Sept. 26, 1939. C. F. WALLACE 2,174,296

OSCILLATOR APPARATUS

Filed June 11, 1937

Fig. 1

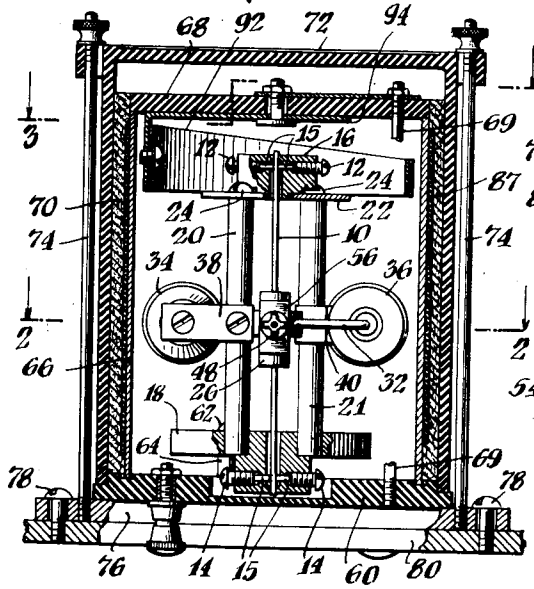


Fig. 2

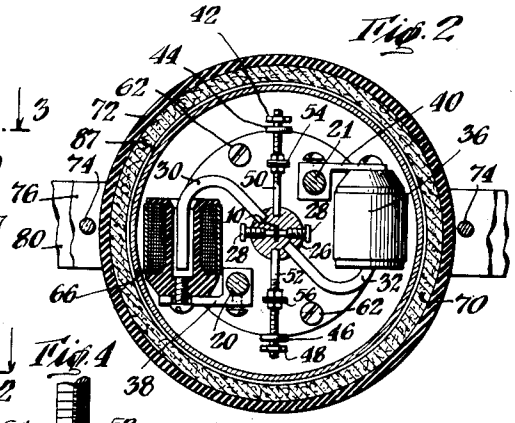


Fig. 4

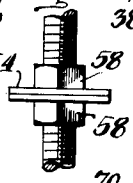


Fig. 3

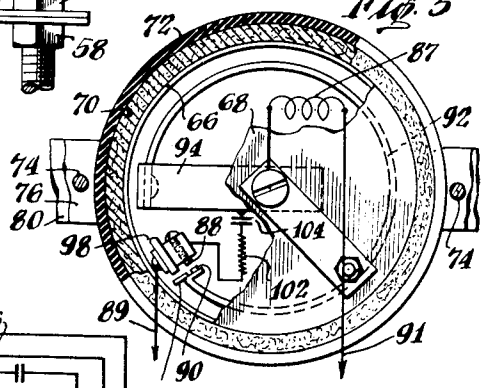


Fig. 5

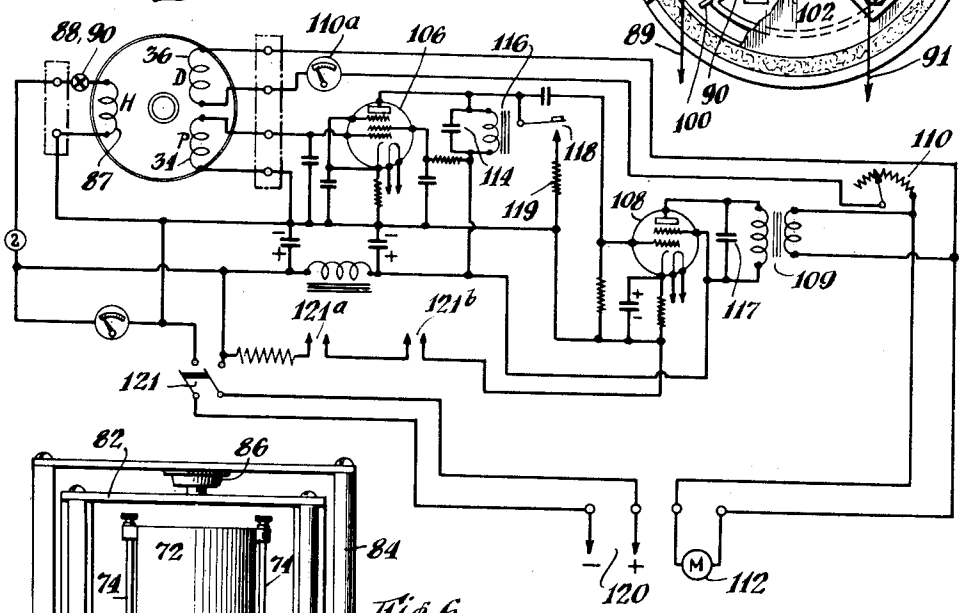


Fig. 6

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OSCILLATOR APPARATUS

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Application June 11, 1937, Serial No. 147,641

6 Claims. (Cl. 178—44)

This invention relates to oscillators, and more particularly to electro-mechanical devices and cooperating apparatus, for producing electrical oscillations, an important object of the invention being to provide for the generation of a constant frequency alternating current, such, for example, as may afford current supply for a signal timer.

One form of signal timer used heretofore comprises, in general, cam contactor mechanisms and a motor for driving them provided with a governor to maintain the rate of operation substantially constant. Ordinarily, however, and particularly in the use of a signal timer to control the automatic transmission of signals from a radio beacon for the guidance of shipping or aircraft (where accurate timing of the signals may be an essential factor in enabling the navigator or pilot to determine his position), or in the control of other beacons or signalling apparatus where accuracy of timing is important, it is necessary to employ, along with the governor-controlled motor, supplementary timing and correctional devices. Furthermore, the timing and correctional devices used heretofore have been objectionable for accurate operation over a long period of time because they embody delicate electrical contacts and bearings or similar moving parts, which wear or which require frequent oiling, adjustment, replacement or other attention.

With the foregoing in mind, the present invention contemplates the provision of improved oscillator apparatus, which will effect the generation of a constant frequency alternating current of adequate output and accuracy for driving the contactor mechanisms of a signal timer by a suitable motor supplied with such current; which will thereby obviate the use of supplementary timing and correctional devices as heretofore; and which does not include such contacts, bearings or other moving parts as have contributed to the disadvantage of the supplementary timing and correctional devices.

The invention also contemplates the provision of improved oscillator apparatus of the character described; which is relatively simple and rugged in construction; which has great power of frequency discrimination, operating very sharply and accurately at the intended period of oscillation; which may be easily and effectively adjusted and tuned to a predetermined frequency; which is notably free from variation in frequency upon change in the temperature about the apparatus; in which the mechanically operating and adjacent, electrical parts can be kept at a uniform temperature; in which the mechanically oscillating elements are automatically compensated for temperature variation; which has electromagnetic oscillating instrumentalities, efficiently adapted for use in combination with a vacuum tube amplifier; which has its mechanical oscillations effectively and uniformly sustained and controlled by feedback from an attendant vacuum tube circuit; which is adapted to function readily and properly over long periods of time, with great accuracy, for example, to provide for a 60-cycle current at an accuracy of the order of one second per twenty-four hours; and which is particularly effective for the accurate and sustained production of low-frequency oscillations, of the order of sixty cycles; further objects of the invention being therefore to provide oscillator apparatus having one or more of the characteristics hereinabove stated.

Other objects and advantages include those hereinafter stated or apparent in connection with the following description of a presently-preferred embodiment of the invention. That embodiment, which is set forth by way of example, is illustrated in the accompanying drawing, in which:

Fig. 1 is a vertical section, with certain parts in elevation, of the electro-magnetic oscillator device;

Fig. 2 is a section on line 2—2 of Fig. 1, with certain parts in plan;

Fig. 3 is a section on line 3—3 of Fig. 2, with certain parts broken away and certain electrical elements diagrammatically shown;

Fig. 4 is an enlarged, detail, fragmentary view taken from Fig. 2;

Fig. 5 is a wiring diagram of the oscillator device or unit and associated vacuum tube circuits; and

Fig. 6 is an elevational view showing the manner of mounting the oscillator unit.

With reference to Figs. 1 and 2, the vertically extending member 10 is a relatively stiff strip of spring steel or other stiff but resilient material, for example, a stiff but resilient material having a low temperature coefficient, such as the material which is manufactured and sold under the trade name "Elinvar." The strip 10 is fixed at each end in a rigid frame by set screws 12, 12 and 14, 14. For the purpose of preventing distortion of the strip 10 when the set screws are tightened, separate steel plugs or inserts 15 are placed intermediate the screws and the strip, having flat ends squarely abutting the side faces of the strip. The frame includes a brass upper member or head 16, a brass lower member or plate 18—respectively carrying the set screws

12, 12 and 14, 14, supporting the corresponding ends of the strip 10—and brass posts 20 and 21. The member 16 has a downwardly extending reduced portion, as shown, having a press fit in a brass disk 22 to which the upper ends of the posts 20 and 21 are fixed by studs 24. The lower ends of the posts 20 and 21 have a press fit in the member 18. A block 26, conveniently made of brass, or in some cases, of ferrous material, is disposed on the member 10 intermediate the ends of the latter and is fixed rigidly thereon by set screws 28.

A pair of similar, complementary parts 30 and 32, conveniently consisting of bent steel rods, form jointly an S-shape permanent-magnet armature, the respective adjacent ends of these parts having a press fit in the block 26 to fix them rigidly with respect to the latter. It will be understood that the members 30, 32 are conveniently separate permanent magnets which may be disposed with their outer ends oppositely poled, or may be otherwise arranged (as when the block 26 is of non-magnetic material).

The assembly just described, together with such additional parts as are carried thereby, constitutes a torsional pendulum, and the respective parts are so proportioned and designed that the suspended armature, with the adjusting means hereinafter described, has a predetermined natural frequency of oscillation, about the axis of strip 10, which may be, for example, sixty cycles per second.

To provide electromagnetic pick up and driving means for the torsional pendulum, the opposite free ends of the permanent-magnet armature are respectively enclosed by, and out of contact with, stationary solenoids 34 and 36. The solenoid 34 functions as a pick-up coil and is supported rigidly from the post 20 by a bracket 38. The solenoid 36 functions as a driving coil and is supported rigidly from the post 21 by a bracket 40. The coils 34 and 36 are preferably positioned, as shown, so that no appreciable inductive relationship exists between them, and so as to provide for free oscillation of the armature at its predetermined natural period, i. e., so that at the full amplitude of oscillation, the ends of the armature may pass freely further into, or out of, the solenoids. It may be noted that the torsional pendulum is preferably so proportioned, and the supplied driving power preferably so controlled, that the full amplitude of oscillation at its natural period is relatively small in angular extent (of the order of 5° or 10°), greater accuracy and efficiency being thereby attained in many cases, as in the arrangement shown.

For the purpose of calibration, or adjustment of the natural period of vibration of the armature element 30, 32, relatively small nuts or collars 42, 44, 46 and 48 are employed, these being threaded, as shown, on supporting rods 50 and 52 which are screwed tightly into the block 26 and are disposed in the same plane as the S-shape armature element 30, 32. The inner nuts 44, 46 may have a solid configuration and be made of relatively heavy material, e. g., brass, while the outer nuts 42, 48, may have a skeleton or spider shape and be made of light material, e. g., aluminum; coarse or rapid adjustment can then be made by turning the relatively heavy inner nuts, and a fine or "vernier" adjustment attained by turning the very light outer nuts.

To compensate for the effect of temperature variation on the parts carried by the strip 10 of the torsional pendulum, vertically-extending bi-metallic strips 54 and 56 are mounted on the rods 50 and 52 and held in adjusted position on the latter by collars or nuts 58 threaded on these rods. The arrangement is such that in operations, as the temperature increases above a predetermined normal operating temperature for which the oscillator unit is adjusted, the protruding ends of the bi-metallic elements 54 and 56 will turn inwardly toward the member 10 to effect substantial compensation for the occurring expansion of the rods 50 and 52 (which would place the nuts 42, 44, 46 and 48 at a greater distance from the member 10), as well as for the expansion of other elements, viz., block 26 and armature elements 30, 32.

Likewise, if the temperature falls below the predetermined normal operating temperature, the bi-metallic elements will flex in the opposite (i. e., outward) direction to compensate for the occurring corresponding contraction of the rods 50 and 52, and other elements.

For the physical protection of the assembly just described, and for thermally insulating it, the following housing structure may conveniently be provided. The supporting frame of the assembly is fixed rigidly to a heavy Bakelite base 60 by screws 62 passing through the lower frame member 18 and through intermediate brass spacers 64. The base 60 is recessed, as shown, to accommodate the reduced portion of the frame member 18 and the set screws 14. The assembly is enclosed by a brass cylinder 66 fitted to the base 60 and a heavy Bakelite cover plate 68, which locks the brass cylinder in place by virture of clamping rods such as rod 69 (shown broken away). A layer 70 of woolen or other suitable heat-insulating material is disposed about the brass cylinder 66, and the entire assembly is enclosed by a Bakelite casing 72 secured over and against the base 60 by tie rods 74 connected to a brass strap 76 passing under the base.

In order to minimize the effect of extraneous shocks, vibration or other mechanical disturbance, the housed oscillator device is secured by screws 78 to the bottom cross member 80 of a rigid frame 82 which is mounted or supported within an outer, rigid frame 84 by shock and vibration-absorbing devices 86 of a conventional design. The frames 82 and 84 may be made of brass or other suitable material.

For the purpose of maintaining the temperature of the mechanical oscillator device constant at a predetermined temperature for which it may be adjusted, a non-inductively wound heating coil 87 is placed upon the brass cylinder 66, being electrically insulated from the cylinder and disposed between the latter and the heat-insulating layer 70. This coil is connected, as shown (see Figs. 3 and 5) through the contacts 88 and 90 of a thermostat, to a direct current supply across leads 89, 91, of Fig. 3. As the heater coil is non-inductively wound, it may in some cases be excited from an alternating current supply—even of the same frequency as that of the oscillator—without inducing any E. M. F. of the frequency of such supply, into the driver winding 34 or any elements or circuits associated therewith. The contact 88 is fixed, and the contact 90 is mounted at the end of a curved bi-metallic thermostat element 92 supported from the cover plate 68 by a bracket 94. The bi-metallic element 92 is thus mounted within the housing and near the oscillating elements, and it is arranged so that upon a decrease of temperature from a predetermined setting it will curl up, closing the contacts

88, 90, and will uncurl and thus open the contacts, upon an increase in temperature.

In operation, when the contact 90 is moved almost into engagement with the stationary contact 88, it is drawn into engagement with the latter with a quick, snap action by the attraction of a stationary, permanent-magnet 98 for a shoe 100 of paramagnetic material, carried by the free end of the bi-metallic element and disposed adjacent to the movable contact 90. Likewise, the attraction of magnet 98 for shoe 100 will hold the contacts closed against relatively slight and inconsequential temperature variations from the temperature of closure (to avoid chattering or other imperfect contact), and will afford a snap opening of the contacts when the temperature is definitely brought above the predetermined operating temperature and consequently definite restoring force is exerted by the bi-metallic strip. A resistance 102 and a condenser 104 are connected in series, as shown in Fig. 3, across the contacts 88 and 90 to eliminate any appreciable arcing between the latter.

It will thus be understood that when the temperature of the oscillator unit drops below the predetermined normal operating temperature, the contacts 88 and 90 close to connect the heating coil 86 to the supply circuit, and that when the temperature rises above the predetermined normal operating temperature, these contacts open to disconnect the heating coil from the supply circuit. At the same time, it will be appreciated that the thermostatically operated means (e. g., strips 54, 56) for maintaining constant the moment of inertia of the torsional pendulum, cooperates with the thermostatically controlled heating means just described (and likewise with the thermally-insulated housing for the device), for keeping the natural period of the pendulum constant irrespective of temperature variations around the unit, and for doing so more effectively than ony one of these separately useful instrumentalities. That is, the operation of the strips 54, 56, will not only compensate for the small temperature variations usually incidental to the intermittent operation of the heating device, but will afford effective compensation independently of the latter, for example, in case the external or atmospheric temperature should rise above the predetermined normal operating temperature, or if the effect of the heater winding is impaired, as by an interruption of its current supply.

The pick-up and driving coils of the oscillator device are conveniently connected for feed-back through a vacuum tube circuit or system which comprises one or more vacuum tubes and which may be tuned for resonance at the electrical frequency which the oscillator is to generate, i. e., at a frequency corresponding to the period of mechanical oscillation of the torsional pendulum. Thus the pick-up coil may be connected in an input or grid circuit of such a system and the driving coil connected in an output or plate circuit, and it will now be understood that the driving coil is so wound or poled that the electromagnetic driving impulses which it imparts to the armature are in proper predetermined phase relation to the E. M. F. generated in the pick-up coil by the resulting deflections or oscillations of the armature.

That is, assuming that at a particular moment the permanent magnet armature is moving into the pick-up coil, it will (through the instrumentality of the latter and the amplifying circuit) cause an amplified current to flow through the driving coil in the proper direction to repel the end of the suspended armature which is disposed, and has a free movement, in the driving coil. When the armature reaches maximum swing in this direction, it starts back in the opposite direction, and accordingly produces (through the medium of the pick-up coil and amplifier) a reversal of the amplified current in the driving coil to develop a magnetic field which reacts on the driving coil end of the armature in the opposite direction to draw it into the driving coil and build up and sustain oscillation of the armature assembly.

The amplifier may advantageously be resonated at the natural frequency of the oscillator, as stated above, whereby maximum output is obtained and discrimination is afforded against extraneous impulses, such as might exist on the power lines, or be otherwise set up in the amplifying circuits.

Notably efficient results, particularly when the load applied to the output terminals is constant, have been obtained with a two-stage amplifying system wherein the first stage comprises a voltage amplifier and the second a power amplifier. Referring to the wiring diagram, Fig. 5, which includes such a system, having a voltage amplifier tube 106 and a power amplifier tube 108, the pick-up coil 34 of the oscillator device is connected in series with the grid circuit of the voltage amplifier tube 106, as shown, and the output circuit of the latter is coupled to the power amplifier tube 108. The output circuit of the latter is connected to the primary of a transformer 109, and the secondary of the transformer is connected directly to the output terminals and also through a variable impedance 110 to the driving coil 36.

The desired constant frequency alternating current may be obtained from the aforesaid output circuit; for example, if the current is desired for operating a motor 112 to drive the cam contactor mechanisms of a signal timer, the motor 112 may be connected to the output terminals across the secondary of the output transformer 109, as shown. This motor is preferably of resonance type, and particularly satisfactory operation of a signal timer has been obtained by employing a resonance motor of the kind patented in my (Wallace) Patent No. 1,995,270 granted March 19, 1935 upon application Serial No. 675,285, such motor being connected as stated above, to be supplied with the constant frequency alternating current which is generated by the oscillator device and associated instrumentalities.

The efficiency of the resonance motor just described is relatively high, and thereby permits the use of a relatively small power amplifier for its proper operation. It is, however, capable of continuously carrying a load twice that of the cam contactor mechanisms in a signal timer of a type heretofore employed, without overheating or loss of synchronism; moreover, such motor does not embody brushes or contacts of any kind, and requires a minimum of gear reduction, as it may conveniently have a basic speed of 60 R. P. M.

As previously explained, the amplifier may in some cases be resonated at a frequency corresponding to the predetermined natural period of the oscillator device, as by means of condenser 114 and choke 116 in the output of the voltage amplifier stage. It will be understood that impedance 110 may be varied to obtain adjustment of the amplitude of oscillation of the oscillator

device, and thus to obtain accurate adjustment of the frequency of the latter.

The micro-ammeter 110*a*, in one of the leads to the driving coil 36, indicates the current flowing through that coil, and ordinarily variations in such current, as shown by the meter, may be taken to indicate corresponding variations in amplitude of the oscillator device.

To afford means for positively starting the oscillator, in cases when the latter may not otherwise be set in operation, a key 118 is provided to connect a resistance 119 across the plate-cathode circuit of tube 106. When the key is closed briefly and repeatedly the resulting variation of grid voltage on the power amplifier tube causes momentary impulses of current to flow through the driving coil 36 to produce an initial movement of the armature element 30, 32, after which oscillation of the latter is automatically built up and sustained due to the operating action as explained hereinabove. It will be understood that key 118 is normally open, i.e., both when the apparatus is idle and when it is fully in operation.

The high voltage direct current supply for the amplifier is generally designated 120, and is connected through a switch 121, normally closed when the apparatus is in use.

For simplicity of illustration and description portions of the circuits connecting the tube heaters to their current supply leads 121*a*, 121*b*, are not shown, and certain other parts of the amplifier are not here described in detail, but such arrangements are known and will be fully understood by those skilled in the art of vacuum tube amplifiers. Various types of amplifiers may be employed, as special requirements or conditions may dictate; it being chiefly important that the amplifier permit an efficient construction of the mechanical oscillator device so as not to sacrifice its sensitivity or accuracy for the sake of developing any great amount of power in the pick-up coil 34.

Under some conditions, such as when the load applied (as at M) may vary, or when the power factor of such load is subject to change, it may be desirable to drive the oscillator device directly by means of the vacuum tube 106, or by means of a separate driver amplifying stage controlled by tube 106.

It will be appreciated that various arrangements or modifications, which will be understood by those skilled in the art, may be effected to eliminate any reaction on the oscillator device (for example, due to variations in external load); as for instance, by replacing the choke 116 with the primary of a transformer, and connecting the circuit of driving coil 36 (including variable impedance 110 and meter 110*a*) across the secondary of such transformer instead of to the output of tube 108.

It may also be noted that if the line voltage applied at terminals 120 for the amplifier is subject to considerable variation, it may be of advantage to hold the voltage applied to the screen, or to both the plate and screen, of the tube 106, constant, as by means of an additional resistance and a gaseous voltage regulator tube (for instance, a tube such as that commonly known as R. C. A.—874), connected in manner well known to those familiar with the art.

It will now be appreciated that the arrangement of the invention provides oscillator apparatus of simple and rugged construction, and affords an accurate and dependable method of producing electrical oscillations having a frequency that remains constant over a long period of time. The apparatus is remarkably free from frequency change or irregularity, as might be caused by temperature variations, shocks or other external disturbances. At the same time, the frequency at which the oscillator is designed to operate may be any one of a large range, with efficient results in each case and paticularly at low frequencies (of the order of 60 cycles or less) for which tuning fork oscillators, for example, would be extremely large and cumbersome and especially difficult to control.

Furthermore, the use of delicate electrical contacts, or bearings, or similar moving parts,—which wear or which require frequent oiling, adjustment, replacement or other attention,—may be avoided, without sacrifice of operating accuracy or power output; and for these as well as other reasons, the apparatus is of special advantage in providing current supply for a signal timer or the like, and in eliminating the need for supplementary timing or correctional means with such devices. For example, a single arrangement of the kind illustrated has been found effective in producing sufficient sixty-cycle current, e. g., 0.2 ampere or more, at 6 volts, to drive all cam contactor mechanisms of a widely used type of radio beacon signal timer, and to do so effectively and over long periods of time without attention or adjustment of any sort; and it has been found that under such circumstances and with proper careful adjustment the oscillator operates with extreme accuracy, having a variation of not more than about one second (and usually much less) per twenty-four hours of continuous operation.

It is to be understood that the invention is not limited to the embodiments and procedures herein illustrated and described, but may be carried out in other forms without departure from its spirit as defined by the following claims.

What I claim is:

1. Oscillator apparatus comprising a permanently magnetized member torsionally suspended for rotative oscillation at a natural period, and stationary pick-up and driving coils disposed for magnetic reaction with said member, whereby sustained oscillation of the latter may be effected.

2. In oscillator apparatus, in combination, a torsional pendulum comprising a relatively stiff member of spring material fixed at each end thereof and an S-shape permanent-magnet armature element fixed intermediate its ends rigidly with respect to said member for oscillatory movement about the longitudinal axis of the latter, said pendulum having a given natural period of oscillation, a pick-up coil enclosing and supported out of contact with one end of said element, and a driving coil enclosing and supported out of contact with the other end of said element.

3. In oscillator apparatus, in combination, a torsional pendulum comprising a relatively stiff member of spring material fixed at each end thereof, a block disposed on said member and fixed with respect thereto, and a pair of similar complementary parts forming jointly an S-shape permanent-magnet armature and having their respective adjacent ends fixed to said block, a pick-up coil enclosing and supported out of contact with the free end of one of said armature parts, and a driving coil enclosing and supported out of contact with the free end of the other of said armature parts.

4. Oscillator apparatus comprising a perma-

nent-magnet armature torsionally suspended for rotative oscillation at a natural period, and stationary pick-up and driving coils respectively disposed for magnetic reaction with separate poles of said member, whereby sustained oscillation of the latter may be effected in accordance with its periodic displacement relative to said coils.

5. Oscillator apparatus comprising an S-shape permanent-magnet armature torsionally supported intermediate its ends for rotative oscillation about a given axis at a natural period, and pick-up and driving coils respectively enclosing and supported out of contact with corresponding ends of said armature, whereby sustained oscillation of the latter may be effected.

6. Oscillator apparatus comprising a permanently magnetized member torsionally suspended for rotative oscillation at a natural period, and stationary pick-up and driving coils respectively mounted for movement of corresponding ends of said member into and out of said coils respectively, for magnetic reaction of the coils with said member, whereby sustained oscillation of the latter may be effected.

CHARLES F. WALLACE.