PATENT SPECIFICATION

1,034,793

1,034,793

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in and relating to Crystal-Controlled Transistor Oscillators

We, The British Broadcasting Corporation, a British Body Corporate, of Broadcasting House, London, W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to crystal-controlled transistor oscillators.

In oscillators which are required to maintain a very precise frequency of oscillation, crystals are usually employed because of their high Q and inherently stable characteristics.

In a circuit which employs a conventional method of achieving the phase shift required for making self oscillation possible, for example a Colpitts or Hartley circuit, an active element is also necessary in order that the losses inherent in the circuit may be overcome. When the active element is a transistor the frequency stability of the crystal is offset by changes in the parameters of the transistor, particularly temperature-dependent changes. On the other hand the use of a transistor has many advantages.

One of the objects of the present invention is to provide an improved crystal-controlled oscillator embodying a transistor which has a good frequency stability.

According to the present invention an oscillator comprises a transistor amplifier having its output circuit coupled to its input circuit through a phase-shift network suitable to permit self-oscillation, the external circuit connecting the emitter of the transistor to a point of fixed potential having a negative feed-back circuit connected in series therein, the feed-back circuit comprising two parallel-connected branches one containing a resistive element and the other a piezo-electric crystal, the resistive element having a value such that in the absence of the crystal the negative feed-back is sufficient to prevent oscillation, and the crystal serving at a predetermined frequency to reduce the effective resistance of the feed-back circuit sufficiently to cause oscillation at this frequency to take place.

As is well known, a piezo-electric crystal has a low resistive impedance at a frequency known as a zero, thus behaving as a series-resonant circuit. At frequencies on either side of a zero the impedance is reactive (inductive or capacitive) and at poles the impedance is again resistive but has a much higher value than at a zero, the crystal then behaving as a parallel-resonant circuit. The present invention makes use of a crystal operating at a zero. In general crystals have more than one zero and in the present invention the circuit is such that the crystal operates at only one of the zeros.

The circuit according to the invention as hereinbefore defined provides a frequency-dependent amount of A.C. negative feed-back, and also D.C. negative feed-back. The D.C. negative feed-back, as is known, reduces the variations in collector-emitter and base-emitter current with change in temperature. This D.C. stabilisation will also stabilise that portion of the emitter-base capacitance which is a function of the emitter current. The A.C. negative feed-back serves to reduce the effect of the input capacitance, as seen between the base of the transistor and the end of the feed-back circuit which is connected to one of the two supply terminals from which operating current is derived (in the case of a P.N.P. transistor, the positive supply terminal).

According to a subsidiary feature of the

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invention a capacitor is connected in series in the branch of the feed-back circuit containing the crystal. The capacitor serves primarily as a blocking capacitor to prevent the application of a unidirectional potential to the crystal and secondarily to effect a small change in the frequency of the crystal zero. The capacitor may be fixed or variable.

With this form of the invention the resistive branch of the feed-back circuit affects both the A.C. and the D.C. feed-back, and the crystal-containing branch affects only the A.C. feed-back.

A zener diode may be provided to stabilise the base-emitter bias potential.

According to a further subsidiary feature of the invention, one terminal of the crystal is connected to a point of fixed potential, usually earth. This permits the ready measurement of crystal dissipation, which is an important practical advantage in the construction of such equipment. It enables the circuit to be set up to give optimum reliability, a process which is practically impossible to perform with any reasonable accuracy if both sides of the crystal are at other than earth potential.

A number of embodiments of the invention will be described, by way of example, with reference to the drawings accompanying the Provisional Specification in which

Fig. 1 is a circuit diagram of a simple embodiment,

Fig. 2 shows the addition to the circuit of Fig. 1 of a capacitor in the crystal branch of the feed-back circuit,

Fig. 3 shows the addition of a stabilising diode to the circuit of Fig. 2, and

Figs. 4, 5 and 6 are circuit diagrams of oscillators according to the invention in the common emitter, common base, and common collector configurations respectively.

Although in all the Figures a P.N.P.-type transistor is shown, a transistor of N.P.N. type may be substituted, the polarities of the supplies being reversed and, in the case of Figs. 3 to 6, the stabilising diode being reversed also.

Referring to Fig. 1, a frequency-selective phase-shift network 10 is connected between the base and the collector of a transistor 11. The network 10 may take the form, for example, of a Colpitts or a Hartley oscillatory circuit and provides the phase shift required to sustain oscillations. The negative terminal 12 of a source of current is connected through the network 10 to the base and collector. The base is also connected through a resistor 13 and a bias source 14 to the positive terminal 15 of the current source. A negative feed-back circuit is connected between the emitter of the transistor and the terminal 15, this feed-back circuit consisting of a resistor 16 in parallel with a piezo-electric crystal 17.

The resistor 16 has a value such that in the absence of the crystal 17, or at frequencies other than that corresponding to a zero of the crystal, the negative feed-back is sufficient to prevent oscillation. At a zero of the crystal 17, however, the crystal presents a sufficiently low resistance in parallel with the resistor 16 to permit oscillation.

The circuit in Fig. 2 is the same as that of Fig. 1 excepting that a capacitor 18 is connected in series with the crystal 17. As already stated the capacitor 18 may be fixed or variable.

In Fig. 3 the supply terminal 12 is connected to the base through two resistors 19 and 20 in series and the junction of these resistors is connected through a zener diode 21 to the supply terminal 15. The diode 21 serves to stabilise the base-emitter bias potential.

The circuits of Figs. 1 to 3 are of a common-emitter configuration in which the emitter circuit is common to the input and output circuits which are coupled together by the phase-shift network 10. Fig. 4 shows the circuit of Fig. 3 in which the phase-shift network 10 is a version of the Colpitts circuit and comprises a resistor 22, an inductor 23 and capacitors 24, 25 and 26.

Fig. 5 shows a circuit in the common base configuration in which the phase-shift network coupling input and output is constituted by a resistor 27, an inductor 28 and capacitors 29, 30 and 31. The capacitor 29, although acting as a decoupling capacitor, nevertheless forms part of the phase-shift network insofar as, because of it, the base of the transistor is at the same instantaneous A.C. potential as the terminal 15.

Fig. 6. shows a circuit in the common collector configuration in which the phase-shift network coupling input and output is constituted by an inductor 32, which may be the primary winding of an output transformer, the secondary winding 33 of the transformer and capacitors 34 and 35.

WHAT WE CLAIM IS:—

1. An oscillator comprising a transistor amplifier having its output circuit coupled to its input circuit through a phase-shift network suitable to permit self-oscillation, the external circuit connecting the emitter of the transistor to a point of fixed potential having a negative feed-back circuit connected in series therein, the feed-back circuit comprising two parallel-connected branches one containing a resistive element and the other a piezo-electric crystal, the resistive element having a value such that in the absence of the crystal the negative feed-back is sufficient to prevent oscilla-

tion, and the crystal serving at a predetermined frequency to reduce the effective resistance of the feed-back circuit sufficiently to cause oscillation at this frequency to take place.

2. An oscillator according to claim 1, wherein a capacitor is connected in series in the branch of the feed-back circuit containing the crystal.

3. An oscillator according to claim 1, wherein a zener diode is provided to stabilise the base-emitter bias potential.

4. An oscillator according to claim 1, 2 or 3, wherein one terminal of the crystal is connected to a point of fixed potential.

5. An oscillator substantially as hereinbefore described in any one of Figures 1 to 6 of the drawings accompanying the Provisional Specification.

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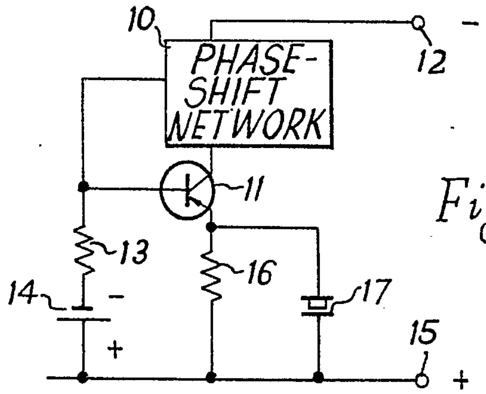

Fig. 1.

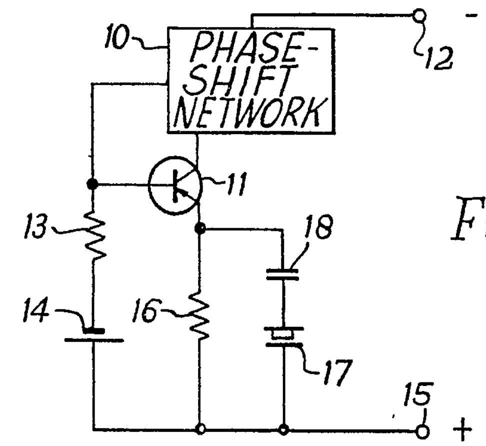

Fig. 2.

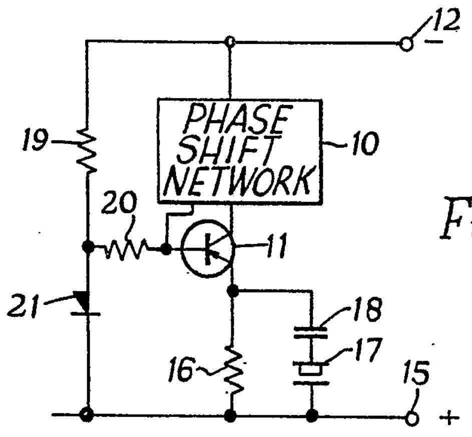

Fig. 3.

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SHEETS 1 & 2

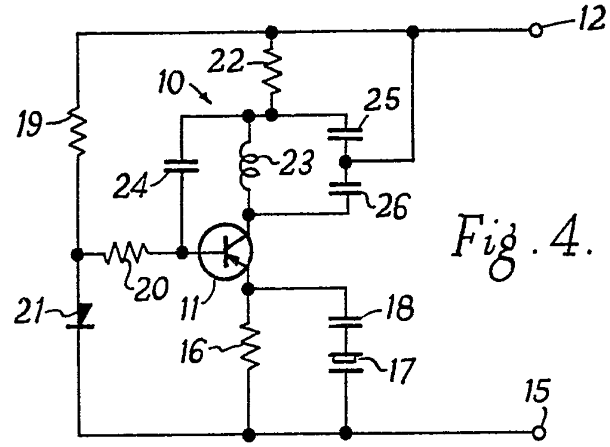

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Fig. 4.

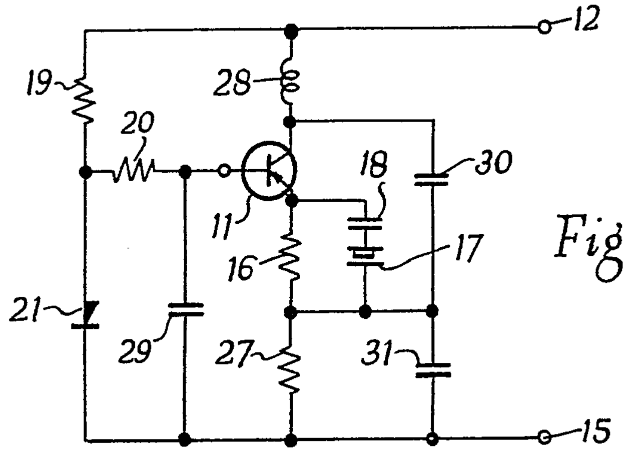

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Fig. 5.

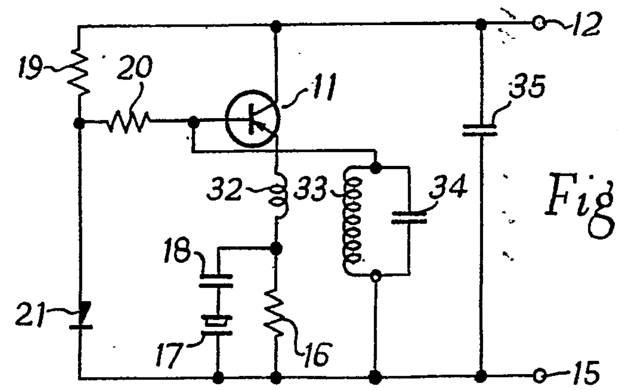

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Fig. 6.

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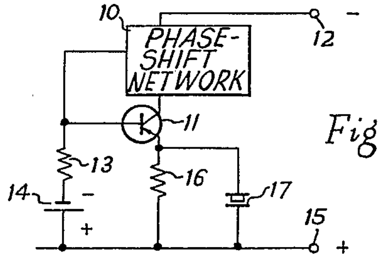

Fig. 1.

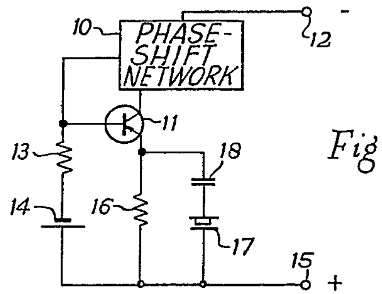

Fig. 2.

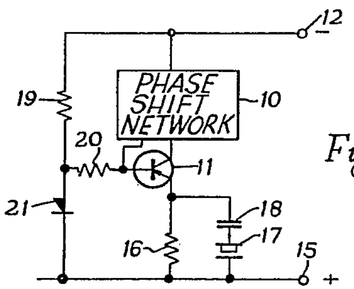

Fig. 3.

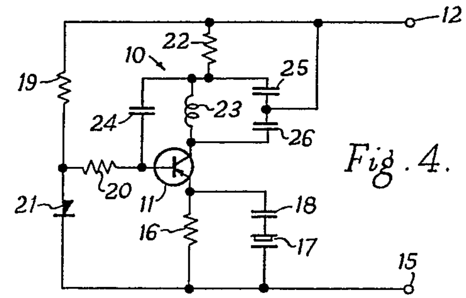

Fig. 4.

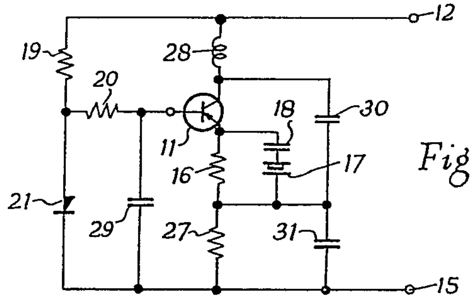

Fig. 5.

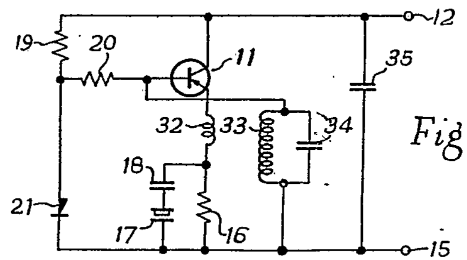

Fig. 6.