Sept. 15, 1925. 1,554,007

K. S. JOHNSON

ANTISIDE TONE CIRCUITS

Filed Dec. 31, 1919 2 Sheets-Sheet 1

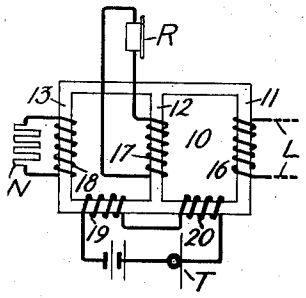


Fig. 1

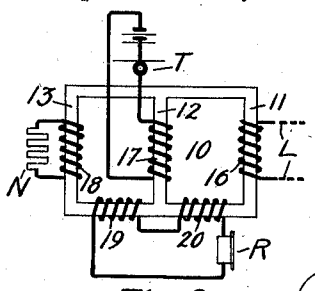


Fig. 2

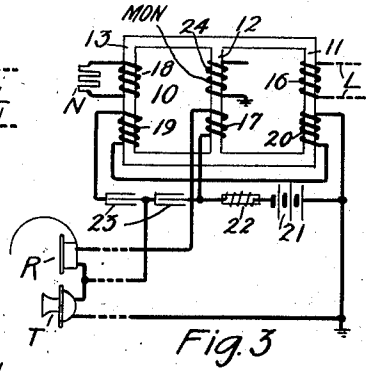


Fig. 3

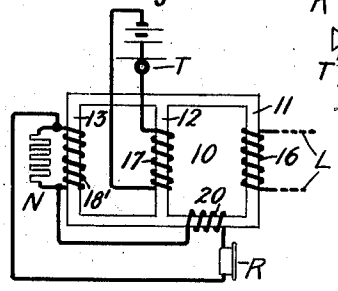


Fig. 4

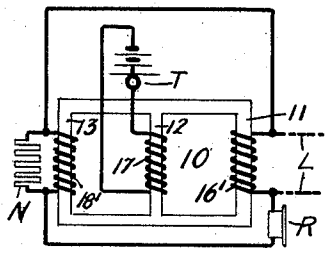


Fig. 5

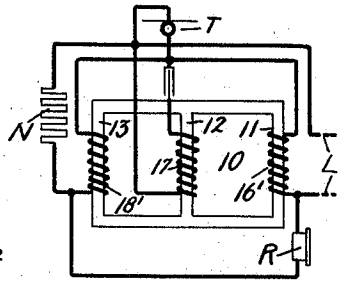


Fig. 6

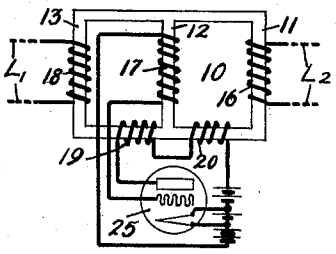


Fig. 7

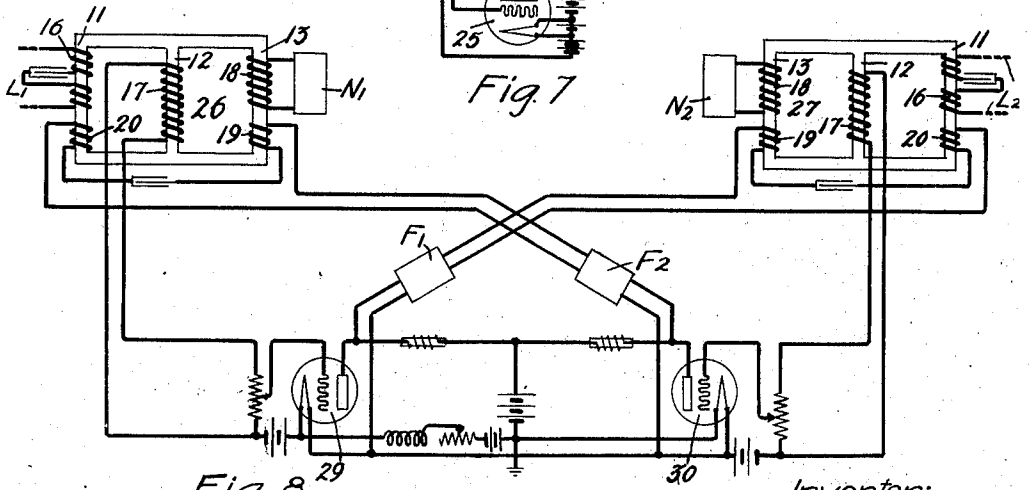


Fig. 8

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ANTISIDE TONE CIRCUITS

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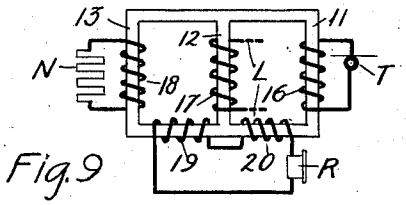


Fig. 9

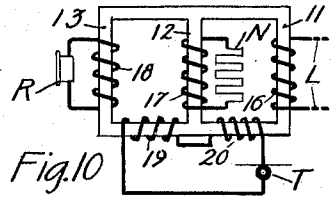


Fig. 10

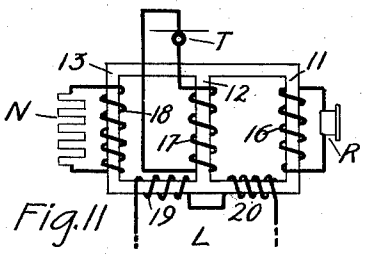


Fig. 11

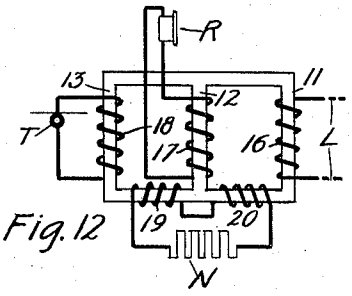


Fig. 12

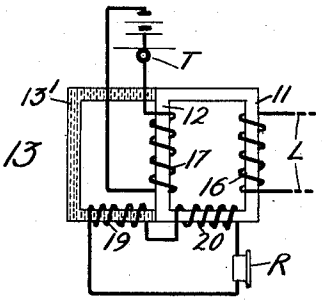


Fig. 13

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Patented Sept. 15, 1925. 1,554,007

UNITED STATES PATENT OFFICE.

KENNETH S. JOHNSON, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ANTISIDE TONE CIRCUITS.

Application filed December 31, 1919. Serial No. 348,507.

To all whom it may concern:

Be it known that I, KENNETH S. JOHNSON, a citizen of the United States, residing at Jersey City, in the county of Hudson, State of New Jersey, have invented certain new and useful Improvements in Antiside Tone Circuits, of which the following is a full, clear, concise, and exact description.

This invention relates to anti-side tone circuits and more particularly to circuits of this type which are adapted for use in telephone substations or two-way repeaters.

It is an object of the invention to provide an arrangement of three or more circuits so related to each other that one of the circuits, which may be called a receiving circuit, will be responsive to electric impulses set up in another of the circuits, for example, a telephone line, but will not be responsive to electric impulses set up in a third circuit, such as substation transmitter circuit or the output circuit of a repeater, feeding into the line.

This result has heretofore been accomplished by balancing electromotive forces in the electrical circuits of the substation or repeater set. In accordance with this invention one of the associated circuits is rendered anti-side tone or conjugate with respect to another by the use of a transformer having a divided core formed with three or more legs or branches. The transformer windings are so related to the core branches and the associated circuits that the magnetic fluxes produced in the core branches may balance each other. The magnetic forces may be so adjusted that there will be no flux in one of the core branches and consequently no current in the circuit inductively associated therewith, or they may be so adjusted that the flux in two of the legs may induce equal and opposite E. M. F.'s in one of the circuits, thus rendering it conjugate. For a complete discussion of the requirements of a circuit, one portion of which is conjugate with another, reference is made to U. S. patent to G. A. Campbell, #1,254,471, dated January 22, 1918.

A wide variety of arrangements employing this invention is possible, only a few of which are shown in the drawings. It may be stated in general that the transformer core should have at least three branches, each having one or more windings associated therewith. The circuits, usually four in number, are connected to these windings, at least one of the circuits being connected across two of the windings. When it is desired to have all of the circuits insulated from each other, as in an operator's head set or a repeater set, five windings are employed. A lesser number of windings, however, may be employed, the minimum being three.

In the arrangements disclosed herein, one of the four circuits is a line, one a telephone receiver circuit or the input circuit of a repeater, one a transmitter circuit or the output circuit of a repeater, and the fourth a line balancing circuit including a resistance or network of impedance simulating the impedance of the line. The latter circuit can be omitted in certain cases where the magnetic reluctance of one branch of the core can be made of a proper value to give the desired balance.

The invention further resides in the details of the circuits herein disclosed, for a full understanding of which reference is hereby made to the following description and claims taken in connection with the accompanying drawings, in which Fig. 1 is a schematic view of a circuit embodying the invention in which five windings are employed; Fig. 2 is a similar view in which the relative position of the transmitter and receiver is reversed; Fig. 3 is a modification of Fig. 1 especially adapted for use as an operator's set; Figs. 4, 5 and 6 are modifications of Fig. 2 in which less than five windings are employed; Fig. 7 is a view showing the application of the invention to a two-way, one repeater circuit; Fig. 8 is a similar view showing the invention applied to a two-way, two repeater circuit. Figs. 9, 10, 11 and 12 represent variations of the circuit shown in Fig. 1, and Fig. 13 represents the circuit of Fig. 2 with the balancing network circuit replaced by the use of a core material for the corresponding leg which has the requisite degree of reluctance to balance the line impedance.

Referring to the drawings by reference characters, in Fig. 1 is shown a transformer having a core 10 which has legs or branches 11, 12 and 13. On these branches are the windings 16, 17 and 18 respectively. In addition, branch 13 has the winding 19 and

branch 11 has the winding 20. Connected across winding 16 is the line L; across the winding 17 is the receiver R; across the winding 18 is a line balancing impedance N, and across the two windings 19 and 20 in series is the transmitter T.

The operation of this circuit is briefly as follows: When transmitting, alternating currents, having their source in the transmitter T, flow in the windings 19 and 20, these, in turn, produce magnetic fluxes in the legs 11 and 13. The relation of the impedances of the line L and line balancing impedance N to the number of turns in windings 16, 18, 19 and 20 is such that equal aiding fluxes are induced in branches 11 and 13 of the core. The magnetic forces at the ends of branch 12 are equal, and there is no flux in this branch. Thus, it will be seen that the receiver is anti-side tone or conjugate with respect to the transmitter.

When receiving currents from the line L, a flux is induced in the branch 11, which, in turn, induces currents in the receiver and transmitter circuits. The magnetic flux will be confined to that portion of the core containing legs 11 and 12. Since the windings 19 and 20 are connected in series, the signal component of the current flowing in the transmitter circuit will set up a magnetic force in branch 13, which will be substantially equal and opposite to the magnetic force acting in branch 12. There will, therefore, be substantially no flux changes in branch 13, and no energy dissipated in the balancing impedance N.

Referring now to Fig. 2, this circuit differs from Fig. 1 in that the receiver and transmitter are interchanged. When transmitting, a flux is produced in the branch 12 which divides and flows in parallel in branches 11 and 13. This induces equal and opposite E. M. F.'s in windings 19 and 20 so that there is substantially no current in the receiver circuit, and the energy is dissipated in the line L and the balancing network N. When receiving the current flow is substantially the same as in Fig. 1.

In Fig. 3 is shown an adaptation of the circuit shown in Fig. 1, for use as an operator's head set at a central office. In this circuit an electromagnet receiver is employed and connections are made whereby current from a common battery 21 can be used to energize both the receiver and the transmitter. A choke coil 22 prevents the flow of alternating current in the battery circuit and condensers 23 confine the direct current to a simple circuit in which the receiver and the transmitter are in series. A winding 24 can be conveniently placed on branch 12 for use as a busy test or for monitoring purposes.

In Figs. 1 and 2 the four related circuits are insulated from each other. This is substantially true in Fig. 3 also. It is particularly advantageous in an operator's set, such as that shown in Fig. 3, to have the transmitter and receiver circuits insulated from the line.

In Fig. 4 an arrangement is shown in which the winding 18′ is made to perform the functions of both windings 18 and 19 in the previous circuits. The balancing resistance and the receiver are each connected across the winding 18′. In Fig. 5 a similar combination is made of the windings 16 and 20, the winding 16′ performing the functions of both. In Fig. 6 is shown a circuit differing from the circuit shown in Fig. 5 in that the impedance N is connected in series with windings 18′ and 17 and the line L is connected in series with windings 16′ and 17. The transmitter circuit is directly connected to the line thus permitting a common battery to be employed to energize the transmitter.

The series of circuits shown in Figs. 2, 4, 5 and 6 represents a transition from a five winding circuit, in which all of the related circuits are insulated from each other, to a three winding circuit in which all of the circuits are directly connected to each other. The operation, however, is essentially the same. In a five winding circuit, such as that shown in Figs. 1, 2 and 3, greater freedom is had in selecting impedances for the various elements of the substation circuit; that is to say, the transmitter, receiver and balancing impedance may be given any desired value regardless of the impedance of the line, their effective impedance being readily adjusted by changing the number of the turns in the respective windings. In a circuit, such as that shown in Fig. 6, the impedances of the various substation elements must be properly chosen with reference to each other and the line in order to obtain the greatest efficiency.

In Fig. 7 is shown the transformer arrangement of Fig. 1 applied to a two-way repeater in which a single repeater element is employed. The input circuit of the vacuum tube repeater 25 is connected across the winding 17 in place of the receiver R, the output of the repeater is connected across the windings 19 and 20 in place of the transmitter T. In this type of repeater, instead of a line L and balancing resistance N, the two lines L_1 and L_2 are made effectively to balance each other. For example, current coming in from line L_1 induces a current in the input circuit of the repeater, and the amplified current passing through windings 19 and 20 produces a series aiding flux in branches 13 and 11 and corresponding currents in the lines L_1 and L_2. If the relation of the impedances of lines L_1 and line L_2 to the number of turns in windings 16, 18, 19 and 20 is properly chosen no cur-

rent will be induced in the winding 17 as the result of the amplified current. There will accordingly be substantially no tendency for the repeater to sing.

In Fig. 8 the same transformer arrangement is shown applied to a two-way repeater circuit having two oppositely directed repeaters. In this case transformers 26 and 27 are provided for lines L_1 and L_2 respectively, and balancing networks N_1 and N_2 are associated with the respective lines. The input circuit of repeater 29 is connected across the winding 17 of a transformer 26, while its output circuit is connected across the windings 19 and 20 of the transformer 27. In a similar way repeater 30 has its input circuit associated with the middle branch of the transformer 27 and its output circuit with the outside branches of the transformer 26. Filters F_1 and F_2 may be interposed in the output circuits to control the frequency range of the currents transmitted.

The effective impedances of balancing networks N_1 and N_2 are made equal to the impedances of the respective lines. The output energy of each of the repeaters is divided between the corresponding line and balancing network and substantially none of it is fed back into the input of the other repeater. For a comparison of the circuit of Fig. 8 with a circuit employing electrical balance for a similar purpose, reference is made to U. S. patent to B. W. Kendall, #1,216,136, dated February 13, 1917.

Figs. 1 and 3 represent a circuit which has been found from actual tests as a substation circuit to be very satisfactory. This circuit has therefore been chosen as the preferred form of the invention for the purpose of this application. It is apparent, however, from Figs. 1, 2, 9, 10, 11 and 12 that anti-sidetone circuits may be designed in which the four associated circuits are interchanged in a great number of ways. Not all of the five winding circuits are shown, but it is believed that the number is sufficient to give a full understanding of the nature of the invention. Corresponding variations may of course be made with the four winding and three winding circuits.

As above stated the balancing impedance or network may be omitted and the corresponding leg of the transformer core made wholly or partly of a material having a lower permeability than the other portions of the core. The effective reluctance may also be increased by decreasing the cross-sectional area of this branch. An example of this type of circuit is shown in Fig. 13. When transmitting with this circuit, the flux generated in branch 12 divides between branches 11 and 13 in such a way that equal and opposite E. M. F.'s are induced in the windings 19 and 20.

In none of the circuits shown has there been any attempt to show the ratio of turns of one winding with reference to another, since this ratio will depend on the impedance of the associated elements and in some cases on the direction of the windings. Only in the case of windings 19 and 20, do the drawings purport to show the necessary direction of windings, since in most instances the direction of winding may be reversed.

In certain of the following claims the expression "line balancing circuit" is to be taken to include a real line for balancing another real line as well as an artificial line for this purpose.

What is claimed is:

1. A two-way signaling system comprising a magnetic core having three legs, a winding on each of said legs, a line circuit and at least two other circuits connected to said windings, said line circuit and at least one of said other circuits each being connected directly across two of said windings respectively.

2. A two-way signaling system comprising a magnetic core having three legs, windings on said legs, and two pairs of circuits connected to said windings, the circuits of each pair being conjugate to each other, one circuit of each pair being receptive to currents produced in a circuit of the other pair.

3. A two-way signaling system comprising a magnetic core having three legs, a winding on each of said legs, a line circuit, a receiving circuit and a transmitting circuit connected to said windings, at least two of said circuits each being connected directly across two of said windings respectively, said receiving and transmitting circuits being substantially conjugate.

4. A two-way signaling system comprising a magnetic core having three legs, a winding on each of said legs, a line circuit, a receiving circuit and a transmitting circuit connected to said windings, said receiving and line circuits each being connected directly across two of said windings respectively.

5. A two-way signaling system comprising a magnetic core having three legs, a winding on each of said legs, a line circuit, a line balancing circuit, a receiving circuit and a transmitting circuit connected to said windings, at least two of said circuits each being connected directly across two of said windings respectively.

6. In combination, a magnetic core having at least three branches, a line circuit, a transmitting circuit, a receiving circuit, and a line balancing circuit, each of said circuits being magnetically related to said core, said line and line balancing circuits being conjugate, and said transmitting and receiving circuits being conjugate.

7. In combination, a magnetic core having

at least three branches, windings on said branches, receiving, transmitting, line and line balancing circuits, connected to said windings, at least one of said circuits being connected across two of said windings.

8. In a two-way signaling system, a magnetic core having at least three branches, receiving, transmitting, line and line balancing circuits, three of said circuits each having a winding on a corresponding leg of said core, the other of said circuits having a winding on each of two of said legs.

9. In a two-way signaling system, a magnetic core having at least three branches, receiving, transmitting, line and line balancing circuits, three of said circuits each having a winding on a corresponding leg of said core, the other of said circuits having a winding on each of two of said legs, said circuits being effectively insulated from each other.

10. In a two-way signaling system, a magnetic core having three branches, a winding on one branch, two windings on each of the other branches, a receiver connected across said first winding, a transmitter connected across two windings one on each of the other branches, a line and balancing network connected across the remaining two windings respectively.

11. In a two-way signaling system, a magnetic core having at least three branches, receiving, transmitting, line and line balancing circuits, three of said circuits having a winding on a corresponding leg of said core, the other of said circuits having a winding on each of two of said legs, said circuits being effectively insulated from each other and a common battery supplying direct current to said receiving and transmitting circuits.

12. In a two-way signaling system, a magnetic core having three branches, transmitting, receiving and line circuits having windings on said branches, and a monitoring winding on one of said branches.

13. In a two-way signaling system, a magnetic core having three branches, transmitting, receiving and line circuits having windings on said branches, and a monitoring winding on the branch having the receiving circuit winding.

14. A two-way signaling system comprising a magnetic core having three legs, at least four windings on said legs, one of said windings having a part thereof on one of said legs and another part thereof on another of said legs at least three circuits connected to said windings, one of said circuits being responsive to electric impulses set up in another of said circuits, said first circuit being substantially unresponsive to electric impulses set up in a third of said circuits.

15. A two-way signaling system comprising a magnetic core having three legs, at least four windings on said legs, at least four circuits connected to said windings, one of said circuits being responsive to electric impulses set up in another of said circuits, said first circuit being substantially unresponsive to electric impulses set up in a third of said circuits.

16. In combination, a magnetic core having three legs, a circuit having windings on only two of said legs, a second circuit having a winding on at least one of said two legs and being insulated from any windings on the third of said legs and a third circuit having a winding on the third of said legs, said first and third circuits being conjugate.

17. The combination with a telephone line circuit of a substation set comprising a circuit comprising a telephone transmitter, a second circuit comprising a telephone receiver and a magnetic core having three legs and a winding on each leg, at least two of said circuits each being connected directly across two of said windings respectively, the transmitting and receiving circuits being substantially conjugate.

18. The combination with a telephone line circuit of a substation set according to claim 14, in which the windings on said core are so proportioned that the impedance of said substation set as seen from the line, is substantially equal to the impedance of said line.

19. The combination with a telephone line circuit of a substation set comprising a telephone transmitter, a telephone receiver, a line balancing circuit and a magnetic core having three legs, said transmitter and receiver and each of said circuits being magnetically related to said core, said line and said line balancing circuit being conjugate, and said telephone transmitter and said telephone receiver being conjugated.

20. In combination a magnetic core having at least three branches, windings on said branches, receiving, transmitting, line and line balancing circuits connected to said winding at least one of said circuits being connected across two of said windings in series.

In witness whereof, I hereunto subscribe my name this 30th day of December, A. D. 1919.

KENNETH S. JOHNSON.