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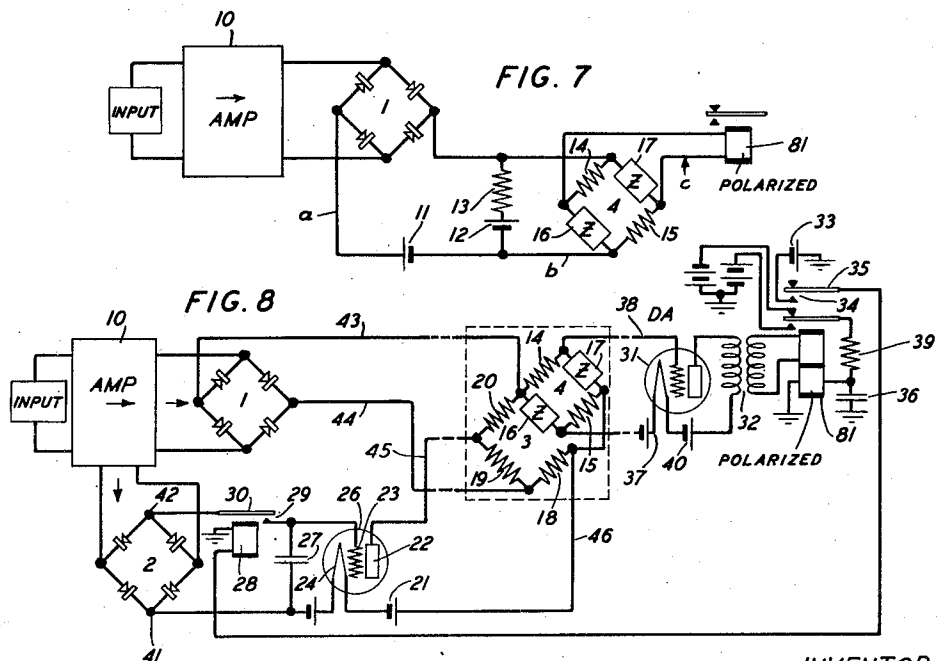
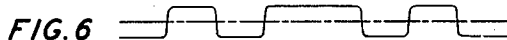
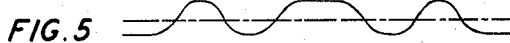
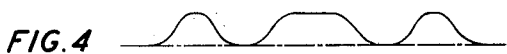
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2,184,978

CARRIER CURRENT TELEGRAPHY.

Filed May 19, 1938

2 Sheets-Sheet 1



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CARRIER CURRENT TELEGRAPHY

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2 Sheets-Sheet 2

FIG. 9

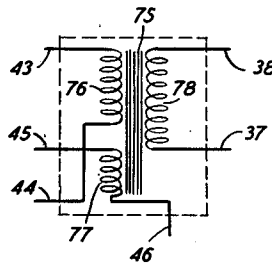
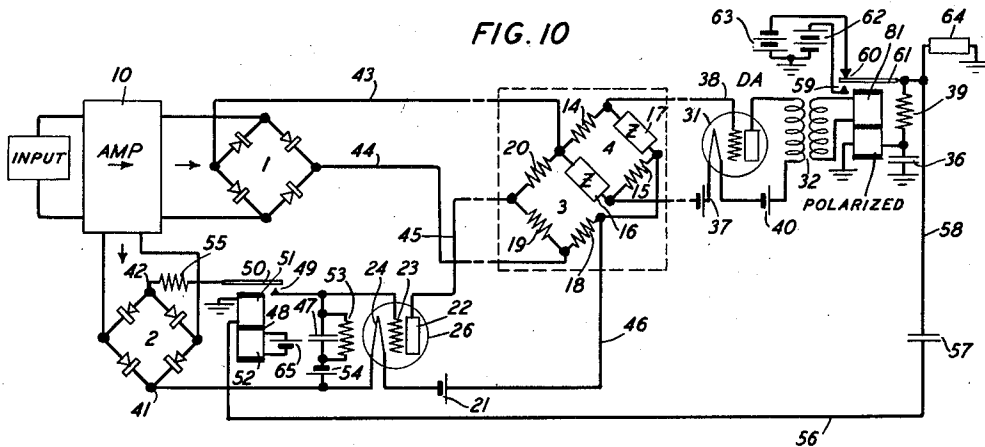


FIG. 10



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CARRIER CURRENT TELEGRAPHY

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Application May 19, 1938, Serial No. 208,760

15 Claims. (Cl. 178—66)

This invention relates to carrier current receiving systems and more particularly to the reception of carrier current telegraph signals.

It is an object of this invention to insure the positive operation of the receiving relay in a carrier current telegraph system.

Another object is to secure in the telegraph impulses received over carrier current transmission systems a substantial reproduction of the original direct current impulses actuating the sending relay.

A further object is to convert sinusoidal waves into waves having substantially flat tops and straight sides.

A paper by Messrs. Hamilton, Nyquist, Long and Phelps, subject Voice frequency carrier telegraph systems for cables, published in the Journal of the American Institute of Electrical Engineers, Vol. XLIV, No. 3, March, 1925, describes a carrier telegraph system of the sort in which my invention has application. It is shown that in such a system, the received carrier current impulses have been rounded off by reason of the characteristic of the transmitting media between sending and receiving. When the rounded carrier impulses are rectified, the resulting direct current impulses are found to be also rounded and of substantially sinusoidal conformation. Such rounded wave shapes compare unfavorably with waves of steep wave fronts in the operation of relays such as the polar relay customarily employed in telegraph circuits of this sort. My invention comprises means for converting the received carrier current impulses into steep-sided direct current reversals, whereby positive relay action is secured.

In the practice of my invention, in accordance with the specific disclosure to follow, I may first amplify and then rectify the incoming carrier current impulses, thus producing direct current impulses of fixed polarity, that is, they may be either positive impulses or negative impulses depending upon the point of reference, but with respect to any fixed reference point in the circuit, current flow is in one direction only. Upon this unidirectional current is then superposed an oppositely poled direct current of suitable magnitude with the result that the impulses are now defined by reversals of current. Before this superposition spacing intervals may be characterized by zero currents, marking intervals by positive currents. After superposition spacing intervals may be characterized by negative currents, marking intervals by positive currents. It is to be noted that by this process of superposition, I

have not changed the shape of the impulse waves, but only the zero or reference axis.

The next step involves the use of a discriminative network such that it transmits small currents readily, but larger currents are suppressed in proportion as they increase in magnitude, this of course within the designed limits of operation of the device. When the reversals obtained by superposition are applied to this device, it is evident current close to zero or the zero axis will pass freely through, whereas large currents will be suppressed to such an extent that the shape of the impulse wave will be altered from one substantially sinusoidal in nature, to one nearly square, that is, having steep sides and flattened tops. I may then amplify this wave and apply it to the receiving relay and satisfactory operation will be attained.

For a more complete understanding of the invention reference is made to the drawings in which:

Fig. 1 represents the form of the direct current wave at the transmitting end of a carrier current telegraph system;

Fig. 2 represents the carrier counterpart of the wave of Fig. 1;

Fig. 3 shows the carrier wave at the receiving end of a carrier current telegraph system;

Fig. 4 is a direct current wave formed from rectification of the received carrier wave;

Fig. 5 shows the change of axis resulting from the superposition of a fixed opposing potential upon the direct current wave of Fig. 4;

Fig. 6 is illustrative of the results obtained in the process of producing steep wave fronts in the wave of Fig. 5;

Fig. 7 is a schematic of the circuit involved in making the transformation from the wave of Fig. 3 to that of Fig. 6;

Fig. 8 is a complete diagram of a preferred arrangement as employed to improve the operation of the receiving relay in a carrier current telegraph system in accordance with the invention;

Fig. 9 is a transformer which may have a non-linear input-output characteristic; and

Fig. 10 is a modification of the arrangement of Fig. 8 which may under some conditions afford practical advantages.

In Fig. 7 the input from the carrier current line is applied to the amplifier 10 and then is led to the rectifier 1. The input to rectifier 1 may have the form shown in Fig. 3 and the output may then have the form shown in Fig. 4 and represent the current flowing through the conductor α . In sequence to the rectifier there are a re-

sistance 13 and two batteries 11 and 12 so arranged that battery 12 causes direct current to be superposed on the detector or rectified currents, but by reason of the interposition of battery 11 no direct current is sent through the rectifier. The purpose of the batteries 11 and 12 is to remove the bias from the rectified wave so that the wave shape of the current flowing through conductor *b* has the form shown as Fig. 5. The bridge 4 is a non-linear device which may be made up for instance of two metallic resistances and two resistances made of a substance the resistance of which decreases as the current through it or the potential across it is increased. This may be a mixture of silicon, carbide and a binder material as described in McEachron Patent 1,822,742, September 8, 1931. The elements are so chosen that the bridge is substantially balanced for large current values and is unbalanced for small current values. For example, assume resistances 14, 15 to be fixed at 100 ohms each and that impedances *Z* are so designed as to be several thousand ohms at low voltages. Thus impedances *Z* may be 5000 ohms each at a potential difference of one volt and 100 ohms each at ten volts. It is apparent that a much greater proportion of the output voltage of bridge rectifier 1 is applied to relay 81 when this rectified voltage is at its minimum than when at its maximum value, and also that the impedance values selected for bridge 4 are dictated not only by the impedances of the connected circuit but more particularly by the peak value of voltage to be applied to it. The effect of the bridge 4 is to remove the peak and steepen the sides of the waves as it exists in conductor *b*. The current in the conductor *c* will then take the form shown in Fig. 6. If the design is such that the magnitude of the wave at *c* as shown in Fig. 6, is sufficiently large to operate the relay 81 easily, that wave is more suitable for relay operation than the wave in conductor *b* as shown in Fig. 5.

In Fig. 8, 1 represents a full wave rectifier which may be of the bridge type, 2 is a second rectifier which may for convenience be similar to rectifier 1 but is not necessarily of the full wave type although so shown, 3 represents a Wheatstone type of bridge having resistance arms 18, 19 and 20, the fourth arm of bridge 3 being formed by non-linear bridge 4. The bridge 4 is so designed that for large values of current, the four arms 14, 15, 16 and 17 approach equality and consequently the current output from the bridge into conductors 37 and 38 approaches zero. For small values of current the bridge output is thus large comparatively. Conductors 37 and 38 connect the bridge 4 into the direct current amplifier 31 which is shown as a single vacuum tube triode, the cathode heating source being omitted from the drawings for simplicity of showing. The output of the amplifier 31 is through the transformer 32 into the receiving relay 81. In practice the direct current amplifier may consist of one or more stages of amplification as required. The relay 81 shown as a two-winding polarized relay may, of course, take any suitable form. By the use of the transformer 32 the bias of the transmitted signal by variations in battery such as battery 40 is prevented. The effect of distortion in the transformer may be equalized by any suitable equalization means. The connection of the condenser 36 in series with the second winding of the relay 81 may be one form of such equalization.

The relay 81 is shown in spacing position. On

the reception of a marking signal, relay 81 operates to marking position and the battery 33 is then connected through contacts 34 and 35 to relay 28, so that contacts 29 and 30 of relay 28 are closed. The output of rectifier 2 is thus connected across the condenser 27 which is permanently connected between grid 23 and cathode 24 of electron discharge device 26, the output circuit of tube 26 including anode 22, bridge 3, anode battery 21 and cathode 24.

Incoming signals such as those shown in Fig. 3 may be amplified as required in amplifier 10 and are then impressed on both rectifiers 1 and 2. Rectifier 1 produces biased impulses such as shown in Fig. 4 which are impressed on bridge 3. A potential of similar wave form appears at the terminals 41 and 42 of rectifier 2 and since the relay 28 is operated at marking intervals closing the contacts 29 and 30, the potential representing the magnitude or peak value of the marking signal is impressed across condenser 27. The rectifier 2 is so poled that the condenser is charged with its negative electrode connected to grid 23 of tube 26 and its positive electrode connecting to cathode 24 of tube 26, so that the control grid 23 of tube 26 is biased negatively and in accordance with the well-known operation of such vacuum tubes, the current flowing in the anode circuit of the tube and hence the potential difference across the bridge 3 is thereby held at a value which is dependent upon and representative of that grid bias potential. Since the grid bias potential is a measure of the marking potential of the signal, the potential impressed upon bridge 3 is also proportional to the magnitude of the incoming signal.

During the spacing interval, contacts 34 and 35 of receiving relay 81 open, relay 28 is deenergized and contacts 29 and 30 open, disconnecting condenser 27 from rectifier 2. Since condenser 27 is insulated it retains its charge at approximately peak value during the spacing interval. However, in practice due to circuit leakage there will be a slight discharge and consequent lowering of potential of the condenser in the spacing interval and the full signal magnitude will then be restored during the next marking interval. By reason of this small fluctuation of charge and discharge the potential on grid 23 of vacuum tube 26 and hence the potential impressed across bridge 3 will always be closely representative of the signal magnitude. If we now assume that bridge 3 had four equal arms 18, 19, 20 and a fourth of the same magnitude, then since across one diagonal of the bridge is impressed the biased signal from rectifier 4 and across the other diagonal a fixed potential representative of the magnitude of the incoming signal as produced by rectifier 2 and vacuum tube 26, if these potentials were properly poled and properly proportioned, there would appear across any one arm a biased wave form such as shown in Fig. 5 and resulting from the superposition of the two potentials. It is apparent that the bridge 3 is thus a device for permitting the superposition of the output of rectifier 2 upon the output of rectifier 1 while yet maintaining the two circuits substantially conjugate. In a preferred arrangement as shown in Fig. 8, the fourth arm of bridge 3 is replaced by bridge 4. By reason of the characteristics of bridge 4 as above described, the wave form of the signal as shown in Fig. 5 is transformed substantially to that shown in Fig. 6.

In order to get a large amount of non-linearity, with the arrangement described, it is necessary to

introduce considerable loss in the wave and for that reason it may be desirable to employ some form of direct current amplifier at this point. This amplifier may employ one or more stages as required. Such an amplifier 31 is shown interposed between the bridge 4 and the receiving relay 81.

An alternate method for the production of steep wave fronts might involve a transformer, Fig. 9, having a highly permeable core 75, as for example a core of permalloy and designed to saturate on small currents. This transformer might have two primary windings 76 and 77, one (76) to carry the rectified signaling wave output of bridge 1 and the other (77) to carry the bias compensating current. The secondary 78 would be connected into the grid circuit of the direct current amplifier, thus the transformer would replace bridges 3 and 4 of Fig. 8. In Fig. 9 the connections have been so laid out and numbered that it may be figuratively transposed into Fig. 8 to replace bridges 3 and 4.

Under some conditions it may be desirable to employ for the rectifier 2, as shown in Fig. 8, one of the imperfect rectifiers such as those employing copper-oxide, which functions by virtue of considerable variations in resistance with change in polarity of the applied potential. Such a rectifier would ordinarily permit the discharge of condenser 27 of Fig. 8 to an extent which would prevent proper functioning of the biasing circuit. Under these conditions there may be used the arrangement of Fig. 10 which is designed to function substantially in the manner described above for the arrangement of Fig. 8 and differs from it essentially only in the details of the biasing circuit, that is, the apparatus designed to convert the signal as shown in Fig. 4 to that shown in Fig. 5.

In Fig. 10 the rectifier 2 is connected through the high resistance 55 to the contact 50 of the relay 48 which has a polarizing winding 52 activated by battery 65 and an operating winding 51 which is connected through condenser 57 to contact 61 of receiving relay 81. The operating circuit of winding 51 of relay 48 is completed through contact 60 and battery 63 or through contact 59 and battery 62 and then to the ground return. The receiving sounder 84 may also be operated from batteries 62 and 63. In the grid circuit of the electron discharge vacuum tube 26 the condenser 47 is shunted by the very high resistance 53 and in series with these is the grid biasing battery 54. The condenser 47 and the resistance 55 are so proportioned as to permit substantially full charge of condenser 47 from the potentials appearing across terminals 41 and 42 of rectifier 2 during the time contacts 49 and 50 of relay 48 are closed. The time constant of the resistance 55 and the condenser 47 may thus be of the order of one-tenth second. The resistance 53 which under some circumstances may comprise the unavoidable leakages of the assembled apparatus is of a value so high as to have no appreciable effect upon the time constant of condenser 47 and resistance 55.

The conditions shown in Fig. 10 may be assumed to be those of spacing position. Assuming that no signal has come through for a considerable time, condenser 47 will have substantially discharged itself into resistance 53 and grid 23 of tube 26 will be biased substantially to the potential of battery 54. The potential of battery 54 is so chosen as to cause the apparatus to remain in an operating condition even after

a very long mark or space. The potential across bridge 3 from tube 26 will not be ideal under such conditions but the apparatus is so maintained that it will not fail to operate at the first incoming signal and will quickly adjust itself to provide the proper bias.

Assume now an incoming mark. Receiving relay 81 operates and battery 62 begins to charge condenser 57 through winding 51 of relay 48. As soon as the current in winding 51 has risen to the point where the magnetic flux produced by it overrides the opposing flux produced by the current in winding 52, the relay will operate and will remain operated until the point is reached where as the charge of condenser 57 approaches completion the charging current and hence the flux due to current in winding 51 falls so low that winding 52 regains control. During the remainder of the marking interval and through all of the spacing interval the relay 48 remains non-operated since when battery 63 is connected in circuit the charging current of condenser 57 aids rather than opposes the effect of battery 65 flowing through winding 52. In this interval condenser 47 will discharge slightly into resistance 53 and thus be in condition to be recharged to a potential representing the magnitude of the next marking signal. Thus, as in the arrangement of Fig. 8 an incoming signal as rectified into the form of Fig. 4 may be converted into the unbiased reversals as in Fig. 5 by the superposition of an opposing potential which is made to vary in magnitude in accordance with the magnitude of the incoming waves.

While preferred embodiments have been shown and described, it is to be understood that various modifications may be made without departing from the spirit of the invention, the scope of which is defined by the appended claims.

What is claimed is:

1. A carrier current receiving system comprising means for transforming carrier current impulses into direct current impulses of fixed polarity, means for superposing upon said direct current impulses a potential of opposite polarity whereby said impulses are characterized by reversals of direct current polarity, means for proportioning the magnitude of said oppositely poled potential in accord with the magnitude of said carrier current impulses whereby said reversals are made substantially symmetrical with respect to zero direct current potential, and means for producing steep wave fronts in said reversals.

2. A carrier current receiving system comprising rectifying means for producing unidirectional direct current impulses from received carrier current impulses, means for biasing said unidirectional impulses to produce equivalent bidirectional impulses, vacuum tube means for weighting said biasing means on the basis of the amplitude of the said received carrier current impulses, and means for producing steep wave fronts in said bi-directional impulses.

3. A carrier current receiving system according to claim 2 in which the means for producing steep wave fronts incorporates a Wheatstone bridge having resistance arms, two opposite arms equal and constant, the other opposite arms equal but having a resistance value which is a function of the current through them.

4. A carrier current receiving system as in claim 2 in which the means for producing steep wave fronts comprises a transformer wound on a high permeability core such that saturation is reached for very small currents.

5. A carrier current receiving system according to claim 1 in which the superposing means comprises a balanced Wheatstone type bridge.

6. A carrier current receiving system according to claim 1 in which the means for transforming carrier current impulses into direct current impulses comprises a Wheatstone-bridge type of rectifier.

7. A carrier current receiving system comprising a bridge-type rectifier for converting carrier current impulses into unidirectional direct current impulses, an electron discharge device having anode, cathode and condenser biased control grid, said condenser charged by rectified carrier current impulses to a potential proportional to the amplitude thereof whereby said electron discharge device delivers a unidirectional direct current potential proportional to the magnitude of the received carrier current impulses, a balanced Wheatstone bridge adapted to permit the superposition of said substantially constant direct current potential upon said direct current impulses in opposition such that said direct current impulses are converted into equivalent bidirectional impulses of substantially equal positive and negative valence, and means for producing steep wave fronts in said bidirectional impulses.

8. A carrier current receiving system according to claim 7 in which said steep wave front producing means comprises a Wheatstone type of resistance arm bridge having two opposite arms equal and of constant resistance and the other opposite arm equal but of a resistance value which is a function of the current through them.

9. A carrier current receiving system according to claim 7 in which said steep wave front producing means comprises a Wheatstone type of resistance arm bridge having two opposite arms equal and of constant resistance and the other opposite arms equal but of a resistance value which is a function of the current through them, and in which said steep wave front producing bridge forms the output arm of said superposition bridge.

10. A carrier current telegraph receiving system comprising means for the conversion of received carrier current telegraph impulses into unidirectional direct current impulses, means for the conversion of said unidirectional direct current impulses into equivalent bidirectional direct current impulses of substantially equal positive and negative valence, means for the conversion of said bidirectional direct current impulses into equivalent direct current impulses having substantially vertical sides and substantially flat tops, and electromechanical means responsive to said impulses.

11. A carrier current telegraph receiving system according to claim 10, in which said electromechanical means comprises a direct current amplifier and a polarized relay.

12. A carrier current telegraph receiving system according to claim 10, in which said electromechanical means comprises a direct current amplifier transformer coupled to a polarized relay, and an equalizing circuit is connected to a winding of said relay, said equalizing circuit being adapted to neutralize and prevent signal distortion due to said transformer.

13. A carrier current telegraph receiving system comprising means for the conversion of received carrier current telegraph impulses into unidirectional direct current impulses, means comprising a Wheatstone bridge and condenser biased electron discharge device for superposing upon said unidirectional direct current impulses an oppositely poled potential adapted to convert said unidirectional direct current impulses into substantially equivalent reversals of substantially equal positive and negative valence, a Wheatstone-type bridge means for producing steep wave fronts in said reversal, a direct current amplifier transformer coupled to a polarized relay responsive to said steep wave front reversals, and auxiliary contacts on said polarized relay adapted to connect said condenser biased electron discharge device to be responsive to the amplitude of said carrier current impulses during marking intervals only.

14. In combination, a source of carrier current impulses, a rectifier responsive to said carrier current impulses, an electron discharge device having a control grid, a cathode and an anode, a work circuit comprising in tandem said anode, cathode, a source of potential and a load circuit, and a control circuit comprising a condenser permanently connected between said grid and said cathode, and arranged to be automatically connected across the output of said rectifier during and in response to the reception of the carrier current impulses and to be disconnected therefrom during spacing intervals whereby the load circuit potential is constantly adjusted to be proportional to the amplitude of the said carrier current impulses.

15. An impulse receiving system comprising a source of biased direct current impulses, means superposing upon said biased impulses an opposing direct current potential, means proportioning said opposing direct current potential according to magnitude of said biased impulses whereby said biased impulses are converted to unbiased reversals, and means for producing steep wave fronts in said reversals.

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