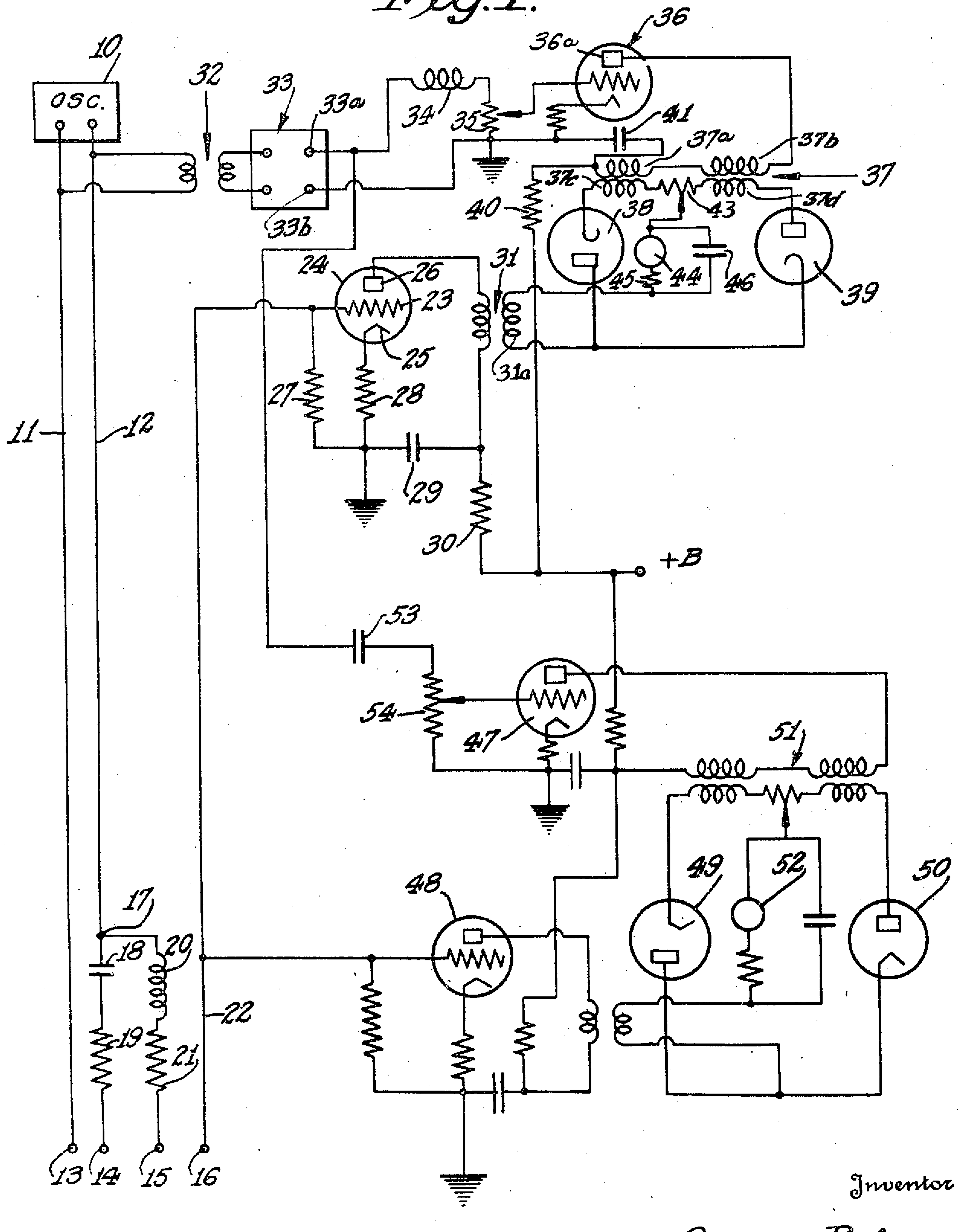
Oct. 4, 1949. C. B. AIKEN 2,483,718

PHASE SELECTIVE SIGNAL TRANSMISSION SYSTEM

Filed Feb. 28, 1946 2 Sheets-Sheet 1

Fig. 1.



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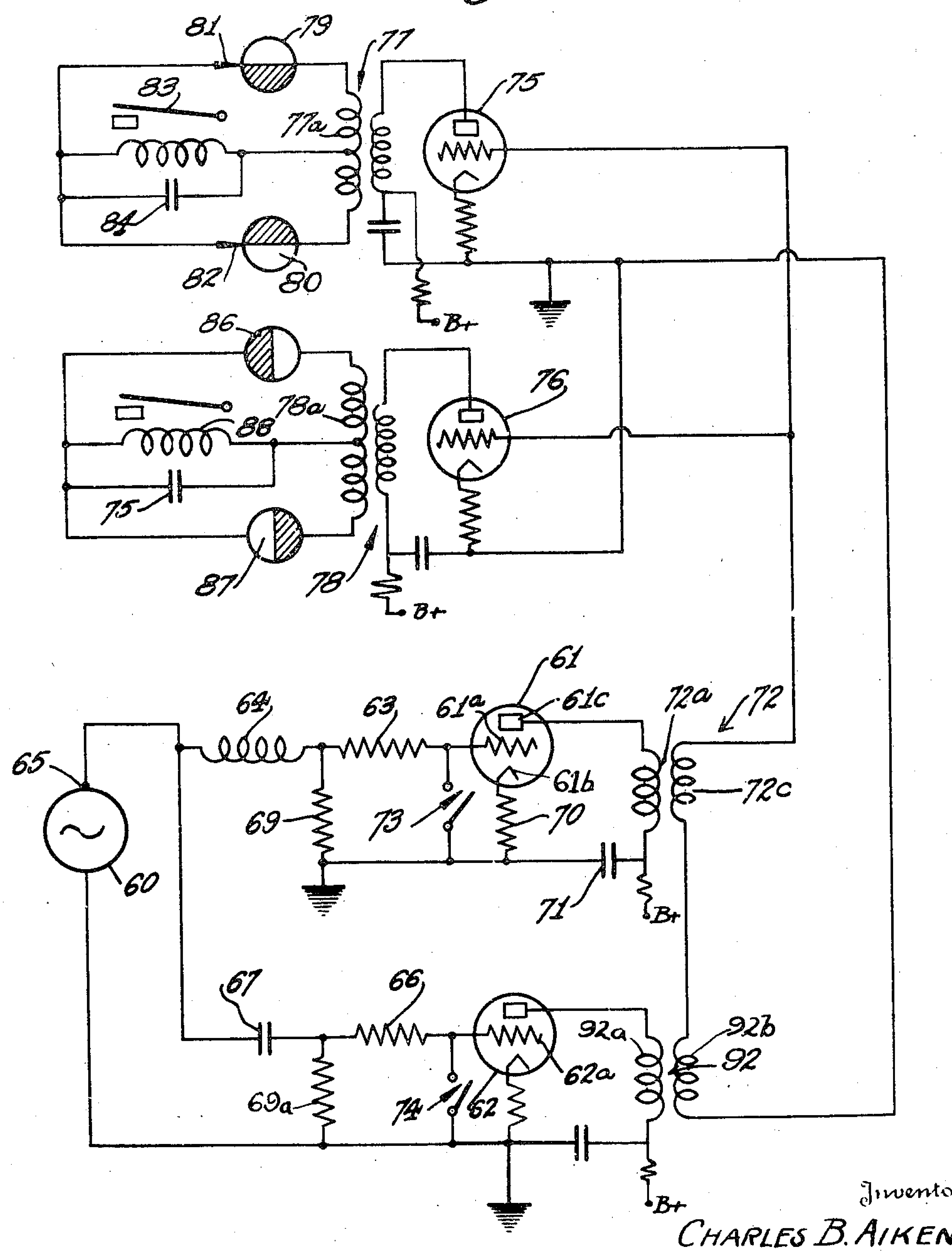
Filed Feb. 28, 1946 2 Sheets-Sheet 2

Fig. 2.



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Patented Oct. 4, 1949

2,483,718

UNITED STATES PATENT OFFICE

2,483,718

PHASE SELECTIVE SIGNAL TRANSMISSION SYSTEM

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Application February 28, 1946, Serial No. 651,013

14 Claims. (Cl. 177—353)

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This invention relates to improvements in signal transmitting systems, such as, for example, systems for transmitting signals produced in electrical well logging, telegraphy, radio and the like. The invention relates particularly to systems for transmitting two different signals simultaneously over a single channel.

An object of the present invention is to provide systems whereby two signals having the same frequency, but of different phase, may be transmitted over a single channel and then separated by means of phase selective networks.

Another object of the invention is to provide systems whereby two signals of different phase may be separated to permit transmission of such signals over a single channel.

An additional object of the invention is to provide alternating current networks that are selective to signals of a selected phase and discriminate against signals in the network that are in phase quadrature to the signals of selected phase.

These and other objects of the invention are attained by impressing a voltage of a selected phase on a network that carries a signal of the same phase as the impressed voltage and also carries another signal substantially in quadrature to the impressed voltage. The impressed voltage renders the network selective to the signal having the selected phase by discriminating against signals in quadrature to the selected phase and thus permits separation of the selected signal from the other signal. Similarly, when voltages substantially in phase quadrature are impressed on different branches of a system carrying two signals of smaller magnitude and having phases the same as the impressed signals, the two branches are rendered phase discriminating and separate indications of the two signals or their magnitudes or values can be obtained.

More particularly, the objects of the invention are attained by transmitting over the same frequency channel, two alternating currents that differ from each other in phase by 90°, and independently keying or modulating these currents so as to provide two signal circuits. At the receiving or detecting end of the system, two branch circuits are provided, one for the reception of each of the signals. Each branch is made phase selective by the use of suitable rectifying or detecting elements. One form of such element embodies the use of a rectifier in conjunction with a locally impressed voltage having the same phase as the received alternating current or voltage, with the result that this particular received voltage actuates the rectifier to give an output that

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is proportional to its intensity at any instant, while the second received voltage, which is in phase quadrature, actuates the rectifier to only a small degree, and gives no output of consequence. In the other branch, a local voltage having the phase of the second received signal is impressed, with the result that this signal gives a useful output, while the first received signal is discriminated against. Other forms of phase selective detectors may be used if desired.

Signal transmitting systems of the type described above are useful in many fields. For example, in electrical well logging operations, it may be desirable to make a plurality of determinations simultaneously and to obtain indications of these determinations at the surface of the earth. If a large number of separate conductors are provided in the well logging cables for transmitting the indications to the surface of the earth, the cables are not only expensive but are necessarily less strong, for a given overall diameter, than are cables containing fewer conductors, since a larger proportion of the available space must be devoted to insulation. Moreover, they are more susceptible to damage because of their size and there is always the possibility of current leakage between the conductors that affects the accuracy of the determinations.

With systems of the type embodying the present invention, it is possible to reduce the number of conductors in the cable and at the same time transmit a plurality of indications or signals to the surface of the earth with relatively simple and compact equipment.

The invention is applicable to message transmission, also, as well as to other fields wherein a plurality of signals must be transmitted from a source or plurality of sources to remote points or when only one of two signals in phase quadrature is of interest.

For a better understanding of the present invention, reference may be had to the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of a typical form of system or network for obtaining two resistivity indications in a bore hole traversing earth formations over a single conductor connected to equipment at the surface of the earth; and

Figure 2 is a diagrammatic illustration of a telegraphic signal transmitting system also embodying the present invention.

As is well understood in the art, it is quite common to conduct a plurality of electrical well logging determinations simultaneously in a bore hole. For example, it may be desired to make resistivity determinations at different depths in a formation by utilizing electrodes in different spaced relationships in order to determine the resistivity of the formations at different zones spaced radially from the bore hole.

The embodiment of the invention illustrated in Figure 1 is an apparatus whereby two resistivity measurements of the earth formations traversed by a bore hole may be conducted simultaneously by supplying alternating current power at the surface, providing a two-wire cable for the current circuit in the hole, and one wire for the voltage pickup circuit. This system includes an oscillator 10 that supplies low frequency alternating current to the conductors 11 and 12. The conductor 11 is connected to an electrode 13 which is located at a sufficient distance from the active electrodes 14, 15, and 16 so that these latter electrodes are not appreciably affected by the current field of the electrode 13. A distance between the electrodes 13 and 14 of 10 to 100 feet usually is suitable, the value depending upon the spacing between the electrodes 14, 15 and 16.

The conductor 12 is connected to the electrodes 14 and 15 at a junction point 17. The current through the conductor 12 divides at the junction point 17, part of it flowing through the condenser 18, the resistance 19, and the electrode 14 out into the surrounding earth. The other part of the current through the conductor 12 flows through the inductance 20, the resistance 21, and the electrode 15.

The four circuit elements 18, 19, 20, and 21 are chosen so that the current through the electrode 14 differs in phase by very nearly 90° from the current passing from the electrode 15. The impedances of the circuit elements 18, 19, 20 and 21 should be sufficiently large so that the changes in the resistance of the electrodes 14 and 15 will not affect the phase relations of currents flowing through these electrodes to any important degree.

The electrode 16 is located in the fields of the electrodes 14 and 15. These two fields impress voltages upon the electrode 16 which are brought to the surface by means of the conductor 22. This conductor is connected to the grid 23 of a triode tube 24 forming a part of a single-stage amplifier. The triode 24 has a cathode 25 and a plate 26. A grid leak resistor 27 of high value is connected between the grid 23 and ground and a cathode bias resistor 28 is connected between the cathode 25 and ground. The amplifier also includes the usual plate bypass condenser 29, a decoupling resistor 30, and a transformer 31 having its primary connected between the plate 26 and ground through the capacitance 29. The transformer 31 couples the output of the triode 24 to a rectifier circuit to be described.

Voltage for the rectifier circuit is taken from the oscillator 10 through the transformer 32 having its primary connected to the conductors 11 and 12 and its secondary connected to the phase shifter 33. One terminal 33*a* of the adjustable phase shifter 33 is connected in series with the inductor 34, the variable resistor 35 and the grid of the triode 36. The plate 36*a* of the triode 36 feeds the primary 37*a* of the transformer 37 which delivers a balanced voltage from its secondary to the two diode rectifiers 38 and 39. The end of the primary winding 37*a* is connected through the capacitor 41 to ground and through the decoupling resistor 40 to positive side of the B voltage supply. The balance of the transformer 37 and the rectifiers 38 and 39 may be trimmed by means of the potentiometer 43. One terminal of the indicating meter or recorder 44 is connected to the potentiometer 43 by the adjustable slide. The other terminal of the indicator 44 is connected in series with a resistance 45, the secondary 31*a* of the transformer 31 and the cathodes of the rectifiers 38 and 39. A capacitance 46 is connected across the indicator 44 and resistance 45 in the usual way.

With this arrangement, the phase shifter 33 is first adjusted with the circuit of the electrode 15 open, until a maximum reading is obtained on the meter 44 due to the current flowing into the earth from the electrode 14. When this occurs, the voltage fed to the diodes 38 and 39 from the transformer 37 is in phase with the signal from the transformer 31, which is proportional to and of the same phase as the signal picked up by the electrode 16 and produced by current emitted from the electrode 14. For best operation, the local signal introduced through the phase shifter 33, the triode 36 and the transformer 37 should be several times as large as the signal introduced into the common leg of the rectifiers 38 and 39 by means of the transformer 31. The local signal preferably should be 3 to 10 times as great as the signal introduced through the transformer 31.

When the circuit is now closed through the inductance 20, the resistor 21 and the electrode 15, the signal from the electrode 15 that is picked up by the electrode 16 will not give a reading on the meter.

A similar arrangement of circuits is provided for selecting voltages due to the flow of current through the electrode 15, while rejecting signals due to the current through the electrode 14. These comprise the triodes 47 and 48 and their associated circuits, the general operation of which is identical with those already described and the balanced rectifier system including the diodes 49 and 50, the transformer 51 and the meter 52. The local signal from the oscillator 10 is supplied to the grid of the triode 47 through a condenser 53 and the resistor 54. The fixed phase shifting network made up of the condenser 53 and the resistance 54 has a fixed quadrature phase relationship to the phase shifting network made up of the inductance 34 and the resistance 35 so that the phases of the voltages supplied to the grids of the triodes 36 and 47 are in quadrature. Thus the phase of the voltage introduced into the circuits of the diodes 49 and 50 by means of the transformer 51 is in quadrature with that introduced into the diodes 38 and 39 by the transformer 37. As a result, the meter 52 will respond to signals caused by the flow of current from the electrode 15 but will not be affected by those caused by the flow of current from the electrode 14.

In the above, it was stated that the phase shifter 33 should be adjusted for maximum response on the indicator 44, when the circuit of electrode 15 was open. Meter 44 then responds to currents flowing from electrode 14, while meter 52 responds to currents flowing from electrode 15. The reverse state of affairs could have been chosen instead, phase shifter 33 being adjusted for maximum response when the circuit of 14 is open. Meter 44 then responds to currents from 15. If the phase shift range of the phase shifter 33 is large enough, either adjustment may be made at will.

In operation, first consider the case in which no signal is received from the conductor 22. No voltage is then supplied by the transformer 31. The transformer 37 is connected so that the voltages developed by the secondary windings 37c and 37d are additive. The diodes 38 and 39 will both conduct on the same alternate half cycles of the alternating voltage delivered by the transformer 37. Each diode will develop pulses of rectified current that will flow through the middle leg of the rectifier system, comprising the condenser 46, the resistance 45, and the meter 44. However, the pulses of the two diodes are of opposite polarity so that the average value of the current through the middle leg will be zero, and the meter 44 will show no reading. The alternating current components of these pulses will be bypassed by the condenser 46 and will not affect the meter 44. If the balance of the transformer 37 is not perfect, the potentiometer 43 may be adjusted to bring the meter reading to zero.

Assume now that a signal that is in phase with the voltage delivered by the transformer 37 is picked up by electrode 16 and delivered to the grid 23 of the tube 24. Let it be assumed further that on one half cycle the right hand ends of the secondary windings 37c and 37d are both positive with respect to their respective left hand ends, and that the voltage delivered by the winding 31a adds to the voltage of 37d and subtracts from that of 37c. Since the voltages delivered by the secondary windings 37c and 37d are both larger than that delivered by the secondary winding 31a, both diodes are able to conduct during this particular half cycle, and, for the conditions stated, the total voltage applied to the diode 39 is increased, while that applied to the diode 38 is decreased. As a result, the rectified currents from the two diodes no longer balance, and the meter 44 shows a reading in a direction indicating that the current from the diode 39 predominates. If the polarity of the voltage from 31a were to be reversed, the reading of meter 44 would also reverse, since in this case the current through 38 would be larger than that through 39.

Now consider the case in which the voltage picked up by the electrode 16 is in such phase as to make the voltage delivered by the transformer 31 differ by 90° from the voltage delivered by the transformer 37. The voltage from the secondary winding 31a must then be vectorially added in quadrature to the voltages delivered by the secondary windings 37c and 37d. Since the voltage from the secondary winding 31a is much smaller than that from the secondary windings 37c and 37d, the magnitude of the resultant voltage will be substantially unchanged, since that resultant voltage is the vector sum of two components in phase quadrature, one of which is much larger than the other. The resultant of such a combination is very closely equal to the magnitude of the larger vector. Hence the currents through the diodes 38 and 39 will be unaffected by the presence of the small signal from the secondary winding 31a. If this latter signal is increased, but is still smaller than the voltage delivered by either 37c or 37d, the magnitudes of the resultant voltages impressed upon the diodes 38 and 39 will be increased somewhat, but by the same amount. The rectified currents developed by the diodes 38 and 39 will then increase together and the meter 44 will show no change, since the rectified currents are of opposite polarity. This will still be true when the voltage of the secondary winding 31a is only slightly less than that of the secondary windings 37c or 37d.

The operation of the phase selective circuit comprising the diodes 49 and 50 is entirely analogous to that of the circuit comprising the diodes 38 and 39 and further explanation is not necessary.

It is thus evident that the rectifier, excited with a local voltage of a certain phase, exercises a pronounced phase selective action. Voltages of the correct phase are rectified with maximum efficiency, and the meter responds accordingly, while voltages of quadrature phase are rectified with minimum efficiency, and the meter shows no reading unless the system is overloaded. For phases in between these two values the system will respond with an intermediate efficiency, and the meter will show a reduced reading, which will be less the nearer the phase of the incoming signal is to quadrature.

The above system is capable of transmitting two different signals of the same frequency over the same channel or circuit, the conductor 22, and separating the signals for observation or recording at a remote point. In this system, the frequency of the oscillator 10 must be quite low for the reason that the phase shift that normally occurs in the cable, including the conductors 11, 12, and 13 must not change more than a few degrees as the cable is lowered into the drill hole. Satisfactory operation of the system is obtained at frequencies in the neighborhood of 16 cycles.

The separation of two signals by phase selection can be accomplished in other ways and with other systems. For example, instead of using full wave rectifiers as illustrated, half wave rectifiers may be used in conjunction with a local signal if desired. Thus, the diodes 38 and 49 and the associated secondary windings of the transformers 37 and 51, respectively, could be eliminated, if desired. The local signal will then give a steady reading which may be balanced out by the use of an auxiliary direct current circuit, or may be ignored.

Also, if desired, synchronous mechanical rectifiers may be used in such transmitting systems, inasmuch as such mechanical rectifiers are also phase selective devices. Rectifiers of this type are well known and usually consists of a rotary commutator driven in phase with the signal and so connected that the alternating voltage impressed upon the rectifier is converted into a series of unidirectional voltages acting on the output circuit. If such a rectifier is adjusted to give a maximum response to a signal of one phase, it will give very little response to another signal of the same frequency but differing in phase from the first signal by 90°.

Such synchronous mechanical rectifiers may be used in a system, for example, for transmitting two telegraphic signals along a single channel. An example of such a short distance telegraph line is illustrated in Figure 2. As illustrated in this figure, a source of alternating current power 60 may supply power to two triodes 61 and 62, each of which is provided with its own phase shifting network so that the grids of the triodes receive voltages that differ in phase by 90°. The triode 61, for example, may have its grid 61a connected by means of an isolating resistor 63 and an inductance 64 to one pole 65 of the alternating current source 60. The grid 62a of the triode 62 is connected through a resistor 66 and a capacitance 67 to the pole 65 of the source of alternating current 60. The midpoint between the resistance 63 and the inductance 64 is grounded through the resistor 69, and is connected to the cathode 61b through the resistance 70. The cathode and grid of the triode 62 are connected similarly. The plate 61c is connected in series with the primary 72a of a transformer 72, a capacitance 71 and the cathode 61b. The plate and cathode of the triode 62 are similarly connected to a primary winding 92a of the transformer 92.

The inductance 64 and the resistor 69, and the capacitance 67 and the resistance 69a act as fixed phase shifters for the triodes 61 and 62, respectively, so that the voltages impressed on the grids 61a and 62a are in phase quadrature.

The signalling is accomplished by means of the telegraph keys 73 and 74 connected between the grids and cathodes of the tubes 61 and 62, respectively, each of which allows a signal to pass when it is open and cuts off the signal when it is closed. The resistances 63 and 66 prevent the keys from changing the load on the oscillator 60 so there is no interaction of the two keying systems.

The triodes 75 and 76 are fed in parallel from the secondary windings 92b and 72c of the transformers 72 and 92, these triodes being at the receiving end of the system. Each of the triodes 75 and 76 supplies energy to separate full wave, mechanical rectifier circuits, to be described, through the transformers 77 and 78. One rectifier circuit includes the secondary 77a of the transformer 77. The opposite ends of the secondary are connected to the commutators 79 and 80 of the mechanical rectifier, these commutators being engaged by the brushes 81 and 82 which are connected to each other. A common leg from the midpoint of the secondary 77a to the midpoint between the brushes 81 and 82 of each of the rectifier circuits contains a telegraph sounder 83 and a bypass condenser 84.

The other rectifier and telegraph sounder circuit is the same and is connected to the secondary 78a of the transformer 78. This circuit includes the mechanical rectifier commutator 86 and 87 and the telegraph sounder 88 in the common leg. The rectifier elements 79 and 80 differ by 90° in mechanical phase from the rectifier elements 86 and 87, with the result that the sounder 83 will respond to one signal only, while the sounder 88 responds to the other.

In order for this system to function properly, it is necessary for the power source 60 and the rectifiers 79, 80, 86 and 87 to maintain a fixed phase relation to each other. If the oscillator 60 is an alternator driven by a synchronous motor and if the rectifiers 79, 80, 86, and 87 are also driven by a synchronous motor, the two can be maintained in correct phase relation by operating both motors from the same power network. In this way, the mechanical rectifiers are able to separate the two signals in phase quadrature and thereby actuate the sounder 83 or 88 in response to a signal of a corresponding phase.

While, as illustrated, dependence is had upon synchronous motors for driving the alternator and the rectifiers, if adequate stability is not available for keeping these elements in the proper phase relationship other known means may be provided.

For example, a phasing signal may be transmitted at intervals over the telegraph line in order to correct the synchronism of the two systems. This phasing voltage preferably would be at 45° with each of the signal voltages and hence the outputs of the two sets of full wave rectifiers, due to the phasing signal alone, would be equal if the phase of the rectifiers is correct with respect to the phase of the transmitting system. If the outputs were unequal, the difference would be made to actuate a mechanism for bringing the motors back into the correct phase relation. This mechanism would be inoperative except during the time that the phase correcting signal was transmitted. Also, if desired, proper synchronism may be attained by providing very stable osciliators in the opposite ends of the system such as, for example, tuning fork oscillators for transmitting the signal and for controlling the operation of the rectifier system at the receiving end. The phase relations of the fork at the transmitting and receiving ends could be corrected at moderately long intervals by means of a special phasing signal, the actual correction being accomplished either automatically or manually, as desired. Many other systems of maintaining synchronism between motors at remote points are known in the art and it is thought that it is unnecessary to describe them in detail herein.

The type of signalling described above can also be applied to radio transmission systems. The simplest application involves the use of two modulating signals of the same audio frequency but in phase quadrature to each other. At the receiving end the output of the conventional detector of the radio receiver contains two signals, both having the frequency of the audio modulation used at the transmitter, and differing from each other in phase by 90 degrees. The detector output is impressed upon two phase-selective circuit branches so that the signals can be separated and made to operate independent signal indicating elements in the manner illustrated in Figure 2.

It is also possible to work directly with the phase of the carrier, using crystal controlled oscillators at each end of the transmission channel and phase correcting signals at intervals. Here the two branches of the receiving circuit are adjusted so that one responds with maximum efficiency to a carrier of a particular phase, and discriminates against a carrier of approximately quadrature phase, while the other branch responds to the carrier of the second phase and discriminates against that of the first. The two components of the carrier are independently keyed or modulated at the transmitter, so that separate signals can be sent.

From the above described embodiments of the invention, it will be apparent that the present invention provides a system whereby two signals of the same frequency but differing in phase can be transmitted over a single channel and then separated. It has the advantage that the phase selective elements may be at the receiving end of the system, an obvious advantage in well logging operations inasmuch as little space is available in the sonde for complex transmitting apparatus.

While the invention has been described with reference to specific forms of apparatus typical of the invention, it will be understood that the invention is applicable in other fields and may be practiced with other apparatus than that disclosed herein. Accordingly, the forms of the invention described herein should be considered as illustrative and not as limiting the scope of the following claims.

I claim:

1. A signal transmitting system comprising a transmission channel, means for impressing on said channel a first electrical signal having a predetermined phase, means for simultaneously im-

pressing on said channel a second electrical signal having a phase substantially in quadrature with the phase of said first signal, phase selective means including a rectifier and an indicator associated with said channel and receiving said first and second electrical signals, and means electrically connected to the rectifier for combining with said first and second signals in said rectifier local a voltage having a greater magnitude than said first signal and the same phase.

2. A signal transmitting system comprising a transmission line, means for simultaneously supplying to said line first and second signals substantially in phase quadrature, rectifying means connected to said transmission line and receiving said first and second signals, and means for impressing on said rectifying means in combination with said first and second signals a local voltage of greater magnitude than said first and second signals and having the same phase as said first signal to render said rectifier selective to said first signal and substantially nonresponsive to said second signal.

3. A signal transmitting system comprising a transmission line, means for simultaneously supplying to said line first and second signals substantially in phase quadrature, rectifying means connected to said transmission line and receiving said first and second signals, means for impressing on said rectifying means in combination with said first and second signals a local voltage of greater magnitude than said first and second signals and having the same phase as said first signal to render said rectifier selective to said first signal and substantially nonresponsive to said second signal, second rectifying means connected to said transmission line and receiving said first and second signals, and means for combining with said first and second signals in said second rectifying means another local voltage having the same phase as said second signal but of substantially greater magnitude to render said second rectifying means selective to said second signal and substantially nonresponsive to said first signal.

4. A signal transmitting system comprising a transmitting station, a receiving station, means for transmitting from said transmitting station over a single channel to said receiving station two signals having the same frequency and phases differing by about 90°, a pair of rectifying means at said receiving station connected to receive said first and second signals, means for energizing one of said rectifying means with said first and second signals and a standard voltage having the same phase as one of said signals but of substantially greater magnitude to render one of said rectifying means responsive to one of said signals, and means for energizing the other rectifying means with said first and second signals and a second standard voltage having substantially the same phase as said other signal but of substantially greater magnitude to render said other rectifying means responsive to the other signal to separate said signals according to their phase.

5. A signal transmitting system comprising a transmitting station, a receiving station, means at said transmitting station for providing first and second signals of the same frequency and having phases differing by about 90° for transmission over a single channel to said receiving station, a first synchronous mechanical rectifier at said receiving station, a second synchronous mechanical rectifier at said receiving station, and means for operating said first and second rectifiers in phase with said first and second signals, respectively, to render each of said rectifiers selective to signals having the same phase and nonresponsive to signals substantially in quadrature with the selected phase.

6. A signal transmitting system comprising means for supplying to a single transmission channel first and second signals having the same frequency and phases differing by about 90°, first and second rectifying means for receiving signals transmitted by said channel, and means for supplying electrical energy having the same frequency and phases, respectively as said first and second signals but of substantially greater magnitude to said first and second rectifying means, respectively, in combination with said first and second signal to render said first and second rectifying means selective to said first and second signals, respectively.

7. A signal transmitting system comprising an oscillator for supplying to a single transmission channel first and second signals having the same frequency and phases differing by about 90°, first and second mechanical rectifiers for receiving signals transmitted by said channel, and means for supplying electrical energy to said oscillator and to said rectifiers for maintaining said first and second rectifiers in phase with said first and second signals, respectively, to render said rectifiers selective to signals having substantially the same phase as the rectifiers.

8. A signal transmitting system comprising a transmission channel, means for impressing upon the sending end of said channel two superimposed electrical signals of the same frequency that are substantially in phase quadrature with each other, phase selective means at the receiving end of said transmission channel, said selective means comprising two branches, the first branch comprising phase selective means for selecting one of the two received signals and rejecting the second received signal, the second branch comprising phase selective means for selecting the second received signal and rejecting the first received signal.

9. A signal transmitting system comprising a transmitting channel, transmitting means for impressing on the channel two superimposed electrical signals of the same frequency that are substantially in phase quadrature with each other, phase selective receiving means having two branches communicating with said channel, means for rendering one of said branches selective to the phase of one of said signals and discriminating against the other signal, and means for rendering the other branch selective to the phase of the other signal and discriminating against said one signal.

10. A signal transmitting system comprising a transmitting channel, transmitting means for impressing on the channel two superimposed electrical signals of the same frequency that are substantially in phase quadrature with each other, phase selective receiving means having two branches communicating with said channel, means for supplying an alternating voltage at the same frequency as said signals and of the same phase as one of said signals to one of said branches to render said branch selective to said one signal and discriminating against the signals in quadrature with said one signal, and means for supplying an alternating voltage to the other branch at the same frequency as said signals and of the same frequency as the other

signal to render said branch selective to said other signal and discriminating against said one signal.

11. A method of obtaining separate indications of at least one of two superimposed alternating current signals that are substantially in phase quadrature, comprising providing a standard periodically variable voltage having substantially the same phase as one of said signals but of substantially constant greater amplitude, combining said two signals and said standard voltage so that the amplitude of said combined signals and voltage varies in accordance with said one signal but is not substantially affected by said other signal of quadrature phase, and utilizing said combined signals and voltage to produce effects in accordance with said one signal.

12. A method of obtaining separate indications of two superimposed alternating current signals that are substantially in phase quadrature, comprising providing a first standard periodically variable voltage having substantially the same phase as one of said signals but of substantially greater constant amplitude, combining said two signals and said first standard voltage so that the amplitude of said combined signals and first standard voltage varies in accordance with said one signal but is not substantially affected by said other signal of quadrature phase, utilizing said first combined signals and voltage to produce effects in accordance with said one signal, providing a second standard periodically variable voltage having substantially the same quadrature phase as the other of said two signals but of substantially constant amplitude, separately combining said two signals and said second standard voltage so that the amplitude of said combined signals and second standard voltage varies in accordance with said other signal of quadrature phase but is not substantially affected by said one signal, and utilizing said combined two signals and second standard voltage to produce effects in accordance with said other signal of quadrature phase.

13. Apparatus for obtaining separate indications of at least one of two superimposed alternating current signals that are substantially in phase quadrature, comprising means providing a standard periodically variable voltage having substantially the same phase as one of said signals but of substantially greater amplitude, means for combining said two signals and said standard voltage so that the amplitude of said combined signals and standard voltage varies in accordance with said one signal but is not substantially affected by said other signal of quadrature phase, and means responsive to said combined signals and standard voltage.

14. Apparatus for obtaining separate indications of two superimposed alternating current signals that are substantially in phase quadrature, comprising means providing a first standard periodically variable voltage having substantially the same phase as one of said signals but of substantially greater amplitude, means for combining said two signals and said standard voltage so that the amplitude of the combination varies in accordance with said one signal but is not substantially affected by said other signal of quadrature phase, means responsive to said combined signals and standard voltage, second means providing a second standard periodically variable voltage having substantially the same quadrature phase as the other of said signals but of substantially greater amplitude, second means for separately combining said two signals and said second standard voltage so that the amplitude of the combination varies in accordance with said other signal of quadrature phase but is not substantially affected by said one signal, and means responsive to said combined two signals and second standard voltage.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
579,473	Davidson	Mar. 23, 1897
1,813,929	Hough	July 14, 1931
2,100,467	Borden	Nov. 30, 1937
2,111,352	Blake	Mar. 15, 1938
2,298,794	Howell	Oct. 13, 1942
2,300,505	Hubbard	Nov. 3, 1942

Certificate of Correction

Patent No. 2,483,718

October 4, 1949

CHARLES B. AIKEN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 49, for the word "consists" read *consist*; column 9, line 9, for "local a" read *a local*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of February, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.