

Sept. 16, 1958

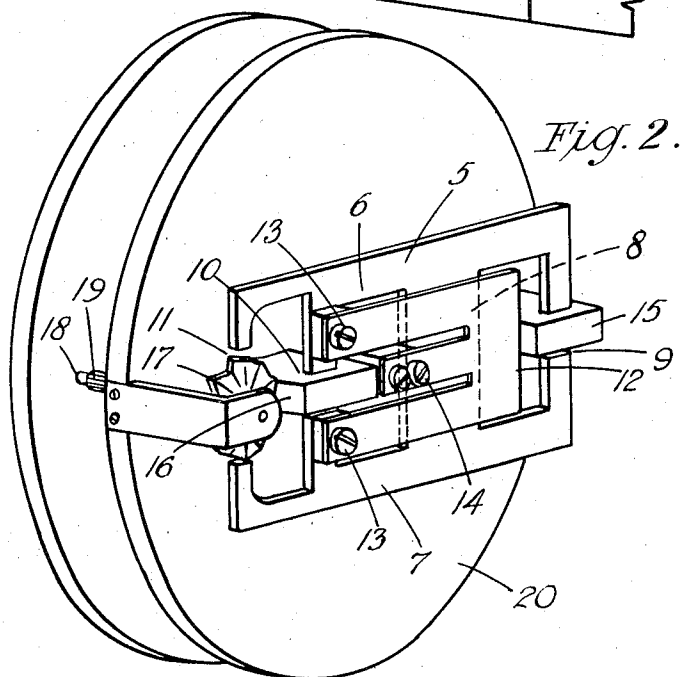
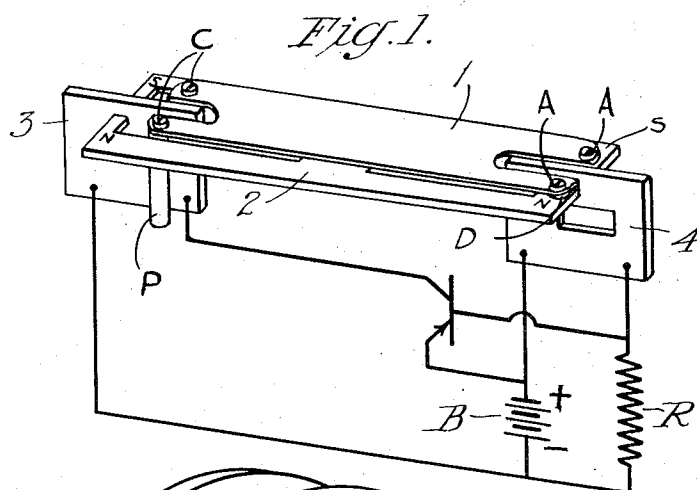
C. F. CLIFFORD

2,852,725

ELECTRICALLY-MAINTAINED VIBRATORY OSCILLATOR

Filed Nov. 7, 1955

2 Sheets-Sheet 1



*Cecil Frank Clifford
by Rockwell, Bartholomew
attorneys*

2,852,725

ELECTRICALLY-MAINTAINED VIBRATORY OSCILLATOR

Cecil Frank Clifford, Bath, England

Application November 7, 1955, Serial No. 545,449

Claims priority, application Great Britain
November 5, 1954

4 Claims. (Cl. 318—128)

This invention relates to a new or improved electrically-maintained vibratory oscillator which is useful for various purposes and particularly for electric clocks or time switches in which it will serve both as a driving mechanism and as a time-keeping oscillatory governor.

According to the invention, an electrically-maintained vibratory oscillator consisting of a magnet supported free to vibrate by means of a spring is electro-dynamically coupled to both a "signal" coil from which a signal generated by the movement of the magnet is fed to the emitter of a transistor, and a "driving" coil to which a driving current is fed from the collector of the transistor whereby mechanical oscillation is maintained at the frequency determined by the mass of the magnet and the resilience of the spring. Advantageously the spring and magnet are balanced about their support so that they oscillate substantially about their centre of gravity as described in United States Patent No. 2,690,646.

To avoid unwanted feed-back due to mutual inductance between the signal and driving coils, these coils are arranged in separate gaps in the magnet and are arranged so that as the pole faces formed by one gap move towards the axis of one coil, the pole faces formed by the other gap move away from the axis of the other coil.

To enable the transistor to operate from a single battery, the internal resistance of the signal coil is utilised to bias the emitter of the transistor without the aid of any additional series resistance in the signal coil circuit.

The invention and its subsidiary features will be fully understood from the following more detailed description with reference to the accompanying drawings in which:

Figure 1 illustrates one form of vibratory oscillator according to the invention;

Figure 2 illustrates a similar construction but arranged to drive a rotor, and

Figure 3 is a view similar to Figure 2 but showing an auxiliary oscillator provided to counteract the effect of the principal oscillator in transmitting vibrations to the support.

Figure 1 illustrates one form of the invention employing a "balanced reed" type of vibratory oscillator constructed in accordance with the principles described in our prior patent specification above referred to. This oscillator consists of a leaf spring 1 mounted at C on a pair of posts P supporting a vibratory magnet 2 in the form of an H-shaped flat plate by means of screws A and intermediate spacing washers D. The H-shaped plate forms two pairs of parallel arms extending in opposite directions from a cross-bar located midway between the ends of the plate. These ends have tips which project inwardly toward one another so as to form a relatively narrow gap in which a strong magnetic field exists due to the permanent magnetism of the plate. The magnet 2 thus has separate pairs of pole faces formed by separate gaps in the magnet. In these separate gaps, two inductance coils 3 and 4 are supported so as to be electro-dynamically coupled to the magnet, the arrangement being such that, the magnet oscillates with the

pole faces at one end of the magnet moving towards the axis of one coil, as the pole faces at the other end of the magnet move away from the axis of the other coil.

Figure 1 depicts a circuit arrangement for driving the mechanical oscillator from a P-N-P type junction transistor. In this circuit the "signal" coil 4 is connected directly between the base and emitter of the transistor, the driving coil 3 is connected between the collector of the transistor and the negative terminal of the battery B or equivalent current source whose positive terminal is connected to the emitter, and a bias-adjusting resistance R is connected between the negative of a battery and the base of the transistor. By this arrangement, the internal resistance of the signal coil 4 is utilised to apply the required bias to the emitter without the aid of any additional series resistance in the signal coil circuit. A high degree of sensitivity to the signal voltage induced in the signal coil 4 is thus achieved.

The following particulars of a practical oscillator operating at a frequency of 90 cycles per second are given with reference to Figure 1 to illustrate by way of example the method of performing the invention: The signal and driving coils each have 2760 turns of .002" enamelled copper wire, giving an ohmic resistance of 550 ohms. The magnet gaps are approximately 3½ mm. wide, and the coils they embrace are 3 mm. thick. With a resistor of 11000 ohms the voltage can be varied from 5.6 to 8.0 volts with a resulting variation in the amplitude of the oscillator of only from 1.7 to 2 mm. and a time-keeping variation of only 3 seconds per day. The value of the 11000 ohms resistor is not critical; it can be varied from 10000 ohms to 12000 ohms with no perceptible effects. The oscillator, although self-starting in 10 seconds, is quite stable. The transistor used in this example is a standard telephone transistor 3X/301 N.

To match the signal and driving coils to the transistor the impedance of the signal coil is made substantially the same as the impedance of the emitter and the impedance of the driving coil is made substantially the same as the impedance of the collector at the frequency chosen. A condenser of the order of .0075 microfarad may be connected across the signal coil or driving coil, or two such condensers may be connected one across each coil, to eliminate parasitic high-frequency oscillations.

An N-P-N transistor may be used instead of the P-N-P type shown, and in that case the positive and negative polarities must of course be reversed.

Figure 2 shows one construction of a vibratory oscillator according to the invention arranged to drive a rotor, thus forming a combined driving mechanism and time-keeping oscillatory governor for an electric clock.

In this construction, the vibratory magnet consists of an H-shaped magnet 5 composed of two parallel bars 6 and 7 joined together by a cross-bar 8 located approximately midway between the ends of the plate. The arms 6 and 7 are of opposite magnetic polarity and have three pairs of inwardly projecting opposed poles forming three air-gaps 9, 10 and 11 in which strong magnetic fields exist by reason of the permanent magnetism of the plate 5. The plate 5 is supported by a three-armed leaf spring 12 having two longer arms attached to the plate 5 by screws 13 and a shorter arm anchored to a suitable support by screws 14, so that the plate can vibrate in the manner of a see-saw by flexing the spring, i. e. so that its two ends move in opposite directions. The point of support of the spring is so arranged that the spring and magnet oscillate substantially about their center of gravity as illustrated in United States Patent No. 2,690,646. A signal coil 15 corresponding to the coil 4 shown in Figure 1 is mounted in the gap 9 and a driving coil 16 corresponding to the coil 3 shown in Figure 1 is mounted in the gap 10, these two

coils forming part of a transistor amplifier by which the mechanical oscillatory system consisting of the plate 5 and spring 12 is maintained in vibration in the manner already described. The circuit of the transistor amplifier may be exactly the same as that shown in Figure 1 and is therefore not repeated in Figure 2.

The inwardly directed pole-pieces formed by the third gap 11 of the magnet shown in the accompanying drawing cooperate with a rotor 17 formed with a wavy magnetic path designed to co-operate with the poles as described in United States Patent No. 2,606,222. The rotor 17 is so constructed and arranged that the pole pieces guide and are guided by the wavy path by reason of the magnetic attraction across the air gap and thus convert the vibratory movement of the magnet into a rotational movement of the rotor 17 as described in the specification just referred to. The rotor 17 is attached to a spindle 18 carrying a pinion 19 for driving any required mechanism which may be contained in a casing 20 to which the oscillator is attached.

If the oscillator has a high frequency and is fairly massive as compared with the size and weight of a clock or other mechanism to which it is attached, then the vibrations transmitted from the oscillator to the mechanism may cause difficulties. For instance, time-keeping may be affected by the rigidity of mounting say of a clock to the dash-board of a motor-car. Or again, the transmission of these vibrations may render the oscillator non self-starting or may even prevent it from working at all if held in the hand. Figure 3 of the accompanying drawing shows an auxiliary oscillator designed to overcome this difficulty by vibrating in contra-phase to the principal oscillator. As shown, the auxiliary oscillator consists of a weight 21 attached to one end of a reed 22 whose other end is attached to the same support as the spring 12. This auxiliary oscillator is tuned to the same frequency as the main oscillator so that it will vibrate in opposition thereto and is thus designed to cancel out the effect of the principal vibrator in transmitting vibration to the common support.

A further feature of the construction herein described is that the signal and driving coils are arranged so that an excessive amplitude of vibration of the magnet would cause the co-operating poles to move out of alignment with the coils. The amplitude of vibration of the oscillator is thus automatically limited by the reduction of signal and drive which occurs with increasing amplitude of vibration beyond a certain point.

By means of the transistor amplifier described, a reed-type oscillator such as that shown in the accompanying drawing can be driven from a continuous current source of low voltage, e. g. of the order of from three to twelve volts. The arrangement described thus provides a D. C. motor of such highly accurate speed that it may be used as the drive for the hands of a clock or time switch.

An adjustable rider and/or a magnetic frequency regulator may be provided to regulate the frequency of the vibrator.

I claim:

1. An electrically-maintained vibratory oscillator comprising a magnet, a spring supporting said magnet, means supporting said spring, a signal coil and a driving coil operatively associated with the magnet and electro-dynamically coupled thereto, a transistor, means coupling the transistor to said coils to feed a signal generated by movement of the magnet to the emitter of the transistor and to feed a driving current to the driving coil from the collector of the transistor whereby mechanical oscillation of the magnet is maintained at the frequency determined by the mass of the magnet and the resistance

of the spring, said magnet being provided with two pairs of cooperating poles having gaps therebetween, the signal coil being located in one of said gaps and the driving coil being located in the other of said gaps, the arrangement being such that as the pole faces at one gap move toward the axis of one coil the pole faces at the other gap move away from the axis of the other coil, said magnet being provided with a third set of pole faces having a gap therebetween, and a rotor mounted in said third gap, said rotor having a wavy magnetic track co-operating with the third set of pole faces whereby the vibration of the magnet is converted into rotation of the rotor.

2. An electrically-maintained vibratory oscillator comprising a magnet, a spring supporting said magnet, means supporting said spring, a signal coil and a driving coil operatively associated with the magnet and electro-dynamically coupled thereto, a transistor, means coupling the transistor to said coils to feed a signal generated by movement of the magnet to the emitter of the transistor and to feed a driving current to the driving coil from the collector of the transistor whereby mechanical oscillation of the magnet is maintained at the frequency determined by the mass of the magnet and the resistance of the spring, said magnet being of substantially H-shaped form having two pairs of pole faces, one pair upon each side of an intermediate point on said magnet, each pair of pole faces providing a gap therebetween with the driving coil located at one gap and the signal coil located in the other gap, the spring supporting said magnet for oscillation about an axis between said pairs of pole faces whereby, as the pole faces at one gap move toward the axis of the associated coil, the pole faces at the other gap move away from the axis of the other coil.

3. An electrically-maintained oscillator as in claim 2, having a third pair of pole faces, and a rotor rotatably supported between said last-named pole faces, said rotor having a wavy magnetic track thereon cooperating with said last-named pole faces whereby vibration of the magnet effects rotation of the rotor.

4. An electrically-maintained vibratory oscillator comprising a magnet, a spring supporting said magnet, means supporting said spring, a signal coil and a driving coil operatively associated with the magnet and electro-dynamically coupled thereto, a transistor, means coupling the transistor to said coils to feed a signal generated by movement of the magnet to the emitter of the transistor and to feed a driving current to the driving coil from the collector of the transistor whereby mechanical oscillation of the magnet is maintained at the frequency determined by the mass of the magnet and the resistance of the spring, an auxiliary oscillator attached to said supporting means, which auxiliary oscillator vibrates in contraphase to the first-named oscillator to counteract the effect of the first-named oscillator in transmitting vibration to the supporting means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,259,131	Fleischer	Oct. 14, 1941
2,594,749	Ehrat et al.	Apr. 29, 1952
2,628,343	Murray	Feb. 10, 1953

FOREIGN PATENTS

367,012	Great Britain	Feb. 11, 1932
1,090,564	France	Oct. 20, 1954

OTHER REFERENCES

Transistors and their Applications, by Garner pub., by Coyne Electric School, Chicago, 1953; pp. 37 and 38.