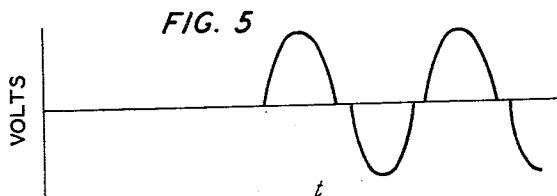
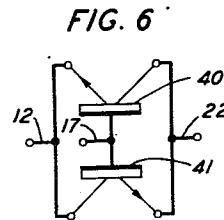
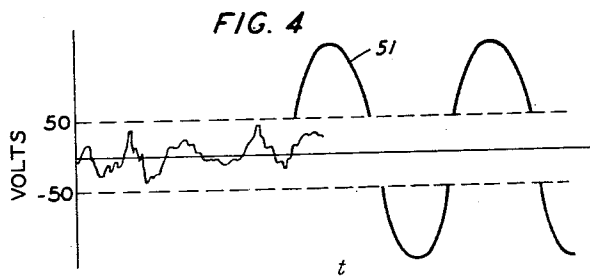
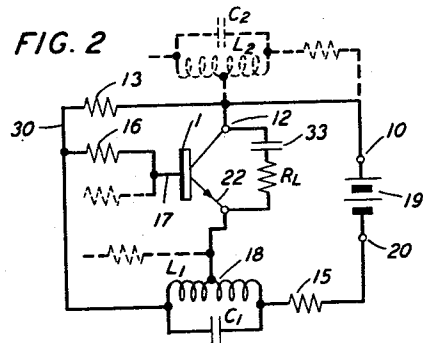
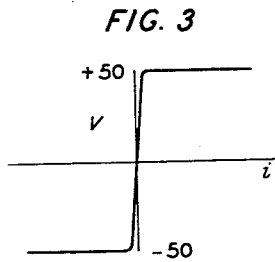
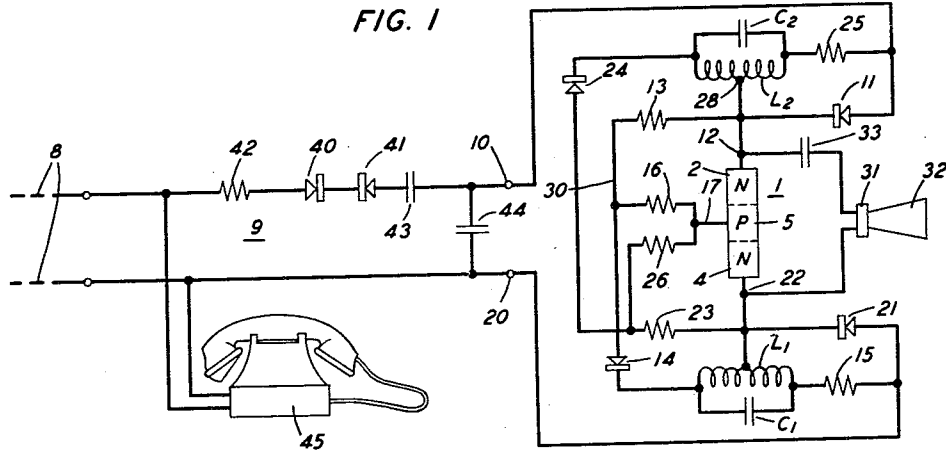


Sept. 4, 1956

R. L. WALLACE, JR
MULTIFREQUENCY OSCILLATOR

2,761,909

Filed Jan. 28, 1953



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2,761,909

MULTIFREQUENCY OSCILLATOR

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Application January 28, 1953, Serial No. 333,763

11 Claims. (Cl. 179—84)

This invention relates to multifrequency oscillators. Its principal object is to generate two different tones in alternation, the selection of the tone being determined by the polarity of a control signal and the rapidity of alternation being determined by the frequency of the control signal. A specific object is to generate the familiar audible ringing signal of the ordinary telephone subscriber's set without resort to moving mechanical parts.

After extensive tests of the many different possible signals any of which might be employed as a telephone ringing signal, the one which is now standard has been adopted as constituting an optimum compromise between many different requirements. It is sufficiently loud to call the subscriber's attention, but not so loud as to annoy him. It does not disturb by being harsh or grating on the ear, nor does it have the flat and uninteresting quality of a pure tone. It has character by virtue of employing more than one frequency, but not the beauty of a musical chord. It alternates rapidly between two different frequencies which are preferably enharmonically related. It is thus entirely distinctive and is seldom, if ever, confused with any other signal.

This standard telephone ringing signal is normally produced by a pair of bells which are struck in alternation by a clapper which rides between them and is magnetically actuated by the standard 90 volt—20 cycle ringing current. While in general this ringing apparatus is satisfactory, it is open to the objection that it requires high precision in the mass of the clapper, the compliance of its support, the spacing of the bells and all other such factors which contribute to its operation. It is also subject to damage from mechanical wear and from dust.

Attempts to substitute vacuum tube oscillators for the conventional mechanical telephone ringer have failed to achieve commercial importance, partly because the vacuum tube requires filament or heater current and anode voltage which it is difficult or inconvenient to furnish and partly because, with the vacuum tube which is a one-way device, it is difficult to simulate the balanced operation of the mechanical bell-and-clapper arrangement.

The situation is altered by the advent of the transistor. With the exercise of care at certain points in the process of transistor fabrication, the transistor readily becomes, if it is not intrinsically, a symmetrical structure and therefore, in operation, a bidirectional or two-way device, operating equally well as an amplifier from left to right or from right to left, in dependence only on the biases applied to its electrodes. W. G. Pfann has described such a reversible transistor of the point contact variety in a letter to the Editor, published in the Proceedings of the Institute of Radio Engineers for October, 1950, vol. 38, page 1222. The internal structural symmetry of the double junction transistor described in Shockley Patent 2,569,347 renders it inherently reversible. Such a symmetrical junction transistor may be fabricated in various ways and by various processes, among which may be mentioned those published in the

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Proceedings of the Institute of Radio Engineers for November 1952, vol. 40, pages 1352 and 1358.

In accordance with the present invention the ready reversibility of the transistor is turned to account in the construction of a symmetrical two-frequency oscillator embodying one such transistor, two independent frequency-selective "tank" circuits, and rectifiers connected to enable and disable the tank circuits in succession while simultaneously enabling the transistor for operation alternately in opposite directions under the action of an alternating control signal. The invention is well suited to employment as the ringer in a telephone subscriber's set, in which cases biases of the proper magnitude for the transistor are readily available in the standard ringing current whose alternations control the direction of transmission through the transistor and the selection of one or other of the two tank circuits.

The invention will be fully apprehended from the following detailed description of a preferred illustrative embodiment thereof taken in connection with the appended drawings, in which:

Fig. 1 is a schematic circuit diagram showing telephone ringer apparatus embodying the multifrequency oscillator of the invention;

Fig. 2 is a simplified circuit diagram explanatory of Fig. 1;

Fig. 3 presents the voltage-current characteristic of a pair of saturation rectifiers;

Figs. 4 and 5 are wave form diagrams illustrating the action of a voice current-ringing current discriminator; and

Fig. 6 shows the connection of two asymmetric transistors to simulate the action of a symmetric reversible transistor.

Referring now to the drawings, Fig. 1 shows a transistor 1 which for the sake of illustration is indicated as of the double junction variety fully described in Shockley Patent 2,569,347. It comprises a semiconductor body, e. g., germanium, having oppositely located zones 2, 4 of like conductivity type, e. g., N-type, separated by an intermediate zone 5 of the opposite conductivity type, e. g., P-type. The actual conductivities of the end zones 2, 4 as well as other properties, are preferably alike also. The unit is thus symmetrical in its internal structure, and is therefore capable of operation in either direction. A point contact transistor to the point contacts of which like "forming" processes have been applied, as described by W. G. Pfann, can also serve.

Because of the fact that in the operation to be described the roles of the transistor electrode connections will be interchanged, it is misleading to designate any particular electrode as "emitter" or as "collector." It is convenient to designate them by nonfunctional terms, and accordingly, the connection to the lower N-type zone 4 is designated the "a-terminal," the connection to the upper N-type zone 2 is designated the "c-terminal" and the connection to the intermediate P-type zone 5 is designated the "b-terminal." Thus, in operation, when the biases are such that the a-terminal serves as emitter and the c-terminal as collector, signal translation may be said to take place in the a-c direction while, to the contrary, when the biases are reversed so that the c-terminal serves as emitter and the a-terminal as collector, signal translation takes place in the c-a direction.

This transistor constitutes the active element of each of two different oscillator circuits, being common to both of them. The first of these oscillator circuits utilizes the upper N-type zone 2 (the c-terminal) of the transistor as a collector and the lower one 4 (the a-terminal) as an emitter. It may be traced from the upper terminal 10 of the apparatus, to which one side of a telephone line 8 is connected by way of a filter 9 to be described through a rectifier 11 to the upper N-type zone connection 12

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and through a resistor 13, a rectifier 14, a tank circuit L_1-C_1 and a resistor 15 to the lower terminal 20 of the incoming line. The left-hand terminal of the tank circuit L_1-C_1 is connected by way of the rectifier 14 and a resistor 16 to the base electrode 17, i. e., to the P-type zone 5 of the transistor, while the lower N-type zone 4 is connected by way of its electrode connection 22 to an intermediate point 18 of the tank circuit, e. g., to a tap on the coil L_1 .

This circuit and its operation are best understood by referring to Fig. 2 which shows it in solid lines, the transistor 1 being indicated by its conventional symbol in which the angularly disposed conductor bearing the arrowhead represents the emitter, the other angularly disposed conductor represents the collector, and the conductor which makes contact with the other side of the semiconductor body represents the base electrode. The connections to these electrodes are designated by the reference characters 22, 12, and 17, respectively, as in Fig. 1. Under the condition that the incoming signal is instantaneously of such a polarity that the upper line terminal 10 of Fig. 1 is positive and the lower one 20 is negative, these line terminals may be replaced by the battery 19 of Fig. 2; and the rectifiers 11, 14, of Fig. 1, biased as they are by this line voltage into their low resistance conditions, are of virtually negligible impedance and can be disregarded and are therefore omitted from Fig. 2.

It will be observed that the positive terminal of the battery 19 is connected directly to the collector connection 12 and its negative terminal is connected by way of the resistor 15 to the emitter connection 22. The base connection 17 is connected by way of the resistor 16 to the conductor 30 which, but for the interposition of the coil L_1 , is the tap of a voltage-divided potentiometer comprising the resistors 13, 15.

The various resistors 13, 15, 16 may all have like magnitudes, e. g., 10,000 ohms. With such resistance values then, when the transistor 1 is removed from its socket, the conductor 30 adopts a potential midway between that of the positive terminal of the battery and that of its negative terminal. But when the transistor is connected in the circuit as shown, its relatively low emitter-to-base resistance drives the potential of the conductor 30, and therefore of the base connection 17, much lower, i. e., to a volt or less above that of the negative terminal 20 of the line or of the battery 19. This is the correct bias, both in magnitude and in sign, for amplifier operation of a P-type transistor. (Each transistor "type" is named for the conductivity type of its base electrode zone.)

For signal frequency purposes, the right-hand end of the tank circuit L_1-C_1 is connected by way of the resistor 15 and the battery 19, incoming line, or other source, to the collector connection 12, its left-hand end is connected by way of the resistor 16 to the base connection 17, and the tap of the coil L_1 is connected directly to the emitter connection 22. The circuit is thus of the well known Hartley oscillator variety. With an applied voltage of 10 volts or so, it oscillates steadily and stably at a frequency determined by the tuning of the tank circuit L_1-C_1 , e. g., 800 cycles per second, and at a power level sufficient to actuate an electromagnetic transducer 31 which generates air waves and may deliver them to a horn 32. The transducer and the horn are represented in Fig. 2 by a load R_L . A blocking condenser 33 is included to prevent the application of line voltage to the transducer.

In Fig. 2, those portions of the symmetrical circuit, which take no part in the operation under this condition, are shown by broken lines or are omitted entirely.

Under the opposite condition, namely that the upper incoming line terminal 10 be negative and the lower one 20 positive, the upper tank circuit L_2-C_2 comes into operation. Positive bias voltage is now applied by way of a rectifier 21 to the lower N-type zone 4 (the a-terminal) as the collector, while negative bias voltage is applied to

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the upper N-type zone 2 (the c-terminal) as the emitter and a bias voltage of intermediate magnitude derived from a point of the potentiometer comprising the resistors 23 and 25 is applied by way of a resistor 26 to the base electrode connection 17. The left-hand end of the upper tank circuit L_2-C_2 , shown in broken lines in Fig. 2, is now connected by way of a rectifier 24, omitted in Fig. 2, and a resistor 26 to the base connection 17, while its right-hand end is connected by way of a resistor 25 and the source 19, or 10, 20, to the lower N-type zone 4, i. e., the collector connection. The upper N-type zone 2 is connected to an intermediate point 28 of the upper tank circuit L_2-C_2 , e. g., to a tap on the coil L_2 . The load circuit 31, 32, 33 is unchanged. The circuit now oscillates with substantially the same amplitude as before, but at a frequency determined by the tuning of the tank L_2-C_2 .

When a signal is applied over the incoming line of suitable magnitude and of alternating polarity, e. g., the standard telephone ringing signal of 90 volts, 20 cycles per second, the upper and lower tank circuits are excited in alternation at the same frequency, and the output consists of a sequence of short bursts of sound, first at the frequency to which the lower tank is tuned and then at the frequency to which the upper tank is tuned.

Two oppositely poled saturation diode rectifiers 40, 41 are included in series with the ringer oscillator to prevent energization of the transistor 1 by signals not intended for it, e. g., by voice signals, dial pulses, and the like, which are in general of much less strength than 90 volts. The use of saturating rectifiers or so-called Zener diodes in this fashion is disclosed in an application of W. Shockley, Serial No. 211,212, filed February 16, 1951. Suitable saturation devices and their characteristics are discussed in an article by G. L. Pearson and B. Sawyer published in the Proceedings of The Institute of Radio Engineers for November 1952, vol. 40, page 1348. The composite characteristic of the oppositely poled pair is shown in Fig. 3. Fig. 4 is illustrative of its action as an amplitude discriminator. Here the broken lines located at amplitudes of +50 volts and -50 volts, respectively, correspond to the upper and lower breaks in the characteristic of Fig. 3. A voice frequency wave 50 whose amplitude is normally much less than 50 volts, positive or negative, lies well within both thresholds. Consequently, it does not reach the ringer oscillator circuit. The ringing voltage 51, on the other hand, whose amplitude is normally of the order of 90 volts, exceeds the positive threshold for about one quarter cycle and the negative threshold for another quarter cycle, thus furnishing a voltage to the ringer oscillator which has the wave form indicated in Fig. 5. It operates to energize the oscillators in turn, with a slight pause between.

A filter 9 comprising a resistor 42 and a condenser 43 connected in series and another condenser 44 connected in shunt may be interposed to prevent the feeding of the oscillations generated by the apparatus back into the telephone line 8. Voice currents are applied from the line to a telephone instrument 45 or from the instrument to the line in conventional fashion.

Fig. 1 is not to be interpreted as showing the preferred relative location of the apparatus of the invention and the telephone instrument 45, but only their electrical connections. As a practical matter the entire oscillator apparatus, the discriminator 40, 41, the filter 9, the transducer 31 and the reproducer 32 may well be enclosed in the base of the instrument 45.

The operation of a symmetrical reversible transistor may be simulated by employing two conventional asymmetric irreversible transistors 40, 41 connected back-to-back in the fashion shown in Fig. 6, i. e., emitter to collector, collector to emitter, and base to base. With application of an energizing voltage of one polarity between the terminals 12 and 22 of this pair, one of these transistors

is enabled and the other disabled. With reversal of the polarity of the energizing voltage, the transistors interchange their roles.

The above-described arrangements are illustrative of the application of the principles of the invention. Other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A two-frequency oscillator which comprises a symmetrical transistor having a semiconductive body, a first rectifier electrode, a second rectifier electrode, and base electrode, a first feedback path interconnecting said first electrode with said base electrode and including a first frequency determining circuit, said second electrode being coupled to a point of said first path, a second feedback path interconnecting said second electrode with said base electrode and including a second frequency determining circuit, said first electrode being coupled to a point of said second path, signal-controlled means for biasing said first electrode alternately in the forward and reverse directions and for simultaneously biasing said second electrode alternately in the reverse and forward directions thereby to render said transistor alternately operative in opposite directions, and means for simultaneously disabling said feedback paths in alternation.

2. A two frequency oscillator which comprises an amplifier having a first terminal, a second terminal and a third terminal and being capable of signal amplification in a first direction from said first terminal to said third terminal or in a reverse direction from said third terminal to said first terminal in dependence on the polarity of a biasing potential applied between said first and third terminals, a first frequency-determining circuit connected between the second terminal and the third terminal, the first terminal being coupled to an intermediate point of said first frequency determining circuit, a second frequency-determining circuit being connected between said second terminal and said first terminal, said third terminal being coupled to an intermediate point of said second circuit, means for biasing said amplifier for amplification in the direction from the first to the third terminals and for thereby disabling said second circuit, and means for biasing said amplifier for amplification in the reverse direction from the third to the first terminals and for thereby disabling said first circuit.

3. In combination with apparatus as defined in claim 2, signal-controlled means for activating said two named biasing means in alternation.

4. A two-frequency oscillator which comprises an amplifier having a first terminal, a second terminal, and a third terminal and being capable of signal amplification in a first direction from said first terminal to said third terminal or in a reverse direction from said third terminal to said first terminal in dependence on the polarity of a biasing potential applied between said first terminal and said third terminal, a first frequency-determining circuit connected between the second terminal and the third terminal, means for maintaining the first terminal at a potential substantially equal to that of a point of said second circuit, a second frequency-determining circuit connected between the second terminal and the first terminal, means for maintaining the third terminal at a potential substantially equal to that of a point of said second circuit, means for biasing said amplifier for amplification in the direction from the first to the third terminal and for thereby disabling said second circuit, and means for biasing said amplifier for amplification in the reverse direction from the third to the first terminal and thereby disabling said first circuit.

5. In combination with apparatus as defined in claim 4,

signal-controlled means for activating said two named biasing means in alternation.

6. A two-frequency oscillator which comprises an amplifier having a first terminal, a second terminal, and a third terminal and being capable of signal amplification in a first direction from said first terminal to said third terminal or in a reverse direction from said third terminal to said first terminal in dependence on the polarity of a biasing potential applied between said first terminal and said third terminal, a first frequency-determining circuit connected between the second terminal and the third terminal, a second frequency-determining circuit connected between the second terminal and the first terminal, means for biasing said amplifier for amplification in the direction from the first to the third terminal and for thereby disabling said second circuit, and means for biasing said amplifier for amplification in the reverse direction from the third to the first terminals and for thereby disabling said first circuit.

7. In combination with apparatus as defined in claim 6, signal-controlled means for activating said two named biasing means in alternation.

8. A two-frequency oscillator which comprises an amplifier having at least a first terminal and a second terminal and being capable of signal amplification in a first direction from said first terminal to said second terminal or in a reverse direction from said second terminal to said first terminal in dependence on the polarity of a biasing potential applied between said first terminal and said second terminal, a first frequency-determining circuit connected in circuit with the second terminal, a second frequency-determining circuit connected in circuit with the first terminal, means for biasing said amplifier for amplification in the direction from the first to the second terminal and for thereby disabling said second circuit, and means for biasing said amplifier for amplification in the reverse direction from the second to the first terminal and for thereby disabling said first circuit.

9. In combination with apparatus as defined in claim 8, signal-controlled means for activating said two named biasing means in alternation.

10. In combination with a telephone line having terminals, a telephone instrument connected to said line terminals, a two-frequency oscillator comprising an amplifier having at least two terminals and being selectively operable in either of two opposite senses in dependence on the polarities of biases applied to said amplifier terminals, a first frequency-determining circuit connected between two of said amplifier terminals, a second frequency-determining circuit connected between two of said amplifier terminals, means for biasing said amplifier for operation in one of said senses and for disabling said second circuit, means for biasing said amplifier for operation in the other of said senses and for disabling said first circuit, a filter interconnecting said line terminals with said amplifier terminals, said filter comprising means for excluding incoming voice currents from said oscillator, and means for excluding oscillations generated by said oscillator from said telephone line.

11. Apparatus as defined in claim 10 wherein said voice current excluding means comprises a pair of oppositely poled saturable rectifiers.

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