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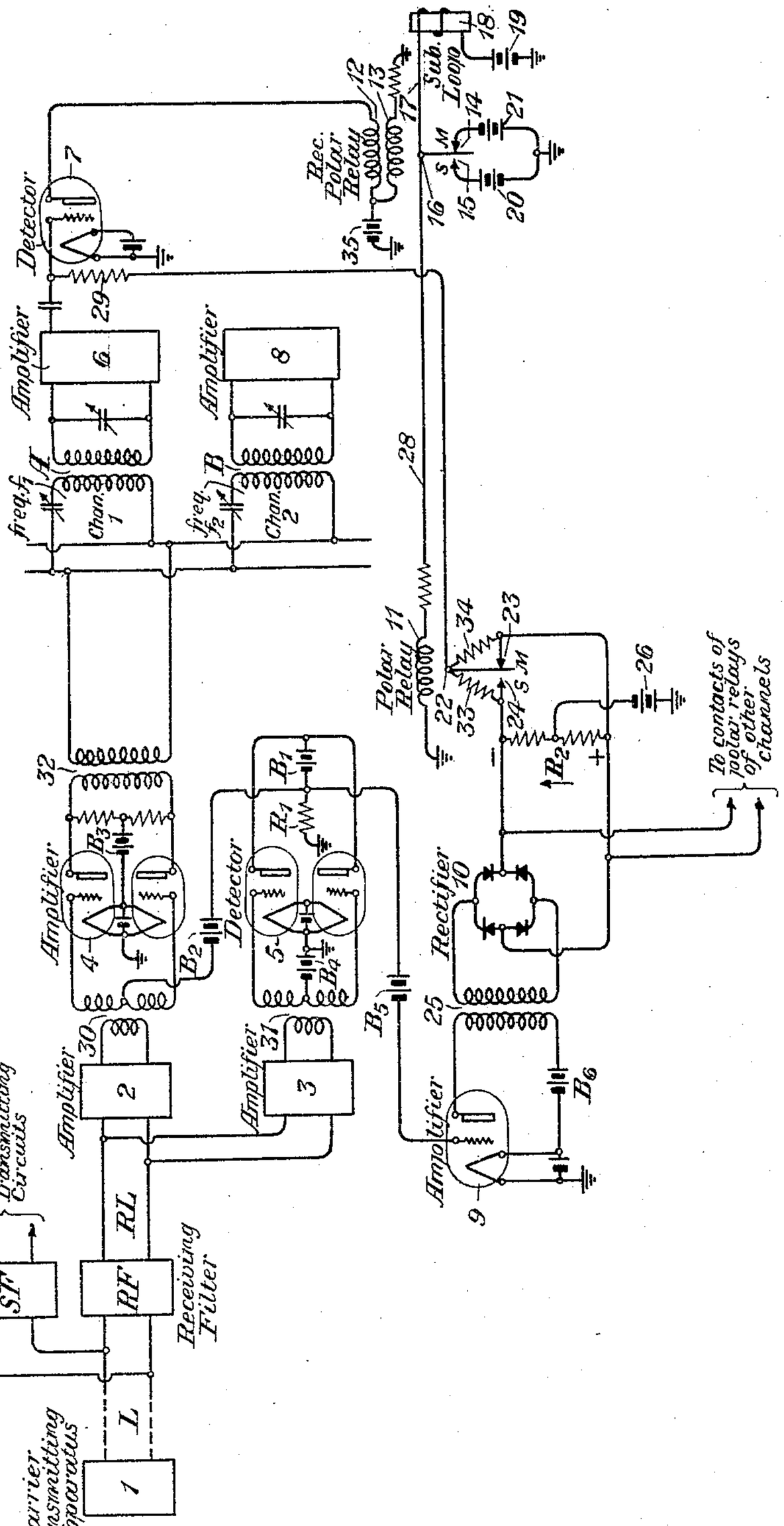

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REDUCTION OF INTERFERENCE IN CARRIER SYSTEMS

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This invention relates to A. C. telegraph systems, and particularly to means for reducing the effect of extraneous interference upon the receiving apparatus of such systems.

In the carrier telegraph systems of the types that are well known in the art, the carrier currents received from the transmitting medium are rectified, and the rectified currents used to operate a polar relay. This relay normally has a biasing winding through which a current flows steadily of such a value that it neutralizes approximately one-half the effect of the normal operating current when both currents are flowing. This causes the armature to be moved from one contact to the other with equal force in either direction, as the operating current is alternately on and off. Interfering currents set up in the transmitting medium by sources extraneous to the system itself often cause false operation of the relay which in turn causes false signals to be received on the receiving mechanism.

Lightning hits are usually of very short duration but of large magnitude, this latter effect causing sustained oscillation of the receiving selecting circuits over a period comparable to a dot length in high speed signaling. Current limiting devices ahead of the tuned circuits have been used to some extent to reduce the shock excitation of these circuits and such a device, in conjunction with other arrangements, forms a part of this invention. For best protection against interference it has been found from experience that the current limiting device should have a drooping characteristic; that is, when the amplitude of the incoming wave exceeds a predetermined value the output of the device is reduced to only a small fraction of its previous value. For this reason the incoming signaling currents are also eliminated for the duration of the interfering hit, sometimes causing a false spacing signal. This invention provides an arrangement which eliminates the latter undesirable effect.

This invention will be clearly understood from the following description when read in connection with the accompanying drawing, the figure of which illustrates schematically a circuit arrangement embodying the invention.

In the drawing the line L represents a transmission circuit or medium over or through which a plurality of carrier frequencies such as f_1 and f_2 may be transmitted from the carrier transmitting apparatus 1 to the carrier receiving apparatus connected with the other end of the said transmission circuit. At the receiving station the apparatus is rendered selective to the incoming group of receiving frequencies by the receiving filter RF. After passing through the interference suppression apparatus, later to be described, the carrier signaling frequencies are directed to their respective detectors by the tuned circuits A and B which are selective to frequency bands based upon the carrier frequencies f_1 and f_2 respectively. While a tuned circuit has been shown for the selection of a particular frequency band, such showing is purely illustrative, since other well-known selective devices, such as filters, may be used. The output of the tuned circuit is connected to amplifier 6 and the output of amplifier 6 is connected to the grid circuit of detector 7. The plate circuit of this detector, which includes a source of plate voltage 35, is connected with the winding 12 of polar relay 27. The grid potential of this detector is maintained sufficiently negative to prevent the flow of plate current when no signal is being received. Another winding 13 of this relay is connected to battery 35 and ground. This winding is so poled and the magnitude of the current so adjusted as to tend to hold the armature 16 against its spacing contact. The contacts of relay 27 are connected with sources of potential 20 and 21 which have opposite poles connected to ground. The armature 16 is connected by conductor 17 to the relay 18 of the telegraph substation. Armature 16 also has connected to it a leak circuit 28 which includes the winding of a polar relay 11. The armature 22 of this relay connects to the grid circuit of the signal channel detector 7 through resistance 29. When no lightning interference or carrier signal is being received, the negative potential on the grid of detector 7 is the same

as the potential of the battery 26. Since the purpose of the polar relay 11 and the manner in which it cooperates with other apparatus will be apparent from the description of the mode of operation of the system, it is believed that further description of it is unnecessary at this point.

The lightning suppression arrangements will now be described. The currents of the received signal frequencies, and such extraneous interfering currents as may be present, pass through the receiving filter RF and encounter amplifiers 2 and 3 in parallel. Amplifier 2 is coupled to the input of amplifier 4 by the transformer 30. The output of amplifier 4 is connected to the signal channel receiving selecting circuits by transformer 32. Amplifier 3 is coupled to full-wave detector 5 by transformer 31. The source of grid potential B_4 and the source of plate potential B_1 of detector 5 are so adjusted that, for normal amplitude of the combined currents of the incoming carrier signaling frequencies and with no interference present, the plate current of detector 5 will be zero. Under this condition the grid potential of amplifier 4 will equal the potential of battery B_2, and amplifier 4 will function as an ordinary amplifier having a constant gain. When an interfering current of large amplitude is impressed on the normal combined signal currents, it will cause plate current to flow in detector 5. This plate current, supplied by battery B_1, flows from the positive terminal of this battery to the detector plates, then to the filament, to ground, from ground to resistance R_1, through R_1 to the negative terminal of battery B_1. The IR drop across R_1 increases the negative grid potential applied to amplifiers 4 and 9. In the case of amplifier 4, this increase in negative potential on the grids increases the plate-to-filament impedance, which reduces considerably the overall gain of the amplifier which momentarily eliminates both interference and marking signals. The increase in negative grid potential of amplifier 9 reduces momentarily the plate current in amplifier 9. The plate circuit of amplifier 9 includes the battery B_6 and one winding of transformer 25. The sudden reduction in plate current through this winding induces a voltage in the secondary of transformer 25 to which is connected a full-wave rectifier of any well-known type such as the copper-oxide type. This rectified current flows through resistance R_2 and the IR drop thereby produced is used to vary the potential applied to the grids of the signal channel detectors while a lightning hit is coming in. The polar relay 11, operating from the armature of the signal channel receiving relay, will follow the incoming telegraph signals. Its armature will rest on the marking contact 23 when a marking signal is being received and on the spacing contact 24 when a spacing signal is being received. Thus the change in negative grid potential of detector 7, that is, whether the negative potential is increased or decreased when a lightning hit comes in, is determined by the position of the armature of polar relay 11 which is determined by the incoming telegraph signal, that is, whether it is marking or spacing. Resistances 33 and 34 are connected between the armature and spacing and armature and marking contacts respectively, of relay 11, in order to maintain the grid potential of detector 7 during the travel time of the armature of relay 11.

The operation of the system may be briefly summarized as follows: When no interference is coming in, the received group of carrier frequencies is selected by the receiving filter RF, amplified by amplifiers 2 and 4 and passed on through transformer 32 to the individual signal channel selecting circuits. The frequencies are ultimately rectified and used to operate the respective receiving relays. The current of the received group will also be amplified by amplifier 3 and impressed on detector 5, but no change occurs in detector 5 or amplifier 9 since the negative potential of source B_4 applied to the grids of detector 5 is somewhat higher than the maximum peak of the combined incoming signals; hence, no plate current flows in the plate circuit of detector 5. Since there is no plate current flowing in resistance R_1, there is no change of potential of the grids of amplifiers 4 or 9. There will be no voltage applied to rectifier 10; hence, no rectified current will flow in resistance R_2 and the steady grid potential applied to the grid of detector 7 will be that of battery 26. This condition will exist regardless of the position of the armature of polar relay 11 so long as no lightning hit is coming in. Assume now that a marking signal is being received on channel 1 and a lightning hit of large magnitude occurs near the transmission medium L. The amplitude of the received wave will be sufficiently large to overcome the potential of B_4 applied to the grids of detector 5 and plate current will flow through R_1. The resulting IR drop across R_1 will increase the negative potential applied to the grids of amplifiers 4 and 9. In the case of amplifier 4, its gain will be greatly reduced as explained previously, thus preventing the lightning hit from passing through to the signal channel tuned circuit and setting up sustained oscillations. The reduction in gain of amplifier 4 will also momentarily eliminate the signal current being received and, without other features described herein, a false spacing signal might be received. This is prevented as follows: The change in potential of the grid of amplifier 9 will cause a change in plate current of that tube. The voltage setup across the secondary of transformer 25 will cause

rectified current to flow in resistance R_2 in the direction indicated by the arrow. The IR drop across the lower half of resistance R_2 will subtract from the potential of the battery 26, making the potential applied to the grid of detector 7 less negative, which will maintain the plate current in detector 7 and hence maintain the marking signal.

Assume now that a spacing signal is being received on channel 1. The action of the suppression arrangements will be described below for this spacing or no current condition. Since no carrier current is being applied to the grid of detector 7, no plate current is flowing in that tube because the negative potential provided by battery 26 is sufficiently large to prevent flow of plate current. The biasing current through winding 13 of the receiving polar relay will hold the armature of the relay on its spacing contact. Polar relay 11 will have its armature resting on the spacing contact 24. When a lightning hit arrives, the action of amplifier 4, amplifier 9, detector 5, and rectifier 10 will be identical to that described for the case when a marking signal is being received. During the period while the incoming interfering wave is building up to the value where detector 5 starts to function to reduce the gain of amplifier 4, some current will pass through amplifier 4 to the signal channel selecting circuit. Some delay will be encountered while the signal is passing through the selecting circuit of channel 1. Meanwhile, the rectified current flowing through R_2 will produce an IR drop which will add to the negative potential of battery 26, since the armature of relay 11 is on its spacing contact. This added negative potential applied to the grid of detector 7 will maintain the spacing signal.

The operation of other channels, such as channel 2, will be similar in all respects to that of channel 1 and therefore need not be described.

It should be noted that the neutralizing arrangement supplied in addition to the current limiting circuit is a fast operating device. In previous neutralizing devices, tuned circuits have been used to select a narrow band of the interfering frequencies, rectifying these currents and passing the rectified currents through a winding of the receiving relay in such a way as to oppose the interfering pulse which occurs in the regular signal channel detector. In the latter arrangement the interfering pulse is usually prolonged by the oscillation of the tuned circuits in such a way that the receiving relay armature is not permitted to change its position during this period of oscillation which may result in serious distortion of the telegraph signal. In the arrangement disclosed herein, the signal channel tuned circuit is protected against shock excitation by the action of the current limiting portion of the circuit, and a holding or neutralizing pulse is produced without the use of tuned circuits, this latter feature producing a neutralizing pulse which lasts only for the duration of the interfering lightning hit which is ordinarily extremely short.

The neutralizing pulse is unidirectional, as the direction of the current through the resistance R_2 is determined by the full-wave rectifier 10. Either the positive or negative end of the resistance R_2 is connected to the grid of detector 7, depending on the position of the armature of relay 11, which in turn depends upon whether a marking or spacing signal is being received on the signal channel receiving relay 27.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a high frequency receiving circuit, the combination with an amplifier upon which high frequency signaling currents and interference currents may be impressed, the said amplifier being adjusted to limit the amplitude of the current wave transmitted therethrough, of a detector effectively connected to said amplifier, a signal receiving device connected to the output of said detector, another detector upon which the said signaling and interference currents may be impressed, the said other detector being connected to said amplifier to control the limits of the latter, and means also controlled by said other detector, to regulate the action of said first mentioned detector whenever the said amplifier is functioning to limit the current therethrough.

2. In a high frequency receiving circuit, the combination with a main receiving path, upon which high frequency signaling currents and interference currents may be impressed, containing a current limiting amplifier, a detector effectively connected to the output of said amplifier, a signal receiving device, responsive to marking and spacing impulses, connected to said detector, a control path, bridged across said main path, containing another detector having its output connected to the amplifier of said main path to adjust the setting thereof whenever the current in the control path reaches a fixed limit and means connected between said other detector and said first mentioned detector to prevent false operation of said signal receiving device by the functioning of said amplifier during the receipt of signals.

3. In a high frequency telegraph receiving system, the combination with a vacuum tube amplifier upon which signal currents and interference currents may be impressed, of a vacuum tube detector having its input circuit effectively connected to the output circuit of

said amplifier, a polar relay connected to the output circuit of said detector, a second vacuum tube detector upon which also the said currents may be impressed, the said second detector being so adjusted that the current in the plate circuit thereof is substantially zero, a resistance connected to the said plate circuit, means to apply to the grid circuit of said amplifier the negative voltage due to the flow of current through said resistance, another vacuum tube amplifier having its grid connected to said resistance, means effectively connected to the plate circuit of said other amplifier to rectify the current variations in said plate circuit, and another polar relay, controlled by the said first mentioned polar relay, to apply the rectified impulses of said other amplifier to the grid of said first mentioned detector in such manner as to prevent false operation of said first mentioned polar relay when the current limiting amplifier operates during the receipt of marking and spacing impulses.

4. In a high frequency telegraph receiving system, the combination with a detector of a polar relay for receiving signals, means connected to the input of said detector to limit the amplitude of the currents applied thereto and means also connected to said detector to prevent the false operation of the polar relay by the functioning of the current limiting means during the receipt of signals.

5. In a high frequency telegraph receiving system in which marks and spaces are represented by the presence and absence respectively of a train of waves, the combination with a vacuum tube detector to rectify the received waves of a polar relay having an armature movable from one contact to another whenever the received signal changes in character, a vacuum tube amplifier functioning as a current limiting device connected between the source of high frequency signals and the said detector, a rectifier, responsive only to currents of predetermined values to apply an increasing negative voltage to the grid of the said amplifier to limit the current passed thereby, and means, also controlled by said rectifier, to apply a voltage to the grid of said detector of such magnitude and polarity as to keep the armature of the receiving relay on that contact upon which it was resting when the current limiting action began.

In testimony whereof, I have signed my name to this specification this 15th day of June, 1932.

VAUGHN P. THORP.