Sept. 13, 1927. 1,642,499

J. S. JAMMER

TRANSMISSION REGULATION

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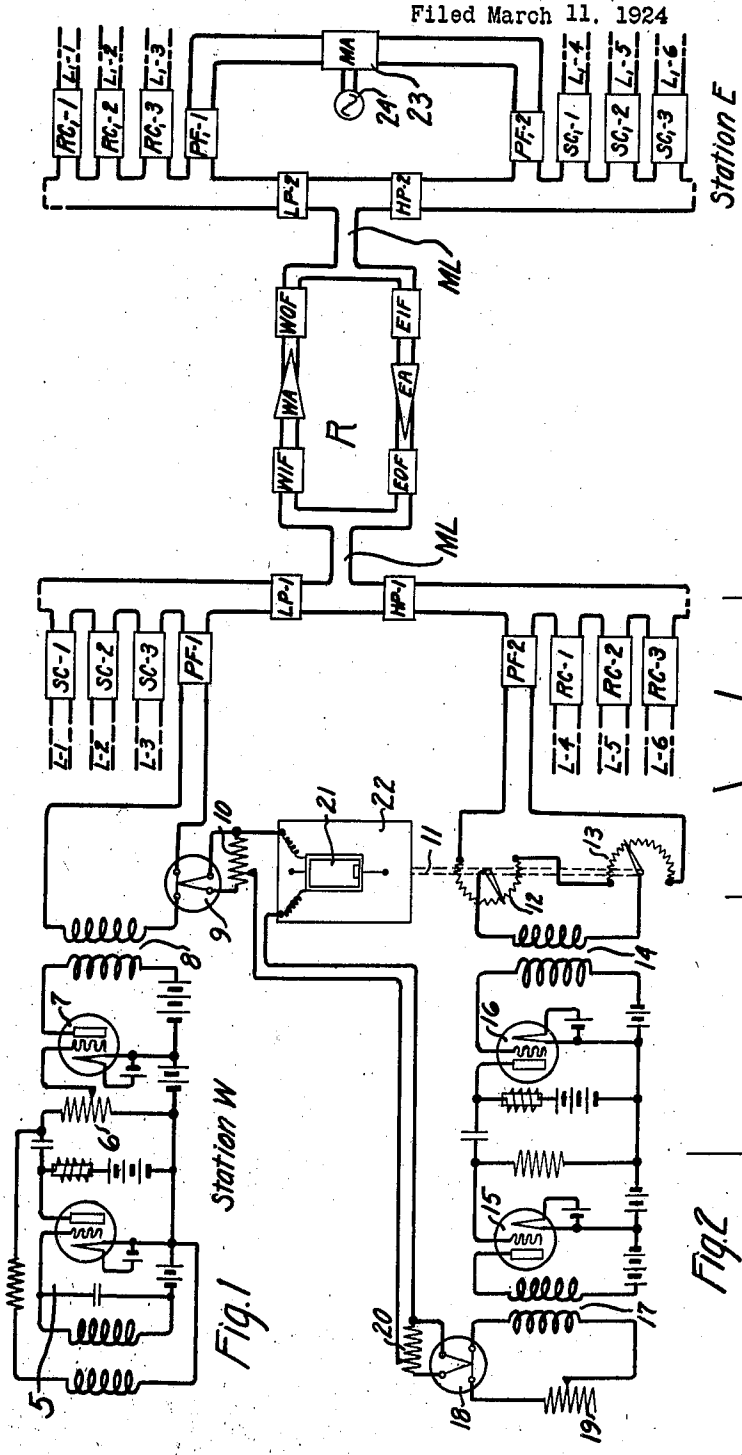


Fig. 1

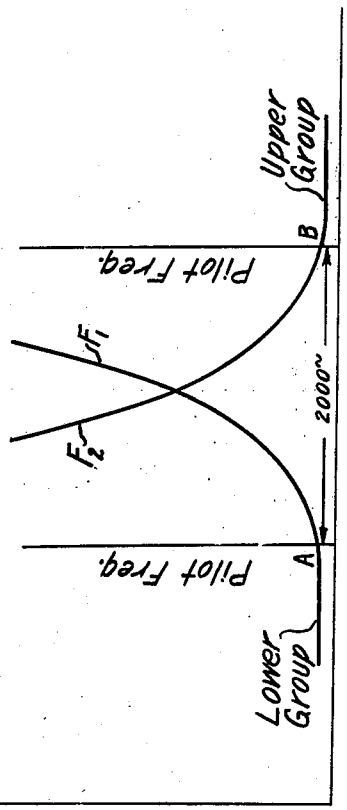


Fig. 2

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UNITED STATES PATENT OFFICE.

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TRANSMISSION REGULATION.

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This invention relates to transmission regulation and is particularly adapted for use in multiplex signaling systems.

An object of the invention is to stabilize the transmission characteristics in two-way signaling systems.

A related object of the invention is to facilitate the construction, installation and maintenance of a transmission regulating system.

Another object of the invention is to centralize the control of a transmission regulating system at one terminal thereof.

Another object of the invention is to provide a method and means for indicating changes of line equivalent in either direction in a two-way transmission system.

It is well known that in radio and carrier signaling systems employing fairly high frequencies the transmission characteristics of the transmission line or other medium are subject to variations which render it difficult to maintain satisfactory signaling conditions.

Changes in the attenuation of the transmission medium of a system of the above type produce corresponding variations in the over-all transmission equivalent of the system, and result in large fluctuations in the volume of a telephone or other message being transmitted. Various means have been proposed for overcoming the effect of these variations. Some systems provide means for automatically recording such variations as they occur, thus enabling the attendants at the stations throughout the system to adjust the elements of the circuit accordingly. In other systems the adjusting or compensating means are operated automatically by the control or recording mechanisms.

Briefly, this invention provides a system of transmission regulation in which one channel of the system is set aside as a control or pilot channel. Over this channel, current is transmitted for the purpose of indicating the condition of the transmission medium over which the telephone or other signals are transmitted. The pilot current may operate a recording device or an automatic compensator, or, if desired, may operate both recording and compensating devices. In order to simplify the description of the invention only the means for indicating the changes in line equivalent are shown and described. It will be evident, however, as the description proceeds, that automatic compensating means may also be employed without departing from the invention.

According to a feature of the invention, all of the transmission regulating mechanisms are located at a common point in the system. More specifically, the pilot current is impressed upon the line at one station which may be called the control station for transmission to a second station geographically remote therefrom. At the remote station the received pilot current is impressed upon the line for transmission back to the control station. The incoming pilot current at the control station is amplified and passed through a detector. A similar detector is also included in the output of the pilot transmission circuit at the same station, and potentials derived from these detectors are balanced against each other in a differential galvanometer. If a change in line equivalent occurs the incoming pilot current changes and thus produces an unbalance of potential across the galvanometer. The resulting deflection of the galvanometer causes the adjustment of a potentiometer in the pilot receiving channel at the control station and adjusts the input of this circuit to balance the current in the two detectors. At the same time the deflection of the galvanometer operates a recording device to give an indication of the line change.

The system outlined above is arranged to automatically compensate for variations in the output of the pilot current generator. If the output of this generator changes this results in a change in the potential across the detector in circuit therewith, but since a corresponding change is produced in the receiving detector, the galvanometer does not change its position.

The present invention effects a considerable saving in apparatus over systems employing separate apparatus to indicate changes in the opposite directions. Furthermore, since changes in the transmission efficiency of the line affect the pilot current transmitted in both directions, a larger change is produced in the received current for a given increment of line change, thus reducing the sensitivity required in the receiving circuit. This system also simplifies

the testing of the pilot channel without interfering with the transmission of signals.

Other features and advantages of the inventon will appear from the following description taken in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic illustration of a carrier signaling system embodying the invention.

Fig. 2 shows curves illustrating the operation of the system of Fig. 1.

The system shown in Fig. 1 is represented as comprising two terminal stations W and E, respectively, interconnected by the multiplex line ML. One or more repeater stations R may be connected to the line ML intermediate the terminal stations.

Low frequency lines L^1, L^2 and L^3, which may be telephone lines or other signaling lines, are arranged for simultaneous and independent communication over the line ML with corresponding similar lines L_1^1, L_1^2, and L_1^3 at station E. Similar low frequency lines L_1^4, L_1^5 and L_1^6 at station E are arranged for communication over the line ML with corresponding similar lines L^4, L^5 and L^6 at station W. The low frequency lines L^1 and L^4, L^2 and L^5, and L^3 and L^6 at station W are associated through the usual hybrid coil circuits, not shown, to form groups of two-way communication channels. A similar arrangement is employed at station E.

Carrier currents are utilized for transmission over the line ML and are grouped according to their frequencies, the lower frequencies, as a group, being used for transmission from station W to station E, and the higher frequencies as a group being used for transmission from station E to station W. Low pass grouping filters LP^1 and LP^2 at the respective terminal stations are each paired with a high pass filter HP^1 and HP^2. These filters serve to separate the directional groups of carrier waves to the respective terminal transmitting and receiving circuits. These filters and each of the other filters shown throughout the system may be constructed and designed in accordance with the principles laid down in the United States patent to Campbell No. 1,227,113, issued May 22, 1917.

For the purpose of the present description, a low pass filter may be taken to be any filter which transmits freely currents of all frequencies between zero and a preassigned limiting frequency and suppresses the transmission of currents of all frequencies higher than said limiting frequency. Conversely, a high pass filter may be taken to be any filter which freely transmits currents of all frequencies higher than a pre-assigned limiting frequency and suppresses currents of all frequencies lower than said limiting frequency. Specific types of both of these kinds of filters are shown, for example, in Fig. 11 of the above mentioned Campbell patent.

Each of the low frequency lines L^1, L^2 and L^3 is connected to one of the transmitting circuits SC^1, SC^2 and SC^3, respectively, which comprise the usual oscillator, modulator and transmitting filter. The low frequency lines L_1^4, L_1^5 and L_1^6 are connected to similar transmitting circuits correspondingly lettered but with subscripts affixed thereto. The low frequency lines L^4, L^5, L^6 and L_1^1, L_1^2 and L_1^3 are connected to corresponding receiving circuits RC^1, RC^2, etc. each comprising the usual receiving filter, demodulator and amplifier. A transmission system of this general character is shown in Fig. 49 of a paper entitled "Carrier current telephony and telegraphy" by E. H. Colpitts and O. B. Blackwell, published in the Transactions of the American Institute of Electrical Engineers, volume 40, 1921.

The repeater R, which forms no part of the present invention, may be of any suitable type such as that disclosed in the United States patent to Raibourn, No. 1,413,357, issued April 18, 1922. Each of the repeater channels includes an input filter, an amplifier and an output filter, for further details of which reference may be made to the Raibourn patent.

In addition to the signaling channels indicated, a control or pilot channel is also connected with the line ML employing a frequency different from that of any of the signaling channels and including band pass filters PF^1 and PF^2 at station W and filters PF_1^1 and PF_1^2 at station E for the pilot frequency. The pilot channel associated with filter PF^1 at station W includes a transmitting oscillator 5 of any suitable type, an adjustable current regulator 6 and an amplifier 7. The output of the amplifier 7 is coupled to the filter PF^1 by means of a transformer 8. A thermocouple 9 is inserted in circuit with the secondary of the transformer 8. The thermocouple 9 may be of any well known type comprising a filamentary element which is heated by the alternating current passing between its two terminals in the pilot channel, this filament being arranged to heat a junction of two dissimilar metals so that a direct current E. M. F. is produced between the terminals of these metals, this E. M. F. being proportional to a function of the amplitude of the alternating current flowing through the filament. A variable resistance element 10 is included between the terminals of the two dissimilar metals of the thermocouple for a purpose hereinafter to be described. In place of the thermocouple it will be obvious to use a suitable rectifying detector or other quantitative indicator.

The receiving pilot channel associated with the filter PF^2 at station W includes a

pair of variable rheostats 12 and 13 the contact arms of which are mounted on a common control shaft 11. The contact arms of the variable rheostats 12 and 13 are connected in series with the primary of a transformer 14 the secondary of which is connected to the input of an amplifier which may comprise a pair of three-element electric discharge tubes 15 and 16. The output of this amplifier is coupled by means of a transformer 17 to the heating element of a thermocouple 18 in series with an adjustable current regulator 19. The thermocouple 18 is identical to thermocouple 9, a variable resistance element 20 similar to the element 10 being connected across the terminals of its two dissimilar metals.

The variable rheostats 12 and 13 serve the purpose of automatically adjusting the input of the thermionic amplifying tubes 15 and 16 in accordance with variations in the transmitted and received pilot current. The thermocouples 9 and 18 form part of a control circuit the condition of balance or unbalance of which determines the direction and extent of adjustment of the rheostats 12 and 13. The thermocouples 9 and 18 are connected through their respective variable resistance elements 10 and 20 to the input of a differential galvanometer 21. The galvanometer 21 indicates the balanced or unbalanced condition of the circuit, and the relation between this galvanometer and the adjusting mechanism comprising the rheostats 12 and 13 is secured through the medium of an automatic controlling apparatus generally indicated at 22.

The controlling apparatus 22 by itself forms no part of the present invention and has not been illustrated in detail, since it may comprise any suitable or well known arrangement by which the control shaft 11 is held stationary while the galvanometer 21 is in its zero or mid-position, and is automatically rotated in one direction or the other dependent upon the direction of deflection of the galvanometer. Such rotation persists, continuously or by steps, until the galvanometer is again brought to its zero position. The control apparatus 22 is also preferably of the type having a recording chart and associated mechanisms for making a permanent record of the variations produced by the deflection of the galvanometer 21. One specific system for accomplishing this result is shown and described in the United States patent to Brewer, No. 1,356,804, issued October 26, 1920.

The pilot current generated by the oscillator 5 is continuously transmitted from station W to station E and thence back to station W, this current, as pointed out above, being of a frequency different from that of any of the signaling channels. At station E since the system herein shown and described is operated on a group frequency basis, the incoming pilot current is passed through a frequency converter or amplifier-modulator 23 where it is amplified and combined with the current generated by a source of alternating current 24, and is then impressed upon the line ML for transmission back to station W. This frequency conversion is necessary to enable the pilot current to pass through the repeater directional filters EIF and EOF and the grouping filters HP^1 and HP^2 which are high pass filters and hence suppress current of the original pilot frequency which is a low frequency designed to pass through the low pass repeater directional filters WIF and WOF and the grouping filters LP^1 and LP^2.

The transmission of the pilot current is illustrated graphically in Fig. 2 in which attenuation is plotted against frequency. The curve F_1 indicates the attenuation of the lower frequency grouping filters LP^1 and LP^2 and the repeater directional filters WIF and WOF, and the curve F_2 indicates the attenuation of the higher frequency grouping filters HP^1 and HP^2 and the repeater directional filters EIF and EOF. The pilot frequency generated by the oscillator 5 and transmitted from station W to station E is represented by the letter A, while the pilot frequency transmitted from station E to station W is represented by the letter B. It will be seen that currents of the frequency of pilot current A are transmitted with substantially negligible attenuation by the low pass grouping and repeater directional filters, but that currents of this frequency are greatly attenuated by the high pass grouping and repeater directional filters. The pilot frequency A may be located near the frequency limit above which the attenuation of the low pass filters begins to increase, as shown in Fig. 2, and similarly the frequency B may be near the lower limit of the high pass filters. If the separation between the oppositely directed pilot frequencies is say 2,000 cycles, the pilot current A may be combined with a current of 2,000 cycles frequency in the frequency converter 23 at station E and thence passed through the pilot filter PF_1^2 which may be designed to transmit only the upper side band produced by such modulation. It will be seen that the modulated pilot current B will be transmitted by the grouping filters HP^1 and HP^2, and the repeater directional filters EIF and EOF.

If, instead of operating the system on a group frequency basis, the signaling system employs the same frequency in both directions, no frequency conversion is necessary at the remote station, the pilot current simply being amplified and impressed upon the line for transmission back to the control station.

The operation of the system is as follows: The variable resistance elements 10 and 20 are adjusted so that equal potentials are derived from the thermocouples 9 and 18 under the desired transmission conditions of the line ML. After such adjustment the elements 10 and 20 may remain in their adjusted positions at all times. The pilot current A generated by the oscillator 5 is transmitted through the pilot filter PF^1 and low pass grouping filter LP^1 to the line ML and thence through the repeater directional filters WIF and WOF and amplifier WA to the remote station E. At station E the pilot current is transmitted by the low pass grouping filter LP^2 and is selected by the pilot filter PF_1^1. The pilot current A is amplified and combined in the amplifier-modulator 23 with the current generated by the alternating current source 24 in the manner described above to produce the return pilot current B. The pilot current B is transmitted through pilot filter PF_1^2 and high pass grouping filter HP^2 to the line ML, and thence through repeater directional filters EIF and EOF and amplifier EA to station W. At station W the pilot current B is transmitted by the grouping filter HP^1 and is selected by the pilot filter PF^2 from which it is transmitted to the receiving pilot channel where it is amplified and passed through thermocouple 18.

If a change in line equivalent occurs anywhere in the system the incoming pilot current changes and produces a corresponding change in the potential derived from the thermocouple 18. When the potential derived from the thermocouple 18 varies from the potential derived from thermocouple 9 a resulting unbalance of potential is produced in the windings of the differential galvanometer 21. The resulting deflection of the galvanometer causes a corresponding adjustment in the automatic controller 22 which in operating rotates the shaft 11 to adjust the variable rheostats 12 and 13 in the input circuit of the receiving amplifier tubes 15 and 16 until the output of this amplifier is returned to normal. When the amplifier output is returned to normal the galvanometer 21 likewise returns to its normal or center position. The recording mechanism associated with the controller 22 makes a permanent record of the line change which may be compensated for by adjusting electrical elements in the transmission line at the station W or at the repeater stations or at the other terminal, or partly at each of these points. If the output of the oscillator 5 changes, this results in a change in the potential across the thermocouple 9, but since the potential across the receiving thermocouple 18 is similarly affected, the galvanometer does not change its position.

If desired, the controller 22 may be employed to automatically control adjusting elements in the transmission circuit to compensate for changes of line equivalent in either direction of transmission. Various other changes may also obviously be made without departing from the spirit of the invention. Accordingly, the system illustrated and described in detail should be considered as merely defining one form of the invention, but is not to be construed as limiting the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. The method of transmission regulation which comprises transmitting a control wave from a control station to a remote station over a medium whose transmission efficiency is variable under different conditions, amplifying the wave received at the remote station, retransmitting over said medium to the control station a wave of an amplitude proportional to that of the control wave received at the remote station, and utilizing the transmitted wave and the retransmitted wave at the control station to indicate variations in the transmission characteristics of said medium.

2. The method of transmission regulation which comprises transmitting a control wave from a control station to a remote station over a medium whose transmission efficiency is variable under different conditions, retransmitting over said medium to the control station a wave of an amplitude proportional to that of the control wave received at the remote station, and utilizing potentials derived solely from the waves transmitted from the control station over said medium to the remote station and the waves retransmitted from the remote station and received at the control station to indicate variations in the transmission characteristics of said medium.

3. The method of transmission regulation which comprises transmitting a control current between two terminals of a loop circuit whose transmission efficiency is variable under different conditions, combining the transmitted current with another current at a point intermediate said terminals, and utilizing potentials derived from the current transmitted at one terminal and received at the other terminal to indicate variations in the characteristics of said circuit.

4. The method of transmission regulation which comprises transmitting a control current from a control station to a remote station over a medium whose transmission efficiency is variable under different conditions, amplifying and impressing the current received at said remote station upon said medium for transmission back to said control station, and impressing potentials derived from the current transmitted from the control station and the current received at said control station upon a control device.

5. The method of transmission regulation which comprises transmitting a control current from a control station to a remote station over a medium whose transmission efficiency is variable under different conditions, modulating the current received at said remote station, impressing the modulated current upon said medium for transmission back to said control station, and impressing part of the currents transmitted and received at said control station upon a common control device.

6. The method of transmission regulation which comprises transmitting a control current from a control station to a remote station over a medium whose transmission efficiency is variable under different conditions, impressing the current received at said remote station upon said medium for transmission back to said control station, and differentially impressing potentials derived solely from the transmitted and received currents upon a common control device.

7. The method of transmission regulation which comprises transmitting a control current from a control station to a remote station over a medium whose transmission efficiency is variable under different conditions, combining the current received at said remote station with another current, impressing the combined current upon said medium for transmission back to said control station, and impressing the current received at said control station upon a control device.

8. The method of transmission regulation which comprises transmitting a control current from a control station to a remote station over a medium whose transmission efficiency, is variable under different conditions, combining the current received at said remote station with another current, impressing the combined current upon said medium for transmission back to said control station, and differentially impressing potentials derived from the currents transmitted and received at said control station upon a control device.

9. A system of transmission regulation comprising a medium whose transmission efficiency is variable under different conditions, a control station and a remote station associated therewith, means at said control station for impressing a control wave upon said medium for transmission to said remote station, means for amplifying the wave received at the remote station, means for retransmitting over said medium to the control station a wave of an amplitude proportional to that of the control wave received at the remote station, and means controlled by the outgoing wave and the incoming wave at the control station to indicate variations in the transmission characteristics of said medium.

10. A system of transmission regulation comprising a medium whose transmission efficiency is variable under different conditions, a control station and a remote station associated therewith, means at said control station for impressing a control wave upon said medium for transmission to said remote station, means for retransmitting over said medium to the control station a wave of an amplitude proportional to that of the control wave received at the remote station, an indicating device, and means at the control station for differentially impressing potentials derived only from the waves transmitted and received over said medium upon said device.

11. A system of transmission regulation comprising a medium whose transmission efficiency is variable under different conditions, means for transmitting a control current between two terminals of said medium, means for combining the transmitted current with another current at a point intermediate said terminals, a control device, and means for differentially impressing the current transmitted and received at said terminals upon said device.

12. A system of transmission regulation comprising a transmission line extending between a control station and a remote station and terminating in an outgoing channel and an incoming channel at said control station, means at said control station for impressing a control wave upon said outgoing channel for transmission over said line to said remote station, means for retransmitting over said line to the control station, a wave of an amplitude proportional to that of the control wave received at the remote station, means at said control station for transmitting the received wave to said incoming channel, an indicating device, means for impressing potentials derived from said outgoing and incoming channels upon said indicating device, a variable circuit controlling element in said incoming channel, and means controlled by said indicating device for controlling said variable element.

13. A system for indicating variations in transmission equivalent, a control station and a remote station, a loop circuit connecting said stations and terminating in a transmitting and a receiving branch at said control station, the transmission efficiency of said circuit being variable under different conditions, an indicating device, thermocouples in said transmitting and receiving branches differentially connected to said indicating device, a variable rheostat in said receiving branch, and means controlled by said indicating device for controlling said rheostat.

14. In combination, a transmission medium, a control station and a remote station associated therewith, means at said control station for impressing a control current upon said medium for transmission to said remote station, means at said remote station for

impressing the received current upon said transmission medium for transmission back to said control station, and an indicating device at said control station controlled solely by the control current transmitted over said medium to the remote station and by the current retransmitted from the remote station to the control station.

15. In a carrier wave transmission system in which waves comprised in a lower frequency group are transmitted in one direction through the system and waves comprised in a higher frequency group are transmitted in the opposite direction, terminal stations for said system, means at the first station to generate and transmit a control wave of a frequency comprised in one of said groups, means at the other station to receive said wave and to retransmit to the first station a wave of a frequency comprised in the other respective group and of an initial amplitude proportional to that of the control wave received at said other station, and means at the first station to receive the retransmitted wave and to utilize it to indicate variations in the transmission characteristics of the system.

In witness whereof, I hereunto subscribe my name this 7th day of March, A. D. 1924.

JACOB S. JAMMER.