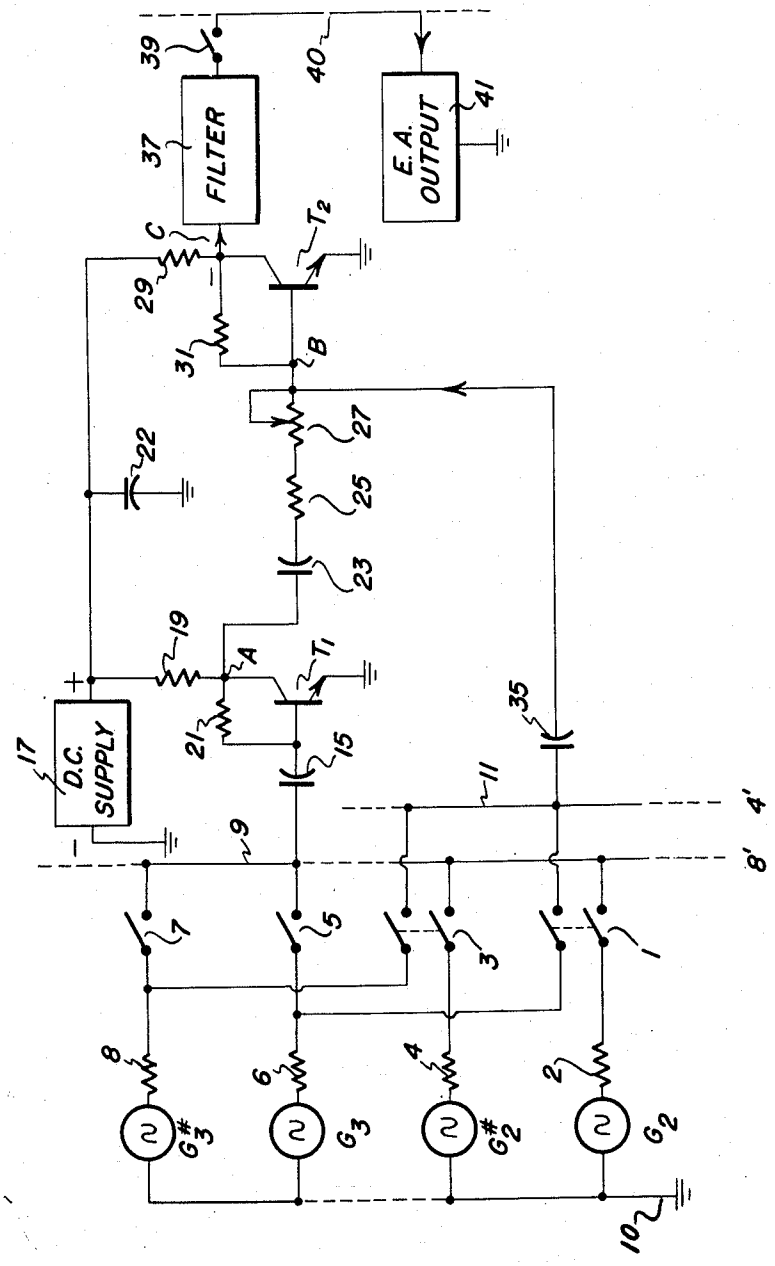
Dec. 13, 1960 A. B. BERESKIN 2,963,933

TRANSISTOR CIRCUIT

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INVENTOR

ALEXANDER B. BERESKIN

BY

AGENT

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TRANSISTOR CIRCUIT

Alexander B. Bereskin, Cincinnati, Ohio, assignor to The Baldwin Piano Company, Cincinnati, Ohio, a corporation of Ohio

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1 Claim. (Cl. 84—1.2)

My invention pertains to electronic musical instruments, particularly of the type wherein tone currents or oscillations corresponding to notes of a musical scale are derived from locked-octave source. Specifically, the invention concerns improvements in "outphasing" systems, wherein harmonically-related complex tone signals are combined in such fashion at to cancel, or at least reduce, the amplitudes of unwanted frequency components, so as to simulate, for example, certain of the woodwind family of musical instruments.

In United States Patent No. 2,148,478 to Kock is presented basic teachings relating to outphasing and in United States Patent No. 2,233,948 (Figure 9) is provided a teaching of its application to an electronic organ of the type wherein complex tone signals are filtered in various ways to achieve a variety of voices.

Kock's outphasing system employs vacuum tubes, which require comparatively large amounts of electrical power for their heater elements and high anode voltages, and are generally inefficient in performing the functions required by my invention. These power requirements necessitate heavy, bulky power supplies for converting alternating current at low and high voltage, i.e., for heaters and for anodes, respectively. And, although space is not usually at a premium in electronic organs of the Kock type, the trend toward more compact instruments for home use renders more necessary electronic circuitry requiring less physical space.

Accordingly, an important object of my invention is to provide an electronic musical instrument with improved outphasing circuits.

A further object of the present invention is to provide outphasing circuits of increased electrical efficiency and lower power requirements than have been hitherto available.

A further object of the invention is to provide an improved outphasing system of improved dependability and longer life.

An important feature of the invention is to provide an outphasing system which will operate from one voltage, supplied by a small, low-cost power supply.

A still further object is to provide an outphasing circuit requiring less space than previous systems of the same general type.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

The single figure of the drawings is a schematic circuit diagram of a system according to the invention.

Briefly, I provide an outphasing system which employs solid-state, semi-conductor devices commonly known as transistors, which are capable of amplifying electrical signals, and which are described in currently available texts such as Transistor Circuit Engineering, edited by R. F. Shea (Wiley, 1957). I employ two stages of grounded-emitter amplification, as will be described in detail hereinafter, one for reversing the phase of a basic tone signal and one for re-reversing the phase of the same signal as modified by the combination therewith of a harmonically-related signal, for the cancellation or reduction in amplitude of undesired harmonics in the former. These stages may preferably perform an amplifying function.

Referring now more particularly to the accompanying drawing, I employ four exemplary sources of a series of complex oscillations G2, G3, G#2 and G#3, which may be of any suitable type, such as, for example, those described in the above-mentioned Kock Patent No. 2,233,948. G2 and G3 refer to tones an octave apart, and of musical nomenclature G. In accordance with the teachings of the above-mentioned Kock Patent No. 2,148,478, however, harmonically-related generators, such as G2 and G3, must be locked into integral frequency relationship, such as 1:2, in the exemplary case provided, the fundamental of the oscillations from the higher source (G3) being in phase with the second harmonic of the lower (G2). One terminal of each source is preferably connected to a conventional common return (ground), as at **10**. The other terminal of each source G2, G#2, G3 and G#3 is connected via decoupling resistors **2**, **4**, **6** and **8**, respectively, to playing-key-operated switches **1**, **3**, **5** and **7**, respectively, in the manner disclosed in Kock 2,233,948. The switches **1** and **3** are of a suitable double-pole, single throw type.

For the sake of simplicity of illustration, only four tone sources and four key switches are illustrated, it being understood by those familiar with this art that in a conventional type electronic organ there would be one source and at least one key switch for each note in the scale. See, for example, the Kock patents, above referred to. Switches **5** and **7** and the lower deck of switches **1** and **3**, which may be of the variable-resistance type illustrated in Kock and Jordan Patent 2,215,124, are in turn connected, as shown, to a bus **9**, designated as an 8′ bus, in accordance with common practice in electronic organ art. (For a manual keyboard, 8′ pitch is normal for a given key, while 4′ is an octave above.) The upper decks of switches **1** and **3** may connect sources G3 and G#3 to a 4′ bus **11**.

Thus, in a manner well-known in the art, tone signals may be made selectively available on buses **9** and **11** for filtering, as desired, by suitable tone color circuits (not shown). The buses may have associated therewith impedance (not shown) for obtaining balance between ranges, as taught in Kock Patent No. 2,233,948.

In accordance with the teachings of the present invention, connection may be made from the 8′ bus **9** to the base of a transistor **T1** via a coupling capacitor **15**. The transistor **T1**, in the embodiment illustrated, is the NPN type; but, with suitable circuit modification, a PNP type may well be employed. The emitter of transistor **T1** is connected to a common return path, such as ground.

A D.C. supply **17**, of conventional type, per se, may be connected at its positive terminal to the collector of transistor **T1** through a suitable load resistor **19**, a bias resistor **21**, being shown connected between the collector and base of transistor **T1**. If a PNP transistor is employed, the polarity of supply **17** will, of course, be reversed. A suitable filter capacitor **22** is shown, connected from the positive terminal of the D.C. supply **17** to the common return path, to which is also connected the negative side of the D.C. supply **17**.

From the collector of transistor **T1** coupling is made to the base of a second NPN transistor **T2**, via a coupling capacitor **23**, coupling resistor **25** and variable resistor **27**, all in series. The collector of transistor **T2** is connected to the positive terminal of the supply **17** via a suitable load resistor **29**, a bias resistor **31** being connected between the collector and base of transistor **T2**.

The emitter of transistor T2 is grounded, as is the emitter of transistor T1.

To the base of transistor T2 is brought the signal content of 4' bus 11 via a coupling capacitor 35. The output of the transistor T1 stage may be passed via a suitable tone forming filter 37 of the Kock type (United States Patent No. 2,233,948), stop-tab-operated switch 39 and a collection bus 40 to a common electro-acoustic output system 41 of conventional type, the latter having connection in the usual way to a common return path.

Table of exemplary components

Resistors:		
2, 4, 6, 8	ohms	5,000
19	do	10,000
21	do	270,000
25	do	4,700
27	(ohms max.)	50,000
29	ohms	10,000
31	do	270,000
Transistors:		
T1		2N94
T2		2N94
Capacitors:		
15	μf	5
22	μf	50
23	μf	5
35	μf	5

Upon actuation of a playing key (not shown), a double-pole key switch 1 simultaneously feeds octavely-related tone signals from sources G2 and G3 to buses 9 and 11, respectively. The signal on 8' bus 9 is phase inverted and amplified by the transistor T1 and appears at the point A with an overall voltage amplification of about 200 (for the exemplary circuit values given) with respect to the bus 9. The signal at point A produces input current to the base of transistor T2. Additional input current to this base is obtained directly from 4' bus 11 through capacitor 35. The level of the signal input (from the transistor T1) to transistor T2 may be controlled by the variable resistor 27. Since the phase of the 8' signals has been reversed by transistor T1, the combination therewith of unreversed 4' signals at point B results in cancellation effects between those components of the two signals which have the same frequencies.

In the example set forth the variable resistor 27 may be employed to vary the level of the 8' signal until, if desired, even-order harmonics are reduced in amplitude, or even cancelled entirely, if the wave-forms are of such character that the opposing even-order harmonic components are all of the same amplitude and phase when combined at point B.

After the "outphasing" phenomenon has been accomplished, the resultant signal is amplified and phase-reversed by transistor T2 for filtering, if desired, by filter 37 and subsequent combination with other voices in bus 40 and translation to sound in the output system 41, if desired. The phase of the combined signal at point B is phase-reversed by T2 in order that it will have the proper phase relationship to other tone signals which may be present in bus 40.

For the exemplary components set forth above, an overall voltage amplification of approximately 600 is obtained between the 8' bus 9 and point C and of approximately 200 between the 4' bus 11 and point C.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claim.

What I claim is:

An outphaser for an electronic musical instrument, comprising an 8' bus, a 4' bus, a ground circuit and a direct current supply, the combination of a first transistor having a first base, a first emitter and a first collector, a first load resistance connected between said direct current supply and said first collector, a second bias resistance connected between said first collector and said first base, said first emitter being directly connected to said ground circuit, a second transistor having a second base, a second emitter and a second collector, said second emitter being connected directly to said ground circuit, a second load resistance connected between said direct current supply and said second collector, a second bias resistance connected between said second collector and said second base, a low reactance coupling and direct current isolating capacitor connected directly between said 8' bus and said first base, a series circuit connected between said first collector and said second base, said series circuit consisting of a coupling and direct current isolating capacitor, a fixed resistance and a variable resistance, all connected in series, a circuit consisting of a coupling capacitor connected directly between said 4' bus and said second base, and a key controlled formant filter connected to said second collector, said capacitors having all approximately the same capacitance.

References Cited in the file of this patent

UNITED STATES PATENTS

1,906,607	Jacobs	May 2, 1933
1,940,093	Lindridge	Dec. 19, 1933
2,148,478	Kock	Feb. 28, 1939
2,233,948	Kock	Mar. 4, 1941
2,750,456	Waldhauer	June 12, 1956