Oct. 25, 1949. G. S. BURROUGHS 2,485,560

ELECTRONIC REVERSING SWITCH

Filed May 7, 1945 2 Sheets-Sheet 1

Fig. 1.

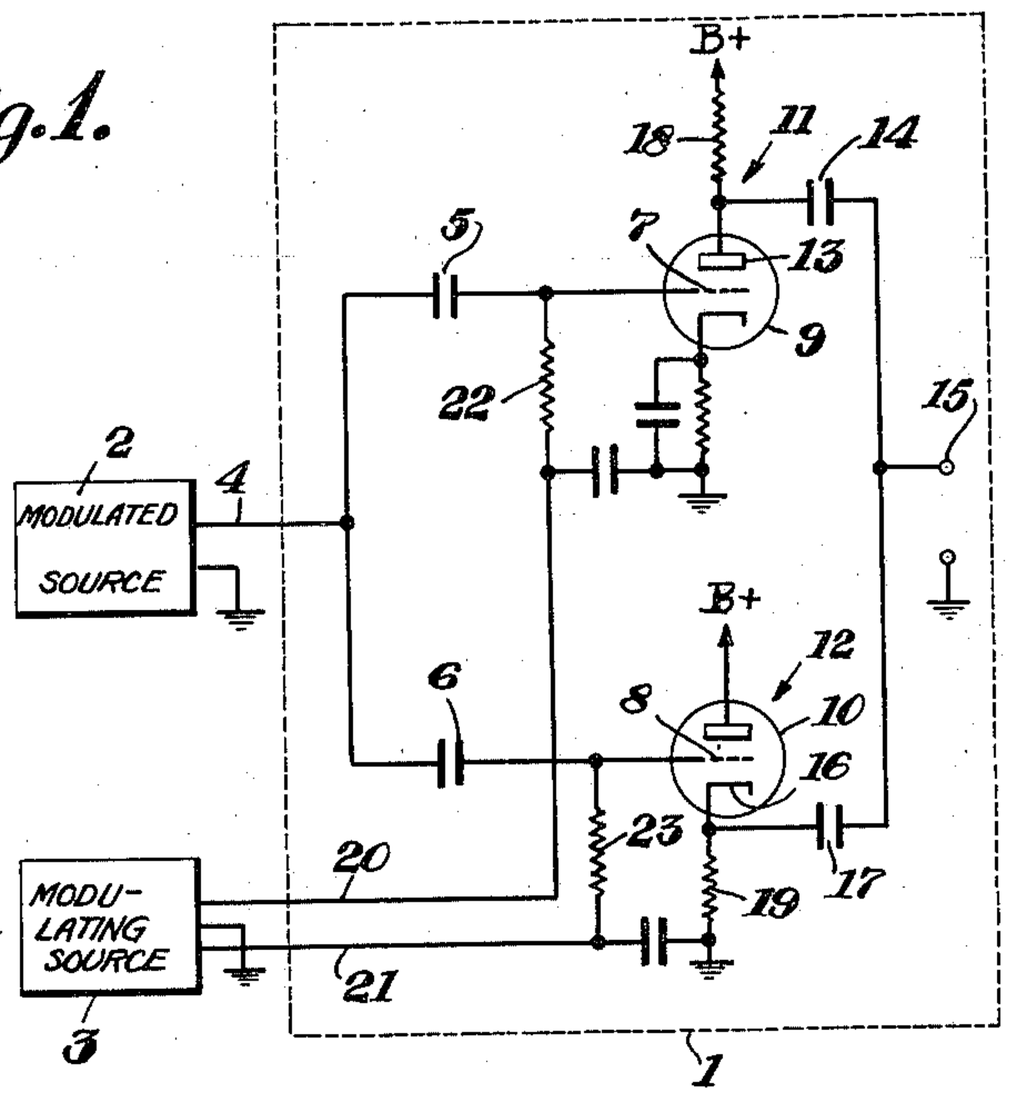

Fig. 2.

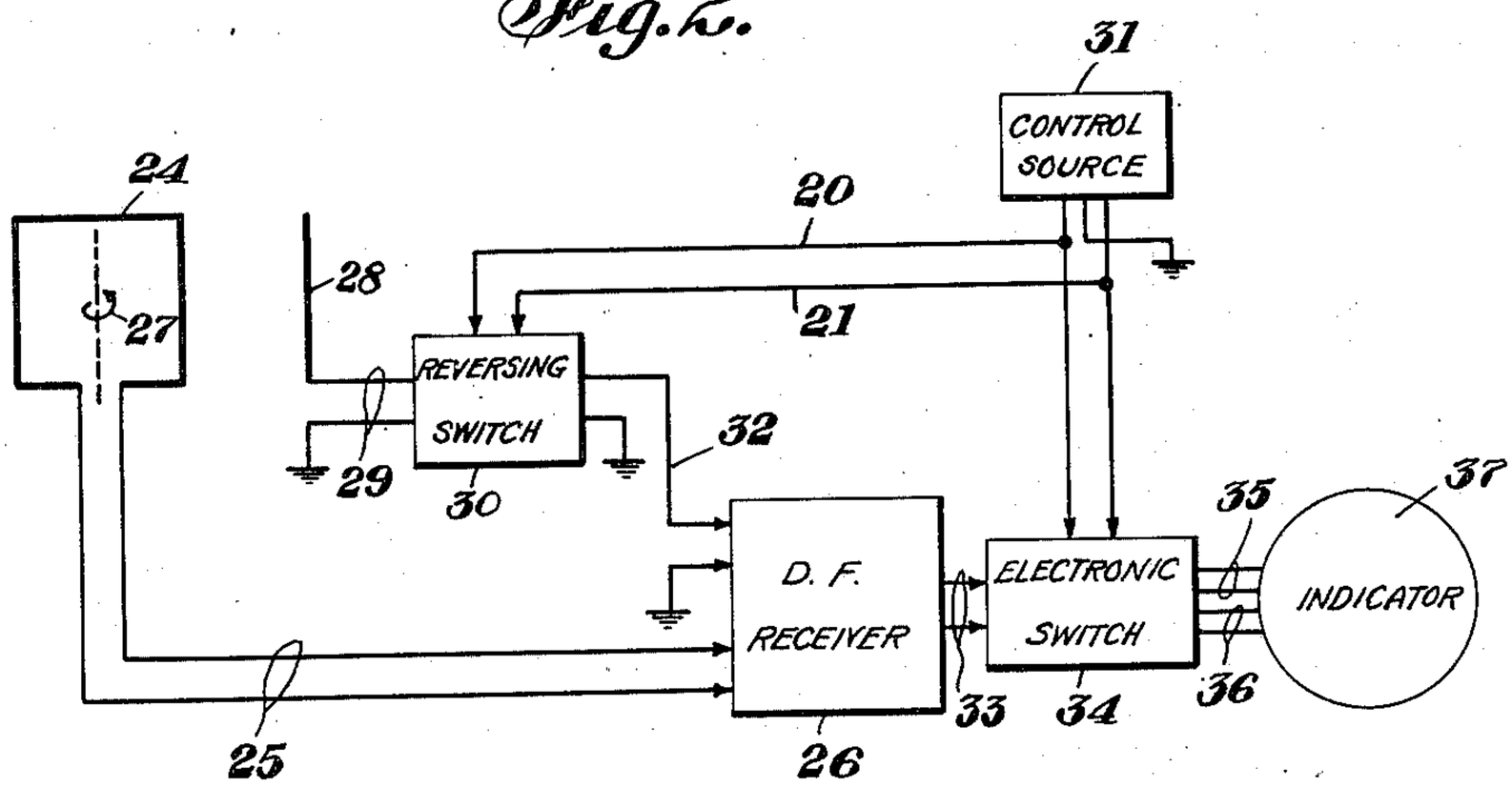

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Fig. 3.

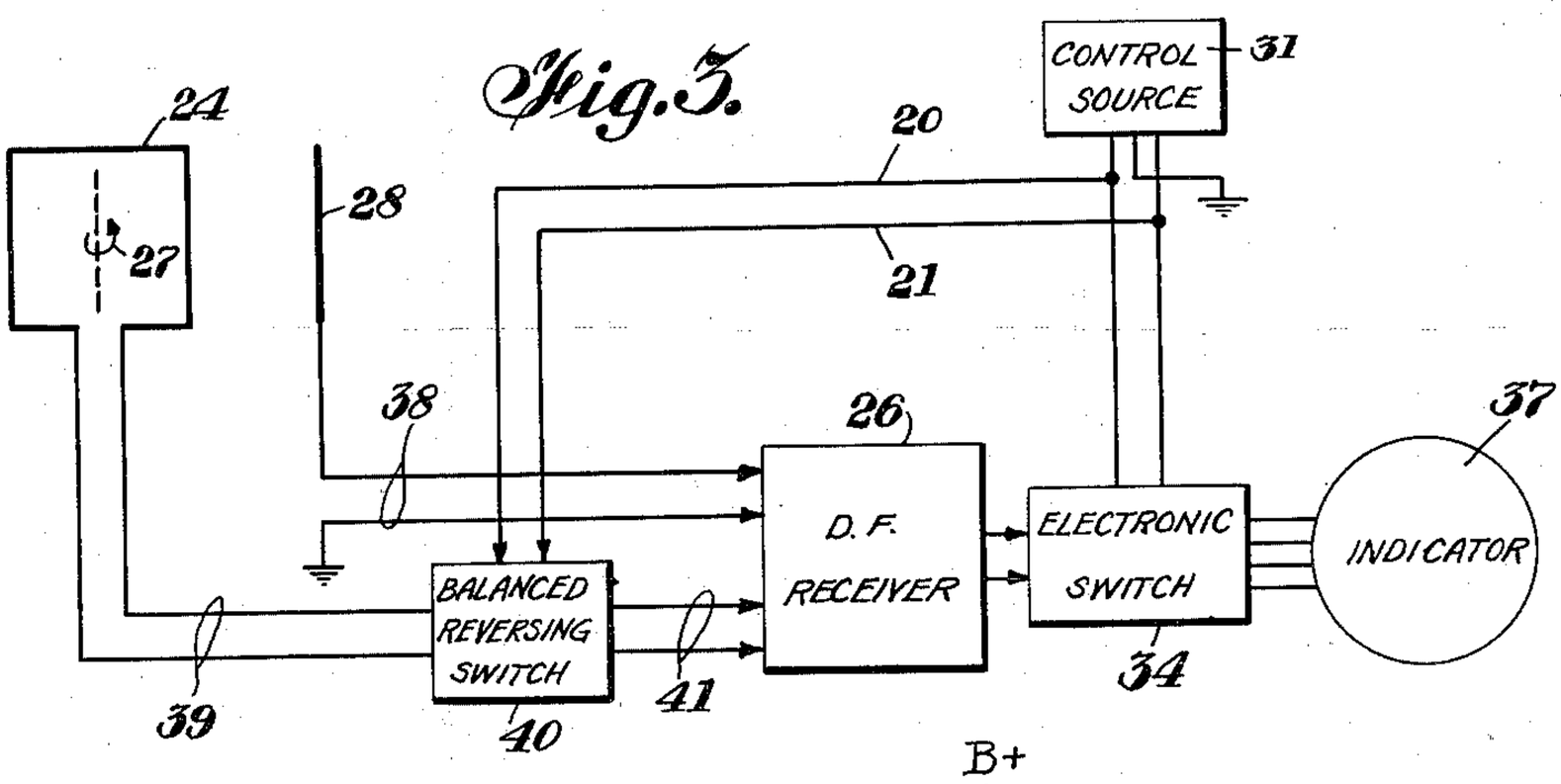
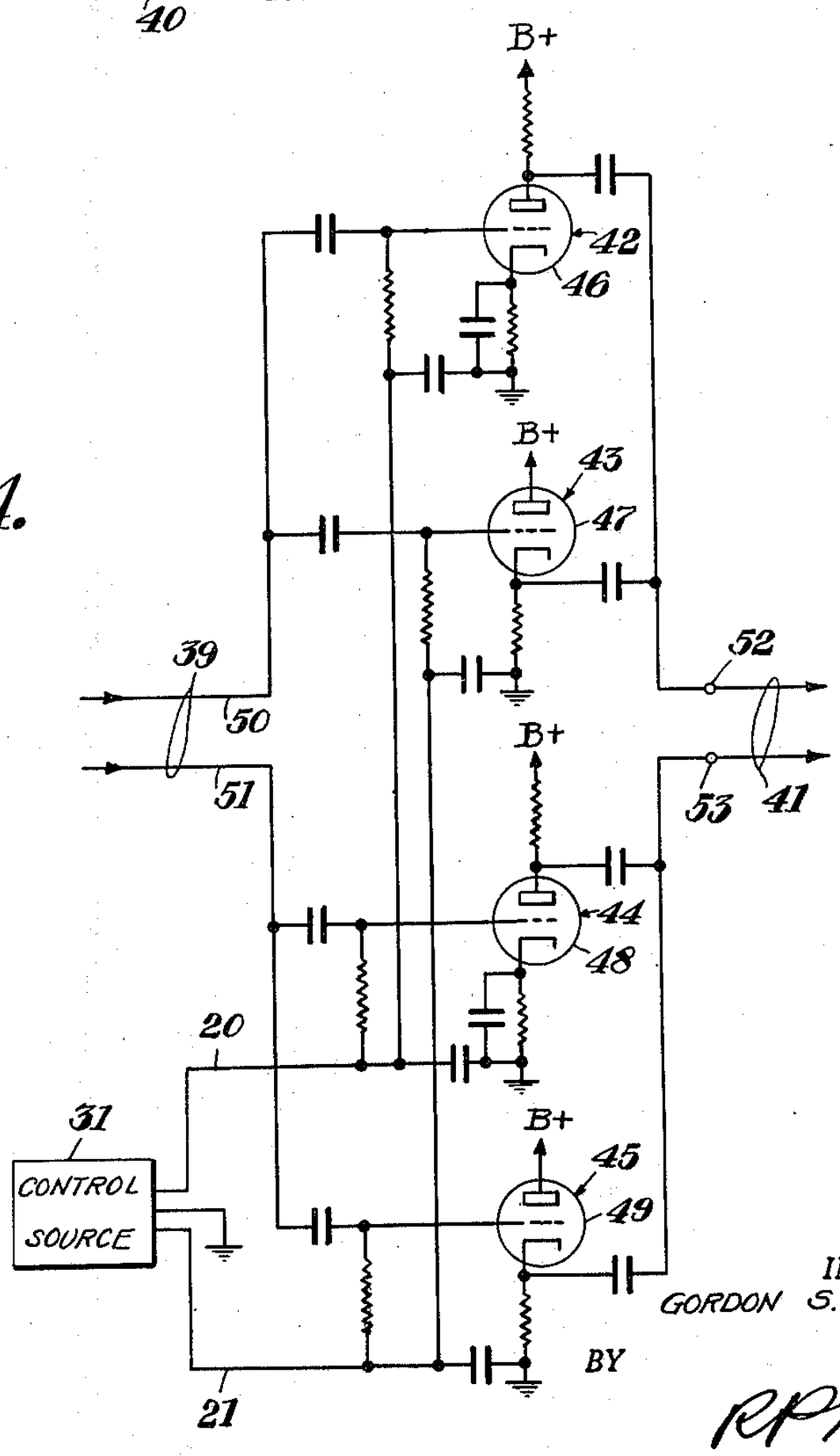


Fig. 4.



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ELECTRONIC REVERSING SWITCH

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9 Claims. (Cl. 343—121)

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The present invention relates to balanced modulators which may be employed as reversing switches, and particularly as switches adapted for continuous and rapid controlled operation as in direction finding systems.

An object of the present invention is the provision of an improved balanced modulator, particularly one adapted to operate as a reversing switch.

In certain systems it is required that the phase in which a source is coupled to a load be continuously reversed. One such system is the type of direction finder in which antennas are arranged to produce a figure-of-8 radiant action pattern and a sensing antenna is employed to change said pattern into a cardioid. The direction in which said cardioid points depends on the relative phase of the coupling between the sensing antenna and the other antennas: a reversal of said phase reverses the resulting cardioid pattern. In certain of such systems, the phase of the coupling of the sensing antenna or of the other antennas is automatically and continuously reversed, usually at an audio frequency rate, and a comparison is made between the amplitude of the separate energies received according to the opposite cardioid patterns thus alternately produced.

While mechanical reversing switches have been used for the foregoing purpose, they are limited as to speed and present the usual mechanical difficulties such as those introduced by wear, unevenness of contact, etc. Moreover these mechanical types of reversing switches are not readily synchronized with the operation of the rest of the system and not readily and reliably controlled by electrical pulses of low voltage which are used in controlling the rest of the system.

Another object of the present invention is the provision of an improved electronic reversing switch which is capable of being operated at high speed, and further which may be readily and reliably controlled by electrical pulses of relatively low voltage.

Another object of the present invention is the provision of an improved electronic reversing switch adapted to reverse the phase between an unbalanced source and a load.

Another object of the present invention is the provision of an improved electronic reversing switch adapted to reverse the phase in which a balanced source is coupled to a load.

In direction finding systems in which a sense reversing switch is employed in producing alternating directional patterns, the energy received according to each of the patterns is alternately

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fed into the direction finding receiver, where said energy is translated, that is, usually it is amplified, heterodyned and detected. In order to compare the relative level of the energy received in accordance with each pattern, at some place in the receiver or in its output the energy derived according to one of said patterns is separated from the energy derived according to the other of said patterns. For this purpose a switch, preferably electronic, is employed at some stage in the receiver or in its output to separate the energy derived from each pattern. If a mechanical phase reversing switch is employed with the antenna system while an electronic switch is used at the receiver output to separate the energy derived according to each pattern, it becomes difficult to synchronize the operation of said switch.

A further object of the present invention is the provision of a direction finding system in which an electronic reversing switch is used to switch between different directional patterns and which reversing switch is controlled by energy from the same source that controls the switching used to separate energy derived from each pattern in order to enable said separate energies to be compared.

Other and further objects of the present invention will become apparent and the invention will be best understood from the following description of an embodiment thereof, reference being had to the drawings, in which:

Fig. 1 is a schematic and block diagram of a balanced modulator embodying my invention;

Fig. 2 is a schematic and block diagram of a direction finding receiver embodying my invention in which the balanced modulator is employed as a reversing switch for reversing the phase of energy from a source unbalanced in relation to ground;

Fig. 3 is a schematic and block diagram of another direction finding system embodying my invention in which the balanced modulator serves as a reversing switch for a source balanced in relation to ground; and

Fig. 4 is a detailed view of the balanced reversing switch employed in the system of Fig. 3.

Referring now to Fig. 1, the numeral 1 generally designates an unbalanced modulator in which energy from a source 2 is modulated by energy from a modulating source 3. Source 2 may be a source of carrier frequency and source 3 may be a source of audio frequency. One side of source 2 is coupled to ground and the other side is connected by a line 4 to two condensers 5 and 6 which are respectively connected in turn to grids 7 and 8

of electron discharge devices or vacuum tubes 9 and 10. Electron discharge device 9 forms part of an anode loaded circuit generally designated by the numeral 11, while electron discharge device 10 is part of a cathode follower circuit generally designated by the numeral 12.

The anode 13 of electron discharge device 9 is connected through a blocking condenser 14 to one output terminal 15 while the cathode 16 of electron discharge device 10 is connected through another blocking condenser 17 to the same output terminal 15. Anode load resistor 18 and cathode load resistor 19 are provided in circuits 11 and 12 respectively.

The modulating source 3 supplies, over lines 20 and 21 respectively, voltages that are balanced with respect to ground but 180° out of phase with each other, and these voltages may vary sinusoidally. Lines 20 and 21 are connected through resistors 22 and 23 respectively to grids 7 and 8. The voltages applied through lines 20 and 21 to grids 7 and 8 respectively vary the conductivity of tubes 9 and 10 in opposite vectorial directions so that while the conductivity of one tube is increasing, the conductivity of the other of said tubes is decreasing and vice versa. Thus energy from the modulating source 3 modulates energy from the modulated source 2.

If in accordance with my invention, the modulating source supplies along lines 20 and 21 rectangular pulses which are 180° out of phase with each other, then the modulator 1 acts as a phase reversing switch, and reverses the phase of the energy introduced thereto from the modulated source 2. This mode of operation is employed as illustrated in Fig. 2 in a direction finding system.

Referring now to Fig. 2, a loop antenna 24 has the ends thereof coupled over transmission line 25 to a direction finding receiver 26. The loop may be a rotatable loop adapted to rotate around a vertical axis indicated by the broken line 27. A sensing antenna 28 is arranged immediately adjacent the loop 24 in a known manner and said sensing antenna 28 and ground are coupled by lines 29 to a reversing switch 30. The reversing switch 30 is similar to the modulator 1 of Fig. 1, the antenna 28 and ground serving in place of the modulated source 2, while a control source 31 in Fig. 2 serves in place of the modulating source 3 of Fig. 1. The control source 31 generates substantially rectangular wave pulses which pulses are applied to the tubes of the reversing switch alternately to alternately render said tubes conductive. The output of the reversing switch 30 is then coupled by a line 32 to the direction finding receiver 26. The reversing switch 30 serves to reverse the phase relation of the antenna 28 to the receiver and consequently serves to reverse the sense of the cardioid pattern produced by the cooperation of the loop 24 with the antenna 28. Any known arrangement for mixing the energy from the antenna 28 and the loop 24 is provided within the direction finding receiver 26. The direction finding receiver 26 delivers across its output line 33 pulses of energy, alternate ones of which are derived from the same sense of the cardioid pattern or more correctly from the same cardioid pattern. The electronic switch 34 serves to separate the energy derived according to each pattern so that said energy may be fed over separate channels 35 and 36 to an indicator 37, where the energies derived according to the separate patterns are compared in terms of their amplitudes. Electronic switch 34 is preferably controlled by substantially rectangular pulses from control source 31 which controls the operation of the reversing switch 30. Thus the operation of reversing switch 30 and of the electronic switch 34 is synchronized and readily controlled by the same control source 31.

Referring now to the direction finder in Fig. 3, this differs from that in Fig. 2 in that the phase of the loop is reversed instead of the phase of the sensing antenna. An advantage of this system is that when the loop is aligned so that the energy received according to each pattern is equal, the switching frequency will not be heard. In Fig. 3 the sensing antenna 28 is coupled over a line 38 directly to the direction finding receiver while the loop 24 is coupled over line 39 to a balanced reversing switch 40 whose output is in turn connected by a line 41 to the direction finding receiver. Since the loop is balanced as to ground, the arrangement indicated in relation to Fig. 2 and more specifically shown in Fig. 1, which is unbalanced as to ground, is preferably replaced by an arrangement which is balanced as to ground, as is its source, the loop 24. For this reason the balanced reversing switch 40 differs from the unbalanced reversing switch of Fig. 2, as will be seen from Fig. 4 in which the details of the balanced reversing switch are illustrated. The balanced reversing switch of Fig. 4 consists of four circuits generally designated by the numerals 42, 43, 44 and 45, said circuits including electron discharge devices or tubes 46, 47, 48 and 49 respectively. Circuits 42 and 44 are anode loaded circuits while circuits 43 and 45 are cathode follower circuits. Line 39 which connects the loop 24 to the input of the balanced reversing switch consists of two conductors 50 and 51, conductor 50 being coupled to the grids of tubes 46 and 47 and conductor 51 being coupled to the grids of tubes 48 and 49. The anode of tube 46 and the cathode of tube 47 are coupled to one output terminal 52 while the anode of tube 48 and the cathode of tube 49 are coupled to the other output terminal 53. Thus circuits 42 and 43 form one reversing switch while circuits 44 and 45 form another reversing switch. By applying controlling voltages to control the conductivity of the various circuits so that the anode loaded circuits conduct alternately with the cathode follower circuits, both switches operate synchronously to reverse the phase of the energy transmitted therethrough. Consequently the energy which is balanced at the input of said reversing switch is likewise balanced as to ground at the output terminals 52 and 53 thereof. Terminals 52 and 53 are connected over transmission line 41 to the direction finding receiver as is indicated in Fig. 3.

While I have described above the principles of my invention in connection with specific apparatus, and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of my invention as defined in the accompanying claims.

I claim:

1. A balanced modulator for modulating energy from a first source with energy from a second source comprising a cathode follower circuit and an anode loaded circuit, each of said circuits including an electron discharge device having an anode, cathode, and control element, means coupling said first source to the control elements of said devices in parallel, means coupling the output of the anode load circuit and the cathode follower circuits in parallel, and means coupling

said second source to said electron discharge devices in push-pull.

2. A balanced modulator for moduating energy from a first source with energy from a second source comprising a cathode follower circuit and an anode loaded cicruit, each of said circuits including an electron discharge device having an anode, cathode, and control element, means coupling one side of said first source to the control element of each of said devices, means coupling the anode of the anode loaded circuit and the cathode of the cathode follower circuit to the same side of the output of said modulator, and means coupling said second source to said electron discharge devices to vary their conductivity in opposite vectorial directions.

3. A reversing switch for reversing the phase in which a source is coupled to a load comprising a cathode follower circuit and an anode loaded circuit, each of said circuits including an electron discharge device having an anode, cathode and control element, means coupling one side of said source to the control element of each of said devices, means coupling the anode of the anode loaded circuit and the cathode of the cathode follower circuit to the same side of said load, and means for rendering said devices alternately conductive.

4. A reversing arrangement for reversing the phase in which a source balanced with respect to ground is coupled to a load comprising a pair of reversing switches each comprising a cathode follower circuit and an anode loaded circuit, each of said circuits including an electron discharge device having an anode, cathode and control element, means coupling one side of said source to the control elements of the devices of one of said reversing switches, means coupling the other side of said source to the control elements of the devices of the other of said reversing switches, means coupling the anode of the anode loaded circuit and the cathode of the cathode follower circuit of one of said switches to one side of said load, means coupling the anode of the anode loaded circuit and the cathode of the cathode follower circuit of the other of said switches to the other side of said load; and means for rendering the electron discharge devices of the anode loaded circuits alternately conductive with the electron discharge devices of the cathode follower circuits.

5. In a direction finding system, a directional antenna and a sensing antenna, means coupling said antennas to the direction finding receiver, a reversing switch for continuously reversing the phase in which one of said antennas is connected to the direction finding receiver to thereby produce two different radiant action patterns, said switch comprising a cathode follower circuit and an anode loaded circuit, each of said circuits including an electron discharge device having an anode, cathode, and control element, means coupling one side of one of said antennas to the control element of each of said devices, and means

coupling the anode of the anode loaded circuit and the cathode of the cathode follower circuit to the same terminal of the direction finding receiver, an electronic switch arranged in the output of said direction finding receiver and adapted to separate the energy derived according to each of said directional patterns and a control device for synchronously controlling said electronic switch and said reversing switch, said control device rendering the electronic discharge devices of the reversing switch alternately conductive.

6. A direction finding system according to claim 5 wherein said control device applies substantially rectangular pulses synchronously to said electronic switch and said reversing switch.

7. An electronic switching and phasing system for input signals from a given source comprising a source of switching signals, a pair of electron discharge devices each having an input and an output circuit, one of said output circuits comprising a plate load circuit and the other output circuit comprising a cathode load circuit, a given load circuit, means for alternately applying said input signals of a given phase and of a phase opposite to said given phase to said given load circuit comprising means for applying said input waves cophasally to each of said input circuits, means for applying said switching signals in push-pull to said input circuits, and means for coupling said given load circuit across said plate load circuit and said cathode load circuit.

8. An arrangement according to claim 7, wherein said device comprising a load circuit comprises a phase inverter stage and said device comprising a cathode load circuit comprises a cathode follower stage.

9. An electronic switching system comprising a source of control signals and a source of input signals, two groups of electron discharge devices, each group comprising a phase inverter stage and a cathode follower stage, means for applying said input signals in push-pull to corresponding stages of each group, means for applying said control signals in phase opposition to said groups of devices, means for combining the output of each of said devices in a group to obtain a group output, means for combining said group outputs to obtain balanced signals, alternately phase reversed or in phase with said applied input signals at the frequency of said applied control signals.

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