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RECEIVING CIRCUIT FOR TELEGRAPH SIGNALING SYSTEMS

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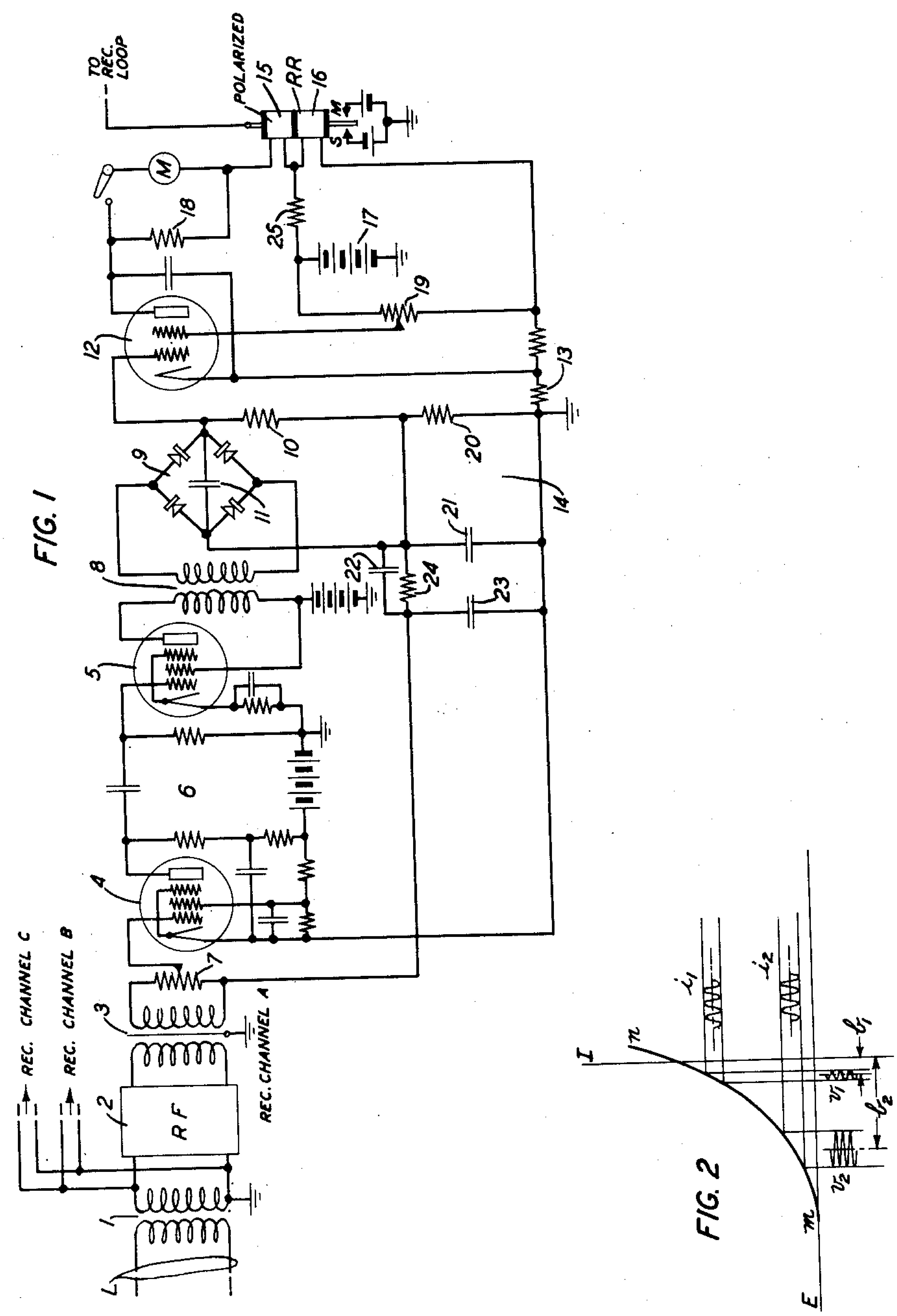

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RECEIVING CIRCUIT FOR TELEGRAPH SIGNALING SYSTEMS

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2 Claims. (Cl. 178—66)

The invention relates to telegraph signal transmission systems and particularly to the signal receiving circuits used in such systems.

The invention is particularly applicable to a carrier telegraph system in which the spurts or pulses of alternating carrier current transmitted over the system represent marking signals and the intermediate intervals of no carrier represent the spacing signals, and in which the receiving circuit of the system includes one or more stages of vacuum tube amplification for the received carrier pulses followed by a signal demodulator and a polarized relay controlled from the output of the latter for repeating the detected marking and spacing signals. It has been found that the signals transmitted over such a system undergo a form of distortion, known as "telegraph bias," which is evidenced by a difference in the durations of the marking and spacing signals as repeated by the receiving relay from those which they had at the transmitting end of the system, due mainly to changes in the level of the received carrier caused by variations in line equivalent, and to a lesser extent due to changes in battery voltages and receiving relay adjustments. Telegraph bias has been minimized by the use of automatic control circuits, known as level compensators, operating to apply a variable bias to the control grid of one or more of the vacuum tubes in the circuit to adjust the gain of the receiving circuit in accordance with the amplitude level of the detected signals.

An object of the invention is to provide improved operation of such telegraph receiving circuits.

A more specific object is to reduce signal distortion in a telegraph transmission system including that type of distortion known as telegraph bias.

These objects are attained in accordance with the invention partly by deriving the variable bias applied to the control grid of one or more amplifier tubes in the receiving circuit to adjust their gain for level compensation, from the control grid circuit of an amplifying tetrode connected between the demodulator and the polar receiving relay; and in part by a special arrangement of the biasing and operating windings of the polar receiving relay so as to provide a more rapid transition from "mark" to "space" and vice versa.

The various objects and features of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawing in which:

Fig. 1 shows schematically a receiving circuit for a voice frequency carrier telegraph system embodying the invention; and

Fig. 2 shows curves illustrating the operation of the level compensator in the circuit of Fig. 1.

The receiving circuit of the invention is shown in the drawing incorporated in one channel, A, of a voice frequency carrier telegraph system. The input of the receiving channel A (illustrated in detail) of the carrier telegraph system of Fig. 1 is connected in parallel with the inputs of the other receiving channels B, C . . . to the telegraph line L through the 1:1 ratio transformer or line coil 1 used primarily to separate the line, which is balanced to ground, from the receiving band filters which are unsymmetrical networks with one side grounded. The receiving channel A includes in its input a band-pass filter 2, one side of which is grounded as shown, for selecting from the carrier modulated telegraph signal waves received over the transmission line L, the particular frequencies assigned to that channel. The output of the filter 2 is connected by an input transformer 3, which gives voltage amplification and serves to isolate the rest of the circuit from the ground on the receiving filter 2, to the input of an amplifier comprising two pentode amplifying vacuum tube stages 4 and 5 coupled in tandem by the resistance-condenser coupling circuit 6. The first stage tube 4 is operated with a variable control grid bias, and the second stage amplifier tube 5 is operated with a fixed control grid bias so that it serves as a simple amplifier. The potentiometer 7 in the input of the amplifier tube 4 is provided to regulate manually the strength of the incoming signals.

The plate-cathode circuit of the amplifier tube 5 is coupled by output transformer 8 across the input diagonal of the full-wave copper-oxide rectifier bridge 9 and the resistance 10 and parallel condenser 11 provided for filtering out the alternating current component of the detected signals are shunted across the output diagonal of the latter. The control grid-cathode circuit of the amplifying tetrode 12 is coupled through the series resistance 13 and shunt resistance 10 across the output of the rectifier 9, and is coupled by a feedback circuit including the condenser-resistance network 14 to the control grid-cathode circuit of the first tube 4 of the alternating current amplifier to provide the variable bias on that tube for level compensation.

The operating winding 15 and the opposing biasing winding 16 of the polar receiving relay RR are connected in series between the plate and cathode of the amplifying tetrode 12, and both windings are connected to the plate battery 17 of that tube through a rather large common resistance 25. The screen grid of the tetrode 12 is positively biased by the plate battery 17 through the rheostat 19 shunted around the biasing winding 16 of relay RR and reistance 25 in series.

The other elements of the circuit of the invention as shown in the drawing will be referred to in the following complete description of operation.

When no carrier current has been received from the line L for some time, the control grid of the first tube 4 of the alternating current amplifier is unbiased and the cathode of the direct current amplifier tube 12 is positive with respect to the control grid of that tube because of the voltage drop produced in the resistance 13 by current from the plate battery 17. Under these conditions, the plate current of the direct current amplifier tube 12 and hence the current transmitted through the operating winding 15 of the polar relay RR are negligible. On the other hand, current of about 17 mils flows through the biasing winding 16 of the relay RR from battery 17, causing the armature of that relay to be held firmly on the spacing contact S.

The incoming carrier wave modulated in accordance with the marking and spacing signals, generated at the transmitting end of the system (not shown) received over the transmission line L is impressed by the line coil 1 on the input of the receiving channels A, B, C.... That portion within the frequency range assigned to the receiving channel A will be selected by the receiving band-pass filter 2 therein, and the selected waves will be impressed by the transformer 3 on the control grid-cathode circuit of the first pentode amplifying stage 4 of the alternating current amplifier. The impressed carrier pulses will be amplified by the amplifying tubes 4 and 5 of the alternating current amplifier, and the amplified waves will be applied by the output transformer 8 to the input of the copper-oxide rectifier bridge 9 and will be rectified therein. The resultant direct current voltage across the resistance 10 due to rectification of the carrier pulses in copper-oxide rectifier bridge 9, will be impressed between the cathode and the control grid of the direct current amplifier tube 12. This positive voltage will be large compared to the negative bias on the control grid of that tube, and hence the control grid-cathode space of tube 12 becomes conductive. The resultant control grid current through the resistance 20 will cause the condensers 21, 22 and 23 in the condenser-resistance network 14 to be charged. The voltage drop across the condenser 21 is in a direction to add to the original bias between the cathode and the control grid of the direct current amplifier tube 12 causing that grid to become somewhat more negative, but the effect on the operation of the tube is very slight because the change in control grid bias is but a small fraction of the whole. Part of the voltage across the condenser 21 appears across the condenser 23 and is impressed on the control grid of the alternating current amplifier tube 4.

The signaling voltage impressed on the control grid-cathode circuit of the amplifier tube 4 across the potentiometer 7 is quite small compared to the total range of the tube characteristic. The relation is shown graphically in Fig. 2. By changing the bias b, the point of operation on the characteristic may be shifted. It will be evident that the greater b is in the negative direction, the smaller the current i will be for a given value of voltage v. Hence, if the input voltage increases due to a decrease in the loss of line L to a value such as v_2, the resulting current i_2 may be kept identical with i_1 by changing the bias from b_1 to b_2. The amplifier tube 4, therefore, may be made to act as a transmission-level compensator by providing it with a suitable varying control grid bias. The control grid of the tube 4 is negative with respect to its cathode under all operating conditions.

It will be clear from the foregoing that, in so far as level compensation is concerned, the tetrode 12 serves principally as a means for producing a variable biasing voltage, while the pentode tube 4 does the actual regulation by acting as an amplifier of varying amplification.

After a very long spacing signal, the condensers 21, 22 and 23 in the condenser-resistance network 14 will all be discharged and the sensitivity of the amplifier tube 4 will be at a maximum. If the distant station associated with the other end of the telegraph line L sends a marking signal under these conditions, a large voltage will be applied to the control grid-cathode circuit of the amplifier tube 12, a heavy control grid-cathode current resulting and the condenser 21 charges quickly to a voltage which is excessive, because the control tube 4 has not had time to act. The proper biasing voltage to apply to the control grid of the amplifier tube 4 is, therefore, less than that across the condenser 21. This is taken care of by the action of the voltage divider formed by the two condensers 22 and 23 in which the condenser 22 has only about one-twelfth of the capacity of the condenser 23. Hence, at first only one-twelfth of the voltage across the condenser 21 is applied to the control grid of the tube 4. This reduce its gain somewhat. As current continues coming in, the condenser 22 gradually discharges through the parallel resistance 24, thereby increasing the voltage across the condenser 23 and further reducing the amplification of the amplifier tube 4. Condenser 21 discharges through the parallel resistance 20 at about the same rate, since the two circuits have approximately equal time constants. If marking is maintained for a sufficient length of time, the condenser 22 will become fully discharged while the voltage across the condenser 23 will become equal to that across the condenser 21 without objectionable oscillations developing in the control grid bias of the tube 4 due to "hunting" between the charges on condensers 21 and 23. During the transmission of ordinary telegraph signal text, there is a tendency for the level compensator condensers 21 and 23 to discharge during the spacing intervals and to charge during the marking intervals, but the voltage across the condenser 21, which is a large condenser, does not change much, while that across the condenser 23 changes a great deal less.

The effect of the condenser 22 is to screen the condenser 23 from sudden changes in the voltage of the condenser 21 while permitting the condenser 23 to assume the same average voltage as the condenser 21. This is brought about because the resistance 24 in parallel with the condenser 22 is unresponsive to rapid voltage changes and for such rapid voltage changes acts as if it were not there so that the voltage divides in inverse proportion to the capacity of the condensers 22 and 23, where the condenser 23 is large compared to condenser 22. However, in the case of slow changes in voltage across the condenser 21, such as will result from variations in the transmission loss of the line L, the resistance 24 will act practically as a short circuit around the condenser 22 and the voltage of the condenser 23 will follow these slow voltage changes faithfully. An advantage of the condenser-resistance arrangement 14 is that "hits," such as result from distant lightning, have little effect on the control grid bias of the amplifier tube 4.

After rectification and amplification, the envelopes of the carrier signals supplied from the input of the receiving filter 2 in the receiving channel A appear as direct current pulses closely similar to those originating in the sending channel at the other station. These direct current pulses will pass from the plate of the amplifier tube 12 through the operating winding 15 of the polar relay RR which is biased to its spacing contact S by the normal current flowing through the biasing winding 16 from battery 17, causing the operation of the relay to its marking contact M. Because of the large resistance 25 connected between the mid-point of the operating winding 15 and the biasing winding 16, and the positive terminal of the plate battery 17, as the plate current of the amplifier tube 12 increases the biasing current in the biasing winding 16 of the polar relay RR will decrease. The various resistances shown in the circuit of the biasing winding 16 are proportioned so that when no carrier current is received and the plate current of the amplifier tube 12 is zero, the baising current through the biasing winding 16 of relay RR has a maximum value of about 17 mils, while when the plate current of tube 12 rises to its maximum value which was about 25 mils in the receiving circuit which has been constructed, the biasing current is very small. The two currents equalize when each is about 10 mils. This, therefore, corresponds to the operating point of the relay. The arrangement of the biasing and operating windings of the relay RR which has been described, provides a rapid transition in the magnetizing force operating on the relay armature as the signals go from "mark" to "space" and vice versa, which favors distortionless operation. The point of operation of the relay RR may be varied over a considerable range to secure unbiased signals by changing the screen grid voltage of the amplifier tube 12 by adjustment of the movable arm of rheostat 19. It will be noted that with this arrangement zero bias is obtained by varying the operating current of the relay to compensate for a fixed bias instead of the reverse as is usually the case.

The milliammeter M shown as connected across the series resistance 26 in the plate circuit of the amplifier tube 12 by the switch may be used for reading directly the current passing through the operating winding 15 of the polar relay RR.

As pointed out above, the amplifier 12 is arranged to give a substantially constant current into the receiving relay RR for a considerable range of variation in its input. Since increases and decreases in its input level due to variations in the loss of the line L are equally likely to happen, the sensitivity of the detector 9 should be adjusted to correspond to approximately the middle of the compensation range when the level of the received current is at its normal value.

Various modifications of the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In a telegraph system in which pulses of carrier current separated by intervals of no current are used for marking and spacing telegraph signals, respectively, a transmission medium subject to variable loss for transmitting said signals and a signal receiving circuit connected to said medium including a rectifier for rectifying the received signal pulses, an electron discharge amplifying device having electrodes including a cathode, an anode and a control grid, and circuits therefor, a source of anode current for said device, means for applying the rectified signal pulses to the control grid-cathode circuit of said amplifying device, a large resistance, a polar relay for repeating the marking and spacing signals amplified by said amplifying device comprising a relay armature, an operating winding and an oppositely poled biasing winding connected in series between the anode and cathode of said device, and to said anode battery in common through said large resistance so that when the current through the operating winding of the relay increases during marking signaling intervals the biasing current to said biasing winding decreases, to provide a more rapid transition in the magnetizing force operating on the relay armature as the signals go from mark to space and vice versa.

2. A receiving circuit for a carrier telegraph system transmitting pulses of alternating carrier current separated by intervals of no current respectively representing marking and spacing telegraph signals, comprising an amplifier for amplifying the received carrier pulses, a rectifier for rectifying the amplified pulses, an electron discharge amplifying device having a control grid-cathode circuit supplied with the rectified pulses, and an anode-cathode circuit including a source of space current, a polar telegraph relay having an armature, marking and spacing contacts, a biasing winding normally energized from said source to maintain the relay armature on its spacing contact, and an operating winding energized by the output current of said amplifying electron discharge device in response to the rectified marking signals applied to the control grid-cathode circuit of said device, to operate said armature to its marking contact, the operating and biasing windings of said relay being connected to said space current source through a relatively large common resistance so that the biasing current flowing in said biasing winding decreases as the operating current in said operating winding increases, thus providing a more rapid transition in the magnetizing force applied to said relay armature when operated from said spacing contact to said marking contact and vice versa.

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