

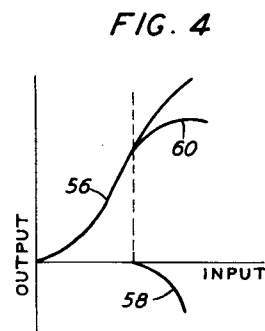
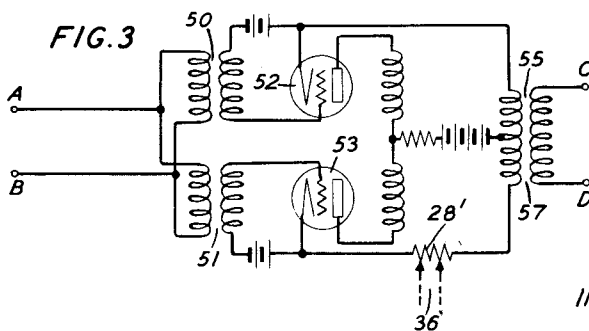
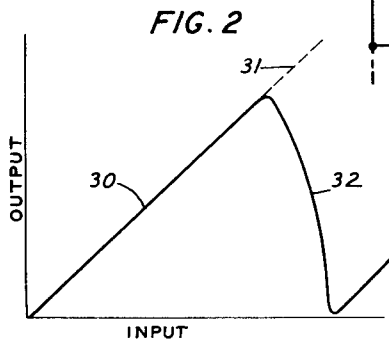
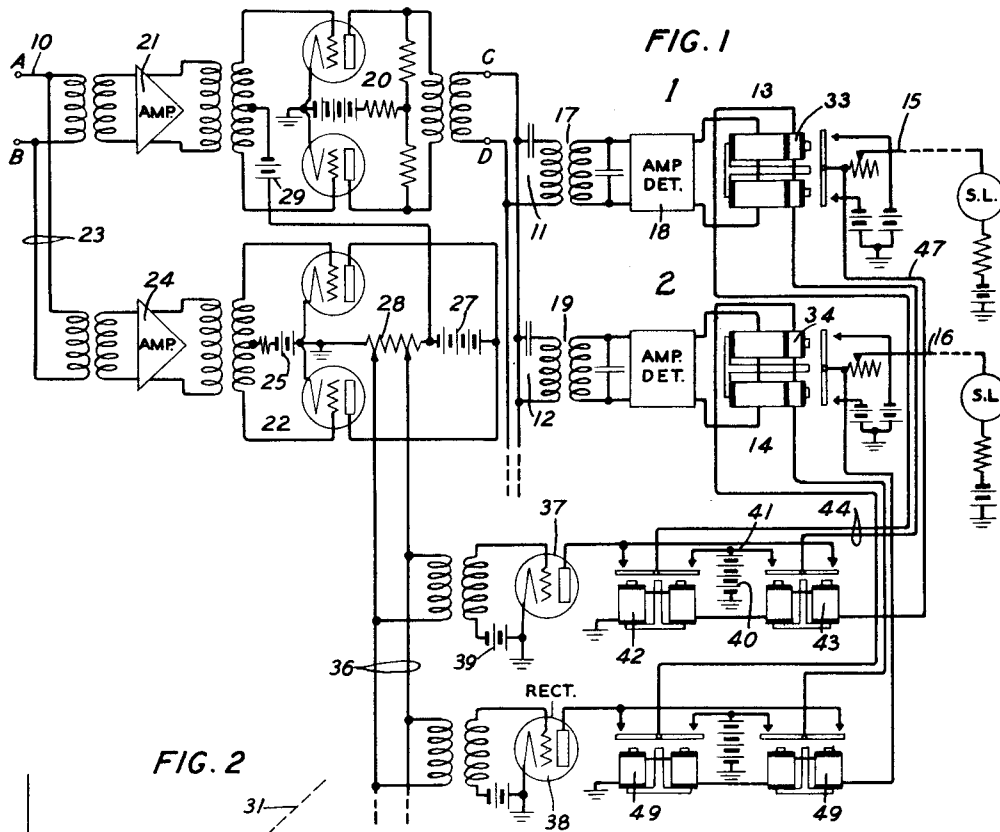
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W. A. PHELPS ET AL

1,919,035

CARRIER TELEGRAPH INTERFERENCE SUPPRESSOR

Filed June 4, 1931



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CARRIER TELEGRAPH INTERFERENCE SUPPRESSOR

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The present invention relates to the prevention of interference in a signal receiving system, such, for example, as a carrier telegraph receiving system. In particular the invention has reference to the prevention of false signals or interruption of service due to lightning or severe atmospheric disturbances.

An object of the invention is effectively to prevent excess surges of energy incident upon the system from deleteriously affecting the signal receiving apparatus and at the same time to reduce inter-channel modulation to a negligibly low value during normal operation of the system.

A general type of multiplex carrier telegraph system to which the invention is applicable is shown in Phelps-Jones Patent No. 1,793,491 patented February 24, 1931. As shown in that patent the receiving terminal of a multiplex carrier telegraph system includes a number of individual channels branched from the multiplex line, each channel being selective of the particular signaling frequencies utilized by the signals in that channel. The selective elements in the individual channel may include filtering elements such as tuned circuits including inductances and capacities. These selective circuits ordinarily have low damping in order to render them sharply selective. When a large surge of energy from lightning, atmospheric effects or other causes is received in such a system, there is a tendency for these resonant circuits to become excited and to continue oscillating in a somewhat erratic manner for a considerable time interval after the original impulse may have ceased. The effect is probably increased by the fact that there are a number of these resonant circuits which interact with one another when impulsed by a large surge of energy. Thus the deleterious effect of a lightning impulse which may of itself be of short duration in comparison with a dot signal is prolonged and intensified. As was pointed out in the Jones-Phelps patent this effect may be reduced by preventing the lightning or other energy surge from impulsing the tuned receiving circuits, as by placing in the common receiving circuit in ad-

vance of all of the resonant circuits a common current limiting device which restricts the amplitude of the current transmitted to the individual receiving channels to substantially the normal signaling levels.

A practical difficulty arises in applying this type of protection, in sharply distinguishing between the maximum signaling level and the level of the disturbing impulses and at the same time maintaining the inter-channel modulation to a negligibly low value. In any practical system the level of the received signals undergoes a considerable variation from time to time depending upon line transmission changes or other causes. Unless the voltage limiting circuit is to be practically continuously adjusted an operating margin must be left to accommodate these variations in signal level. If as in the prior art systems the voltage limiting circuit possesses a considerable modulating range between the normal signal level range and the limiting range, variations in line transmission characteristics are liable to carry the signal level into the modulating region for considerable periods of time resulting in inter-modulation between the different channels and a consequent lowering of signal quality.

The present invention provides for sharp discrimination between the limiting range and the normal signaling range while at the same time reducing the inter-channel modulation to a negligibly low value.

Furthermore, because of the drooping characteristic of the present device, greater latitude in adjustment is allowable. That is, a greater difference between the limiting level and the normal signaling level may be tolerated than in the Jones-Phelps device, without forced oscillations occurring in the tuned circuits.

A further feature of the invention comprises the use of opposing windings on the individual channel receiving relays, these windings being energized under control of a rectifier which rectifies the excess current surges in the incoming line. These opposing relay windings are preferably used in conjunction with the current or voltage lim-

iting circuit above referred to although in some instances they may be used separately.

A better understanding of the various features and objects of the invention will be had from the following detailed description of a preferred embodiment of the invention as disclosed in the accompanying drawing.

In the drawing

Fig. 1 is a schematic circuit diagram of a carrier telegraph receiving system embodying the present invention;

Fig. 2 is a characteristic curve showing the action of the voltage limiter;

Fig. 3 shows an alternative type of voltage limiter which may be used in the system of Fig. 1; and

Fig. 4 shows a characteristic curve of the voltage limiter of Fig. 3.

The receiving system shown in Fig. 1 would in practice be accompanied by a suitable type of transmitting system for transmitting over the main line in the opposite direction from which the system of Fig. 1 receives. The manner of associating a transmitting and receiving terminal with a main line is disclosed in the Jones et al. Patent 1,793,491 above referred to.

The receiving system of Fig. 1 includes the multiplex receiving line 10 leading from the main line. This multiplex receiving line is provided with a number of channels, two of which are shown at 11 and 12 branched off from the circuit 10, there being in practice any desired number of these receiving channels as indicated by the dotted line extension in the drawing. Each channel terminates in a relay such as 13 or 14 the armature of which may control any suitable type of receiver, such as a local sounder or printer or other receiving device or it may repeat signals into a subscriber's loop 15 or 16 as indicated in Fig. 1.

Receiving channel 11 is provided with frequency selective means shown as a transformer 17, the primary of which is series tuned by means of a suitable capacity and the secondary of which is also preferably tuned by another capacity, both capacities being suitably related to the inductance of the circuit to tune the individual channel to the frequency range utilized by the signals traversing that particular channel. Following the resonant input circuit 17 is a suitable type of amplifier-detector 18 for enabling the received telegraph-modulated carrier waves to operate the receiving relay 13.

The apparatus in channel 12 may be identical with that in channel 11 except that its resonant circuit 19 is selective of a different range of frequencies so that a different message may be received simultaneously on each of the two channels. Each of the other channels will also be individually tuned to its respective message frequencies.

Included in the multiplex receiving line 10

between its input terminal and the point from which the individual receiving channels are branched is a push-pull space discharge tube circuit 20 which acts as the amplifier and a voltage limiting circuit. Circuit 20 is preceded by a suitable amount of amplification indicated generally at 21 but which in practice may comprise any desired number of stages in cascade.

A full-wave rectifier 22 comprising a pair of space discharge devices oppositely related to each other is coupled to the multiflex receiving line 10 at a point in advance of the circuit 20, this branch including input circuit 23 and a suitable amount of amplification shown at 24 which may comprise one or more stages in cascade as found necessary or desirable. The rectifier circuit 22 has its grid normally biased by battery 25 at a potential so far negative with respect to the cathode that the plate circuit of the rectifier transmits no current except when the incoming voltage applied to its grids exceeds by a predetermined amount the maximum normal signal level. Impulses or surges of energy in excess of the maximum normal signal level drive one or the other grid of rectifier 22 in a positive direction by a sufficient amount to cause current to flow in the plate circuit of the corresponding tube from battery 27 through resistance 28.

In the absence of any current flow in the output circuit of rectifier 22 the amplifier-limiter 20 is normally biased at the proper operating point on its characteristic by battery 29, there being under these conditions no voltage drop across resistance 28.

For the normal signal level range, therefore, circuit 20 operates as an amplifier, the characteristic being shown in Fig. 2 comprising the solid line 30 which, if it were not for the effect of the rectifier, would continue on as shown in the dotted line portion 31.

Excess surges of incoming current of sufficiently high amplitude to be rectified by the rectifier 22 result, in a manner already described, in the production of current flow through the resistance 28 setting up a difference in potential across the terminals of this resistance. This difference in potential is in such direction as to aid the negative grid bias voltage of battery 29 causing the grids of the circuit 20 to be thrown more and more negative with increasing amplitude of received impulses. As a result of this action the circuit 20 is changed from an amplifying element to an element having a net loss as is shown by the reversed portion 32 of the solid line characteristic of Fig. 2. The change may amount to 70 or 80 db. for a very small change in input. It is found in practice that the change from the portion 30 to the portion 32 of the characteristic shown in Fig. 2 can be made very abrupt so that the line of demarkation between the normal sig-

nalizing level and the limiting level can be made quite sharp. Factors which influence this comprise the rectifier characteristic, the magnitude of resistance 28, the amount of amplification introduced at 21 and at 24 and of course the characteristic of the circuit 20. Due to the fact that the portion 30 of the characteristic remains substantially linear close to the limiting point a practical margin can be allowed for variations in line characteristic and other factors affecting received signal levels without introducing serious inter-modulation. Received currents in excess of the prescribed maximum normal level results almost immediately in a sharp limiting action by the circuit 20.

The secondary rise occurring at the lower end of curve 32 is due to the fact that, when the input to the rectifier 22 increases beyond the limiting value, the plate impedance of the rectifier tubes 22 falls rapidly. This impedance finally falls to a value which is low compared with the external resistance 28 so that practically the entire voltage drop due to the flow of plate current appears across resistance 28, and any further reduction of the plate impedance of rectifier 22 produces only a slight increase in the voltage drop across resistance 28. Thus the grid bias on tubes 20 becomes practically constant and the input-output curve rises. Before this point is reached the gain of the amplifier, stage 20 has been decreased by as much as 70 or 80 db., or more, so that the excess currents have been greatly attenuated.

By use of the circuit as described thus far it has been found that lightning surges or other impulses of excess energy can be very effectively prevented from reaching the resonant circuits 17, 19, etc., in sufficient amount to cause those circuits to oscillate to an undesired degree.

The invention provides as a feature a further precaution against false operation by interfering impulses, as will now be described. Each of the receiving relays such as 13, 14, etc. is provided with an opposing winding 33, 34, etc., in addition to the operating winding connected to the amplifier-detector. When an abnormal surge of energy is received a current is caused to flow through these opposing windings in such a direction as to compensate for the effect of the abnormal surge on the received signal. The momentary currents applied to the opposing windings 33, 34, etc., are controlled from the rectifier 22 in the following manner.

Some of the voltage across the resistance 28 in the output of rectifier 22 is applied to circuit 36 leading through high-impedance transformers to a number of rectifiers 37, 38, etc., one for each receiving channel. The output circuit of rectifier 37 (and also each of the corresponding rectifiers) is normally

without current on account of the use of a large negative bias in the grid circuit derived from battery 39. Abnormal current surges rectified at 22, however, cause current flow through each of the rectifiers 37, 38, etc., from their corresponding plate battery 40, wire 41, one or the other armature of relay 42 or 43 depending upon which way the armatures are thrown, one conductor 44, winding 33 and back over the other conductor 44 to the armature of the opposite relay 42 or 43, anode of rectifier 37 to ground. Relays 42 and 43 are commutating relays controlled from contacts of the signal receiving relay 13 as the armature of relay 13 vibrates between its contacts and applies positive or negative battery over lead 47 to the windings of relays 42 and 43 in series to ground. The armatures of relays 42 and 43 are therefore caused to vibrate in unison with the armature of relay 13 and they control the direction of current flow through the winding 33. For example, the control may be such that for a spacing signal winding 33 may oppose the operating winding while for a marking signal it may aid the operating winding. Thus, if circuit 20 does not completely suppress the abnormal current impulses but still allows a small amount of current to reach relay 13 for example, during a spacing interval when the relay 13 should normally be without current, an impulse is sent through winding 33 reducing the effect of the disturbing current in the operating winding to zero. The effect of winding 33 during a marking interval is, however, to insure operation of relay 13 during severe atmospherics which might be of such direction as to tend to reduce the operating currents, if the disturbance is of opposite sign to the signal impulse.

It will be understood that rectifier 38 in conjunction with commutating relays similar to 42 and 43 indicated at 49 control current through winding 34 of relay 14 in a manner similar to that described in connection with relay 13. A similar rectifier and pair of commutating relays would be used in connection with each of the other receiving relays not specifically shown in the drawing.

While it is preferable to use the rectifiers 37, 38, the commutating relays and the opposing windings 33 and 34 as supplemental to the voltage limiter circuit 20 in protecting a system against false operation, these opposing windings and their associated control circuits may in some instances, if desired, be used without the limiter 20. That is, the output of amplifier 21 may feed directly into selective circuits 17, 19 etc., the limiter 20 being merely omitted.

An alternative current limiter circuit which may be substituted for the amplifier-limiter 20 and the rectifier 22 of Fig. 1 is

shown in Fig. 3. For example, all of the portion of the circuit of Fig. 1 included between the terminals A, B and C, D may be removed from the circuit (leads 36 being severed above the input of 37) and the circuit of 23 may be inserted making proper connection at the four terminals A, B, C and D. Circuit 36 leading to rectifiers 37 and 38 will then be connected as indicated across a part or all of resistance 28' corresponding in its operation to resistance 28 of the circuit of Fig. 1.

The manner of operation of the system when the circuit of Fig. 3 is inserted as described is as follows: Currents of the normal signaling range received from the multiplex receiving line 10 are applied to the input transformers 50 and 51 of both vacuum tubes 52 and 53. Only tube 52 however transmits these currents in the normal signal level range because the grid of tube 53 is biased too far negative to allow this tube to transmit current in response to grid potential variations within this range. The normal signals applied to tube 52 are amplified and transmitted through output transformer 55 to the circuit across terminals C and D leading to the individual receiving channels as shown in Fig. 1. The amplifying characteristic of tube 50 may be as indicated in Fig. 4, the full line portion 56 lying to the left of the vertical dotted line.

Currents in excess of the normal maximum signal level are sufficient to overcome the negative grid bias of tube 53 and allow this tube to transmit as well as tube 52. Currents therefore flow through both primary windings of transformers 55 and 57 in such a sense to oppose one another in their effect on the output or secondary circuit. The initial portion of the characteristic of tube 53 is indicated in Fig. 4 at 58, this curve being drawn below the zero output line since it opposes the current transmitted through tube 52. The net effect is indicated in Fig. 4 by the portion 60 obtained by subtracting curve 58 from curve 56; that is, the overall characteristic of the circuit is as shown at 56 for the normal signaling level range and at 60 for the limiting range.

The excess rectified currents through tube 53 corresponding to the disturbing energy flow through resistance 28' corresponding to resistance 28 of rectifier 22 of Fig. 1. These impulses are applied in part to circuit 36 which may lead to rectifiers 37 and 38 identically as in the case of Fig. 1.

It will, of course, be understood that various modifications and variations may be made departing widely from the specific disclosure but within the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a carrier telegraph system, a multiplex receiving line, a plurality of receiving channels coupled thereto each including fre-

quency selective means selective of a different respective range of frequencies, an element in said receiving line in advance of all of said receiving channels, comprising a space discharge device, having anode, grid and cathode elements, and means determining the action of said element as a net gain element or a net loss element comprising an auxiliary circuit coupled to said line and capable of transmitting current only in response to impressed voltage in excess of normal, said auxiliary circuit biasing the grid negative by an amount dependent upon the input amplitude in excess of normal.

2. In a carrier telegraph system, a multiplex receiving line, a plurality of receiving channels branched therefrom, each including a resonant circuit, and means protecting said channels against excess current surges comprising a space discharge device in said receiving line in advance of said receiving channels and common to a plurality of said channels, a full-wave rectifier branched from said receiving line on the input side of said discharge device, and means for biasing said discharge device from said rectifier, said device operating as a normal repeater of signals, the rate of change of bias with input level as determined by said rectifier being such as to cause said discharge device to operate as a net loss element for applied voltages in excess of the normal range.

3. A multiplex carrier telegraph receiving system comprising a plurality of channels each having a resonant input tuned to a different frequency range and a relay in its output, a space discharge device in the common line leading to said channels, a rectifier coupled to said line in advance of said device for rectifying excess surges of incoming current, said rectifier controlling the transmission characteristic of said device and supplying compensating current to each of said relays to protect said relays against false operation by excess surges of current.

4. In a telegraph receiver, a relay having an operating winding and a compensating winding, a space discharge device in the circuit leading to said relay, a rectifier for rectifying excess surges of incoming energy, and means for applying the rectified current from said rectifier to said space discharge device and to said compensating winding in such sense as to oppose the effect on said relay of such excess energy.

5. In a multiplex carrier telegraph receiving system a multiplex line, a plurality of receiving channels branched from the line, each selective of a different frequency range, individual relays in said channels, each having an operating winding and a compensating winding, a push-pull space discharge tube circuit in the line leading to said channels operating as a normal amplifier of signals for all of the channels, a rectifier branched from

said line biased against response to signals of normal amplitude but rectifying excess surges of line current, and means for applying the output of said rectifier to said compensating windings and also as a negative grid bias to said push-pull circuit, in such sense as to protect said relays from false operation by such excess surges.

6. In a multiplex carrier telegraph system, a multiplex line, a plurality of receiving channels branched from said line, each selective of an individual frequency range and including a relay, a rectifier bridged across said multiplex line and biased against operation within the normal signal level range but rectifying excess current, and means for utilizing a portion of the output of said rectifier to control the operation of each of said relays to prevent their false operation by excess line current.

7. An interference preventer for a signal receiving system comprising a push-pull space discharge tube circuit operating as an amplifier of received signals at the normal signal level, a rectifier for rectifying excess level currents, and means utilizing the current from said rectifier to bias the tubes of said push-pull circuit against transmission whereby the characteristics of said push-pull amplifier is reversed so that it becomes a net loss element.

8. In a multiplex carrier telegraph receiver, an incoming multiplex line, a plurality of receiving channels branched therefrom, each selective to its individual signal frequency range, a push-pull discharge tube circuit in said line in advance of said channels, operating as an amplifier throughout the normal signal level range, and an auxiliary circuit coupled to said line and operating in response to input energy of excess level for causing said push-pull circuit to attenuate the excess

level energy to a level below the normal signal range before it reaches said receiving channels.

9. In a high frequency signaling system the combination with a medium, over which high frequency signaling currents and interference currents may be transmitted, of a receiving circuit, upon which the transmitted currents may be impressed, containing an amplifier, a detector and a receiving relay, controlling means connected to the receiving circuit to limit the output current of said amplifier whenever the currents impressed on said receiving circuit reach a prefixed value, and means responsive to said controlling means to effectively hold the armature of the receiving relay against the contact where it happens to be resting when the limitation occurred in the output current of said amplifier.

10. In a high frequency receiving circuit, upon which high frequency signaling currents and interference currents may be impressed, the combination with a current limiting device, of a signal responsive device, means to render the current limiting device effective whenever the impressed currents exceed a prefixed value, and means to prevent false operation of said signal responsive device whenever the current limiting device is rendered effective.

11. In a high frequency telegraph receiving system, the combination with a signal receiving circuit of means connected thereto, and controlled by a circuit external thereto, to limit the amplitude of current traversing said receiving circuit, and means, controlled by said external circuit, to prevent false indication of signals as the result of the functioning of the current limiting apparatus during the receipt of signals.

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