

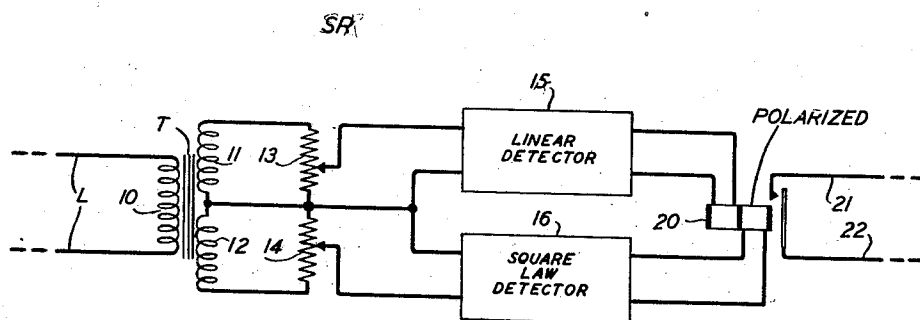
May 12, 1942.

D. K. GANNETT

2,282,719

SIGNALING SYSTEM

Filed Oct. 25, 1940



INVENTOR
D. K. GANNETT
BY
R. O. Covell
ATTORNEY

UNITED STATES PATENT OFFICE

2,282,719

SIGNALING SYSTEM

Danforth K. Gannett, Mountain Lakes, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 25, 1940, Serial No. 362,781

8 Claims. (Cl. 178-44)

This invention relates to signaling systems and particularly to systems employing voice frequency currents for transmitting signals.

Objects of the invention are an increase in the reliability of alternating current signaling and the prevention of false operation in response to interference currents.

In signaling systems in which current of one or more voice frequencies is used for signaling, the signal receiver must respond to signaling current without being responsive to voice currents or interference currents of signaling frequency. It is known in such systems to employ frequency selective or time delay arrangements for preventing false signal operations.

This invention is a signal device which is operatively responsive to application of signaling currents of sinusoidal wave form and which is operatively non-responsive to currents of other wave forms.

According to one feature of the invention, false signal operation is prevented in a voice frequency signaling system by distinguishing between signaling currents which are of sine wave form and voice currents which have a relatively high peak factor. That is, the ratio of the maximum to the root mean square amplitude of sine wave signaling current is low enough compared with the ratio of the maximum to the root mean square amplitude of voice currents so that this difference may be used to prevent signal operation in response to voice currents.

Another feature of the invention is a signal receiver in which the signal relay has a first winding connected by a linear detector to the line over which voice and signal currents are transmitted and a second winding connected to this line by a square law detector, the windings being differentially energized and the relative level of the output of said detectors being so adjusted that the energization of the first winding exceeds the opposite energization of the second winding by a large enough margin to cause operation of the relay upon the transmission of sine wave signaling current in the line. But when voice currents

are being transmitted, either alone or at the same time as signaling current is being transmitted, the energization of the second winding is strong enough to prevent operation of the relay.

5 A signal receiver arranged in accordance with the invention is shown in the drawing which consists of a single figure. Referring to the drawing, a signal receiver SR is connected to a line L over which signals and voice currents are transmitted.

10 The signal receiver SR consists of a transformer T having an input winding 10 and two output windings 11 and 12, potentiometers 13 and 14, a linear detector 15, a square law detector 16, and 15 a polarized signal relay 20. The left winding of relay 20 is connected in the output circuit of the linear detector and its energization tends to operate the relay; while the right winding is connected in the output circuit of the square law detector and opposes operation. The potentiometers 13 and 14 are adjusted so that in response to sine wave signaling current the output of the linear detector exceeds that of the square law detector sufficiently to operate relay 20. But in response to voice currents, having a relatively large peak factor, the output of the square law detector is relatively larger compared to that of the linear detector and the energization of the right winding of relay 20 will prevent its operation. A constant output amplifier may be added 20 between the detectors and the line. The operation of relay 20 responsive to signaling current closes a circuit through conductors 21 and 22 to effect any desired result.

25 The performance of such a signal receiving arrangement may be analyzed by assuming that the signaling currents have a pure sine wave form and that the voice currents consist of rectangular impulses of alternate polarity, each impulse having an amplitude h and lasting for a small fraction k of a half cycle. The output of the detectors 15 and 16 in response to such a rectangular wave having a high peak factor will be compared to the output of these detectors in response 30 35 40 45

to a sine wave. The characteristics of the two waves are as follows:

	Sine wave	Rectangular wave
Root mean square value---	$\frac{A}{\sqrt{2}}$	$h\sqrt{k}$
Peak amplitude-----	A	h
Peak factor-----	$\sqrt{2}$	$\frac{1}{\sqrt{k}}$
Ratio of peak factors $R = \frac{1}{\sqrt{2k}}$		(0)

The direct current output of the linear detector is

$$I_L = \frac{m_L}{\pi} \int_0^\pi y(\alpha) d\alpha \quad (1)$$

and the direct current output of the square law detector is

$$I_s = \frac{m_s}{\pi} \int_0^\pi [y(\alpha)]^2 d\alpha \quad (2)$$

where $y(\alpha)$ is the wave applied to the input of the circuit, and m_L and m_s are constants related to the sensitivities of the two circuits.

For the sine wave, $y(\alpha) = A \sin \alpha$, and

$$\left. \begin{aligned} I_L &= \frac{2A}{\pi} m_L \\ I_s &= \frac{A^2}{2} m_s \end{aligned} \right\} \quad (3)$$

The relay will operate whenever the net operating current exceeds some minimum value. That is, when

$$I_L - I_s \geq I_o$$

$$\frac{2A}{\pi} m_L - \frac{A^2}{2} m_s \geq I_o \quad (4)$$

It is evident by inspection that the relay operates for a range of values of A lying between the two solutions of the above equation, which are:

$$\left. \begin{aligned} A_1 &= \frac{2m_L}{\pi m_s} + \left(\frac{4m_L^2}{\pi^2 m_s^2} - \frac{2I_o}{m_s} \right)^{1/2} \\ A_2 &= \frac{2m_L}{\pi m_s} - \left(\frac{4m_L^2}{\pi^2 m_s^2} - \frac{2I_o}{m_s} \right)^{1/2} \end{aligned} \right\} \quad (5)$$

It is generally desired that the device responds to a definite range of received currents. Let

$$\frac{A_1}{A_2} = q$$

It can be shown that this calls for the following relation between m_L and m_s :

$$\frac{m_L^2}{m_s} = \frac{\pi^2}{8} I_o (q^{1/2} + q^{-1/2})^2 \quad (6)$$

and

$$\left. \begin{aligned} A_1 &= \frac{\pi I_o}{2m_L} (1+q) \\ A_2 &= \frac{\pi I_o}{2m_L} \left(1 + \frac{1}{q} \right) \end{aligned} \right\} \quad (7)$$

Now consider the rectangular wave. In this case

$$y(\alpha) = h, [\alpha = 0 \text{ to } \alpha = k\pi]$$

$$= 0, [\alpha = k\pi \text{ to } \alpha = \pi]$$

$$I_L = khm_L$$

$$I_s = kh^2 m_s$$

If this wave is to operate the relay, the following condition must be fulfilled:

$$I_L - I_s \geq I_o$$

or

$$khm_L - kh^2 m_s \geq I_o$$

Solving for h,

$$h = \frac{m_L}{2m_s} \left[1 \pm \sqrt{1 - \frac{4m_s I_o}{km_L^2}} \right] \quad (8)$$

This has a real solution only when

$$\frac{4m_s I_o}{km_L^2} < 1 \quad (9)$$

But from (6),

$$\frac{m_L^2}{m_s} = \frac{\pi^2}{8} I_o (q^{1/2} + q^{-1/2})^2$$

and from (0),

$$k = \frac{1}{2R^2}$$

Therefore, the expression becomes

$$\frac{64R^2}{\pi^2 (q^{1/2} + q^{-1/2})^2} < 1 \text{ or } R < \frac{\pi}{8} (q^{1/2} + q^{-1/2}) \quad (10)$$

which is the condition for false operation on the rectangular wave.

As a numerical example, assume $q=4$ (indicating a response to a range of sine wave signals of about 12 decibel spread). Then the rectangular interfering wave would, under no conditions, cause false operation if its peak factor bore a ratio to that of a sine wave greater than

$$R = \frac{\pi}{8} \left(2\frac{1}{2} \right)$$

which is about unity. With $q=9$ (about 19 decibels), no false operations will occur if R exceeds about

$$\frac{4}{3}$$

If the peak factor just meets the condition of (10) permitting false operation, the necessary amplitude of the interference is

$$h = \frac{m_L}{2m_s} = \frac{\pi^2 I_o}{16m_L} (q^{1/2} + q^{-1/2})^2$$

The ratio of this to A_2 , the minimum signal amplitude which will operate the relay, is

$$\frac{\pi}{8} (1+q)$$

when $q=4$, this ratio is about 2; and when $q=9$, it is about 4.

From the above, it is found there is a sufficient margin between the output of the linear and square law detectors to enable satisfactory discrimination between sine wave signaling current and voice currents.

The invention is not limited in its application to voice frequency signaling but is generally applicable to any signaling system in which signal operation is desired responsive to sinusoidal signal currents but not in response to currents having some other wave form.

What is claimed is:

1. In a signaling system including a line subjected to voice currents and to signals consisting of voice frequency currents of sine wave form, a signal receiver for responding to incoming signals, said receiver comprising a differential signal relay, two detectors connected in multiple for response to currents transmitted through said line, one of said detectors being a linear

detector and the other of said detectors being a square law detector, the output of the linear detector connected to one winding and the output of the square law detector connected to another winding of said relay, and means controlling the input to said detectors so that the output of the linear detector is enough larger than the output of the square law detector to effect the operation of said relay in response to signal currents in said line but is not enough larger to effect the operation of said relay when voice currents are being transmitted through said line.

2. In a signal device for connection with a line through which voice currents and voice frequency signaling currents of sine wave form are transmitted, a polarized signal relay, a linear detector, a square law detector, an operating winding of said relay connected in the output circuit of the linear detector, a biasing winding of said relay connected in the output circuit of the square law detector, means comprising a transformer for applying energy from voice and signaling current transmitted through a connected line to both of said detectors, and means for adjusting the relative level of the energy applied to said detectors so that the energization of said operating winding effects the operation of said relay responsive to sine wave signaling currents and so that the energization of said biasing winding prevents the operation of said relay responsive to voice currents.

3. A signal device comprising an input transformer, a linear detector, a square law detector, a signal relay, an operating winding of said relay connected in the output circuit of the linear detector, a biasing winding of said relay connected in the output circuit of said square law detector, and means connecting the input circuits of said detectors to the output circuit of said transformer, the energization of the operating winding of said relay responsive to the application of signaling currents of sine wave form to said transformer being effective to operate said relay, the energization of the biasing winding of said relay being effective to prevent the operation of said relay while voice currents are being applied to said transformer.

4. A signal device comprising an input transformer, a linear detector, a square law detector, a signal relay, an operating winding of said relay connected in the output circuit of the linear detector, a biasing winding of said relay connected in the output circuit of said square law detector, means connecting the input circuits of said detectors to the output circuit of said transformer, and means for adjusting the relative levels of the energy applied to each of said detectors, the output of the linear detector being sufficiently larger than the output of the square law detector responsive to the application of voice frequency signaling current of sine wave form to said transformer to effect operation of said relay, the output of the square law detector being large enough responsive to voice currents to prevent the operation of said relay.

5. A signal device comprising an input transformer, a linear detector, a square law detector, a potentiometer connecting said transformer to said

linear detector, another potentiometer connecting said transformer to said square law detector, a polarized signal relay, an operating winding of said relay connected in the output circuit of said linear detector, and a biasing winding connected in the output circuit of said square law detector, said relay and potentiometers so adjusted that the current in the output circuit of the linear detector is enough larger than the current in the output circuit of the square law detector responsive to the application of voice frequency signaling current of sine wave form to said transformer to effect the operation of said relay and the current in the output circuit of the square law detector is large enough when voice currents are applied to said transformer to prevent the operation of the relay.

6. In a signaling system, the method of selectively distinguishing between currents having a wave form with a high peak factor and currents having a wave form with a low peak factor, said method comprising rectification of the alternating current to obtain a current the amplitude of which is directly proportional to that of the alternating current, rectification of the alternating current to obtain a current the amplitude of which is proportional to the square of the amplitude of the alternating current, the differential combination of the linear and square law rectified currents, and the adjusting of the relative amplitudes of the rectified currents to obtain a desired difference between these currents when the alternating current is of one of said wave forms.

7. In a signaling system, the method of selectively distinguishing between currents having a wave form with a high peak factor from currents having a wave form with a low peak factor, said method comprising rectification of the alternating current to obtain a current the amplitude of which is directly proportion to that of the alternating current, rectification of the alternating current to obtain a current the amplitude of which is proportional to the square of the amplitude of the alternating current and the differential combination of the linear and square law rectified currents.

8. In a signaling system in which signals are transmitted by alternating current of a sine wave form and in which voice currents and other interference currents having a wave form with a high peak factor are present, the method of obtaining a signal response only when signaling current is being transmitted and substantially no voice current or other interference current is being transmitted, comprising rectification of the alternating current to obtain a direct current which is proportional to the first order of the amplitude of the alternating current, rectification of the alternating current to obtain a direct current which is proportional to the square of the amplitude of the alternating current, the differential combination of the two rectified currents, and the adjustment of the relative amplitudes of the rectified currents so as to obtain a signal response only when substantially all of the alternating current is of sine wave form.

DANFORTH K. GANNETT.