Aug. 4, 1942. C. BECKER 2,292,035

ELECTRIC CONNECTION FOR REPRODUCING SOUND RECORDS

Filed Aug. 27, 1940 2 Sheets-Sheet 1

Fig. 1

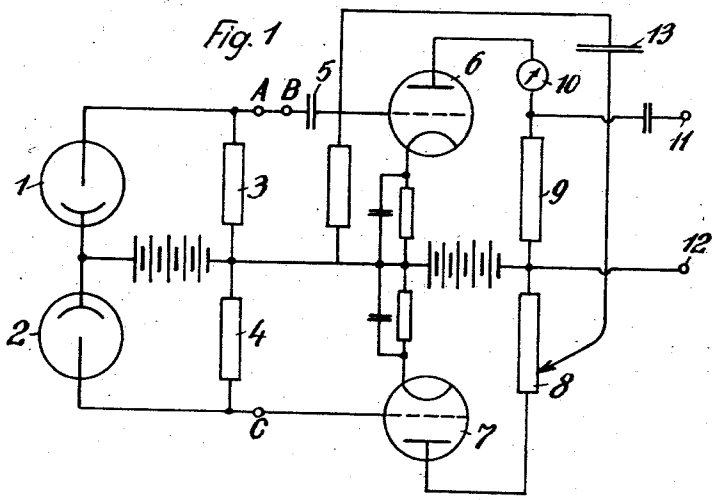


Fig. 2

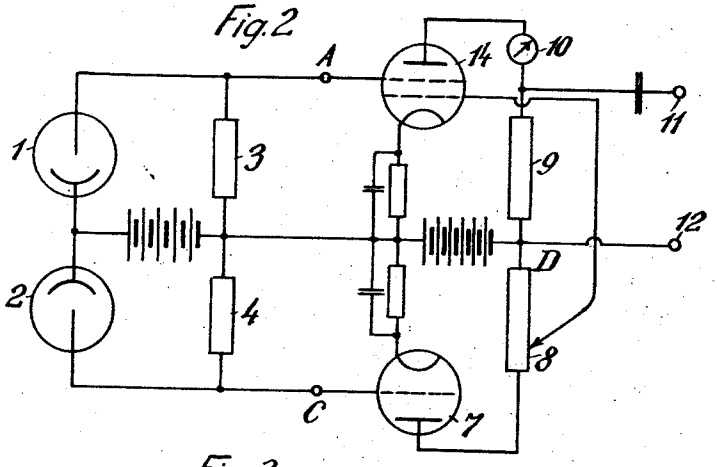
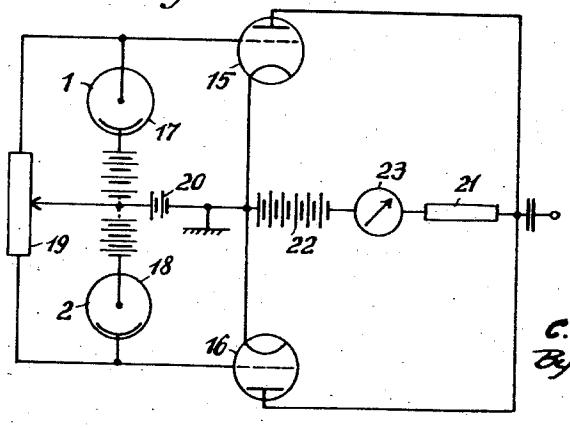


Fig. 3



Inventor:
C. Becker
By: Stevens, Davis, Miller & Mosher
Attys.

Aug. 4, 1942. C. BECKER 2,292,035

ELECTRIC CONNECTION FOR REPRODUCING SOUND RECORDS

Filed Aug. 27, 1940 2 Sheets-Sheet 2

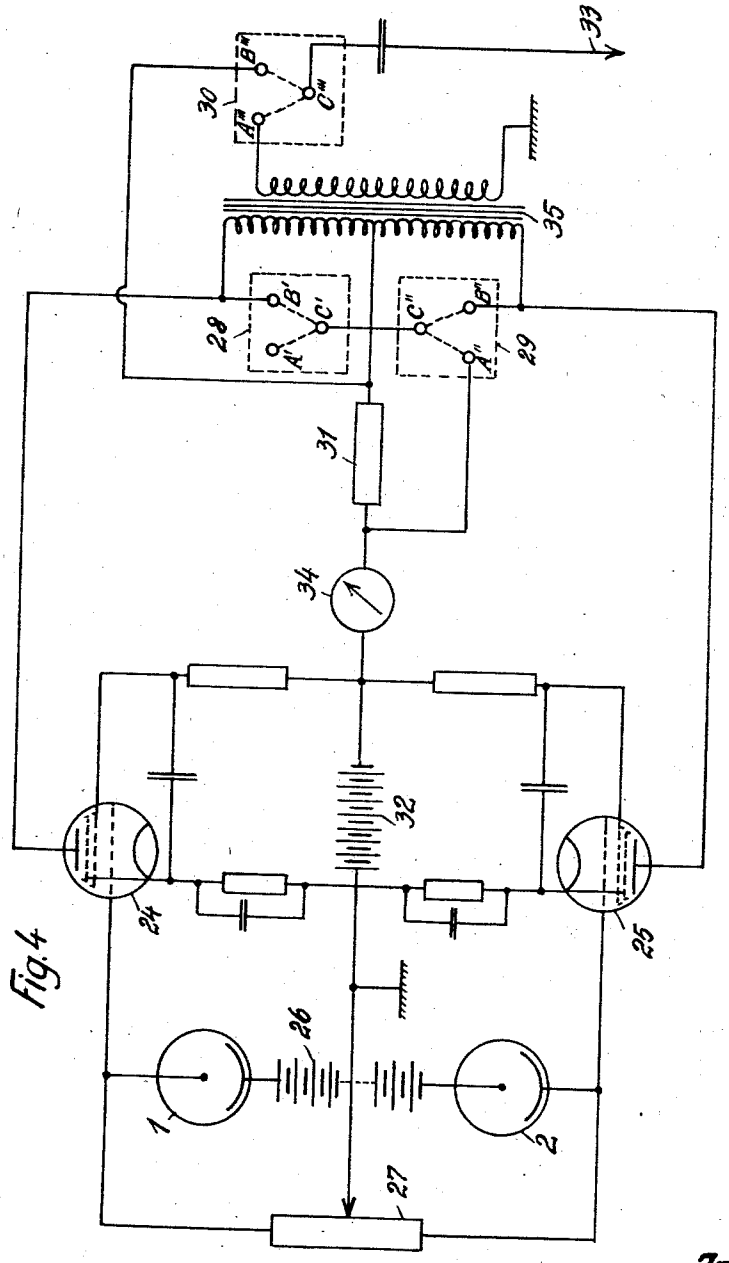


Fig. 4

Inventor:
C. Becker
By: Stevens & Davis
Attys.

Patented Aug. 4, 1942

2,292,035

UNITED STATES PATENT OFFICE

2,292,035

ELECTRIC CONNECTION FOR REPRODUCING SOUND RECORDS

Carlheinz Becker, Berlin-Wilmersdorf, Germany, assignor to Universum-Film Aktiengesellschaft, Berlin, Germany

Application August 27, 1940, Serial No. 354,461
In Germany March 18, 1939

2 Claims. (Cl. 179—100.3)

The reproduction of half-wave sound records which have been recorded separately from each other is effected by scanning the two traces with push-pull photo-electric cells whereby half-wave voltages are obtained that can be combined to a single current by means of a push-pull transformer. The combination may be effected either at the input or at the output of the amplifier, except that in the latter instance the amplifier used must be capable of transmitting half-wave signals without distortion.

Heretofore it has been thought that composition of half-wave signals into a whole wave signal free of distortion was impossible when using a push-pull transformer because half-wave voltages, when impressed upon the push-pull windings of transformer, produce the same effect as alternate opening and closing of an inductance circuit, thus inductive voltages are produced in the corresponding push-pull windings of the push-pull transformer which react through the transformer upon the circuit connected to the other push-pull winding, thereby causing intolerable distortions.

In accordance with the present invention, half-wave signals are combined into a whole-wave signal, not by a push-pull transformer, but by a novel coupling circuit that possesses the advantage over existing types of coupling circuits in that neither the photo-electric cells nor the circuits connected to the latter need be electrically matched or balanced.

This is accomplished by directly applying the half-wave signal derived from the one photo-electric cell to the grid of an amplifier tube and applying the half-wave signal derived from the other photo-electric cell, by way of a phase reversal tube and a variable potentiometer arranged in its anode circuit to the grid of the amplifier tube. By this means, adjustment of the potentiometer permits transmittal of the whole-wave signal to the grid of the amplifier tube. This type of coupling permits easy control of symmetry.

In the accompanying figures of drawings, numbered 1 through 4, several examples of the subject matter of this invention are illustrated by circuit diagrams.

In Fig. 1, two push-pull connected photo-electric cells 1 and 2 are used to scan the traces whereby half-wave voltages are produced across resistances 3 and 4. The half-wave voltage appearing across the resistance 3 is applied to the grid of an amplifier tube 6 by a coupling condenser 5. The half-wave voltage appearing across the resistance 4 is applied to the grid of a phase reversal tube 7 in the anode circuit of which an adjustable potentiometer 8 is provided. The component voltage tapped at the potentiometer 8 also is applied to the grid of the amplifier tube 6 through a coupling condenser 13. If the voltage tapped at the potentiometer 8 has the same amplitude as the voltage appearing across the resistance 3, then the two voltages combine to a single curve at the grid of the amplifier tube 6 because, due to the phase reversal tube 7, the two half-wave voltages appearing across the resistance 3 and at the potentiometer 8 have opposite directions. To avoid phase defects, the anode resistances 8 and 9 of the two tubes 7 and 6, as well as their loadings, must be purely ohmic and the two coupling capacities 5 and 13 must be equal to each other. The alternating voltage occurring between the terminals 11 and 12 then may be supplied to a power amplifier.

The exact symmetry of the half-wave voltages essential for distortion-free reproduction of half-wave sound is obtained by adjustment of the potentiometer 8. A current measuring instrument 10, included in the anode circuit of the amplifier tube 6, facilitates this adjustment and the control of symmetry. If symmetry is not present, i. e., if the amplitude of the one half-wave signal is different from that of the other, the operating signal depends upon the circuit characteristics, thus the average anode current of the amplifier tube 6 fluctuates corresponding to the amplitude of the voltages occurring at the resistances 3 and 4, because excess of voltage of the one half-wave relative to the other is proportional to this amplitude. The measuring instrument 10, indicating the average anode circuit, oscillates when there is lack of symmetry, hence to obtain exact symmetry it is only necessary to adjust the potentiometer 8 until the measuring instrument 10 is completely at rest.

The electrical circuit described above also is adapted for reproduction of normal or whole wave sound records. For this purpose, it is only necessary to interrupt the connection between the points A and B and to connect instead the points A and C.

Fig. 2 shows a further modification of the circuit according to this invention. In this instance, the amplifier tube 14 is not constructed as a triode in which the two half-wave voltages act upon the same control grid, but use is made of an amplifier tube having two control grids (for instance a space charge grid, hexode etc.) in which each half-wave voltage acts upon one of the control

grids. As contrasted to the electrical circuit shown in Fig. 1, increased amplification is obtained with the circuit shown in Fig. 2, or, more particularly, the coupling condensers 5 and 13, required in the circuit shown in Fig. 1, are rendered superfluous, thus phase defects may more easily be avoided. The circuit according to Fig. 2 corresponds, as far as the operation is concerned, to the circuit shown in Fig. 1. For reproducing normal whole wave sound records, the points A and C are connected to each other and the potentiometer 8 is adjusted to zero, i. e., the wiper is connected to the point D.

In accordance with another modification of the present invention, the composition of the half-wave voltages into a pure full-wave alternating voltage is effected by directly opposing the two photo-electric cells of a conventional push-pull scanning device so that the half-wave signals reach the grid of one of the amplifier tubes with exactly the opposite sign to that which reaches the grid of the other amplifier tube.

In contradistinction to conventional scanning circuits using photo-electric cells for reproduction of push-pull records, the opposite electrodes of the photo-electric cells are applied to the grids of the two amplifier tubes, connected in sequence and operating in push-pull fashion. In this type of circuit a voltage source is required for each of the photo-electric cells. If this is undesirable, a voltage source having a middle tap may be used, the end terminals of which are connected to opposite electrodes of the photo-electric cells (not to the electrodes of the photo-electric cells connected to the grids of the amplifier tubes) and the middle tap of which is connected to the common cathode connection of the amplifier tubes. The center tap of the voltage source also is connected to the wiper of the potentiometer, forming the leakage resistances of the photo-electric cells. The two end terminals of the potentiometer are connected to the grids of the amplifier tubes which are also connected to corresponding electrodes of the photo-electric cells.

If the two anodes of the amplifier tubes, connected in sequence and operating in push-pull fashion, are connected together and if the anode voltages supplied to a common resistance, a composite full wave alternating current may be tapped at the ends of this resistance and applied to a power amplifier. Symmetry can be indicated in the circuit by minimum deflections of a lag-free current meter, arranged in the anode circuit, which can be adjusted by regulating the variable leakage potentiometer-type resistances of the photo-electric cells.

Another modification of the present invention is illustrated by the circuit shown in Fig. 3 wherein photo-electric cells 1 and 2 are used for scanning two half-wave records. The anode of the photo-electric cell 1 is connected to the grid of an amplifier tube 15, and the cathode of the photo-electric cell 2 is connected to the grid of the amplifier tube 16. Between the cathode of the photo-electric cell 1 and the anode of the photo-electric cell 2, voltage sources 17 and 18, connected in series, are arranged, the connecting point of which is also connected to the wiper of the potentiometer 19 and to the negative pole of the grid battery 20. The end terminals of the potentiometer 19 are connected to the grids of the amplifier tubes 15 and 16 which are connected in push-pull fashion at the input side. By a grid bias 20, the operating conditions of the amplifier tubes are maintained in the middle of the characteristic curve, as is the case in connection with the push-pull-class A amplifier.

The anodes of the amplifier tubes 15 and 16 are connected to each other and applied at the one end of the anode resistance 21 which is common to both amplifier tubes. The other end of the resistance is connected to the positive pole of the anode voltage source 22. In that portion of the anode circuit which is common to both amplifier tubes, a current measuring instrument 23 of high natural frequency is arranged for facilitating control of the symmetry by indicating the average anode current of the amplifier tubes 15 and 16.

If symmetry exists in the circuit, the half-wave voltages at the control grids of the amplifier tubes 15 and 16 will not affect the average anode current flowing through the anode resistance 21, hence the current measuring instrument 23 will remain at rest. If, however, symmetry does not exist, the average anode current fluctuates, depending upon the amplifier tube wherein the half-wave voltage originates, thus the current measuring instrument 23 oscillates at the frequency of the half-wave voltages. To obtain the desired adjustment of symmetry, it is only necessary to adjust the potentiometer 19 until the current measuring instrument 23 indicates minimum fluctuation.

It is characteristic of the above described circuit that the scanning photo-electric cells provide voltage impulses of opposite sign which are supplied to the two grids of the amplifier tubes when a light impulse causes the cells to operate. If for instance a sinusoidal light impulse strikes one of the photo-electric cells, the grid of the corresponding amplifier tube receives a sinusoidal voltage impulse of a definite sign and a corresponding sinusoidal drop of voltage occurs at the purely ohmic anode resistance of the tube. If, after termination of the light impulse, a second sinusoidal light impulse strikes the second photo-electric cell, as occurs when scanning half-wave records, then a sinusoidal voltage appears at the grid of the second amplifier tube from the second photo-electric cell, the sign of which is opposite to that of the voltage impulse applied to the grid of the first amplifier tube, and a sinusoidal voltage drop also occurs at the anode resistance of the second tube. This last voltage drop, however, has opposite sign. The two sinusoidal half-waves are composed to a full-wave sinusoidal alternating voltage at the anode resistance as above described. When combining half-wave signals, the use of a pure ohmic anode resistance is absolutely necessary if distortion is to be avoided.

If, however, the same light impulse simultaneously strikes both the photo-electric cells, as occurs in the scanning of ordinary push-pull records, the two corresponding anode voltages neutralize each other at the anode resistance, if the connection is exactly balanced. The reproduction of ordinary records, therefore, is impossible with this electrical circuit.

In accordance with a further modification of the present invention, the above described electrical circuit may be used both for the reproduction of half-wave and of whole-wave or ordinary sound records. In this instance, the reproduction of ordinary records is made possible by altering the circuit in a manner such that the common anode resistance is short-circuited, and the anode voltage is supplied to the anodes of the amplifier tubes through a center tap of the pri-

mary winding of the output transformer, the two end terminals of which are directly connected to the anodes.

In this modification of the present invention, rapid change-over from one kind of reproduction to the other is simplified by arrangement of the resistance common to the two anode circuits between the positive pole of the anode voltage source and the middle tapping of the output transformer primary winding, the anodes of the two amplifier tubes being connected to the two end terminals of the primary windings. By use of a two-position switch the middle tapping can be short-circuited with the two ends of the primary winding for the purpose of reproducing half-wave records, or, for the reproduction of ordinary records, the middle tapping can be short-circuited with the positive pole of the anode voltage source.

A further simplification of the change-over can be accomplished by the use of a three-way switch, two switch members of which effect the change-over above described, whereas the third switch member simultaneously serves to connect the output terminal of the electric connection, either with the middle tapping of the primary winding of the output transformer for the reproduction of half-wave records, or, for the reproduction of ordinary records, with the secondary winding of the output transformer.

This modification is illustrated in Fig. 4 of the drawings. Here also the two scanning photo-electric cells are designated with 1 and 2. The anode of the photo-electric cell 1 is connected to the grid of the amplifier tube 24, and the cathode of the photo-electric cell 2 is connected to the grid of the amplifier tube 25. Between the cathode of the photo-electric cell 1 and the anode of the photo-electric cell 2, a voltage source 26 is connected and the middle tap of this source is connected to the wiper of the potentiometer 27. Additionally, the potentiometer wiper is connected to the common grounded cathodes of the amplifier tubes 24 and 25. The ends of the potentiometer 27 are connected to the grids of the amplifier tubes 24 and 25.

Switch members 28, 29 and 30 constitute a three-way switch used in effecting the change-over from the reproduction of half-wave records to the reproduction of full wave ordinary records. In one position of the switch, the terminals C', C'' and C''' are connected to the terminals B', B'' and B''' respectively, whereby the circuit for reproduction of half-wave records is obtained. In this instance, the anodes of the amplifier tubes 24 and 25 are connected to one end of the anode resistance 31, the other end of which is connected to the positive pole of the source 32 of the anode voltage. The amplified and combined alternating full-wave voltage is tapped at the output terminal 33 which, through the switch member 30, is connected to the end of the resistance 31. The adjustment of symmetry is effected as above described by the variable potentiometer 27 and the high natural frequency current measuring instrument 34 whereby, during scanning, the potentiometer 27 is adjusted until the current meter 34 indicates minimum deflection.

For the reproduction of ordinary or full-wave records, the switch members 28, 29 and 30 are so connected that the terminals C', C'' and C''' are connected to the terminals A', A'' and A''' respectively. In this manner, the anode resistance 31 is short-circuited and half of the anode current of the amplifier tubes 24 and 25 now can flow through the primary winding of the output transformer 35. As mentioned above, the simultaneous actuation of the two photo-electrical cells by the same light impulse produces opposite anode currents of the same magnitude in the two amplifier tubes 24 and 25, hence the currents flowing through the two halves of the primary winding have the same direction of flow. The electrical circuit now operates as an ordinary push-pull-class A amplifier. The alternating full-wave voltage here also is tapped between ground and the output terminal 33, which by the switch member 30 is connected with the one end of the secondary winding, and the other end of the secondary winding completes the circuit through ground.

I claim:

1. An electric connection for the reproduction of sound records made in half-wave records in which, before composition, the one half-wave voltage is reversed in phase and one of the opposite electrodes of two scanning photo-electric cells is connected to one of the grids of two push-pull amplifier tubes as well as to the two ends of a potentiometer the wiper of which is connected to the common cathode of the two amplifier tubes and to a middle tapping of the source of voltage to the ends of which the electrodes of the photo-electric cell not connected to the grids of the amplifier tubes are connected, whereas the anode voltage is applied to the anodes of the two amplifier tubes by way of a common resistance at which the composed alternating voltage is tapped.

2. An electric connection as set forth in claim 1 in which a current measuring instrument is arranged in the anode circuit of said amplifier tube for the purpose of supervising symmetry.

CARLHEINZ BECKER.