May 28, 1957 J. CHEVALLEREAU 2,794,134

MECHANICAL GENERATORS OF ISOCHRONOUS OSCILLATIONS

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Fig. 3.

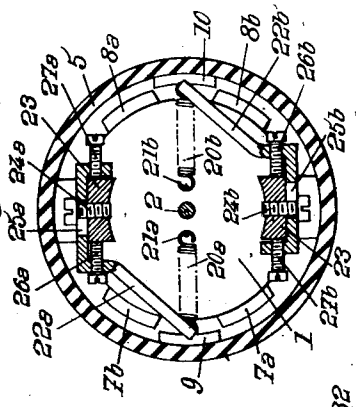


Fig. 4.

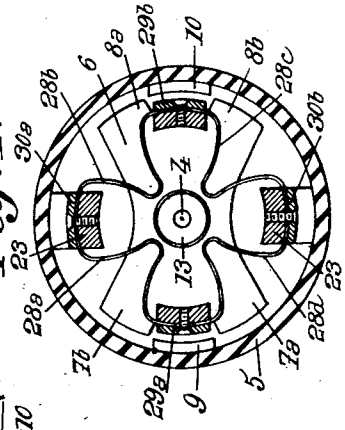


Fig. 2.

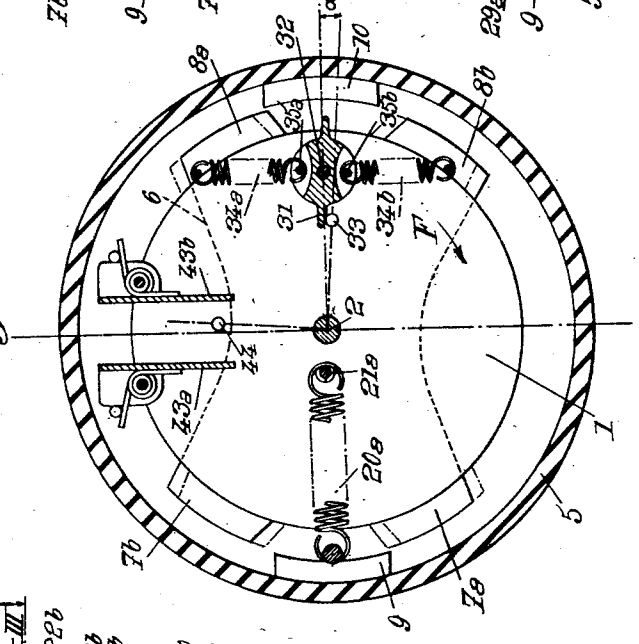
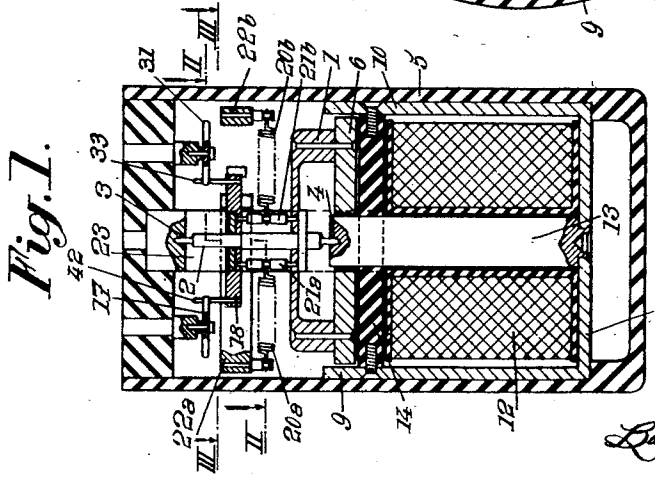


Fig. 1.



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Fig. 14

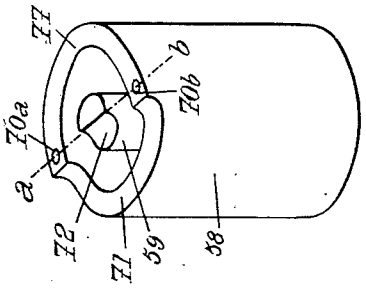


Fig. 12

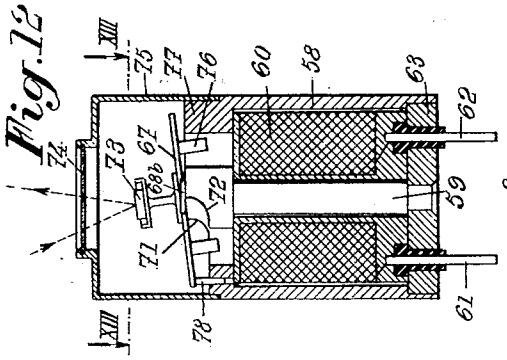


Fig. 13

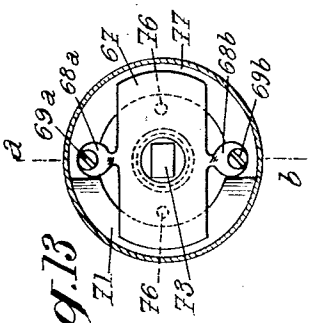


Fig. 10

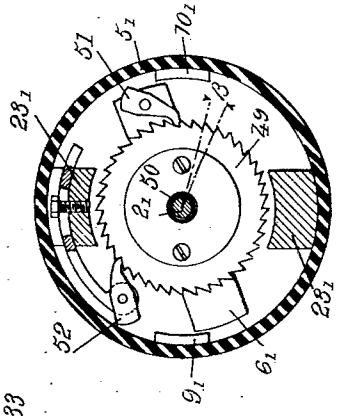


Fig. 11

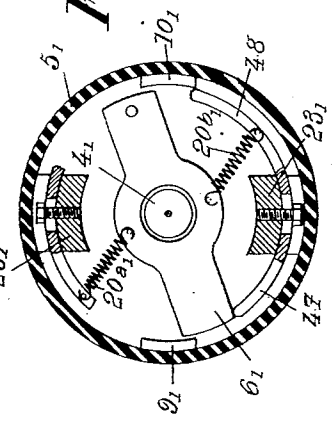


Fig. 5

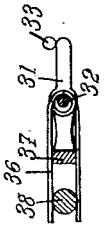


Fig. 6

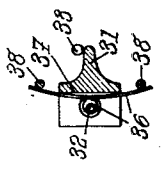
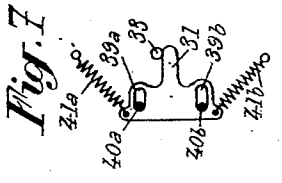


Fig. 7



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Fig. 9

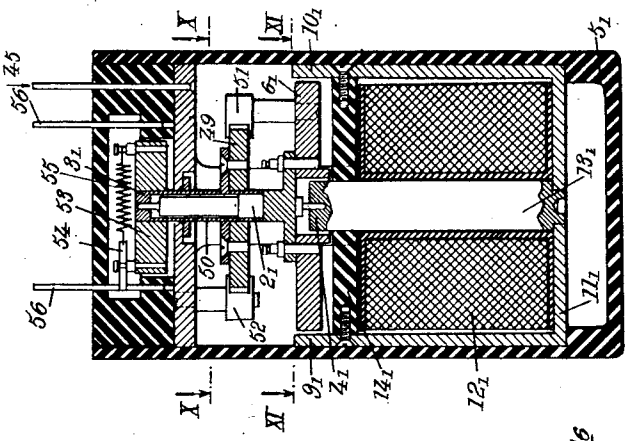
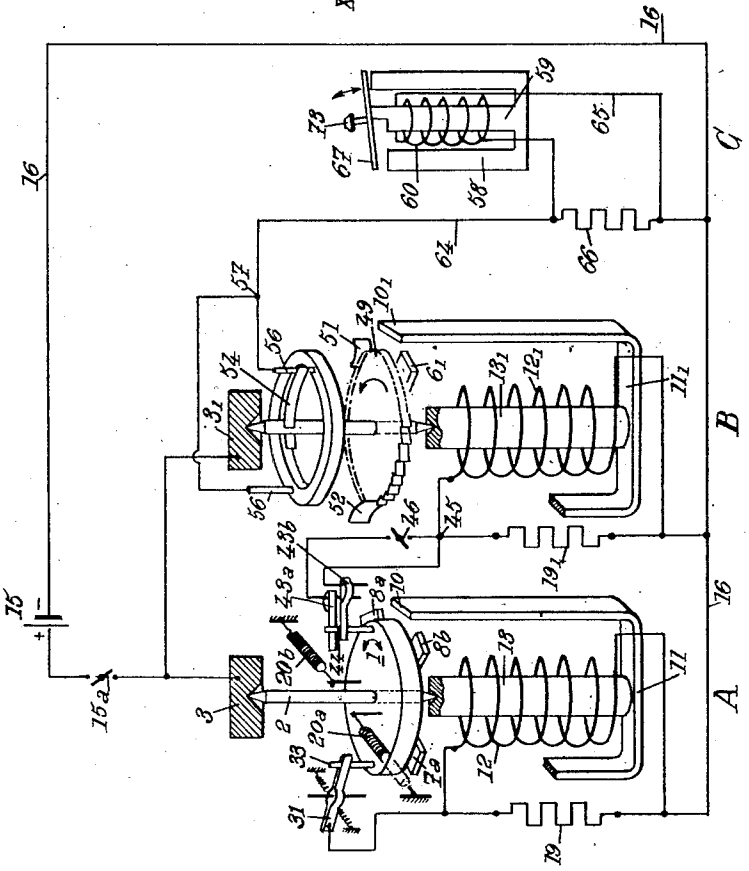


Fig. 8.



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MECHANICAL GENERATORS OF ISOCHRONOUS OSCILLATIONS

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Application July 12, 1954, Serial No. 442,646

Claims priority, application France July 31, 1953

8 Claims. (Cl. 310—39)

The present invention relates to precision apparatus including at least one pendulum oscillating about an axis and subjected to the action of resilient return means and means for transmitting rotation impulses to said pendulum to maintain the oscillating movement thereof.

My invention is more especially but not exclusively concerned with apparatus of this kind intended to be mounted on a moving body subjected to high axial accelerations, which is the case in particular of some apparatus (chronometric apparatus, frequency reducing relays, etc.), intended to be mounted in self-propelled missiles so as automatically to control the operation of other apparatus (signal transmitters, photographic or other cameras, recorders, igniting devices, etc.) either at a predetermined time or at predetermined time intervals.

The chief object of my invention is to provide a device of this kind which is better adapted than those used up to the present time to meet the requirements of practice and, in particular, which is not sensitive to high accelerations.

Preferred embodiments of my invention will be hereinafter described with reference to the accompanying drawings given merely by way of example and in which:

Fig. 1 is a diagrammatic axial sectional view of a chronometric apparatus made according to the invention.

Fig. 2 is a diagrammatic transverse section on an enlarged scale of this apparatus substantially on the line II—II of Fig. 1, the transmission contact being made according to a modification.

Fig. 3 is a transverse section on the line III—III of Fig. 1.

Fig. 4 shows, similarly to Fig. 3, the transverse section of an apparatus made according to a modification of Figs. 1 to 3.

Figs. 5 to 7 each show a different modification of a detail of Fig. 2.

Fig. 8 is a diagrammatic perspective view of the combination of a chronometric apparatus A, a frequency modifying relay B and a signal transmitter C, according to my invention.

Fig. 9 is an axial sectional view of a relay analogous to that of Fig. 8.

Figs. 10 and 11 are sectional views respectively on the lines X—X and XI—XI of Fig. 9.

Fig. 12 shows in axial sectional view a signal transmitter analogous to that of Fig. 8.

Fig. 13 is a sectional view on the line XIII—XIII of Fig. 12.

Fig. 14 is a perspective view of the detail of the core and of the magnetic armature of the apparatus of Fig. 12.

An apparatus made as shown by the drawing essentially includes a pendulum, means for sustaining the oscillating movement of said pendulum and means for resiliently urging this pendulum toward a middle angular position.

The pendulum is essentially constituted by a piece **1** (Figs. 1 and 2) preferably in the form of a body of revolution, rigid with a pivot axis or spindle **2** mounted in

bearings **3** and **4** provided in elements rigid with the casing **5** of the apparatus, which is made of an insulating material.

The means for maintaining the oscillating movement of pendulum **1** consist of a plate **6** rigid with pendulum **1** and made of soft iron or an analogous metal carrying, at 180° to each other, two pairs of symmetrical teeth **7***a* **7***b* and **8***a*, **8***b* and of two pole pieces **9** and **10** mounted at 180° to each other on casing **5**, said pole pieces forming the ends of a U-shaped armature **11**. Pole pieces **9** and **10** are periodically polarized by a coil **12** which is advantageously disposed along the axis of the casing, between the branches of armature **11**. A core **13**, disposed inside coil **12** and carried by the middle or bottom branch of armature **11**, and held at the top by a cross member **14**, extends through plate **6** in such manner as to make the pull in the axial direction practically negligible. Bearing **4** is provided in the end of said core **13**.

The periodically energizing circuit for coil **12**, which is diagrammatically shown on the left hand side of Fig. 8, includes a battery **15** or any other source of current the negative terminal (—) of which is connected through a conductor **16** with one of the terminals of the coil and the positive terminal (+) of which is connected with the other terminal of the coil through a switch **15***a*, bearing **3**, spindle **2**, pendulum **1** and oscillation maintaining contacts **33—31** adapted to close the electric circuit on every half-oscillation of the pendulum, either directly to the pendulum, or as shown by Fig. 1 through a plate **18** carried by spindle **2**. A resistance **19** may be mounted in shunt across the terminals of coil **12** in order to eliminate sparks between contacts **31—33**.

The resilient return means of the pendulum may be constituted as in watches or clocks by a spiral spring of great length. But this arrangement involves some drawbacks. In particular, the adjustment of the characteristics of the spring necessitates a modification of the length thereof and consequently causes a modification of the middle angular position of the pendulum with respect to the pole pieces, which modification requires a new adjustment. Furthermore, the central portion of the spiral spring is very flexible and an acceleration, even moderate, is capable of deforming it, thus modifying its characteristics and therefore preventing the apparatus from working correctly and even stopping it in the application which is being considered to moving bodies having a high axial acceleration.

In order to obviate these drawbacks, according to my invention, the means for resiliently returning the pendulum consist of a pair of springs mounted in opposition, such an arrangement being designated under the name of "push-pull" spring mounting.

Such a resilient return system can be adjusted by acting simultaneously upon the two springs of each pair and therefore without modifying the middle angular position of the pendulum. Furthermore, such a return system is practically unsensitive to high accelerations to which it may be subjected.

According to a first construction, I make use to constitute the return system for the pendulum of helical springs mounted in opposition by pairs and for instance to two such springs **20***a* and **20***b*, as shown by Fig. 1. These springs are fixed by one end to the pendulum along the same diameter thereof, preferably close to its axis of rotation, for instance to pins **21***a* and **21***b*, mounted between pendulum **1** and disc **18** and they are fixed at the other end to supports fixed to casing **5** in an adjustable manner.

These supports may be constituted as shown in detail by Fig. 3. They consist of small bars **22***a*, **22***b* which are fixed respectively to the two branches of a U-shaped

piece 23 carried by casing 5, the middle portion of this U-shaped piece being advantageously used to receive the bearing 3 of the pendulum. Bars 22*a*, 22*b* may be fixed on the U-shaped piece by means of screws 24*a*, 24*b* engaged in longitudinal grooves 25*a*, 25*b* provided in the bars. Screws 26*a*, 27*a* and 26*b*, 27*b* are provided to adjust the position of the bars and, when this adjustment has been made, to fix said bars in the desired position, the whole in order to adjust the strength of the springs 20*a*, 20*b*. Of course the springs might be mounted on supports making it possible to balance the two springs automatically and to adjust them simultaneously.

It should be noted that even if the electric contact between bearing 3 and pivot 2 is not very good, the feed circuit of coil 12 remains closed between said bearing and pendulum 1, through U-shaped member 23, bars 22, springs 20 and pins 21.

According to another construction, the means for resiliently returning the pendulum consist of V-shaped springs mounted in opposition by pairs, the system including for instance four such springs 28*a*, 28*b*, 28*c*, 28*d*, as shown by Fig. 4. These springs are preferably given a section which is flat in the direction perpendicular to their middle plane. These springs are fixed at one end to the pendulum along the same diameter, for instance by means of clips, 29*a*, 29*b* carried by the pendulum 1 (located above the plane of the section of Fig. 4), and at the other end to clips 30*a*, 30*b* carried by casing 5, for instance through U-shaped piece 23. Adjustment of the frequency of the pendulum can be obtained either by modifying the fixation of the springs on clips 29 and/or 30, or by means of masses adjustable in position in the radial direction on said movable system.

According to another feature of my invention which is supposed to be applied to an apparatus of the same kind as above referred to, including a pendulum the movement of which is maintained by the periodical energizing of a magnetic circuit, means are provided for giving the pendulum at rest a relative angular position with respect to the pole pieces such that energizing of the magnetic circuit starts the oscillating movement of said pendulum, the energizing circuit (which is closed for said position of rest) being automatically opened as soon as this oscillating movement is started.

According to an advantageous embodiment, said means are constituted by arranging the apparatus in such manner that in the state of rest the contacts of the energizing circuit for maintaining oscillation move the pendulum away from the balanced position it would assume under the only effect of its return system. Such a balanced position is shown for teeth 7 and 8 in dotted lines on Fig. 2 and in this position plate 6 would be disposed symmetrically with respect to pole pieces 9 and 10 and consequently the attraction forces on teeth 7 and 8 of plate 6 would balance each other without starting the oscillation movement if the energizing circuit were closed by means of switch 15*a*.

For this purpose, the oscillation maintaining contact includes the following elements:

On the one hand, a contact finger 31 carried by the casing 5 of the apparatus so that it can move with respect thereto with a rotating or analogous movement; for instance, this finger is pivoted about spindle 32 (Figs. 1 and 2) rigid with the casing;

And on the other hand, a contact stud 33 carried by the pendulum (for instance by plate 18 which is fixed with this pendulum), this stud being located for said balanced position in the plane passing through the pivot spindle 2 of the pendulum and the spindle 32 of the contact finger.

Contact finger 31 is subjected to the action of a return system which tends to bring it into the plane passing through axes 2 and 32. Due to the thickness of finger 31 and stud 33, the oscillation maintaining contact causes

the oscillating system and in particular disc 6 to rotate through an angle α either in the direction indicated by Fig. 2 or in the opposed direction, according as contact finger 31 is located on the side of stud 33 shown by the drawing or on the opposed side.

Thus, in the state of rest, that is to say when the energizing current is cut off by switch 15*a*, plate 6 can take either of two positions, both dissymmetrical with respect to pole pieces 9 and 10. If now the energizing circuit is closed through switch 15*a*, the disc is urged toward the magnetically balanced position of the system, that is to say in the direction of the arrow F Fig. 2. The oscillating movement is therefore truly started.

The resilient return means for contact finger 31 may be made in different ways:

According to a first construction, this return system is constituted in a fashion analogous to that of the oscillating system (pendulum), that is to say by means of two springs 34*a*, 34*b* in opposition (Fig. 2), these springs being preferably helical springs. One end of each of these springs is fixed to a pin 35*a*, 35*b* carried by contact finger 31 and the other end to a pin carried by casing 5.

According to another construction, the return system is constituted by a torsional spring 36 (Figs. 5 and 6) forming a loop around axis 32 and adapted to bear both upon a surface 37 rigid with finger 31 and upon at least one lug 38 rigid with casing 8. During operation, finger 31 is caused to swing and each of the branches of spring 36 bears alternately upon the fixed finger or one of the fixed fingers 38. As spring 36 is slightly prestressed, finger 31 is strongly urged toward the rest position that is shown, where it is then kept without being able to oscillate.

According to a third construction, finger 31 is provided with two slots 39*a*, 39*b* (Fig. 7) engaged on projections 40*a*, 40*b* carried by casing 5 and it is urged by two springs 41*a*, 41*b*. During operation, finger 31 swings and bears alternately upon pins 40*a* and 40*b* passing through the position of rest where it bears simultaneously upon both of these pins without being able to oscillate. This device gives a very short time of contact between finger 31 and stud 33, which is also favorable to a good operation of the apparatus.

According to still another feature of my invention, which is supposed in the present description to be applied to an apparatus such as above described, said apparatus is so arranged that its oscillating system and the resilient return means thereof are symmetrical with respect to the axis of oscillation of the pendulum and the centre of gravity of the whole of the pieces in movement remains substantially upon said axis.

Thus, in the construction illustrated by the drawings, the following elements are arranged in a symmetrical fashion with respect to the oscillation axis: pendulum 1, spindle 2, plate 6, disc 18, fingers 33 on the one hand, and springs 20 with their pins 21 on the other hand.

When the apparatus is mounted on a movable body, such as a self-propelled missile, subjected to high axial accelerations, said axis of oscillation of the system is disposed parallel to the direction along which these axial accelerations are produced, whereby the apparatus according to my invention is protected against the action of these accelerations and the oscillations are perfectly regular.

A chronometric apparatus as above described works in the following manner:

In the state of rest, switch 15*a* being open, the oscillating system occupies, as above explained, the position shown on Fig. 2 (or a position symmetrical with respect thereto). When switch 15*a* is closed, the oscillating movement is started in the direction of arrow F. Stud 33 passes beyond finger 31 and contact between 31 and 33 is then cut off. Current ceases to flow through the circuit. The pendulum keeps moving against the action

of springs 20*a*, 20*b*, then stops under the effect of these springs and returns in the opposed direction, also under this action. Contact is again established for a very short time between finger 31 and stud 33, this stud being then above finger 31. The plate then occupies a position which is dissymmetrical with respect to pole pieces 9 and 10 and it is urged in the direction which accelerates its movement. The oscillating movement is thus constantly maintained as long as switch 15*a* remains closed. Thus, two contacts and two pulls are obtained for every cycle or period.

The advantages of this apparatus are in particular as follows:

It is not responsive, from the point of view of the frequency of oscillations, to the action of accelerations which may be as high as 150 *g* and parallel to the axis of oscillation of the system. Starting of the device is automatic and its frequency adjustment is very accurate. Its construction is very compact so that it can be mounted in a sealed bulb under vacuum or in an inert atmosphere.

Such a chronometric apparatus may be used as a clock or watch by associating thereto any device for transforming the oscillating movement into a circular movement, as well known in the art.

However, such an apparatus is preferably used to transmit signals of a frequency equal to the frequency of oscillation or to twice this oscillation frequency, for which purpose for instance I make use either of transmission contacts 42—17 (Fig. 1) analogous to oscillation maintaining contacts 33—31, or of two elastic contacts 43*a*, 43*b* (Figs. 2 and 8) cooperating with a contact 44 carried by pendulum 1, the oscillating system being itself connected twice per cycle to the positive terminal of battery 15. In this last case, if contacts 43*a*, 43*b* are connected together through a circuit leading to a point 45 (Fig. 8) and provided with a switch 46, it is possible to receive at this point one or two impulses per cycle according as switch 46 is opened or closed.

The impulses thus transmitted may be either used directly to start the utilization apparatus (signal transmitters, photographic cameras, recorders, etc.), or sent to apparatus for dividing or possibly multiplying the frequency, the impulses emitted in turn by these last mentioned apparatus being then capable of starting utilization apparatus.

For instance, I may associate with the chronometric apparatus A (Fig. 8) a frequency divider B, the impulses emitted by this last mentioned apparatus being sent to a utilization apparatus such as an optical signal transmitter C.

Concerning the frequency divider B, it advantageously includes an oscillating member analogous to that of apparatus A, the oscillations of which are maintained by impulses transmitted from said apparatus A.

The elements of the frequency divider which are analogous to those of the chronometric apparatus have been designated by the same numerals with index 1 (Figs. 9 to 11). Plate 6_1 can oscillate between two adjustable abutments 47 and 48 (Fig. 11). Opposed springs $20a_1$ and $20b_1$ urge the plate toward abutment 47.

Coil 12_1 is connected on the one hand directly to point 45 and on the other hand to the negative terminal of battery 15 through wire 16, without making use of course of an oscillation maintaining contact. It will be understood that the impulses received by coil 12_1 cause the plate to turn toward its abutment 48.

Disc 6_1 is provided with pawl and ratchet means capable of transforming its oscillation movement into an intermittent rotary movement, these means including for instance a ratchet wheel 49 (Fig. 10) mounted on a hollow shaft 50 so as to be able to rotate with respect to spindle 2_1, a pawl 51 mounted on the plate and adapted to drive the ratchet wheel in a predetermined direction, and finally an adjustable pawl 52 carried by U-shaped member 23_1 and adapted to prevent rotation of the ratchet wheel in the opposed direction. Bearing 3_1 is provided inside hollow shaft 50.

At the upper part of hollow shaft 50, there is fixed a plate 53 on which is disposed a rotary distributor including a transmission contact finger 54 journalled on plate 53 and urged radially by a helical spring 55, this contact finger cooperating with one or several studs 56 carried by the insulating casing 5_1.

By way of modification, the transmitting contact may be established in a fashion analogous to the oscillation maintaining contact 17 of the chronometric apparatus.

This frequency dividing apparatus works in the following manner:

On every impulse received at point 45, plate 6_1 has a to and fro movement and ratchet wheel 49 turns through an angle β equal to a fraction $1/n$ of one revolution, n being the number of teeth of ratchet wheel 49, which therefore makes one revolution for n impulses. On every stud 56, there is received only one impulse for the n impulses received at point 45. If p studs 56 are provided, p being a sub-multiple of n and said studs being distributed at equal distances on casing 5_1 and connected together at a point 57, there is received at this point only p impulses on the n impulses received at point 45. It is thus possible to obtain a frequency division according to a ratio p/n, which ratio can be determined at will and by suitably choosing the number of teeth of the ratchet wheel 49 and the number of studs 56 connected together.

The advantages of such a frequency dividing apparatus are as follows:

It has a longitudinal axis in the direction of which all the movable pieces are adapted better to resist mechanically to accelerations. Its elastic systems are themselves protected against said accelerations. Therefore in an apparatus mounted on a body subjected to high axial accelerations, the frequency dividing apparatus will be disposed so that said axis thereof is parallel to the direction of said accelerations. Therefore it has a compact shape making it possible to mount it in a sealed bulb under vacuum or in an inert atmosphere.

Finally, the utilization apparatus C to be energized by the impulses transmitted from the frequency dividing apparatus B (or possibly directly by chronometric apparatus A) preferably includes a pendulum subjected to resilient return means and said utilization apparatus is arranged in such manner that its oscillating system and the resilient return means for this system have their centre of gravity substantially on said axis.

It is essentially constituted by a cylindrical armature 58 and a central core 59 between which there is disposed a coil 60 (Figs. 8 and 12 to 14). This coil is fed, through insulated terminals 61, 62 extending through the bottom 63 of the apparatus, on the one hand by means of a wire 64 connected to the point 57 of the frequency dividing apparatus and on the other hand by means of a wire 65 connected to a negative terminal of battery 15 through for instance wire 16. A reactance may be provided in parallel with coil 60.

The oscillating system of the apparatus is advantageously constituted by a plate 67 which is fixed by its opposed ends 68*a*, 68*b* to armature 58, by means for instance of screws 69*a*, 69*b* engaged in screw-threaded holes 70*a*, 70*b* provided in said armature. The body of plate 67 is connected to its ends 68*a*, 68*b* through thinner portions which enable most of the plate to oscillate substantially along an axis *ab* passing through the heads of fixation screws 69*a*, 69*b*.

I provide on the ends of armature 58 and core 59 recessed portions 71 and 72 intended both to limit the zone of attraction of the armature on the plate to the portion of the armature which is not recessed and to enable most of the plate to rotate about axis *ab*.

The external face of the plate carries a mirror 73 capable of reflecting the light rays transmitted into the apparatus through a transparent window 74 provided in

the cap 75 which constitutes with armature 58 and bottom 63 the casing of the apparatus. On the other face of the apparatus, I provide masses 76 adapted to balance the mirror 73 and its support so that the centre of gravity of the whole oscillating system (which also forms its own return system) is brought back onto the axis of oscillation *ab*.

By way of modification, the plate might be pivoted on an axis and fitted with an independent return system.

The operation of the apparatus is as follows: Upon every signal transmission from coil 60, the portion 77 of the armature 58 attracts the corresponding portion of plate 67. At the end of the signal transmission, the plate is returned by its own elasticity against its abutment 78 (Fig. 12) provided on the recessed portion 71 of the armature. This oscillation has for its effect to change the inclination of the light rays reflected by mirror 73, which may sensitize a recording band.

The advantages of this apparatus are in particular the simplicity of its construction and the fact that it is not responsive to high accelerations whatever be their direction.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

What I claim is:

1. A mechanical generator of isochronous oscillations which comprises, in combination, a casing, a pendulum journalled in said casing about an axis fixed with respect to said casing, spring means interposed between said casing and said pendulum to cause oscillation of said pendulum about said axis at a frequency determined by said spring means, electro-magnetic means carried by said casing, for periodically transmitting rotation impulses in opposed directions to said pendulum about said axis to maintain the oscillating movement thereof, means carried by said casing and responsive to the oscillation of said pendulum for controlling said electro-magnetic means, the whole of the moving parts of said apparatus having its centre of gravity on said axis, and said pendulum and said means being symmetrical about said axis, said spring means being arranged for constantly urging said pendulum toward a mean position thereof, said electro-magnetic means being adjusted to act on said pendulum as it is passing through said position, and means for biasing said pendulum in either direction with respect to said position.

2. For use on a body having a longitudinal axis and intended to undergo high accelerations in the direction of said axis, a mechanical generator of isochronous oscillations which comprises, in combination, a casing, a pendulum journalled in said casing about an axis fixed with respect to said casing, spring means interposed between said casing and said pendulum to cause oscillation of said pendulum about said axis at a frequency determined by said spring means, electro-magnetic means carried by said casing, for periodically transmitting rotation impulse in opposed directions to said pendulum about said axis to maintain the oscillating movement thereof, means carried by said casing and responsive to the oscillation of said pendulum for controlling said electro-magnetic means, the whole of the moving parts of said apparatus having its centre of gravity on said axis, and said pendulum and said means being symmetrical about said axis, said spring means being arranged for constantly urging said pendulum toward a mean position thereof, said electro-magnetic means being adjusted to act on said pendulum as it is passing through said position, and means for biasing said pendulum in either direction with respect to said position.

3. For use on a body having a longitudinal axis and intended to undergo high accelerations in the direction of said axis, a mechanical generator of isochronous oscillations which comprises, in combination, a casing, a pendulum journalled in said casing about an axis fixed with respect to said casing, spring means interposed between said casing and said pendulum to cause oscillation of said pendulum about said axis at a frequency determined by said spring means, electro-magnetic means carried by said casing, for periodically transmitting rotation impulse in opposed directions to said pendulum about said axis to maintain the oscillating movement thereof, means carried by said casing and responsive to the oscillation of said pendulum for controlling said electro-magnetic means, the whole of the moving parts of said apparatus having its centre of gravity on said axis, and said pendulum and said means being symmetrical about said axis, said spring means being constituted by at least two springs mounted in opposition, that is to say in push-pull fashion, said spring means being arranged for constantly urging said pendulum toward a mean position thereof, said electro-magnetic means being adjusted to act on said pendulum as it is passing through said position, and means for biasing said pendulum in either direction with respect to said position.

4. For use on a body having a longitudinal axis and intended to undergo high accelerations in the direction of said axis, a mechanical generator of isochronous oscillations which comprises, in combination, a casing, a pendulum journalled in said casing about an axis fixed with respect to said casing, spring means interposed between said casing and said pendulum to cause oscillation of said pendulum about said axis at a frequency determined by said spring means, electro-magnetic means carried by said casing, for periodically transmitting rotation impulse in opposed directions to said pendulum about said axis to maintain the oscillaing movement thereof, means carried by said casing and responsive to the oscillation of said pendulum for controlling said electro-magnetic means, the whole of the moving parts of said apparatus having its centre of gravity on said axis, and said pendulum and said means being symmetrical about said axis, said spring means being constituted by at least two helical springs mounted in opposition, that is to say in push-pull fashion, said spring means being arranged for constantly urging said pendulum toward a mean position thereof, said electro-magnetic means being adjusted to act on said pendulum as it is passing through said position, and means for biasing said pendulum in either direction with respect to said position.

5. For use on a body having a longitudinal axis and intended to undergo high accelerations in the direction of said axis, a mechanical generator of isochronous oscillations which comprises, in combination, a casing, a pendulum journalled in said casing about an axis fixed with respect to said casing, spring means interposed between said casing and said pendulum to cause oscillation of said pendulum about said axis at a frequency determined by said spring means, electro-magnetic means carried by said casing, for periodically transmitting rotation impulse in opposed directions to said pendulum about said axis to maintain the oscillating movement thereof, means carried by said casing and responsive to the oscillation of said pendulum for controlling said electro-magnetic means, the whole of the moving parts of said apparatus having its centre of gravity on said axis, and said pendulum and said means being symmetrical about said axis, said spring means being constituted by at least two V-shaped springs mounted in opposition, that is to say in push-pull fashion, said spring means being arranged for constantly urging said pendulum toward a mean position thereof, said electro-magnetic means being adjusted to act on said pendulum as it is passing through said position, and means for biasing said pendulum in either direction with respect to said position.

6. A mechanical generator of isochronous oscillations which comprises, in combination, a casing, a pendulum journalled in said casing about an axis fixed with respect to said casing, spring means interposed between said casing and said pendulum to cause oscillation of said pendulum about said axis at a frequency determined by said spring means, electro-magnetic means carried by said casing, for periodically transmitting rotation impulses in opposed directions to said pendulum about said axis to maintain the oscillating movement thereof, means carried by said casing and responsive to the oscillation of said pendulum for controlling said electro-magnetic means, the whole of the moving parts of said apparatus having its centre of gravity on said axis, and said pendulum and said means being symmetrical about said axis, said electro-magnetic means comprising an oscillating member rigid with said pendulum and symmetrical about a plane passing through said axis, a magnetic circuit fixed on said casing and including two pole pieces located on either side of said oscillating member for imparting rotation impulses thereto, a coil for energizing said pole pieces, an electric circuit for feeding current to said coil, said pole pieces being shaped and energized to produce a field the resultant of which is along a diametral line passing through said axis and at right angles thereto, said spring means being arranged for constantly urging said pendulum toward a mean position thereof, where said plane of symmetry of said oscillating member passes through said resultant, said electro-magnetic means being adjusted to act on said pendulum as it is passing through said mean position, and means for biasing said pendulum in either direction with respect to said position.

7. A generator according to claim 6 in which said means for controlling said electro-magnetic means include two contacts, one carried by said pendulum and the other resiliently mounted in said casing, inserted in said electric circuit for feeding said coil, the means for biasing said pendulum being constituted by said resiliently mounted contact.

8. In combination, a mechanical oscillation generator according to claim 1, an electric feed circuit, means operative by said pendulum for opening and closing said feed circuit to produce current pulses therein, and a motor fed with current from said circuit and including speed reducing gear means.

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