

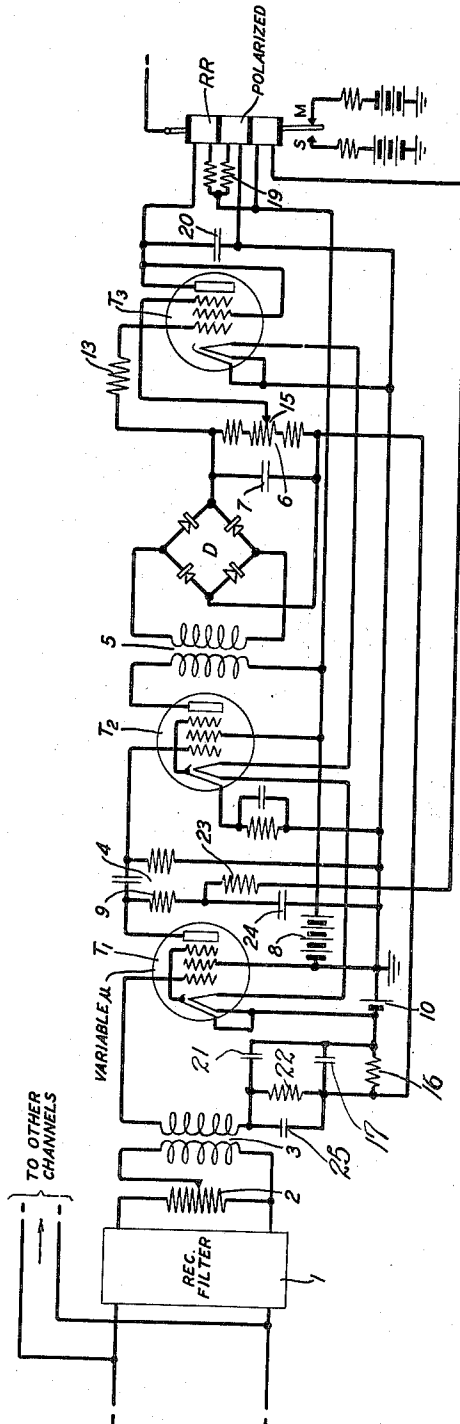
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RECEIVING CIRCUIT FOR SIGNALING SYSTEMS

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RECEIVING CIRCUIT FOR SIGNALING
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The invention relates to signaling systems and particularly to receiving circuits for such systems.

The invention is particularly applicable to a carrier telegraph system in which the marking signals are spurts of carrier while the spacing signals are intervals of no carrier, and in which the receiving circuit of the system includes one or more stages of vacuum tube amplification for the carrier modulated telegraph signals, connected in front of a signal demodulator the output of which controls the operation of a signal receiving relay in accordance with the marking and spacing telegraph signals. Also, it is particularly applicable to a carrier telegraph receiving circuit equipped with automatic control means for adjusting the gain of the amplifier to compensate for a type of distortion known as "telegraph bias" which is the amount of variation in the duration of the received signal pulses as repeated by the receiving relay from those sent, due to changes in receiving relay adjustments, battery voltages, and mainly to changes in level of the received telegraph currents caused by variations in line equivalent.

An object of the invention is to improve the operation of such circuits. A more specific object is to further reduce the effects of variations in incoming signal level on the operation of the receiving telegraph relay in a carrier telegraph receiving circuit.

These objects are attained in accordance with a preferred embodiment of the invention by circuits providing direct partial control of the operation of the receiving relay from a point in the receiving circuit in front of the signal demodulator.

The various objects and features of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing, the single figure of which shows schematically a receiving circuit for a voice frequency carrier telegraph system, embodying the invention.

The invention will be described as applied to a receiving and level compensating circuit for a voice frequency carrier telegraph system, such as is disclosed in the U. S. Patent to Davey et al. No. 2,182,841, issued December 12, 1939.

As the main portion of the receiving and level compensating circuit shown in the drawing is essentially as described and illustrated in the aforementioned Davey et al. patent, only a brief description of that portion of the circuit and its operation will be given here.

In the circuit of the drawing, the carrier cur-

rents modulated in accordance with marking and spacing telegraph signals received over the incoming line L are impressed on the receiving filters of several receiving channels. The particular frequencies assigned to the receiving channel illustrated in detail pass through the receiving filter 1 and, with a level determined by the setting of the potentiometer 2, are impressed by the input transformer 3 on an amplifier comprising two pentode vacuum tube stages T₁ and T₂ coupled by the resistance-condenser coupling 4. The first stage T₁ of this amplifier comprises a variable-mu tube which enables the gain of the amplifier to be varied as described later.

The amplified carrier telegraph signals in the output of the second stage T₂ of the amplifier are impressed by transformer 5 on the input diagonal of a full-wave rectifier or demodulator D comprising a bridge of copper oxide rectifier elements and will be demodulated thereby. The resulting uni-directional currents with the carrier components largely filtered out by shunt condenser 7 are passed through the potentiometer resistance 6 connected in series with the control grid-cathode circuit of a third pentode vacuum tube T₃ forming a stage of direct current amplification, which operates to square up the telegraph signals making them more suitable for operation of the polar receiving relay RR in the output of this direct current amplifier, which in turn repeats the received signals into the desired type of direct current telegraph circuit.

The demodulated telegraph signals in the output of the copper oxide rectifier bridge D are considerably "rounded off" due to the loss of the higher side-band frequencies in the receiving filter of the channel and a sending filter at the transmitting end (not shown). Since the receiving relay RR tends to operate at a definite voltage value of the demodulated signal, any change in amplitude of the signal causes the signals repeated by the relay to be biased. To offset this effect the receiving circuit is designed to compensate for variations in input level of the carrier currents in the following manner.

The direct current signals appearing across potentiometer 6 are applied to the control grid of the direct current amplifier tube T₃ through the series resistance 13. The resistance 13 prevents the control grid from being driven positive with resulting high grid current. The control grid of tube T₃ is biased well beyond cut-off by a negative voltage applied from filament battery 10 through resistance 16 and potentiometer 6, the cathode of tube T₃ being connected to a point

near ground potential. The receiving relay RR is operated by the plate and screen currents of the tube T₃, the condenser 20 serving to further filter the carrier frequency from the relay windings.

When carrier currents are being received, the potential of the control grid of tube T₃ rises to about zero and the resulting plate and screen current through the operating (upper) winding of relay RR holds the relay armature on its marking contact "M." When no carrier current is received, tube T₃ is cut off by its control grid bias, and the plate-screen current is zero. The armature of the relay RR is then held against the spacing contact "S" by biasing current from the plate battery 8 supplied through resistance 19 to the biasing (middle) winding of relay RR.

The suppressor grid of the tube T₃ is connected to the movable arm 15 of potentiometer 6. When the control grid of tube T₃ is near zero potential, and the plate and screen grid are at positive potential, as in this circuit during marking intervals, the suppressor grid will draw considerable current if the potential is raised any appreciable amount above zero with respect to the cathode which is near ground. The suppressor grid electron current flows through potentiometer resistance 6, resistance 16 and through the filament battery 10 back to the cathode. Most of the voltage drop in this path appears across resistance 16 and parallel condenser 17. The voltage across condenser 17 is also applied to a parallel large condenser 21 through series resistance 22. This places a negative voltage on the control grid of the variable-mu tube T₁ which reduces the gain of the amplifier portion of the circuit.

The result of this action is to hold the voltage of the suppressor grid of tube T₃ during marking intervals to a value near zero with respect to the cathode of that tube unless the carrier current being received is not of the necessary level to raise the suppressor grid to zero with the amplifier at maximum gain. By applying approximately one-half of the direct current output signal from the bridge rectifier D to the suppressor grid of tube T₃, the half peak value of this direct current signal wave is kept approximately zero with respect to the cathode. The voltage drop across resistance 16 which supplies the control grid bias on tube T₁ also increases the control grid bias on the tube T₃. This makes the increase in the direct current output voltage of the bridge rectifier D about twice the amount of increase in the voltage across resistance 16. Since the changes in the control voltage drop across resistance 16 are small compared with the total bias on tube T₃, and also because the voltage of the control grid of that tube at which relay RR operates is close to the value at which the suppressor grid exercises its control, the resulting bias of the received signals does not change appreciably with normal variations in the level of the incoming carrier signals. Potentiometer 6 provides means for setting the control point to obtain undistorted signals within the type of wave form being received.

Resistance 22 prevents the control voltage across condenser 21 from changing rapidly. Momentary sudden increases in input level to the detector circuit, such as "hits" which sometimes occur during lightning storms, are prevented by the large condenser 21 and resistance 22 from changing the gain of the amplifier portion of the circuit appreciably. Condenser 17 charges

during the marking intervals from the electron current from the suppressor grid of tube T₃. The charging rate is much faster than the continued discharge through resistance 16 which results in but small variations in the control voltage with changes in the character of the telegraph signals being received. The effect of the condenser 25 shunting the resistance 22 will be described later.

In accordance with the present invention, the plate current of the variable-mu tube T₁ is passed through the biasing (lower) winding on relay RR over a circuit extending from the plate of tube T₁ through resistance 9, resistance 23, lower biasing winding on relay RR and plate battery 8 in series to the cathode of tube T₁. By properly poling the lower biasing winding of relay RR, this current flow is in a direction to aid the plate and screen currents of the direct current amplifier tube T₃ in operating the armature of relay RR to its marking contact. Since the plate current of tube T₁ is a steady current which varies only with the incoming signal level, being larger at low levels, the effect of this current is to cause the received bias to be more positive at low levels and to cause the received bias to change less with level variations. This may be explained as follows:

When a variable-mu tube is used as a variable gain device in an amplifier, by varying the voltage on its control grid, the D. C. component of the plate current varies inversely as the negative control grid voltage; that is, the higher the negative control grid voltage, the lower the D. C. plate current. When the negative control grid voltage is obtained from the incoming rectified carrier signal so as to obtain automatic gain control, as in the circuit of the drawing as described above, the D. C. plate current then varies with the incoming carrier level. At a low carrier level, little grid voltage is required and the plate current (D. C.) is high, and for a high level the negative grid voltage is greater and the D. C. plate current lower. Thus, the D. C. plate current of the controlled tube (variable-mu) or tubes is an indication of the incoming level. The A. C. component of the plate current remains practically constant.

In the system of the drawing, the receiving relay RR is supplied with a fixed bias current through its middle winding. The relay would therefore tend to operate when the operating current supplied to the operating winding (upper) from the output of tube T₃ exceeds the effective value of the biasing current.

The level compensating arrangement in the system of the drawing as described above can only compensate for changes in the level or amplitude of the received carrier. It does not compensate for changes in the shape of the signal envelope caused by distortion in the tubes, filters or other elements in the transmission path. Thus it is found that the received signal bias does not remain absolutely constant with received level.

The effect of passing the D. C. plate current of the controlled variable-mu tube T₁ through the lower winding on the receiving relay RR is to compensate for some of the remaining variations in signal bias not compensated for by the automatic gain adjusting arrangement. By this means the effective biasing current of the receiving relay is made to vary with incoming signal level. It does not change with the signals being received but only with changes in

the average peak level of the signals. The anode current of the tube T₁ is passed through the lower winding of the relay RR in such direction as to oppose the effect of the steady (normal) biasing current supplied through the middle winding of the relay. Thus at low incoming levels when the value of the plate current of the tube T₁ is high, the effective bias on the receiving relay is lowered. As the level of the received signals increases, the plate current of tube T₁ falls and the effective relay biasing current rises.

The effect of the arrangement just described is to tend to lengthen the signal impulses repeated by the receiving relay RR at low incoming levels. This effect tapers off as the level increases. The net effect is to make the signals more marking at low levels than they would be otherwise. The arrangement thus favorably modifies the received bias as level characteristic of the system in a fixed manner depending only on the level of the incoming signals.

The condenser 25 shunting the resistance 22 is provided to prevent a possible undesired characteristic of the automatic gain control feature due to the fact that the voltage *e*₂ across condenser 21 could continue to rise as long as it (*e*₂) was less than the voltage *e*₁ across condenser 17 even though *e*₁ was decreasing by the discharge of condenser 17 through resistance 16. This would result in a peculiar transient response to suddenly increased carrier levels. For a period the gain of the amplifier would be reduced beyond the value necessitated by the suddenly increased level. The gain in adjusting to the new value would "overshoot" and oscillate back and forth finally arriving at the correct value. This effect is eliminated by the condenser 25 connected across resistance 22. It may be shown that if

$$C_3 \geq \frac{R_1 C_1}{R_2}$$

where C₃ is the value of condenser 25, C₁ is the value of condensers 17, R₁ the value of resistance 16 and R₂ the value of resistance 22, that the voltage *e*₂ across condenser 21 will always decrease when the voltage *e*₁ across condenser 17 is decreasing by a free discharge of condenser 17 through resistance 16, even though *e*₁ > *e*₂, the net effect of this being to eliminate the oscillating nature of the gain adjustment.

The presence of the condenser 25 also affords some transfer of high frequency changes in *e*₁ to *e*₂ thus giving immediately some compensation on a rapid level increase such as the beginning of a gain "hit." The presence of C₃ only affects the transient response of the compensating action, greatly improving it. For the steady state (constant level of carrier signals) the circuit acts identically as without condenser 25.

Voltage surges in relay RR are prevented from interfering with the amplifier section of the receiving circuit by means of the filter consisting of resistance 23 and condenser 24.

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

What is claimed is:

1. In combination in a signaling circuit, an alternating current signal amplifier including an electron discharge amplifying device having an output circuit, a detector for detecting the signals in the amplifier output, and a relay hav-

ing an operating winding adapted to be energized in response to the detected signals in the output of said detector, and a biasing winding included in the output circuit of said electron discharge amplifying device and adapted to be energized in response to the output currents thereof in such direction as to aid said operating winding in operating said relay.

2. In combination in a signaling circuit, an alternating current signal amplifier having one or more amplifying stages, a detector for detecting the signals appearing in the output of said amplifier, a relay having an operating winding adapted to be energized in response to the detected signals in the output of said detector, and a biasing winding adapted to be energized in response to the output current of one stage of said amplifier, poled so as to assist said operating winding in operating said relay.

3. In combination in a signaling circuit, an alternating current signal amplifier including an amplifying electron discharge device having an anode-cathode circuit, a detector coupled to said anode-cathode circuit for detecting signals applied thereto from said anode-cathode circuit, and a relay having an operating winding adapted to be energized by the detected signals in the output of said detector, and a biasing winding included in said anode-cathode circuit of said amplifying device, poled so that flow of anode current therethrough tends to aid said operating winding to operate said relay.

4. In combination in a carrier telegraph receiving circuit, an amplifier for amplifying received carrier modulated telegraph signal waves, including an electron discharge amplifying tube having an anode-cathode circuit, a detector for detecting the telegraph signal components of the amplified waves and a relay having an operating winding energized from the telegraph signal output of said detector, and another winding connected in the anode-cathode circuit of said amplifying tube, poled so that the anode current flow therethrough will be in such direction as to assist said operating winding to operate said relay.

5. In combination in a carrier telegraph receiving circuit, an amplifier for received carrier modulated telegraph signals, including a variable-mu amplifying vacuum tube having an anode-cathode circuit, a detector for detecting the telegraph signal components while suppressing the carrier component of the amplified waves, a direct current amplifier for amplifying the detected telegraph signals, and a polar relay having an armature, marking and spacing contacts, an operating winding energized by the amplified telegraph signals, and another winding connected in series with said anode-cathode circuit of said variable-mu tube, poles so that the anode current flow therethrough is in a direction to aid the telegraph signal current supplied to said operating winding to operate the relay armature to said marking contact.

6. In combination in a carrier telegraph receiving circuit, an amplifier for received carrier modulated telegraph signals, including a variable-mu amplifying vacuum tube having an anode-cathode circuit, a detector for detecting the telegraph signal components while suppressing the carrier component of the amplified waves, a direct current amplifier for amplifying the detected telegraph signals, a polar relay including an armature, marking and spacing contacts and an operating winding energized by

the amplified telegraph signals, means responsive to the detected telegraph signals for controlling the gain of said variable-mu tube to compensate for distortion in the signals controlling said relay caused by variations in the amplitude level of said received carrier modulated telegraph signals, and means to further reduce the distortion in the signals controlling

said relay comprising another winding on said relay connected in series with said anode-cathode circuit of said variable-mu tube, poled so that the anode current flow therethrough is in a direction to aid the telegraph signal current supplied to said operating winding to operate said relay armature to said marking contact.

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