wave signaling systems, provided with means for adjusting the gain of the amplifier in accordance with changes in the transmission efficiency of the line. A two-way repeater may be provided by duplicating the circuit to provide a path for operation in the opposite direction.

In addition to the signaling frequencies which are adapted to be amplified in the repeater, a pilot current is also impressed upon the line section W in the usual manner at the distant terminal, not shown.

The pilot current is selected from the output of the repeater, to the exclusion of all other frequencies, by means of a selective circuit 16, which may be either a tuned circuit or a band filter of well-known type. The selected pilot current is then amplified in an amplifier 17, and rectified by means of a rectifier 18 of any well known type. A low pass filter 19 is included in the output circuit of the rectifier to prevent the transmission of any unrectified components of the pilot current to the grid circuit of the coupling tube 9.

The output of the rectifier 18 is so poled that the direct current potential thus impressed upon the grid of the coupling tube will oppose the direct current potential from the grid polarizing battery 14. The potentiometer 15 is so adjusted that the total grid potential, and hence the filament to plate impedance of the coupling tube 9, will be such as to provide the desired amplifier gain when the transmission efficiency of the line section W is normal. An increase or decrease in the direct current potential in the output of rectifier 18, in response to an increase or decrease in the transmission efficiency of the line section W will, therefore, result in a corresponding change in the filament to plate impedance of the coupling tube 9, and hence will produce a compensating change in the amplifier gain. The amplifier is thus made self-regulating, an increase in the amplitude of the pilot current causing a decrease in the gain of the amplifier, and a decrease in the amplitude of the pilot current causing a corresponding increase in gain.

Fig. 3 illustrates the application of the invention to a balanced amplifier circuit. In this circuit the first stage of the amplifier includes a pair of three-electrode electron discharge tubes 20 and 21 connected in push-pull relation, and the second stage of the amplifier includes a pair of tubes 22 and 23 similarly connected. To provide a variable coupling impedance, tubes 24 and 25 are connected in shunt across the input circuit of tubes 22 and 23 in the manner shown. The grid circuits of tubes 24 and 25 are paralleled with respect to the source of grid potential while the plate circuits are paralleled with respect to the source of plate potential. In all other respects, the grid and plate circuits are connected in a manner similar to that described above. This shunt connection provides an alternating current path consisting of the space paths of tubes 24 and 25 in series. The impedance formed by the two discharge spaces in series is not affected by the voltages impressed on the anodes but is dependent upon the voltage impressed upon the grid circuits of these tubes.

While the pilot current may be picked up in the manner described in connection with the system of Fig. 2, it is found that increased sensitivity may be obtained by utilizing the second harmonic of the pilot current for regulating purposes, as disclosed in a copending application of C. W. Green, Serial No. 5,969, filed January 31, 1925, which became Patent 1,565,925, December 15, 1925. The second harmonic of the incoming pilot current may be picked up across the resistance 26 in the common output path of the second stage amplifier where the level of second order modulation products and second harmonics is highest. The second harmonic is then amplified, rectified and applied to the parallel grid circuits of the coupling tubes. When the attenuation of line section W departs from normal, the gain of the amplifier will be automatically adjusted to compensate for the abnormal line conditions. It will also be seen that increased sensitivity is obtained by using the second harmonic of the pilot current, as the amplitude of the second harmonic will vary as the square of the amplitude of the pilot current.

Fig. 4 shows a single stage amplifier employing a vacuum tube as a coupling impedance in its input circuit. This modification may be substituted for the portion of the system above the dotted line *a—b* of Fig. 2 to

provide a single stage pilot-controlled amplifier. In this case the input impedance of the amplifier tube 8 is controlled by coupling tube 9, the filament to plate impedance of which is automatically regulated in response to changes in the incoming pilot current, in the manner described above.

The invention set forth herein is, of course, susceptible of various other modifications and adaptations not specifically referred to, but included within the scope of the appended claims.

What is claimed is:

1. In a system of transmission regulation, a translating device having input and output circuits, a transmission line connected to said translating device, a three-element electron discharge device having a filament, plate and control element, said filament and plate being associated with said input circuit effectively in shunt to said translating device, and means independent of the instantaneous value of current in said line to control the potential of said control element.

2. In a system of transmission of regulation, an amplifier having divided input and divided output circuits, three-element electron discharge devices each having a filament, plate and control element, said filaments and plates being associated with said input circuit effectively in shunt to said amplifier, and independent of said shunt connection means to control the potential of said control elements.

3. In a system of transmission regulation, a variable transmission line, an amplifier comprising a pair of electron discharge tubes connected in tandem, a coupling impedance comprising an electron discharge tube in shunt to said first mentioned tubes, a source of grid potential for said coupling tube, and means independent of the instantaneous value of current in said line for varying said grid potential to regulate the gain of said amplifier.

4. In a system of transmission regulation, a variable transmission line, a translating device having input and output circuits associated with said line, an electron discharge device in said input circuit in shunt to said translating device, and means independent of periodic changes of current in said line for varying the internal impedance of said discharge device when in accordance with the transmission efficiency of said line.

5. In a system of transmission regulation, a variable transmission line, a translating device having input and output circuits associated with said line, a three-element electron discharge device having its filament and plate connected across said input circuit, a source of grid potential for said discharge device, and means independent of periodic changes of current in said line for varying said grid potential in accordance with the transmission efficiency of said line.

6. In a system of transmission regulation, a variable transmission line over which a pilot wave is transmitted, a translating device having input and output circuits associated with said line, an electron discharge device in said input circuit in shunt to said translating device, and means controlled by said pilot wave for adjusting the internal impedance of said discharge device.

7. In a system of transmission regulation, a variable transmission line over which a pilot wave is transmitted, a translating device having input and output circuits associated with said line, a three-element electron discharge device having its filament and plate connected across said input circuit, a source of grid potential for said discharge device, and means for varying said grid potential in accordance with the amplitude of said pilot wave.

8. In a system of transmission regulation, a variable transmission line over which a pilot wave and signaling waves are transmitted, a repeater comprising a three-element electron discharge device having input and output circuits associated with said line, a second three-element electron discharge device having its filament and plate connected across said input circuit, a source of grid potential for said second discharge device, and means for varying said grid potential in accordance with the amplitude of said pilot wave.

9. In a system of transmission regulation, a variable transmission line over which a pilot wave and signaling waves are transmitted, a repeater associated with said line and comprising a pair of three-element electron discharge devices connected in tandem, a coupling impedance comprising an electron discharge tube in shunt to said first mentioned tubes, a source of grid potential for said coupling tube, and means for varying said grid potential in accordance with the amplitude of said pilot wave.

10. In a system of transmission regulation, a variable transmission line over which a pilot wave and signaling waves are transmitted, a repeater comprising a three-element electron discharge device having input and output circuits associated with said line, a second three-element electron discharge device having its filament and plate connected across said input circuit, a grid circuit including a source of grid polarizing current for said second discharge device, means at said repeater for selecting the pilot wave from said line, means to produce from the selected pilot wave a direct current potential whose amplitude depends upon the transmission conditions to which the pilot wave has been subjected, and means to impress the direct current potential so derived upon said grid circuit in opposite polarity to said grid polarizing current to control the gain of said repeater.

11. In a system of transmission regulation, a variable transmission line over which a

pilot wave and signaling waves are transmitted, a repeater associated with said line and comprising a pair of three-element electron discharge devices connected in tandem, a coupling impedance comprising a three-element electron discharge device in shunt to said first mentioned devices, a grid circuit including a source of grid polarizing current for said coupling device, means at said repeater for selecting the pilot wave from said line, means to produce from the selected pilot wave a direct current potential whose amplitude depends upon the transmission conditions to which the pilot wave has been subjected, and means to impress the direct current potential so derived upon said grid circuit in opposite polarity to said grid polarizing current to control the gain of said repeater.

12. In a transmission system, a variable transmission line, an impedance element the impedance of which is independent of the instantaneous magnitude of the voltages of the transmitted currents, and means to apply a control potential to said element in accordance with the attenuation on said transmission line, said impedance being a function of said applied control potential.

13. In a system for transmission regulation, an amplifier having divided input and divided output circuits, a transmission line connected to said amplifier, three-element electron discharge devices having control elements, said devices being connected in said output circuit effectively in shunt to said amplifier, and means for controlling the potential of said control elements in accordance with the current attenuation in said line but independently of instantaneous values of current therein.

14. In a transmission system, an amplifier having input and output circuits, a transmission line connected to said input circuits an impedance element having two pairs of terminals, two of said terminals being connected across said output circuit means independent of the magnitude of potentials applied to said pair of terminals but dependent on controlled potentials applied to the other pair of terminals for controlling the impedance of said element, and means for automatically varying the potential applied to the last mentioned pair of terminals in accordance with the transmission conditions on said line but independent of periodic changes of potential therein.

15. In a transmission system, an amplifier having input and output circuits, a transmission line connected to said input circuit, an impedance element having two pairs of terminals, two of said terminals being connected across said output circuit means independent of the magnitude of potentials applied across said two terminals but dependent upon controlled potentials applied to the other pair of terminals for controlling the impedance of said element, and means for varying the potential applied to the last mentioned pair of terminals only in accordance with the attenuation on said transmission line.

16. A wave translating system comprising a pair of space discharge devices, divided grid and plate circuits therefor each having a common branch, each of said space discharge devices having a cathode, anode and grid element, means to apply currents to the space paths of said devices in series, and means to apply a control potential to the grids of said devices in parallel across the common portion of their grid circuits, said space discharge devices offering an impedance to said currents which is substantially independent of their magnitude but which is a function of said control potential.

17. In a transmission system, a transmitting medium having signaling energy impressed thereon, a space discharge device in shunt to said medium, and control means independently connected to said medium for varying the impedance of said space discharge device only in accordance with transmission conditions obtaining on said medium.

18. In a signalling system, a transmitting medium having signaling energy impressed thereon, a space discharge device connected in shunt to said medium, and control means connected to said medium for varying the impedance of said space discharge device independently of periodic oscillations in said medium but in accordance with the volume of the energy impressed on said medium to control the volume of energy transmitted over the system.

19. In a transmission system, a transmitting circuit having signaling energy impressed thereon, a space discharge device connected in shunt to said circuit, and control means connected to said circuit for varying the impedance of said space discharge device to vary the energy transmitted over the system in accordance with the transmission conditions obtaining on said circuit but independently of periodic variations in said circuit.

20. In a transmission system comprising a variable coupling impedance, means for impressing current variations upon said system, and means for varying said coupling impedance in accordance with the attenuation of said variable current but independently of the instantaneous values thereof.

21. The combination with a signal transmission line whose transmission characteristic is subject to change, of a space discharge device having its cathode and anode connected in shunt relation with respect to said line, said device having a grid or control element, a circuit for varying the potential of the grid of said device in accordance with

changes in the transmission characteristics of said line and means in said circuit for preventing the potential of said grid from following signaling variations transmitted over said line.

In witness whereof, I hereunto subscribe my name this 25th day of February, A. D. 1925.

GEORGE T. LORANCE.