Aug. 19, 1941. W. A. MacNAIR 2,253,079

ELECTRICAL TRANSMISSION CIRCUIT

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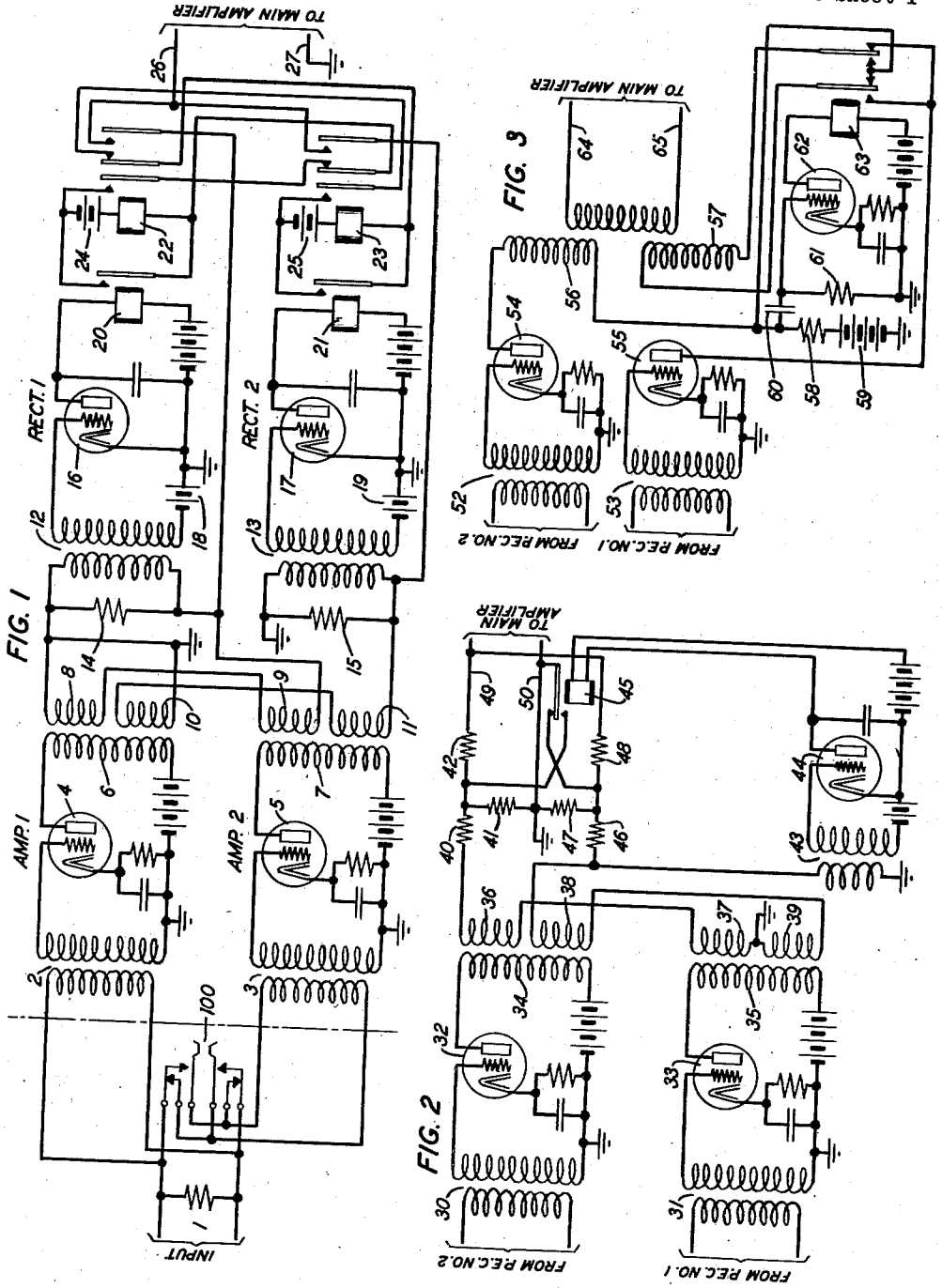

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FIG. 4

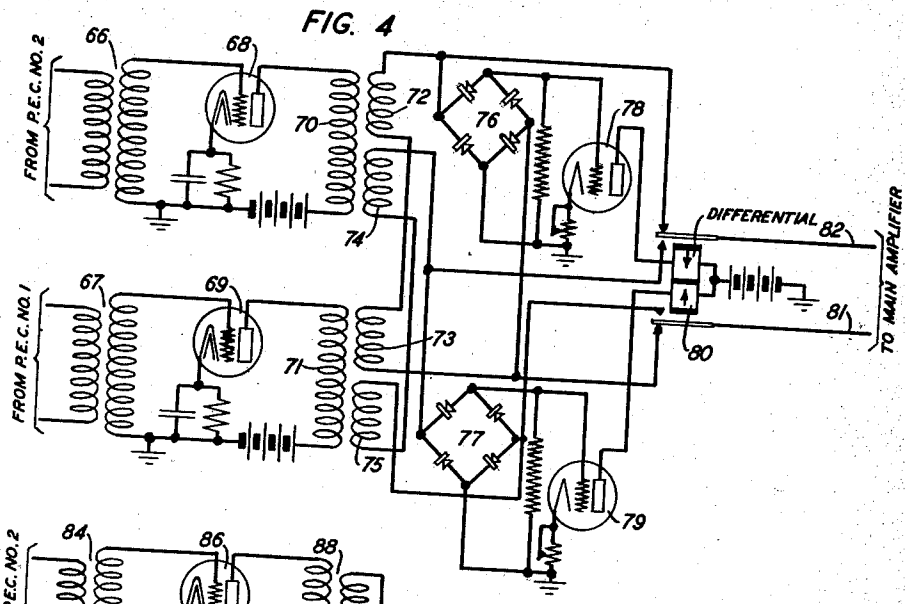
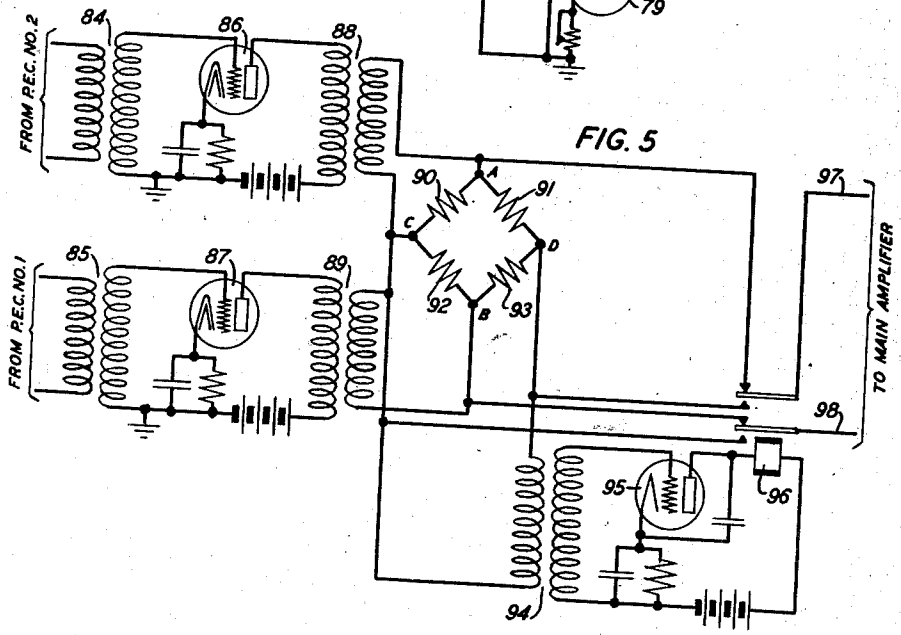


FIG. 5



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ELECTRICAL TRANSMISSION CIRCUIT

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This invention relates to electrical transmission systems and particularly to the transmission circuit of a sound reproducing system.

The object of the invention is to connect two sources of similar currents which may be either in phase conjunction or in phase opposition, automatically to a single utilization circuit so that the current in the utilization circuit will be in phase conjunction.

A feature of the invention is the provision of means for detecting the phase relationship of the currents from the sources.

Another feature of the invention is the provision of means automatically responsive to the phase relationship of the currents from the sources to connect both sources to a single utilization circuit with the currents from both sources in phase conjunction.

Other features of the invention will be apparent from the following description and the drawings.

The invention is applicable to any transmission system having two sources of current, which may be in phase conjunction or phase opposition, but is peculiarly applicable to sound reproducing systems. In two of the known methods of sound recording, particularly the recording of sound on a photographic film, the sound is recorded either on a single record, or on two records in "push-pull" relationship. In connection with the present invention, the single sound record may be considered as two records having the sound recorded in phase conjunction, that is, the two records are in phase, and the push-pull record may be considered as two records in which the sounds are recorded in phase opposition, that is, the two records are 180 degrees out of phase with each other or in opposed phase. Separate pick-ups or reproducers are used for the two parts of the normal, or in phase, record and separate pick-ups are also used for the two parts of the push-pull, or opposed phase, record. These two pick-ups thus act as two sources of currents which may be in phase conjunction or phase opposition. A circuit in accordance with the present invention is connected between the two pick-ups and the usual single channel reproducing circuit. The operator then may play either type of record, or even a single production in which both types of records are used indiscriminately, and the invention will automatically detect the type of record being played and will modify the reproducing circuit so that in all cases the currents from the two sources are supplied to the single reproducing channel in phase conjunction.

The invention is disclosed in greater detail in the following description, and in the drawings, in which:

Fig. 1 shows an embodiment of the invention using two double-wound transformers and separate detectors;

Fig. 2 shows an embodiment of the invention using two double-wound transformers and a single detector;

Fig. 3 shows an embodiment of the invention using a single double-wound transformer and a single detector in the mid-branch;

Fig. 4 shows a modification of Fig. 1; and

Fig. 5 shows an embodiment of the invention using a single detector and a bridged network.

In order to conveniently demonstrate the operation of a circuit embodying the invention, a special input circuit has been used in connection with Fig. 1. Current from some convenient source, such as a conventional pick-up reproducing a known type of sound record, is applied across the terminals of the resistor 1. The primary winding of the transformer 2 is permanently connected across the terminals of the resistor 1, thus the currents in the primary winding of transformer 2 are in phase with the voltage developed across the resistor 1. With the key 100 in the unoperated position, as shown, the primary winding of the transformer 3 is connected to the resistor 1 in the opposite sense to the connection of the primary winding of transformer 2 to the resistor 1, thus the currents in the secondary windings of transformers 2 and 3 are in phase opposition. When the key 100 is operated, the primary winding of the transformers 2 and 3 are connected to the resistor 1 in the same sense, thus, in this case, the currents induced in the primary windings of the transformers 2 and 3 will be in phase conjunction. The input circuit comprising the resistor 1 and the key 100, thus provides a convenient method of observing the operation of the circuit, as the key 100 may be repeatedly operated and released during the reproduction of a single record. In the normal operation of the circuit, one pick-up would be attached to the primary winding of the transformer 2 and a separate pick-up would be attached to the primary winding of the transformer 3. The output of transformer 2, suitably amplified if desired in the amplifier 4, is supplied to the primary winding of transformer 6. Similarly the output of transformer 3, suitably amplified if desired in the amplifier

5, is supplied to the primary winding of the transformer 7. The transformers 6 and 7 each have double secondary windings. The secondary winding 8 of the transformer 6 is connected in aiding relationship with the secondary winding 9 of the transformer 7 and the combined output of these windings is supplied to the transformer 12. The secondary winding 10 of the transformer 6 is connected in opposing relationship to the secondary winding 11 of the transformer 7 and the combined output of these windings is supplied to the primary winding of the transformer 13. The output of transformer 12 is supplied to the thermionic detector 16 having a battery 18 to cause grid rectification and supplying operating current to the winding of the relay 20. Similarly the output of the transformer 13 is supplied to the thermionic detector 17 having a battery 19 for biasing the grid, and supplying operating current to the winding of the relay 21. The resistors 14 and 15 are respectively connected across the primary windings of the transformers 12 and 13 to improve the impedance relationships in the circuit. The operation of relay 20 completes a circuit for the battery 24 through the winding of relay 22 and operates relay 22. Similarly the operation of relay 21 completes a circuit for battery 25 through the winding of relay 23 and operates relay 23.

With the switch 100 in the position shown, that is, the currents in the secondary windings of transformers 2 and 3 and in the windings of transformers 6 and 7 in phase opposition, the currents in the windings 8 and 9 will be in phase opposition and will annul each other, thus no current is applied to the winding of transformer 12, but the currents in the secondary windings 10 and 11 will assist each other and will supply current through the transformer 13 to be detected to the thermionic detector 17 and operate relay 21, thus operating relay 23. The operation of relay 23 completes a circuit from the lower end of winding 11 through the right-hand make contacts of relay 23 to the transmission line 26. The lower end of winding 10 is connected through ground to the transmission line 27, thus the windings 10 and 11 are effectively connected across the transmission line 26, 27 and the outputs of transformers 6 and 7, properly in phase with each other, are supplied to the transmission line 26, 27. The transmission line 26, 27 may be connected to any desired utilization circuit such as a regular single channel sound reproducing equipment.

With the switch 100 operated, that is, the outputs of transformers 2 and 3 in phase conjunction, the currents induced in the windings 10 and 11 will be in phase opposition and will annul each other, thus no current is supplied to the transformer 13. However, as the currents in the transformers 6 and 7 are in phase conjunction, the currents induced in the windings 8 and 9 will also be in phase conjunction and power is supplied to the transformer 12, is detected in the thermionic detector 16, operating relay 20 and causing the operation of relay 22. The operation of relay 22 completes a circuit from the lower end of the winding 9 through the right-hand make contact of relay 22 to the transmission line 26. The upper end of the winding 8 is connected through ground to the transmission line 27, thus the windings 8 and 9 in aiding relationship are effectively connected across the transmission line 26, 27. As, under these conditions, the currents in the transformers 6 and 7 are in phase conjunction, the outputs of the windings 8 and 9, combined in the proper phase relationships are supplied to the transmission line 26, 27.

The operation of relay 22 completes a circuit from the battery 24, through the left-hand make contact of relay 22 and the center break contact of relay 23 through the winding of relay 22 to the battery 24, thus locking up the relay 22 through the break contact of the relay 23. Similarly, the operation of the relay 23 completes a circuit from the battery 25 through the left-hand make contact of relay 23, the center break contacts of relay 22 and the winding of relay 23 to the battery 25 thus locking up the relay 23 through the break contacts of relay 22. The operation of relay 20 thus will cause the operation of relay 22 which will then lock up in the operated condition, independently of the subsequent release of the relay 20. Similarly, the operation of the relay 21 will cause the operation of relay 23 which locks up independently of the subsequent release of relay 21. However, as the relay 22 locks up through a circuit running through the break springs of the relay 23, the subsequent operation of the relay 23 will release the relay 22, and similarly, as the relay 23 locks up through the break spring of the relay 22, a subsequent operation of the relay 22 will release the relay 23.

Thus for each change in the phase relationship of the current supplied to the transformers 2 and 3, there is a corresponding operation of the relay 22 or 23 and the proper windings 8 and 9, or 10 and 11, are connected to the transmission lines 26, 27.

In Fig. 2, current from the two sources are respectively supplied to the transformers 30 and 31, amplified in the amplifiers 32 and 33 and supplied to the transformers 34 and 35. The secondary windings 36 and 37 of the transformers 34 and 35 are connected in aiding relationship, while the secondary windings 38 and 39 of the transformers 34 and 35 are connected in opposing relationship. If the currents in the transformers 34 and 35 are in phase conjunction, or as it might be termed, in parallel, the currents in the windings 36 and 37 will be in phase conjunction and the combined output of these two windings will be supplied through the resistance pad formed by the resistors 40, 41 and 42 to the transmission line 49, 50, leading to a conventional sound reproducing channel. The currents induced in the windings 38 and 39 will be in phase opposition and will annul each other, while the channel from these windings is also short-circuited by the break springs of relay 45.

If the currents in the transformers 34 and 35 are in phase opposition, or as it might be termed in push-pull, the currents induced in the windings 36 and 37 will be in phase opposition and will substantially annul each other. The currents induced in the windings 38 and 39 will be in phase conjunction and will be supplied to the transformer 43, detected in the detector 44 and will operate the relay 45, placing a short circuit across resistor 41 in the channel from the windings 36 and 37 removing the short circuit normally present across resistor 41 in the channel from the windings 38 and 39. The output of the windings 38 and 39 will be supplied through the resistance pad formed by the resistors 46, 47 and 48 to the transmission lines 49 and 50.

In Fig. 1, the transmission channel is incomplete until the application of a current causes

the operation of the appropriate relay to complete the channel or is completed for either type of current, depending on the previous operation, whereas in Fig. 2 the transmission circuit is normally completed for phase conjunction or parallel current, and a relay is operated to modify the channel for the transmission of phase opposition or push-pull currents.

In Fig. 3 currents from the two sources are respectively supplied to the transformers 52 and 53, thence to the input circuit of the thermionic amplifying devices 54 and 55. The anode of the amplifier 54 is connected through the transformer winding 56, resistor 58, anode battery 59, and biasing resistor to the cathode. The anode of the amplifier 55 is connected through the right-hand break springs of relay 63 to the winding 57 of the transformer, thence through the left-hand break springs of relay 63, resistor 58 and anode battery 59 to the cathode. In the unoperated position of the relay 63, the amplifiers 54 and 55 are connected to the windings 56 and 57 in the well-known push-pull connection. Thus if the currents supplied by the transformers 52 and 53 are in phase opposition or push-pull, the outputs of the amplifiers 54 and 55 will be combined by the windings 56 and 57 in the usual manner and supplied to the transmission lines 64 and 65. When two amplifiers are operated in push-pull and the circuit is properly balanced, it is well known that no alternating currents flow in the mid-branch from the center of the output transformer to the cathode, thus no alternating voltages will be developed across the resistor 58.

If currents in phase conjunction, or parallel relationship, are applied to the inputs of the amplifiers 54 and 55, the voltages induced by the windings 56 and 57 will oppose each other and no power will be supplied to the output circuit. However, the amplified current from both amplifiers will flow through the resistor 58 in phase with each other and will develop alternating voltages across the resistor 58 which are applied through the capacitor 60, across the resistor 61, detected by the detector 62 and cause the operation of relay 63. The operation of relay 63 reverses the connections of the winding 57 to the amplifier 55 so that the voltages induced by the windings 56 and 57 are in phase conjunction and the output of both the amplifiers 54 and 55 is supplied in the proper phase relationship to the transmission line 64, 65. However, as the outputs of the amplifiers 54 and 55 are in phase conjunction or in parallel, the alternating current continues to flow in the resistor 58 and thus holds the relay 63 operated so long as the currents in the transformers 52 and 53 are in phase conjunction. If now currents in phase opposition are applied to the transformers 52 and 53, the outputs of the amplifiers 54 and 55 will be in phase opposition, no current will flow in the resistor 58 and the relay 63 will be released, thereby switching the winding 57 back to the push-pull relationship.

In Fig. 4 current from the transformers 66 and 67, suitably amplified if desired in the amplifiers 68 and 69, are supplied to the transformers 70 and 71. The secondary windings 72 and 73 are connected in aiding relationship to the rectifying network 76, which has substantially the same function as the detector 16 in Fig. 1. Similarly the secondary windings 74 and 75 are connected in opposing relationship to the rectifying network 77 which has substantially the same function as the detector 17 in Fig. 1. The rectifying networks 76 and 77 may be of any desired type, and as shown are full-wave bridge type rectifiers, preferably having elements made up of copper, copper-oxide couples. The amplifying devices 78 and 79, respectively, amplify the outputs of the rectifying networks 76 and 77. A double-wound differential polarized relay 80 has one winding connected in the output circuit of the amplifying device 78, and the other winding connected in the output circuit of the amplifying device 79. When currents in phase conjunction, or parallel relationship, are supplied to the transformers 66 and 67, the outputs of the windings 72 and 73 are combined and rectified by the network 76 causing a current to flow in the amplifier 78 and holding the armatures of the relay 80 outward to connect the windings 72 and 73 to the transmission lines 81, 82. If currents in phase opposition, or push-pull relationship, are applied to the transformers 66 and 67, the outputs of the windings 74 and 75 are combined in proper phase relationship and supplied to the rectifying network 77 causing current to flow in the device 79 operating the relay 80 to move the armature of the relay inward and connect the windings 74, 75 to the transmission lines 81, 82. Suitable control means, such as the variable cathode biasing resistors may be associated with the amplifiers 78, 79 to balance the operation of the amplifiers and to adjust the anode currents of the amplifiers to values suited for the operation of the relay 80.

In Fig. 5 currents from the two sources are supplied to the transformers 84, 85, amplified in the amplifiers 86, 87 and respectively supplied to the transformers 88, 89. The secondary windings of the transformers 88, 89 are respectively connected across adjacent arms of the balanced bridge formed by the resistors 90, 91, 92, 93. If the currents in the secondary windings of the transformers 88 and 89 are in phase conjunction, or parallel relationship, an alternating voltage will be developed across the diagonal A—B of the balanced bridge, and no voltage will be developed across the diagonal C—D of the bridge. The voltage developed across the diagonal A—B of the bridge is supplied through the break contacts of the relay 96 to the transmission lines 97, 98 which may be connected to a regular single channel sound reproducing system. If, however, the currents in the secondary windings of the transformers 88, 89 are in phase opposition, or push-pull relationship, no voltage will be developed across the diagonal A—B of the bridge and an alternating voltage will be developed across the diagonal C—D of the bridge. The voltage developed across the diagonal C—D of the bridge is supplied through transformer 94 to the detector 95 and causes the operation of relay 96. The operation of relay 96 disconnects the diagonal A—B of the bridge from the transmission lines 97, 98 and connects the diagonal C—D of the bridge through the make contacts of the relay 96 to the transmission line 97, 98, thus supplying current to the sound reproducing channel.

In all of the figures, a preliminary stage of amplification, such as the transformer 2 and amplifier 4 in Fig. 1, is shown in each channel. If a preamplifier is associated with each of the photoelectric cells, or if the output of the pick-up is sufficiently great, this stage of preliminary amplification frequently may be omitted, and the current from the two sources supplied directly to the second transformers, such as the transformers 6 and 7 in Fig. 1.

In Fig. 1, a sensitive relay 20 having a small

number of contacts is associated with a less sensitive relay 22 having a large number of contacts. It is not always necessary that two relays should be used in this connection as in many cases the relay 20 may be equipped with other contacts similar to those shown on the relay 22 and the relay 22 then may be unnecessary. Similarly in Figs. 2, 3, 4, and 5 where only a single relay is shown, in many cases it may be advisable to use a combination of two relays as shown in Fig. 1.

Three types of push-pull recording are known to the art, and have been designated as type A, type B and type AB. Type A recording is shown in U. S. Patents 1,930,362, October 10, 1933, H. Konemann and 2,077,193, April 13, 1937, E. C. Wente. Type B recording is shown in U. S. Patent 1,338,719, May 4, 1920, F. W. Adsit. Type AB recording is shown in U. S. Patent 2,030,428, February 11, 1936, I. M. Chambers. In type A recording, in the absence of sound, both records are at some convenient point, preferably the center, of the recording characteristics. The first half wave of the sound moves one record upward on the characteristic and simultaneously moves the other record downward on the characteristic. The currents reproduced from such a pair of records, under ideal conditions, have exactly the same wave shape but are opposed in phase, oscillate upward and downward about a mean value, exist at all times, and are, at all times, equal in amplitude. In type B recording, in the absence of sound, both records are at the bottom, or zero value, of the recording characteristics. The first half wave of sound moves one record upward and then downward over the characteristic, the second record remaining unaffected at the zero value. The second half wave of sound, which is essentially opposed in phase to the first half wave, moves the second record upward and then downward over the recording characteristic, the first record remaining unaffected at the zero value. This alternate action continues for the following half waves. The currents reproduced from such a pair of records, under ideal conditions, have the wave shape of successive half waves of the sound, are opposed in phase, oscillate from a minimum value to a larger value then back to the minimum value, do not exist at the same time but succeed each other, and are only approximately of the same amplitude. In type AB recording, for small amplitudes of the sound the record is a type A record, which for larger amplitudes of the sound, becomes a type B record. All of the reproducing systems shown in the present application will reproduce type A records while the system shown in Figs. 2 and 5 of the drawings will also reproduce type B, or type AB, records. In the claims forming part of the present application, the expressions "phase conjunction" and "phase opposition" are to be read as including not only the true, simultaneous, phase relationship of the type A reproduction, but also the pseudosuccessive phase relationship of the type B and type AB reproduction.

What is claimed is:

1. In a sound reproducing system, in combination, a plurality of elements for scanning a plurality of sound records, a sound reproducing circuit, means automatically responsive to the phase relationship of the currents from said scanning elements, and means controlled by said responsive means for connecting the outputs of said scanning elements to said reproducing circuit so that the currents from said elements in the reproducing circuit are in phase conjunction.

2. In a transmission system, a plurality of sources of signal currents, a circuit for utilizing the currents from said sources, means automatically responsive to the phase relationship of the currents from said sources, and means controlled by said responsive means for supplying the currents from both said sources in phase conjunction to said utilizing circuit.

3. In a transmission system, in combination, two sources of alternating currents of similar wave form, a transmission channel for each of said sources, detector means associated with said channels, and means controlled by said detector means for connecting both said channels to a utilization circuit so that the currents from both said sources are in phase conjunction in said utilization circuit.

4. In a transmission circuit, in combination, two sources of alternating currents of similar wave form, a transmission channel connected to each of said sources, a transformer in each of said channels having a double secondary winding, means associated with said transformer for detecting the phase relationship of the currents in said channels, and means associated with said detector means for selectively connecting the secondary windings of said transformers to a utilization circuit so that the currents from both said sources are in phase conjunction in said utilization circuit.

5. In a sound reproducing system, two sound records of the same alternating current, said records being in parallel or in push-pull, scanning means individual to each of said records, a transformer connected to the output of each of said scanning means, said transformer having double secondary windings, detector means associated with the secondary windings of said transformers, a single channel sound reproducing circuit, and means associated with said detector means for so connecting the secondary windings of said transformers to said sound reproducing circuit that the currents fom both of said transformers are in phase conjunction in said sound reproducing circuit.

6. In a transmission system, two sources of alternating currents of similar wave form, a transformer connected to each of said sources, said transformer having double secondary windings, one winding of each of said transformers being connected in aiding relationship and one winding of each of said transformers being connected in opposing relationship, detector means associated with said secondary windings, and means controlled by said detector means for connecting said secondary windings to a utilization circuit in such manner that the currents from said secondary winding are in phase conjunction in said utilization circuit.

7. In a transmission system, two sources of alternating currents of similar wave form, a transformer connected to each of said sources, said transformers having double secondary windings one of the windings of each of said transformers being connected in aiding relationship and one of the windings of each of said transformers being connected in opposing relationship, detector means associated with the aiding windings, other detector means associated with the opposing windings, and means controlled by said detector means for connecting said aiding windings to a utilization circuit when the current from said sources are in phase conjunction and for connecting said opposing windings to said uti-

lization circuit when the currents from said sources are in phase opposition.

8. In a transmission system, two sources of alternating currents of similar wave form, said currents being either in phase conjunction or in phase opposition, transformer means connected to said sources to normally transmit currents having one phase relationship to a utilization circuit, means associated with said transformer means for detecting the phase relationship of the currents from said sources and means controlled by said detector means for switching the connections of said transformer means to said utilization circuit when the currents from said sources are in the opposite phase relationships, whereby the currents supplied from said sources to said utilization circuit are at all times in phase conjunction.

9. In a sound reproducing system, two records of the same sound, said records being either in parallel or in push-pull, individual pick-ups for each of said records, transformer means associated with the outputs of said pick-ups, said transformer means normally connecting the outputs of said pick-ups to a signal reproducer in parallel when one type of record is being reproduced, means associated with said transformer means for detecting the use of a record of the other type, and means associated with said detector means for changing the connections of one transformer to said reproducing circuit whereby the currents from said pick-ups are always supplied to said reproducing channel in parallel relationship.

10. In a sound reproducing system, two records of the same sound, said records being in parallel or in push-pull, scanning devices individual to each record, a transformer in the output of each of said scanning devices, said transformers having double secondary windings, one of the secondary windings of each of said transformers being connected together in aiding relationship and one of the windings of each of said transformers being connected together in opposed relationship, a single channel sound reproducing circuit, a connection from one end of said aiding windings and from one end of said opposing windings to one side of said reproducing channel, a detector amplifier connected to said aiding windings, a relay operated by the output of said detector amplifier to connect the other end of said aiding windings to the second side of said reproducing channel, a detector amplifier connected to said opposed windings, a relay actuated by the output of said second detector amplifier to connect the other end of said opposing windings to the second side of said reproducing channel.

11. In a transmission system, two sources of alternating currents of similar wave form, said currents being in phase conjunction or in phase opposition, a transformer connected to each of said sources, each of said transformers having two secondary windings, one secondary winding of each transformer being connected together in aiding relationship, and the other winding of each transformer being connected together in opposed relationship, said windings connected in aiding relationship and said windings connected in opposed relationship being connected to a load circuit, a detector amplifier connected across said opposed winding and a relay operated by the output of said detector amplifier to short-circuit said aiding winding.

12. In a transmission system, two sources of alternating current of similar wave form, said currents being in parallel relationship or in push-pull relationship, a pair of thermionic amplifying devices having their input circuits respectively connected to said sources, and their output circuits connected in opposed or push-pull relationship to an output circuit, a detector associated with the mid-branch of said output circuits and a relay actuated by the output of said detector to switch said output circuit from push-pull to parallel relationship with said output circuit.

13. In a sound reproducing system, two records of the same sound, said records being in parallel or push-pull relationship, a scanning device for each of said records, a pair of thermionic amplifiers having their input circuits respectively associated with said scanning devices, a sound reproducing circuit, a transformer having two primary windings and a secondary winding connected to said sound reproducing circuit, said primary windings being normally connected to said thermionic amplifiers in push-pull relationship, an impedance in the mid-branch of said output circuits, a detector energized by the voltages developed across said impedance, and a relay operated by the output of said detector to switch one of said windings from the push-pull connection to the parallel connection with the other winding.

14. In a transmission system, in combination, two sources of signal currents, a transmission channel for each of said sources, detector means associated with said channels, and means controlled by said detector means for connecting both said channels to a utilization circuit so that the currents from both said sources are in phase conjunction in said utilization circuit.

15. In a transmission system, two sources of signal currents, transformers respectively connected to each of said sources, each of said transformers having two secondary windings, one pair of secondary windings being connected together in aiding relationship, and the other pair of secondary windings being connected in opposing relationship, each of said pairs being connected to a common load circuit, a detector connected across said opposing windings, and a relay normally short-circuiting said opposing windings and operated by the output of said detector to remove the short circuit from the opposing windings and to short-circuit the aiding windings.

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