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ELECTROMAGNETIC TIMING DEVICE

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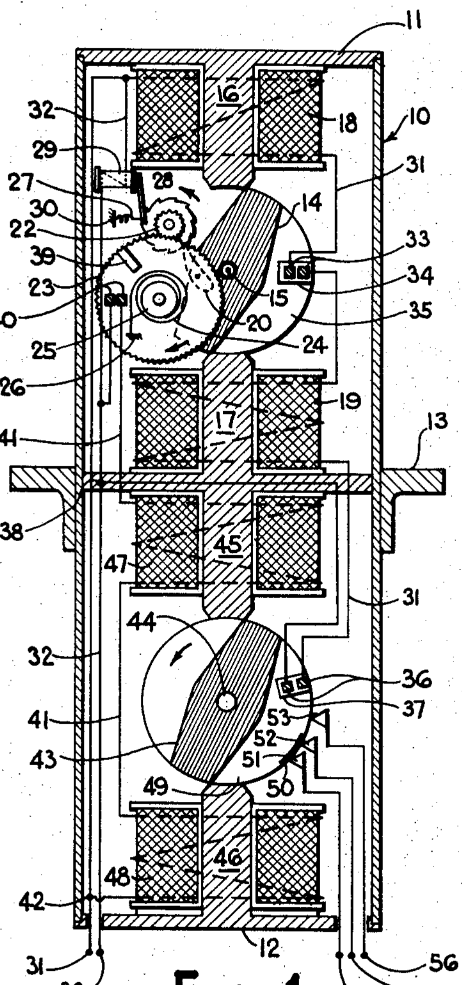

FIG. 1

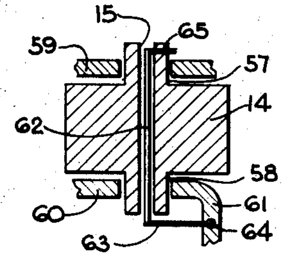

FIG. 2

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ELECTROMAGNETIC TIMING DEVICE

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This invention generally relates to a timing device, and more particularly concerns an electromagnetic actuated timing device for particular application in aircraft structures, guided missiles, and other equipments which may be subject to unusual environmental conditions.

It is well known that components which are incorporated in aircraft or missile structures must meet rigid specifications with respect to vibration and accelerating forces. In addition, specific electrical components must function properly despite poor regulation in the particular power supply employed. With respect to this latter requirement, timing devices of various types have presented serious design problems in view of the fact that variations in the voltage level oftentimes cause a malfunction of the particular timing device and a consequent serious error in the operation of other components which are dependent for their accuracy on the timing sequence established.

In addition, in certain applications it is desirable that the timing device employed result in a given output of mechanical energy in addition to timing signals. A consequent problem has been the realization of relatively high energy output without adversely affecting the primary timing function.

It is, therefore, an object of the present invention to provide a timing device which will operate satisfactorily regardless of unusual accelerating or vibrational forces to which it may be subjected.

Another object of the present invention is to provide an electromagnetic timing device which will provide a high degree of accuracy regardless of variations in the voltage level assuming a given lowest expected voltage level.

A still further object of the present invention is to provide an electromagnetic timing device which can be incorporated in structures so as to directly switch or control low current circuits, or in the alternative actuate a relay for high current switching.

A still further object of the present invention is to provide an electromagnetic timing device which may be simply and economically constructed with a minimum number of wearing parts, and yet which embodies features resulting in an overall rugged component functioning with a high degree of accuracy over an extended period of time.

These and other objects and advantages of the present invention are attained by providing an electromagnetic timing device generally comprising an armature balanced for rotation about a given axis. Electromagnetic means are provided in the device and positioned so as to be adapted to effect angular movement of the armature from a first given or normal position to a second given or actuated position. Force means are further provided and coupled to the armature in a manner such that the force means act to return the armature to the first position as soon as the armature attains the second position. Thus, a reciprocating motion is imparted to the armature as a

result of a co-operating functioning of the electromagnetic means and the force means employed.

Contact means are further included which are movably actuated in response to the movement of the armature. Preferably, the contact means functions to de-energize the electromagnetic means as soon as movement of the armature has taken place, whereby the force means acts to decelerate and finally cause a reverse angular movement of the armature. Auxiliary contact means actuated by movement of the armature may in turn be connected so as to operate a relay or to directly switch a low current circuit after a given interval of time.

In one construction, the force means employed comprises an elongated torsion bar rigidly secured at one end to a stationary part of the device and having its other end adapted to rotate a limited angular degree in response to movement of the armature by the electromagnetic means. With such a design, the torsion bar effects the return of the armature to the first given or normal position at a rate generally proportional only to the mass of the armature involved and the constant of torsion of the particular torsion bar employed. With such a system, a very high degree of resonance may be obtained with a subsequent high level of accuracy.

It is to be understood that although the timing device of the present invention has been generally described as adapted to aircraft and missile applications that it additionally has many other uses, for example, in intervelometers, program timers, repeat cycle timers, extended duration timers, time pulse generators and in time sequence devices. These latter components may be incorporated in moving structures or constructed in stationary equipment.

A better understanding of the present invention will be had by reference to the drawings, showing an illustrative embodiment, and in which:

Figure 1 is a sectional view of the timer of the present invention, partially schematic, showing the timer, as combined to co-function with a relay device; and

Figure 2 is an illustrative cross sectional view of the timing device armature of Figure 1 and its co-operating structural relationship to the torsion bar employed in conjunction therewith.

Referring now to Figure 1 of the drawings, there is shown generally a housing **10**. The housing **10** is provided with an upper end closure **11** and a lower end closure **12**, as viewed in Figure 1. Balanced mounting of the housing **10** may be accomplished as with the bracket **13** secured to the housing **10** about its mid-portion or center of gravity.

The timing device is located in the upper part of the housing **10**, as viewed in Figure 1, and includes an armature **14** designed to rotate about a given axis generally defined by a bore **15** extending therethrough. Poles **16** and **17** are positioned one on each side of the armature and are adapted to be magnetically energized by coils **18** and **19**, respectively.

The armature **14**, in one form, has rigidly attached and pivotably mounted thereon a ratchet arm **20** located so as to actuate a transmission or driving means through a ratchet gar **21**. The ratchet arm **20** is necessarily spring biased (the spring not being shown), towards the position of Figure 1. Thus, in the view of Figure 1, the ratchet gear **21** will move in the direction of the arrow adjacent thereto in response to movement of the armature in a limited clockwise direction about its axis.

The ratchet gear **21** has concentrically mounted therewith a pinion **22** meshed with a gear **23** so that movement of the pinion **22** in the direction of the arrow or counter-clockwise in the view of Figure 1 will in turn effect movement of the gear **23** in a clockwise direction as indicated by the arrow thereon. A clock spring or the like 24 is secured to the central portion of the gear 23 about its axis 25 and has one of its ends rigidly attached to the device as indicated schematically at 26. Thus, as the gear 23 rotates in a clockwise direction the spring 23 is designed to be tensioned so as to create a force tending to bias the gear to move in an opposite counter-clockwise direction for a purpose that will become clearer as the specification proceeds.

Another spring 27 is positioned near the ratchet gear 21 and is attached to one end of a lever arm 28 which, in the position shown, locks the ratchet gear 21 against movement in a clockwise direction. In consequence, despite the biasing action of the spring 24 as the gear 23 rotates in a clockwise direction, the lever arm 28 will prevent any movement of the gear 23 in a counter-clockwise direction in view of the meshing of the pinion 22 with the gear 23.

The lever arm 28 is centrally pivoted and has its other end positioned so as to be held by a magnetic coil or solenoid 29. In the view of Figure 1, this solenoid is shown as being energized such that the core thereof magnetically retains one end of the arm 28 forcing the other end of the arm 28 to lock with the ratchet gear 21 and prevent clockwise rotation thereof. The spring 27 may similarly have one of its ends rigidly secured to the device as indicated at 30.

The initial operation of the timing device is accomplished through electrical power applied to leads 31 and 32 extending through the lower end closure 12 of the housing 10. Lead 31, in the schematic view of Figure 1, runs the length of the housing 10, is connected across the coil 18 through a pair of main stationary contacts 33 shown in the normally closed position with a movable contact 34. The lead 31 is thereafter connected across the other coil 19 of the timing device. Moving contact 34 may be positioned, for example, on a disc 35 adapted for movement with the armature 14.

In the illustrative application shown, the lead 31 after being connected across the coil 19 extends to connect through a pair of stationary contacts 36, shown in a normally closed position, with movable contact 37, and thereafter returns to communicate with the other lead 32 at a terminal point 38.

Mounted on the gear 23 is a movable contact 39, which is adapted to rotate with the gear 23, according to a given interval of time, and finally come into engagement with auxiliary stationary contacts 40.

The relay structure in the lower part of the housing 10, as viewed in Figure 1, may also include an armature 43 designed to rotate about a central axis 44. The armature 43 is disposed between poles 45 and 46, encircled by coils 47 and 48, respectively. The armature 43 may similarly have co-axially mounted therewith an insulating disc 49, on which is mounted the movable contact 37, as heretofore mentioned, and in addition another peripheral moving contact 50. The moving contact 50 is shown as engaging two of the stationary contacts 51, 52 and 53, connected respectively to leads 54, 55 and 56. In the view of Figure 1, the movable contact 50 is more specifically shown as contacting stationary contacts 51 and 52. Thus, the movable contact 50 either engages the contacts 51 and 52 or the contacts 52 and 53 for a three pole double throw switching arrangement.

An important feature of the present invention resides in the force means employed to return the armature 14 of the timing device from a second position in which it is aligned with the poles 16 and 17 to the first position or normal position as shown in Figure 1. For this purpose, in the preferred form, a torsion bar is employed. In one illustrative embodiment, a configuration may be used as shown in Figure 2. In this view, the armature 14 is shown as including an upper hollow shaft extension 57 and a lower hollow shaft extension 58 having an inner diameter defined by the bore 15 as heretofore mentioned. The shaft extensions 57 and 58 may be mounted in sleeve bearings 59 and 60, for example. The bearing 60 may be provided with a depending arm 61 securely attached to some stationary portion of the housing 10.

Extending axially through the bore 15 is a torsion bar 62 which may be in the form of a wire or the like having a lower arm extension 63 rigidly secured to the depending arm 61 as with a screw shown at 64. The other end of the torsion bar 62 is provided with an angular extension 65 secured to the upper hollow shaft extension 57. It will be appreciated with such a construction that as the aramature 14 rotates from the position shown in Figure 1 to the position aligned with the poles 16 and 17, the torsion bar 62 is rotated through an angle such that an increasing force is imposed on the armature 14 through the shaft extension 57 tending to return it to the initial position shown in Figure 1, the force being proportional to the degree of angular movement and the constant of torsion of the member 62.

In operation as soon as power is applied to leads 31 and 32, current will flow through the lead 31 to energize the coils 18 and 19, by passing through the stationary contacts 33 and 36, which are normally closed by the movable contacts 34 and 37, respectively. In addition, the solenoid 29 will be energized since it is connected across the leads 31 and 32. The energization of the solenoid will force the lever arm 28 to the position as shown, locking the ratchet gear 21 against clockwise rotation.

With the energization of the poles 16 and 17, a relatively high torque will be imposed on the armature 14 tending to angularly rotate it in a counter-clockwise direction to align it with the poles 16 and 17. The torque will gradually decrease until the armature rotates from the first position as shown to the second position wherein it is aligned with the poles 16 and 17.

As the armature 14 moves towards the second position, will in turn cause movement of the disc 35 to rotate the moving contact 34 away from the stationary contacts 33. As a consequence, de-energization of the coils 16 and 17 will take place as soon as the armature 14 commences to move towards the second position.

While the movement of the armature is occurring, it is also apparent that the torsion bar 62 will be rotated to build up a force means tending to return the armature 14 to the original position as shown in Figure 1. The amplitude of movement of the armature 14 will depend upon the magnitude of electromagnetic force applied as well as upon the constant of torsion of the member 62 and the mass of the armature, as heretofore stated. As soon as the torsion bar 62 begins returning the armature 14 towards its first position, the ratchet arm 20 will actuate the ratchet gear 21, to in turn rotate the pinion 22 and drive the gear 23 through a given angular degree of rotation. As the resultant oscillatory movement of the armature 14 continues, its reciprocating action will continuously drive the ratchet gear 21 so as to rotate the gear 23 and in turn the moving contact 39 thereon. When the moving contact 39 has moved through an arc of approximately 340°, as shown in Figure 1, for example, it will finally come into engagement with the stationary contacts 40. At this instance, the spring 25 will also be wound up so as to be imposing a return force on the gear 23 tending to rotate it in a counter clockwise direction, limited only by the locking lever 28 on the ratchet gear 21.

As soon as contact is established across the stationary contacts 40, the circuit 41 will be closed so as to energize the relay coils 47 and 48. The coils 47 and 48 will then effect movement of the relay armature 43 from the position as shown to a position aligned with the poles 45 and 46. As a consequence, the insulating disc 49 will force the moving contact 37 thereon out of engagement with the stationary contacts 36 and break the circuit 31 energizing the timer coils 16 and 17 to stop the timer. At the same instance, the disc 49 will move the peripheral moving contact **50** from its position engaging stationary contacts **51** and **52** to a position engaging contacts **52** and **53** whereby switching of a particular circuit is accomplished. In the meanwhile, the locking lever arm **28** continues to hold the timing gear **23** in its original position. Upon interruption of electric power which may be applied to the leads **31** and **32**, the arm **28** will be pivoted by de-energization of the solenoid under the action of the spring **27**, whereby the gear **23** will rotate back to its original position, so that the timing mechanism is reset and again in a position to operate.

Although a particular application has been illustrated for the purposes of describing the invention, it will be appreciated that many modifications and changes may be made within the scope of the invention without departing from the basic features thereof. Thus, it is evident that if high current switching is not required that the relay construction shown in the lower portion of the housing **10** may be eliminated, and the stationary contacts **40** may be directly connected to the circuit to be switched. It is also evident that only one form of possible mechanical means for driving the movable contact **39** has been shown, the desired result being merely to relate the reciprocating or oscillating movement of the armature **14** to some kind of responsive movement of contact means either by step by step rotating transmission or other drives suitable for timing purposes. The timing cycle can, of course, be changed by varying the position of the moving contact **39** on the gear **23** as well as by varying the particular transmission or driven means employed. The torsion bar **62** may be altered in its dimensions or construction in order to tune the device to the time frequency desired.

By providing a design such that the poles **16** and **17** are saturated at the lowest voltage level expected in the particular application, it will be appreciated that regardless of any upward increments of voltage no force increase will occur in the movement of the armature **14**. Further, by providing a balanced armature **14** designed to rotate a given angular degree about its axis, the functioning of the apparatus is not materially affected by gravitational or vibrational forces since these forces are distributed equally throughout the whole timing device.

The timing device of the present invention is of particular importance in conjunction with direct current systems, whereby any predetermined timing frequency may be established. On the other hand, this timing device may also be incorporated in alternating current systems by merely eliminating the contacts **33** and **34** such that a synchronous timer results according to the A.C. frequency applied to the leads **31** and **32**.

The following claims are meant to cover the changes and modifications that will be apparent to those skilled in the art without departing from the basic principles of the invention as heretofore set forth.

What is claimed is:

1. An electromagnetic timing device comprising: an armature balanced for rotation about a given axis; electromagnetic means in said device adapted to effect movement of said armature from a first position to a second position; force means co-axially coupled to said armature, said force means acting to return said armature from said second position to said first position; main circuit means connected from a source of electric power to said electromagnetic means; first contact means in said main circuit means normally closed when said armature is in said first position; movable means coupled for movement with said armature, said movable means effecting an opening of said first contact means in response to movement of said armature from a first position to a second position, whereby said force means may freely return said armature to said first position; and, rotatable driven means coupled for angular step-wise rotation in a given direction from an initial position in response to movement of said armature from said first position to said second position.

2. An electromagnetic timing device, according to claim 1, in which second normally open contact means are provided in said main circuit means; and, in which said rotatable driven means is designed to close said second contact means after a given total of said angular step-wise rotations; and, auxiliary circuit means connected to said source of electric power in response to closure of said second contact means.

3. An electromagnetic timing device, according to claim 1; auxiliary force means biasing said rotatable means towards rotation in an opposite direction; and, locking means in said main circuit means locking said rotatable means against rotation in said opposite direction.

4. An electromagnetic timing device, according to claim 3, and releasing means responsively unlocking said locking means after a given total of said angular step-wise rotations, whereby said rotatable means may return under the biasing action of said auxiliary force means to said initial position.

5. An electromagnetic timing device, according to claim 1, and auxiliary circuit means opening said main circuit means after a given total of said angular step-wise rotations.

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