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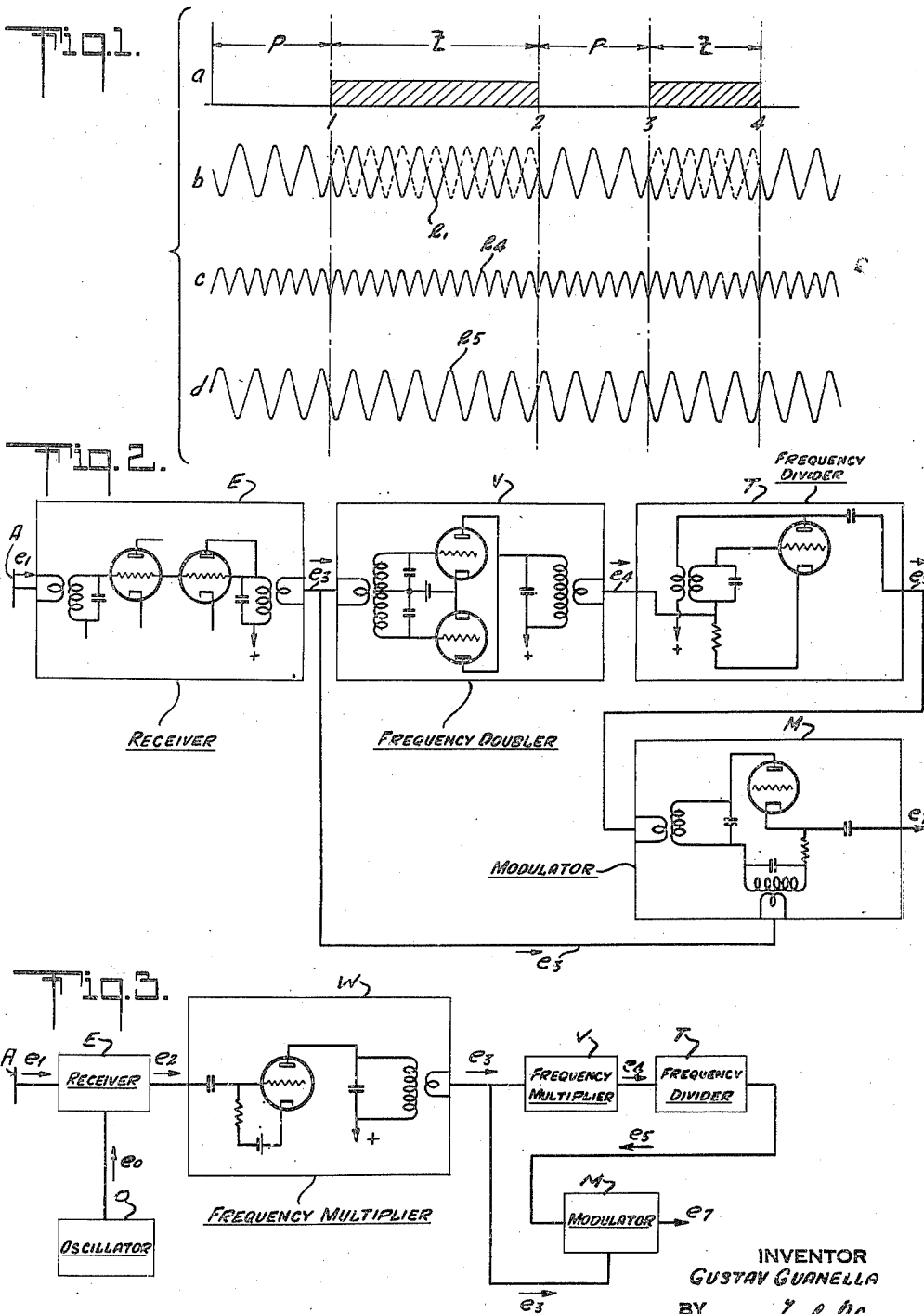
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RECEIVING SYSTEM FOR PHASE-KEYED PULSE SIGNALS

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RECEIVING SYSTEM FOR PHASE-KEYED
PULSE SIGNALS

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The present invention relates to receiving systems for pulse modulated carrier signals, more particularly of the type wherein the signal pulses and spacing intervals are characterized by a phase change between two predetermined time phase positions of the carrier wave of substantially constant amplitude, such as a 180° phase reversal for the signal pulses and spacing intervals, respectively. The invention has many uses such as for the reception of telegraphic and facsimile signals, pulse time and variable pulse position modulated signals and in general all other signals utilizing pulse modulations for the transmission of intelligence, from a transmitting to a receiving station.

Devices are already known which employ phase keying for the transmission of telegraph signals, wherein the signal pulses are distinguished from the spacing intervals by means of a phase position shift of 180° for the continuously transmitted high frequency oscillation. This means of distinguishing the impulses and intervals may also be applied to speech and facsimile transmission using pulse time or an equivalent modulation. At the receiving end the signals are demodulated by superposing them upon an auxiliary voltage whose frequency coincides with the frequency of the received oscillation. Considerable difficulty is encountered in producing this auxiliary oscillation at the receiving end since the oscillation must be in exact phase or in phase opposition with the receiving oscillation. It is known to produce the auxiliary oscillation by means of a frequency-stabilized oscillator whose phase position is adjusted by hand in the desired manner. This manual adjustment makes the practical application of this method very difficult. The disadvantages of this known device are overcome by the present invention.

According to the invention, means are provided for obtaining a harmonic from the receiving frequency wave, there being further provided means for synchronizing the auxiliary oscillation with this harmonic wave. The second harmonic is particularly suitable for this purpose. Other harmonics of a higher order may, however, also be used. Synchronization occurs independently of whether the phase of the received signal voltage is the same or opposite to that of the auxiliary oscillation. For the auxiliary oscillation it is thus of no importance whether the received wave is transmitting a signal pulse or a spacing interval between successive pulses.

The invention both as to its further objects and novel aspects will become more apparent

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from the following detailed description taken in reference to the accompanying drawings, forming part of this specification and wherein:

Fig. 1a to Fig. 1d are diagrams illustrating the shape of a known type of pulse signal characterized by successive phase reversals of a carrier wave, forming the basis of the invention;

Fig. 2 is a schematic circuit diagram for receiving phase-keyed signals of the type according or equivalent to Fig. 1;

Fig. 3 is a circuit diagram, shown partly in block form and illustrating a modification of Fig. 1;

Fig. 4 and Fig. 5 are block diagrams showing further modifications of systems according to Fig. 1;

Fig. 6 is a block diagram illustrating a modified arrangement for carrying out the invention;

Fig. 7 illustrates a special receiving device suitable for use in connection with the invention; and

Fig. 8 is a block diagram showing a modification of a system according to Fig. 6;

Like reference characters identify like parts in the different views of the drawings.

Fig. 1a shows a graphic representation of the telegraph or other pulse signals to be transmitted, and consisting of alternate signal pulses Z and spacing intervals P. The corresponding curve of the modulated high frequency oscillation at the output end of the transmitter is shown in Fig. 1b.

The high frequency oscillations incoming from the transmitter with constant frequency and amplitude but with phase reversals corresponding to the signal keying, reach the receiving antenna A of the receiving arrangement shown in Fig. 2 and then pass to the receiver and amplifier E in the form of an input voltage e_1 . This amplifier may be a multi-stage amplifier of known kind. The output voltage e_3 of the amplifier E is applied to the frequency doubler or multiplier V. This frequency doubler advantageously may comprise two amplifier tubes in push-pull connection and having sharply bent characteristic curves, so that the second harmonic is strongly pronounced. The voltage e_4 which is thus obtained and has double the frequency is halved again in the frequency divider T. This latter apparatus may be a regenerative vacuum tube generator which oscillates at the receiving frequency and is synchronized by the harmonic frequency of voltage e_4 . Voltage e_5 thus contains the same frequency as voltage e_3 , but is not subjected to any phase reversals. The oscil-

lations e_3 , e_4 and e_5 are shown graphically in Figs. 1b, 1c and 1d. At the instants 1, 3, etc., at which the signal pulses start, phase changes occur, these being for instance direct phase reversals of 180° , as shown in the drawing. At the instants 2, 4, etc., i. e. at the end of the signal pulses, the original phase is restored again. The dotted parts of the curve represent the unkeyed or unaffected course of the high frequency oscillations. The oscillations may be raised to double the frequency in the multiplier V, for instance by means of double-wave rectification, as shown in the drawing. Other degrees of frequency multiplication may also be employed. By using rectification to multiply the frequency, an oscillation curve for the voltage e_4 such as is shown in Fig. 1c is obtained. This oscillation curve no longer contains any of the phase reversal of voltage e_3 . The voltage e_4 in turn has its frequency halved in the frequency divider T which follows; that is the frequency is restored to its original value. The voltage e_5 which is thus obtained, is shown in Fig. 1d.

The frequency of voltage e_5 coincides again with the frequency of voltage e_3 , with the difference, however, that the voltage e_5 even with a phase keying of voltage e_3 does not exhibit any phase reversals, since the phase reversals of the signal, oscillations e_3 , has no effect on the voltage e_4 . Voltage e_5 can therefore be used as an auxiliary voltage for demodulating the telegraph signals, inasmuch it coincides exactly with the frequency of the received oscillation. Thus by superposing the voltage e_5 with the phase-keyed voltage e_3 in modulator M, a direct current output voltage e_7 is obtained which according to the phase reversals of voltage e_3 relative to the voltage e_5 , changes its sign between positive and negative values. A diode may be used as a modulator having oscillatory circuits inserted in its output circuit which are excited by the voltages e_5 and e_3 , respectively, as shown in Fig. 2. The resulting direct current in the output circuit changes its direction at the beginning and end of the signal and can serve to actuate a recording device or the like. Modulator M may be of any other type known in the art.

A superheterodyne receiver E having a local oscillator O may also be used as shown in Fig. 3. The intermediate frequency voltage e_2 undergoes the same phase reversals as the received signal voltage e_1 . Instead of doubling the frequency it is also possible to multiply the frequency m -times and to subsequently divide it by m .

Fig. 6 shows an arrangement, wherein the frequency divider T is replaced by a generator G. A harmonic wave e_6 of the generator has its phase corrected to correspond with that of the multiplied received voltage e_4 by means of a discriminator and automatic frequency regulator P.

The invention is not limited to keying by phase reversal, but equally applies to receiving signals which are phase keyed by an angle

$$\varphi = \frac{\pi}{2}, \frac{\pi}{3}$$

or an even smaller amount

$$\frac{\pi}{p}$$

In this manner, in accordance with Fig. 3, the input voltage e_2 which is thus modulated has its frequency doubled or multiplied p -times in such

a manner in a multiplier W that the resulting voltage e_3 again is subjected to phase reversal or changes of 180°

By using several different phase changes it is possible to transmit a corresponding number of different and independent signals upon the same carrier. In this case several demodulators are used to which the receiving voltage e_3 is applied, as well as auxiliary voltages of different phase which are obtained from the voltage e_5 .

Fig. 4 shows a constructional example of the invention for two messages with two phase changes of

$$\varphi = \frac{\pi}{2}$$

and π and with two corresponding modulators. Modulator Ma operates exactly like modulator M in Figs. 2 and 3. Voltage e_5 is supplied to modulator Mb over a phase shift network N designed to effect a phase shift of

$$\frac{\pi}{2}$$

Phase changes in voltage e_3 amounting to $\varphi = \pi$ only produce pulse signals in modulator Ma, while phase changes of

$$\varphi = \frac{\pi}{2}$$

only cause modulator Mb to operate. Modulators Ma and Mb are shown to supply separate output devices, such as recording relays Ra and Rb, respectively, or the like.

When receiving telegraph signals from transmitters with keyed phase changes, it is possible to interchange the signals and the intervals. Since generally the duration of all intervals differs considerably from the duration of all signals, the mean value of the signal current obtained in modulator M may be used to actuate a pole-reversing relay R which is sensitive to the direction of current flow, as shown in Fig. 5. Furthermore the difference between the sum of the duration of the signals and that of the intervals may be determined automatically in a device which is located in the place of relay R in the arrangement shown in Fig. 5. A detailed arrangement of such a device is shown in Fig. 7. In this figure V_1 and V_2 indicate two amplifier tubes which may also be mounted in a common vessel. When the carrier frequency is transmitted, modulator M (Fig. 5) supplies a direct voltage to terminals 1 and 2 (Fig. 7). If terminal 1 is positive relative to terminal 2, then the cathode current of tube V_1 exceeds that of tube V_2 and acts to pull the armature of the polarized relay X away from the position of rest, for instance to the direction O. The polarity at the terminals 1 and 2 is temporarily reversed by the keyed signals. If, however, compared with the time constant of condenser C_1 or C_2 , respectively, together with that of the relay winding, the total duration of the intervals always exceeds that of the signals, the relay armature will remain in this position. Tubes V_1 and V_2 are additionally operated as so-called cathode follower amplifiers for the received signal in the manner shown. Approximately the same voltage fluctuations occur at the resistances R_{K1} and R_{K2} as at the resistances R_{G1} and R_{G2} . A high impedance current source, for instance a diode modulator, may thus be connected to the terminals 1, 2. The internal resistance of the arrangement measured at the terminals 3 and 4 is comparatively very low and this is an advantage as regards any recording device connected to this arrangement.

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With a directional relay arrangement of the type shown in Fig. 7, it is thus possible to maintain at the output terminals 3, 4, pulses of the same polarity, i. e., either positive or negative, independently of any interchange between the pulses and spacing intervals in the received carrier wave or the corresponding demodulated positive and negative pulses supplied by the modulator M and applied to input terminals 1, 2. Thus, if the pulses and spacing intervals are interchanged due to any cause, such as by a phase reversal of local oscillator or frequency divider, the relay X, due to the change of the average or integrated pulse current, will cause its armature and cooperating contacts to switch from the position o to the position u, or vice versa, thus maintaining the proper polarity of the output pulses supplied at the terminals 3, 4.

Another modified form of the arrangement for producing an auxiliary frequency which is independent of the phase keying, is shown in Fig. 8.

The received oscillations e_2 which are amplified in the receiver E and the oscillator oscillations e_3 have their frequency doubled or multiplied by means of the frequency multipliers Va and Vb and are applied to the modulator M₁ acting as a phase comparator. The resulting demodulation voltage e_6 is used as a regulating voltage for controlling the frequency and phase of the oscillator O. By this means it is possible for the frequencies of voltages e_1 and e_3 to be continuously synchronized independently of the phase keying, so that the telegraph signal voltage e_7 may be obtained from the modulator M₂ as a direct voltage with alternating polarity.

While the invention has been described with specific reference to a few desirable embodiments, it is understood that various changes in the construction and arrangement of elements, as well as the substitution of equivalent elements and circuits for those herein shown, may be made without departing from the spirit and scope of the invention as defined by the appended claims. The specification and drawings are accordingly to be regarded in an illustrative rather than a restrictive sense.

I claim:

1. The combination with a system for receiving pulse modulated carrier signals of the type wherein the signal pulses and spacing intervals are characterized by a phase reversal of the carrier wave of substantially constant frequency and amplitude and comprising a signal input circuit and means for producing an auxiliary signal of carrier frequency to be combined with the incoming signal to derive demodulated output signals, said means comprising a frequency multiplier connected to said input circuit for multiplying the frequency of a portion of the incoming signal energy, a frequency divider connected to the output of said multiplier for reducing the multiplied frequency to a value equal to the original signal frequency, and means for combining the received signal with output energy of said frequency divider to produce final output energy of amplitude varying between two limit values in accordance with the signal pulses and spacing intervals, respectively.

2. The combination with a system for receiving pulse modulated carrier signals of the type wherein the signal pulses and spacing intervals are characterized by a predetermined phase change differing from 180° of the carrier wave of substantially constant frequency and amplitude and comprising a signal input circuit and

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means for producing an auxiliary signal of carrier frequency to be combined with the incoming signal to derive demodulated output signals, said means comprising a first frequency multiplier connected to said input circuit for increasing the frequency of the received signal to produce an intermediate signal subject to 180° phase reversals according to the signal pulses and spacing intervals, respectively, further frequency multiplying means connected to said first multiplier for increasing the frequency of a portion of the intermediate signal energy, a frequency divider connected to the output of said further multiplying means for reducing the multiplied frequency to a value equal to the frequency of said intermediate signal energy, and means for combining said intermediate signal with output energy of said frequency divider to produce final output energy of amplitude varying between two limit values in accordance with said signal pulses and spacing intervals, respectively.

3. In a system for receiving pulse modulated carrier signals of the type wherein the signal pulses and spacing intervals are characterized by a phase shift of the carrier wave between predetermined limit values, a signal receiver including means for producing an auxiliary carrier signal of frequency equal to the signal frequency and having a constant phase to be combined with the received signal for deriving demodulated signal pulses, said means comprising frequency multiplying means connected to said receiver for increasing the frequency of a portion of the received signal energy, frequency dividing means connected to said multiplying means for reducing the multiplied frequency to a value equal to the signal frequency, and means for combining the received signal with output energy of said dividing means.

4. In a system for receiving pulse modulated carrier signals of the type wherein the signal pulses and spacing intervals are characterized by 180° phase changes of the carrier wave, a signal receiving including means for producing an auxiliary signal of frequency equal to the signal frequency and having a constant phase to be combined with the received signal for deriving demodulated signal pulses, said means comprising a frequency doubler-amplifier connected to said receiver for increasing the frequency of a portion of the received signal energy, a frequency divider connected to the output of said doubler-amplifier for reducing the multiplied frequency to a value equal to the signal frequency, and means for combining the received signal with output energy of said doubler-amplifier.

5. In a system for receiving pulse modulated carrier signals of the type wherein the signal pulses and spacing intervals are characterized by a pre-determined phase shift differing from 180° of the carrier wave of substantially constant frequency and comprising a signal receiver and means for producing an auxiliary carrier signal to be combined with the received signal for deriving demodulated signal pulses, said means comprising a first frequency multiplier connected to said receiver for increasing the frequency of the received signal to produce an intermediate signal subject to 180° phase reversals according to the signal pulses and spacing intervals, respectively, a frequency doubler-amplifier connected to the output of said first multiplier for increasing the frequency of a portion of the intermediate signal energy, a frequency divider

connected to the output of said multiplier-amplifier for reducing the multiplied frequency to a value equal to the intermediate signal frequency, and means for combining said intermediate signal with output energy of said frequency divider to produce final signal energy of amplitude varying between limits in accordance with the signal pulses and spacing intervals, respectively.

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