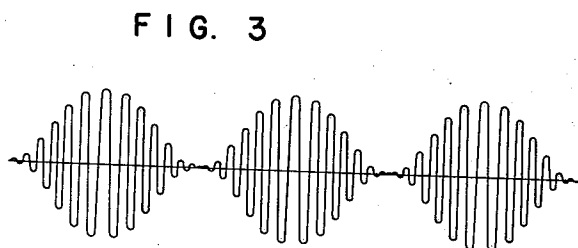
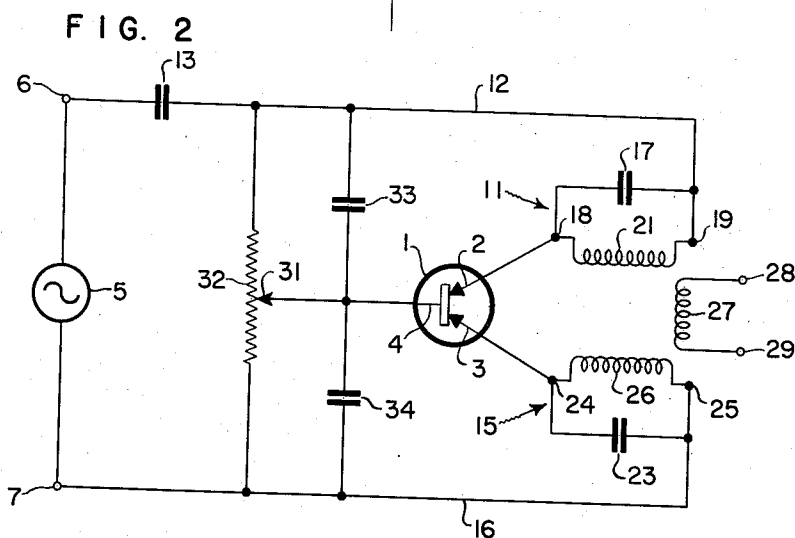
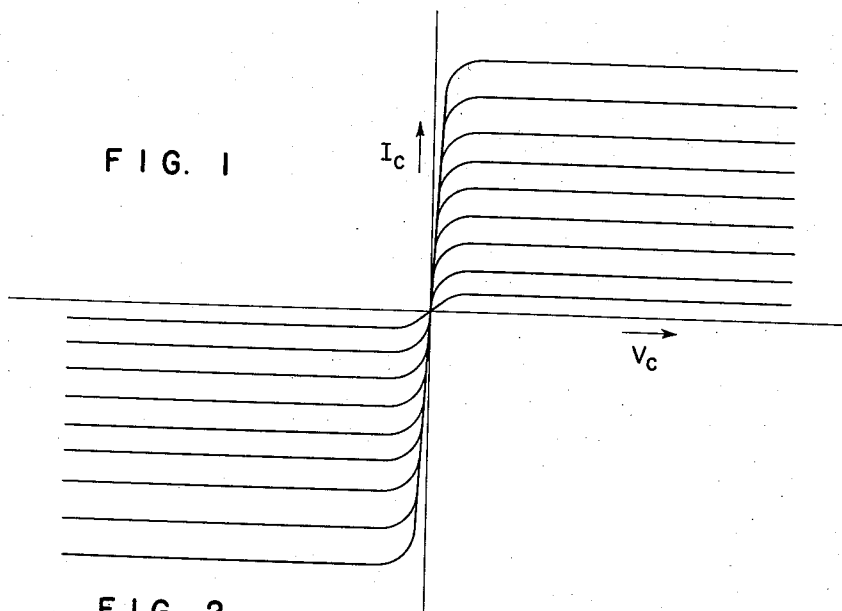


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ELECTRICAL APPARATUS
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ELECTRICAL APPARATUS

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A general object of the present invention is to provide a new and improved oscillator. More specifically, the present invention is concerned with an oscillator employing a transistor as its amplifying element.

Transistors have certain symmetrical characteristics for which there are no equivalents in vacuum tubes and in vacuum tube circuits. One of these characteristics, which is displayed by certain transistors, permits interchange of the emitter and the collector. Thus, a current can flow in either direction controlled alike by the base current. There is no comparable action in vacuum tubes or in vacuum tube circuits because this would require an anode emitting electrons and a thermionic cathode accepting them.

It is a specific object of the present invention to utilize the symmetrical conduction properties displayed by certain transistors to provide a new and improved oscillator.

Another object of the present invention is to provide a new and improved transistor oscillator utilizing a single alternating current bias source.

A further object of the present invention is to provide an oscillator, energized from a single alternating source, which will oscillate during both half cycles of the applied bias.

The various features of novelty which characterize this invention are pointed out with particularity in the claims annexed to and forming part of this specification. For a better understanding of the invention, its advantages, and the specific objects attained with its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of this invention.

Of the drawings:

Fig. 1 shows collector current characteristics of a symmetrical transistor;

Fig. 2 is a circuit diagram of a preferred embodiment of the present invention which utilizes a transistor having the characteristics shown in Fig. 1; and

Fig. 3 shows the wave form of the output of the embodiment of the present invention shown in Fig. 2.

Referring now to Fig. 1, there is shown a typical family of collector current curves for a symmetrical transistor. The abscissa represents the collector voltage and the ordinate the collector current. As shown, the curves depart further from the origin as the base currents are increased. It should be noted that these curves display a symmetry with respect to both the abscissa and the ordinate. Symmetrical transistors and their characteristics are further described in an article entitled "Symmetrical Properties of Transistors and Their Applications," by G. C. Sziklai, published in the Proceedings of the I.R.E., June 1953.

Referring now to Fig. 2 there is shown a circuit diagram of an oscillator which utilizes the symmetry illustrated by the curves of Fig. 1. The numeral 1 represents a symmetrical p.n.p. junction transistor having a collector-emitter 2, an emitter-collector 3 and a base 4. The

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transistor 1 is energized by means of a single source of alternating current bias 5 which is connected between the circuit energizing terminals 6 and 7. The collector-emitter 2 of the transistor 1 is connected by means of a tuned circuit 11, the conductor 12, and the capacitor 13 to the energizing terminal 6. Similarly, the emitter-collector 3 of the transistor 1 is connected by means of a tuned circuit 15 and the conductor 16 to the circuit energizing terminal 7. The tuned circuit 11 comprises a capacitor 17 connected in shunt across the end terminals 18 and 19 of an inductor 21. The tuned circuit 15 comprises a capacitor 23 connected in shunt across the end terminals 24 and 25 of an inductor 26. The inductors 21 and 26 are mutually coupled to each other and to an output winding 27. As shown, the output winding 27 is connected to the circuit output terminals 28 and 29. The base 4 of the transistor 1 is connected to an adjustable contact 31 on a slidewire resistor 32 connected between the conductors 12 and 16. In addition, the base 4 of the transistor 1 is connected to the conductor 12 by means of the capacitor 33 and to the conductor 16 by means of the capacitor 34.

In considering the operation of the circuit of Fig. 2, the circuit energizing terminal 6 will be considered to be negative with respect to the circuit energizing terminal 7 during the first half cycle of the voltage applied across these terminals by the alternating current bias source 5. Thus, during the first half cycle of the bias voltage, the collector-emitter 2 of the transistor 1 will be biased negatively with respect to the emitter-collector 3 of the transistor 1. Under such bias conditions, the collector-emitter electrode 2 may be considered to be a collector and the emitter-collector electrode 3 may be considered to be an emitter. Simultaneously, the base 4 of the transistor 1 is made negative with respect to the emitter-collector 3 by the voltage drop across the resistor 32 between the contact 31 and the conductor 16. The negative signal on the base 4, causes an increase in the negative base current flowing in the transistor 1. As the negative base current flow increases, the current flow through the circuit of the electrodes 2 and 3 increases. This current flows through the inductor 21 causing a voltage to be induced in the inductor 26 such that the end terminal 24 of the inductor 26 is made more positive than the end terminal 25. This voltage makes the base electrode 4 of the transistor 1 more negative than the emitter-collector 3, which causes a still further increase in the current flow through the inductor 21. This regenerative process will produce sustained oscillations at a frequency determined for the most part by the impedance characteristics of the tuned circuits 11 and 15. These oscillations are of course modulated by the envelope of the bias voltage.

During the next half cycle of the applied bias, the emitter-collector 3 is made more negative than the collector-emitter 2. Due to the symmetrical properties of the transistor 1, the emitter-collector 3 may be considered to be a collector and the collector-emitter 2 may be considered to be an emitter. Simultaneously, the base 4 of the transistor 1 is biased more negatively than the collector-emitter 2 by the voltage across the resistor 32 between the contact 31 and the conductor 12. Due to the coupling between the inductors 21 and 26, oscillations are again caused to build up in the manner described for the previous half cycle of the applied bias.

Due to the coupling between the output winding 27 and the inductors 21 and 26, the oscillations developed therein are induced in the winding 27 and appear across the output terminals 28 and 29. Fig. 3 illustrates the wave form of such oscillations which are modulated by the envelope of the applied bias. The capacitors 33 and

34 provide a low impedance path for these oscillations bypassing the resistor 32.

Since no transistor will possess completely symmetrical characteristics, the adjustable contact 31 on the resistor 32 is provided so that the signal applied to the base 4 of the transistor 1 may be varied to supply the proper operating bias to counteract any asymmetry in the characteristics of the transistor 1. The capacitor 13 prevents the transistor 1 from drawing infinite emitter current.

The embodiment of the present invention shown in Fig. 2 illustrates a unique application of the symmetrical properties of transistors to provide an oscillator which can be operated from a single alternating current supply. In addition this oscillator supplies oscillations during both half cycles of this voltage. It should be noted that this results in a substantial saving of components and desirable circuit simplicity.

While, in accordance with the provisions of the statutes, there has been illustrated and described the best form of the embodiment of the invention now known, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention as set forth in the appended claims, and that in some instances certain features of the invention may be used to advantage without a corresponding use of other features.

Having described this invention, that which is claimed as new and which it is desired to secure by Letters Patent is:

1. In combination, a junction transistor having symmetrical characteristics, said transistor having a pair of interchangeable electrodes and a third electrode, a pair of energizing terminals for connection to a source of alternating current bias, a first tuned circuit connecting one of said interchangeable electrodes to one of said terminals, a second tuned circuit connecting the other of said interchangeable electrodes to the other of said terminals, said tuned circuits being inductively coupled to each other in a regenerative manner to cause the circuit including said transistor and said tuned circuit to oscillate at substantially the same frequency during both halves of each cycle of the alternating current bias, third electrode biasing means connected across said terminals, and means connecting said third electrode of said transistor to said biasing means.

2. An oscillator comprising a transistor having symmetrical properties, said transistor having interchangeable collector and emitter electrodes and a base electrode, a pair of energizing terminals for connection to a source of alternating current, a pair of inductively coupled tuned circuits, one of said tuned circuits connecting one of said interchangeable electrodes to one of said terminals, the other of said tuned circuits, connected in series with a current limiting element, connecting the other of said interchangeable electrodes to the other of said terminals,

an output means inductively coupled to said tuned circuits, and impedance means connecting said base electrode to both of said terminals.

3. An oscillator comprising a transistor having an emitter and collector with symmetrical characteristics and a base electrode, a single alternating current bias source, inductively coupled means connecting said emitter and collector to said source, said inductively coupled means being tuned and being regeneratively coupled to cause said oscillator to oscillate at substantially the same frequency during both halves of each cycle of the alternating current bias, and impedance means connecting said base electrode to said source.

4. An oscillator, comprising a symmetrical transistor having two interchangeable electrodes and a base electrode, a pair of terminals for connection to a source of alternating current, a pair of inductively coupled tuned circuits, each of said tuned circuits comprising an inductor and a capacitor connected in parallel, one of said tuned circuits connecting one of said interchangeable electrodes to one of said terminals, the other of said tuned circuits connecting the other of said interchangeable electrodes to the other of said terminals, a slidewire resistor connected across said terminals, circuit means connecting said base electrode of said transistor to the sliding contact on said slidewire resistor, a first capacitor connecting said base of said transistor to one of said terminals, and a second capacitor connecting said base of said transistor to the other of said terminals.

5. Apparatus as specified in claim 4, wherein output means are inductively coupled to said tuned circuits.

6. Apparatus as specified in claim 5, wherein a current limiting impedance is interposed between one of said terminals and the tuned circuit connected thereto.

7. An oscillator comprising a transistor having an emitter and a collector with symmetrical characteristics and a base, a single alternating current bias source, inductively coupled means connecting said emitter and collector to said source, said inductively coupled means being tuned and being regeneratively coupled to cause said oscillator to oscillate at substantially the same frequency during both halves of each cycle of the alternating current bias, an adjustable resistor connected across said source, and means connecting said resistor to said base.

References Cited in the file of this patent

UNITED STATES PATENTS

2,691,073	Lowman	Oct. 5, 1954
2,748,274	Pearlman	May 29, 1956
2,761,909	Wallace	Sept. 4, 1956

OTHER REFERENCES

"The Transistor as a Reversible Amplifier," by Pfann, page 1222 of Pire, vol. 38, No. 10 for October 1950.