March 25, 1969 W. J. LOHNINGER 3,434,424

ELECTROMECHANICAL FUZE TIMER REGULATION

Filed Oct. 28, 1966 Sheet 1 of 5

Fig. 1.

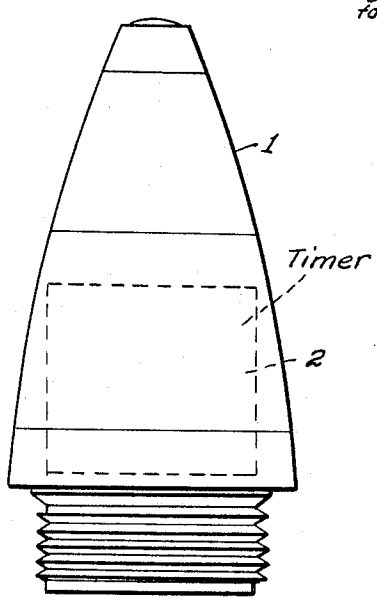


Fig. 2.

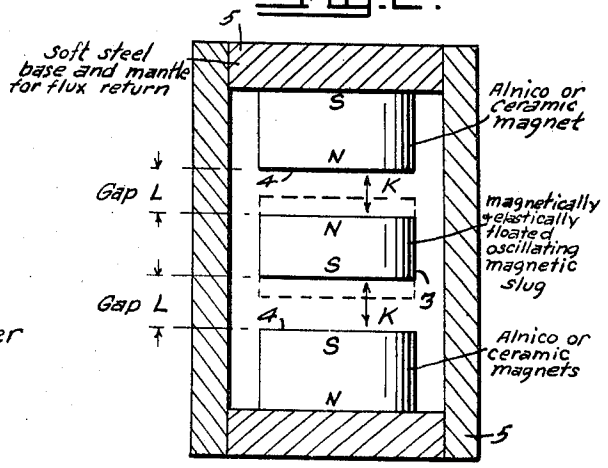


Fig. 4.

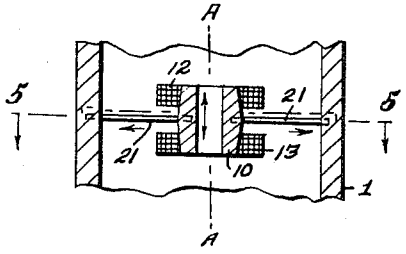


Fig. 3.

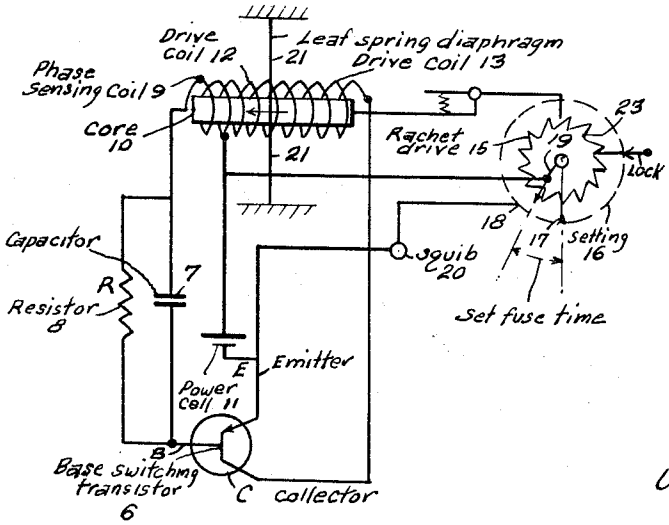
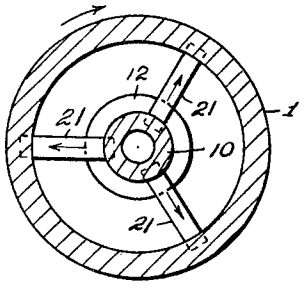


Fig. 5.



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ELECTROMECHANICAL FUZE TIMER REGULATION

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Fig. 7.

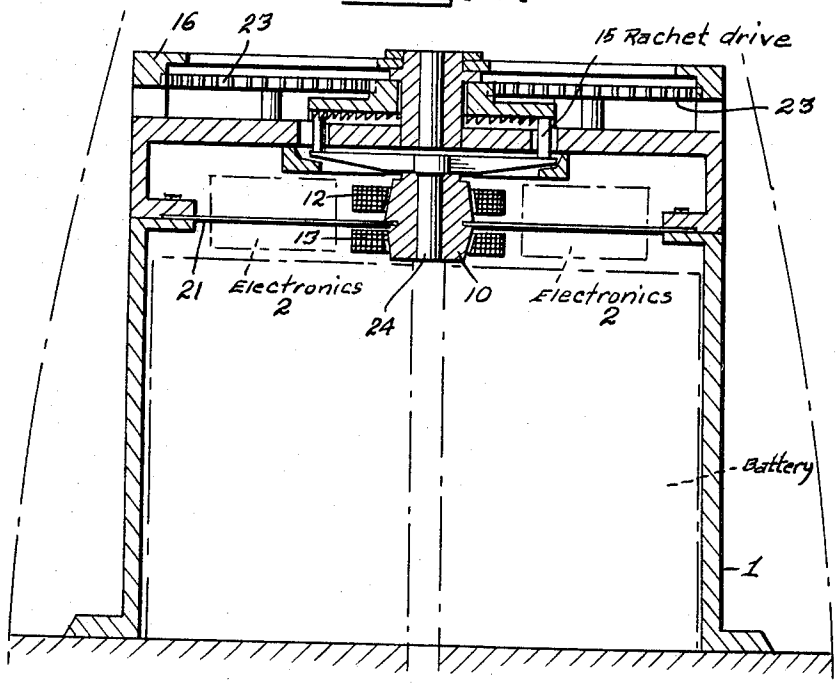


Fig. 10.

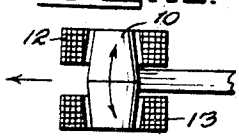


Fig. 8.

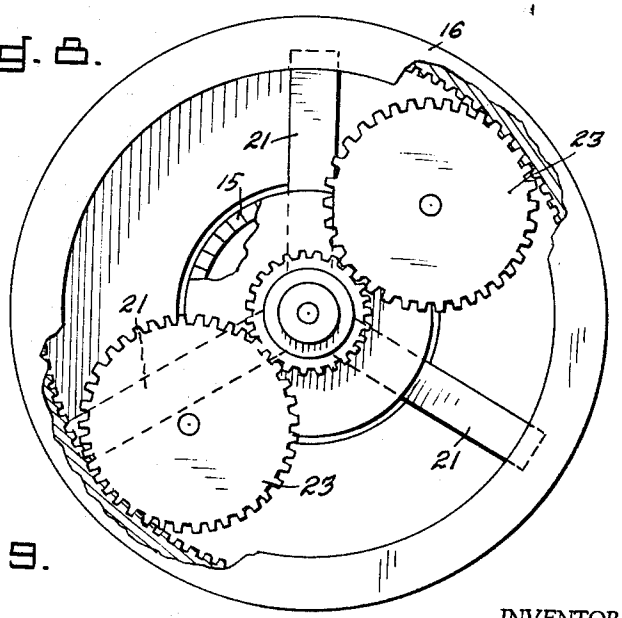


Fig. 6.

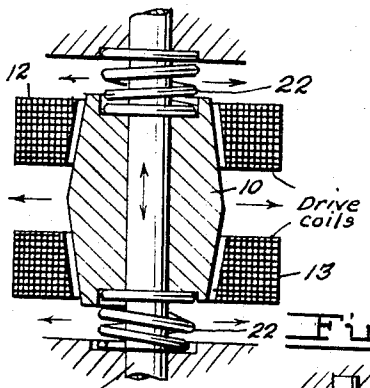
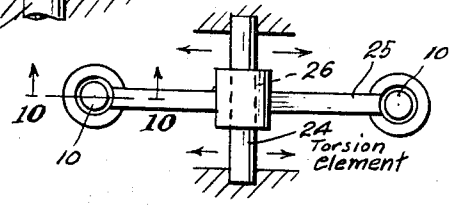


Fig. 9.



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ELECTROMECHANICAL FUZE TIMER REGULATION

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Fig. 11.

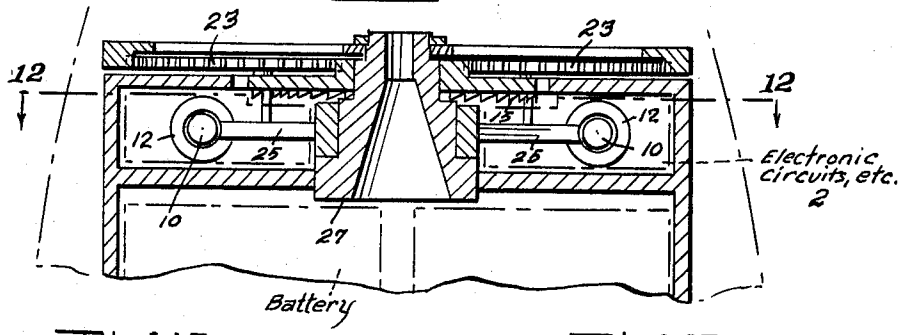


Fig. 12.

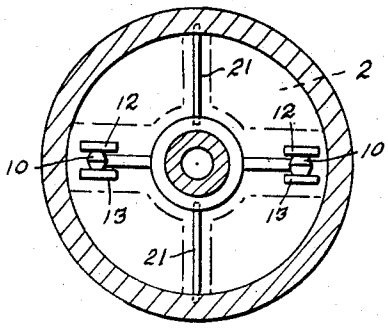


Fig. 13.

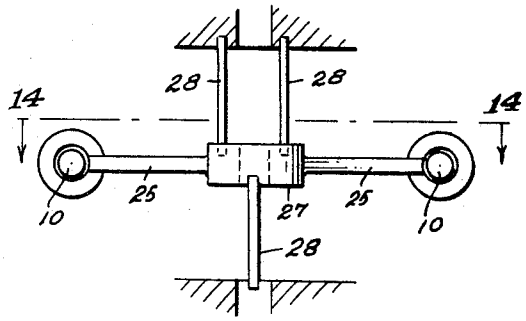


Fig. 14.

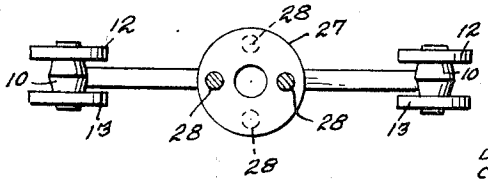


Fig. 15.

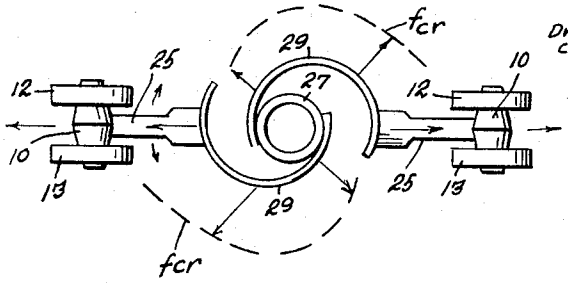
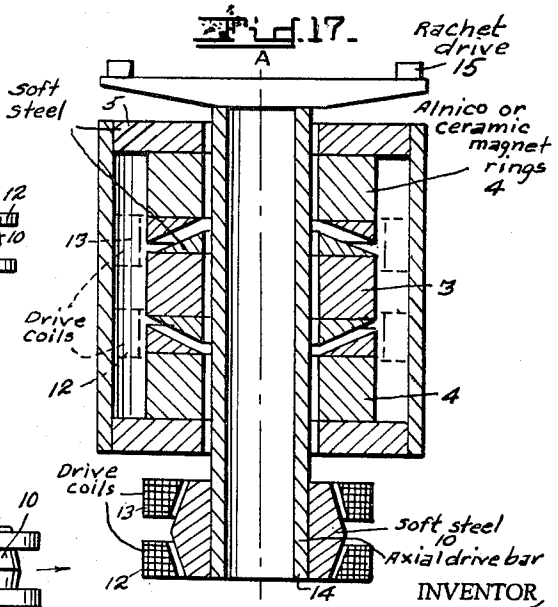


Fig. 17.



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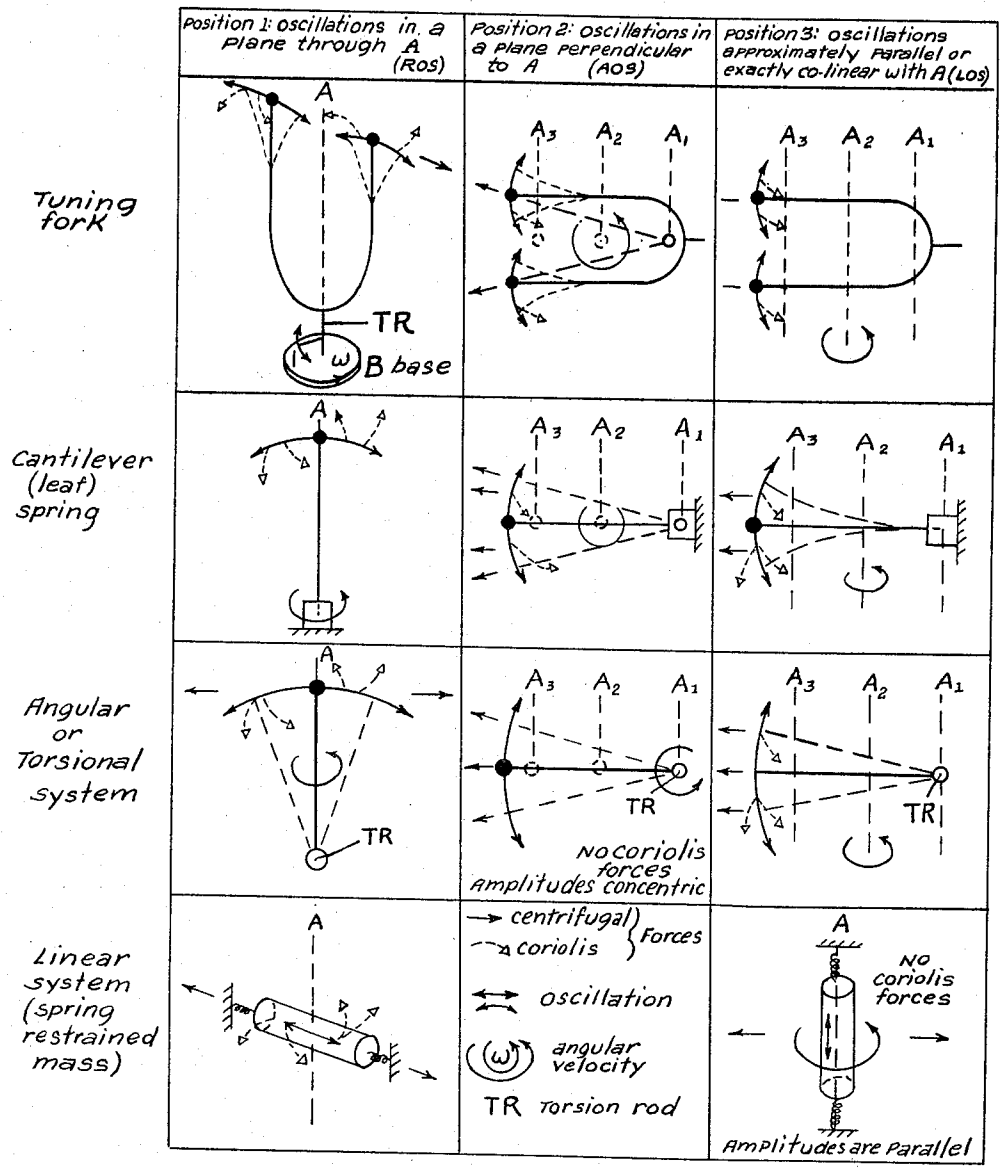
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ELECTROMECHANICAL FUZE TIMER REGULATION

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Fig. 16.



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ELECTROMECHANICAL FUZE TIMER REGULATION

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Fig. 18.

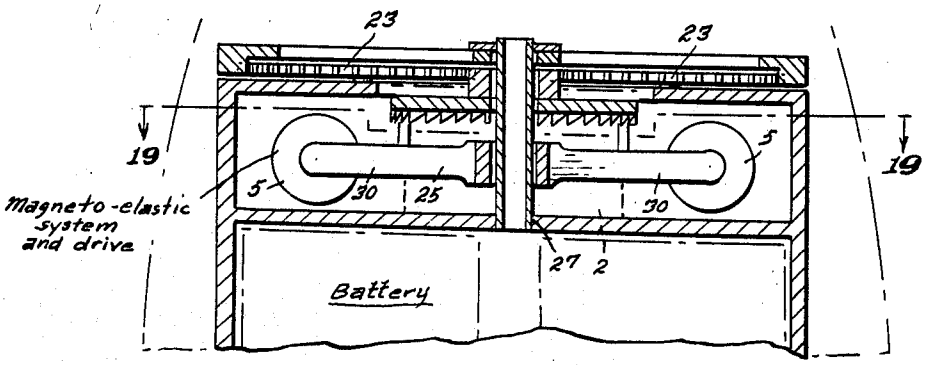
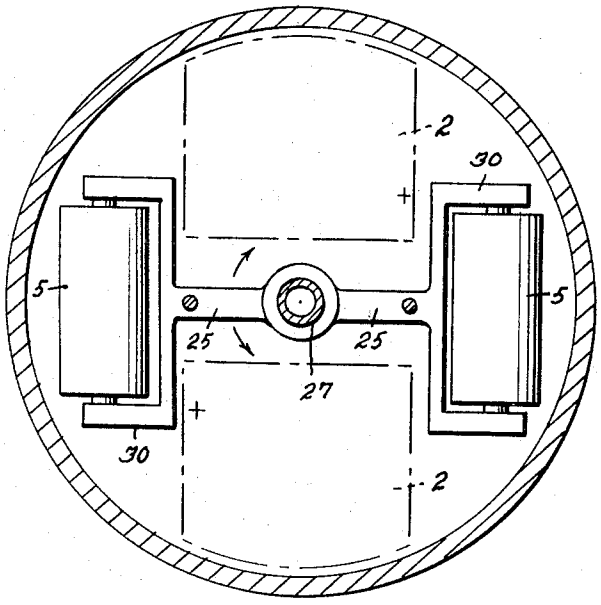


Fig. 19.



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United States Patent Office

3,434,424
Patented Mar. 25, 1969

3,434,424

ELECTROMECHANICAL FUZE TIMER REGULATION

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Filed Oct. 28, 1966, Ser. No. 591,063
Int. Cl. F42c 13/08; F42b 9/08
U.S. Cl. 102—70.2 13 Claims

ABSTRACT OF THE DISCLOSURE

Electromechanical fuze timers for rotating projectiles in which the deviating forces created by projectile rotation are employed to vary the amplitude of oscillation of an elastic timing system. The elastic system oscillates coaxially with the axis of rotation of the projectile, and such oscillation is employed to actuate the fuze timer. The variation in amplitude of the elastic system is employed to correct the timer for deviations due to Coriolis and centrifugal forces generated by projectile rotation.

The invention described herein may be manufactured and used by or for the Government, for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to electromechanical fuze timers for projectiles and particularly to systems for compensating for deviation caused by the rotation of the projectile in flight.

Delicate timer systems have been found to be unsatisfactory in a high spin environment where watches, clocks, etc., having a spring driven balance wheel with escapement, are employed.

The deviation of such timers in a high spin environment are caused primarily by Coriolis and centrifugal forces. Coriolis is the force with which any object moving above the earth with constant velocity is deflected relative to the surface of the rotating earth, the deflection being to the right in the northern hemisphere and to the left in the southern hemisphere. These forces emerge when in or on a rotating body, a mass element moves radially or has a radial component of motion; per unit of mass, centrifugal forces are proportional to the radius and the square of the angular velocity w and Coriolis forces are proportional to the double vectroial cross product of the angular velocity and the radial velocity $v=dr/dt$.

Primarily this invention is concerned with electromechanical systems utilizing basic time giving elements such as the tuning fork, the leaf spring, the torsion element and the helical spring wherein an electromechanical oscillator converts electromechanical energy into mechanical energy. Specifically, the principle of automatic frequency control and stabilization can be applied for such oscillators, when the position of the oscillating element is sensed by a phase sensing coil which triggers a switching transitor for the accurate timing of the current impules actuating the oscillating element; these current pulses act during the instant when this element passes its zero position and during this time fraction, the oscillating element has its maximum kinetic energy and is therefore less sensitive to vibration environment. By the application of a simple rachet drive, the digital mechanical output of these systems can

be converted into digital or intermittent rotation and this characteristic can be utilized for time setting purposes. Depending on the lay-out of the rachet drive, each forward and backward amplitude, or only one of them, can be converted into a uni-directional mechanical motion. Essentially this corresponds to a full or half-wave rectifier.

It is definitely known that any electromechanical oscillator with a radial amplitude of its time giving element, will not be able to reproduce time exactly when arranged in a rotating body. Coriolis and centrifugal forces have a disturbing effect on the frequency and amplitude of any electromechanical timer used in a rapidly rotating body. These disturbing effects are moreover additionally complicated by the fact that the angular velocity w of a projectile decreases with its time of flights. This means that the effects of Coriolis and centrifugal forces as a function of angular velocity w will also decreases; this indicates furthermore that the frequency of any electromechanical timer at firing, will be different from the frequency after a certain time of flight.

The time giving systems considered, have in common, that the basic time giving elements consist of elastic material in specific geometrical forms, commonly called "springs" and these are hereinafter referred to as "material-elastic systems." In such system, consideration indicate that with an appropriate location of the oscillating element with respect to the axis A—A of the rotating projectile, Coriolis forces and their effects can be decreased.

Basically, the oscillating elements of any electromechanical timer systems can be so arranged, that their amplitudes occur.

(a) In a plane through the axis of rotation or what is the same, that the amplitudes act radially and is known as a Radial Oscillation System which tests show will never be able to produce pulses of constant frequency and amplitude;

(b) In a plane perpendicular to the axis of rotation and known as a Angular Oscillating System;

(c) Either parallel or coaxial with axis of rotation and known as a Linear Oscillating System.

Any material-elastic element has to consist of the spring element representing elasticity and some additional mass element to provide and transfer the digital mechanical output, to mechanical time setting devices. It is obvious, that centrifugal forces acting upon this additional mass element, cannot be avoided. Only by arranging this mass element exactly co-linear with the axis of rotation, the centrifugal effects can be forced to act upon this mass element in a balanced and centering manner.

Any material-elastic element has mass and is therefore unavoidably affected by centrifugal forces. To avoid the effects of centrifugal forces in any elastic element, this element has to be without mass. The only technically possible solution of this apparent contradiction, is to utilize the repellant, quasi-elastic forces of electric or magnetic fields, that is, to use these characteristics as an elastic element.

The energy content of an electric field of strength E is given by

$$\frac{1}{8\pi}E^2$$

that of a magnetic field of strength H,

$$\text{by } \frac{1}{8\pi}H^2$$

The "mass" of these field energies is therefore

$$\left(\frac{1}{8\pi}\right)\frac{E^2}{C^2} \text{ and } \left(\frac{1}{8\pi}\right)\frac{H^2}{C^2}$$

respectively, where C is the velocity of light. It is obvious that the "mass" of the fields needed for the problem in question is physically not measurable, that is, practically zero, consequently, the effects of centrifugal forces on such "mass-less" elastic elements can be safely assumed to be zero.

The use of repellent electric fields in this particular apparatus is not considered suitable, because of the high voltage permanently necessary to produce strong repellent electric fields, the difficulty of proper insulation in a small space, such as three cubic inches and the breakdown of the electric field caused by the change of the dielectric constant, such as the humidity in the air, etc. In view of these disadvantages, the use of the repellent, quasi-elastic forces of magnetic fields is considered, as such fields are readily provided by permanent magnets. These desired characteristics are produced by small ceramic magnets which are presently employed for the magnetic suspension bearings of watt-hour meters produced for commercial use. The physical principle of a magneto-elastic element is the arrangement of a permanent magnetic slug floated between two fixed permanent magnetic pole pieces. Any axial displacement of the slug is counteracted automatically by the repellent magnetic forces acting between slug and pole pieces, because these magnetic forces have the tendency to re-establish equilibrium in the flux distribution of the entire assembly.

For a better understanding of the apparatus employed in this invention and the several modifications, reference is made to the drawings in which:

FIGURE 1 is a reproduction of actual size of projectile indicating the size and position of the electromechanical timer;

FIGURE 2 is schematic representation of a magnetically and elastically floated oscillating magnetic slug between two permanent pole pieces;

FIGURE 3 is a schematic diagram of the electronic circuit of the electromechanical timer;

FIGURE 4 shows a linearly oscillating slug;

FIGURE 5 shows a top view of FIGURE 4;

FIGURE 6 shows a linearly oscillating slug suspended between helical springs to dampen the oscillations of the slug;

FIGURE 7 is a longitudinal section of electromechanical timer with a coaxially oscillating slug;

FIGURE 8 is a top plan view of FIGURE 7;

FIGURE 9 shows the principle of a torsion element supporting a central bar with concentric oscillating slugs equidistant from axis of projectile;

FIGURE 10 shows the individual concentric oscillating slug;

FIGURE 11 shows the principles of utilizing angular oscillation incorporated in a complete unit;

FIGURE 12 is a cross section on a reduced scale taken along lines **12—12** of FIGURE 11;

FIGURE 13 is a modification of angular oscillation with the flexural point actuated by double bifilar elastic elements;

FIGURE 14 is a top plan view of FIGURE 13 showing the arrangement of the elastic elements;

FIGURE 15 is a furhter modification of angular oscillation in which the action of pivot is dampened by spiral springs;

FIGURE 16 is a table showing the positions of the oscillating systems with respect to the axis A of the projectile and the resulting forces on the vibrating elements;

FIGURE 17 is a sketch of magneto-elastic element for linear oscillation utilizing an axial drive bar;

FIGURE 18 is a longitudinal section of the assembly employing the principle of the angular oscillation timer with magneto-elastic elements; and

FIGURE 19 is a cross section taken along line **19—19** of FIGURE 18.

In FIGURE 1, the nose **1** of an M–500 projectile is shown in actual size, with the electromechanical timer **2** positioned therein, occupying 3 cu. in. and weighing approximately one pound;

FIGURE 2 shows a magnetically and elastically floated oscillating magnetic slug **3** in zero position with the dotted lines indicating the limit of oscillation of the slug. The slug **3** is floated between two permanent magnetic pole pieces **4**, such as alnico or ceramic magnets, with a housing **5** of a soft steel base and mantle for flux return;

FIGURE 3 is a schematic diagram of the electronic circuit of the electromechanical timer **2**. The transistor **6** in this circuit acts as a relay, although it is an electronic device and therefore has no moving parts or contacts. A relay, by the application of a small current in the coil, will cause the contacts to close and this small amount of current can switch very large currents. The transistor **6** in this circuit has three leads, the emitter E, base B and collector C respectively, and the base-to-emitter leads must be supplied with a current in order to cause the emitter-to-collector circuit to be conducting, i.e., the collector circuit is conducting only when there is current in the base circuit of the transistor. The base-to-emitter connection of the transistor, may be compared with the coil connections to the contacts of a relay. The capacitor **7** with a resistor **8** connected in parallel, is the element which maintains the transistor **6** in a non-conducting condition through most of the cycle of operation of this electromechanical oscillator or linear motor. It follows that an alternating voltage is induced in the phase sensing coil **9** by the linear motion of the mass or magnet core **10** which is the oscillating slug. Through the base circuit B of the transistor **6** which acts as a diode or rectifier, this voltage is added to the power cell **11** voltage to charge the capacitor **7** which functions as a storage tank for electricity. The resistor **8** across this capacitor causes a slight leak with the result that the capacitor will be recharged slightly once each cycle by the peaks of the alternating voltage induced in the phase sensing coil **9**. It is these recharging pulses of current which cause the transistor to conduct momentarily and allow current to flow in the driving coils **12** and **13** to pulse this electromechanical oscillator and maintain its oscillations. The drive coils **12** and **13** are connected in series with the power cell **11** and the transistor **6**. The transistor is caused to conduct at the point where the voltages induced in the phase sensing coil **9** and the drive coils **12** and **13** are about at their maximum instantaneous values, and when the induced voltage of the drive coil is opposite in sign to the power cell voltage. Therefore, if the amplitude of the linear motor should be such that at the instant the transistor **6** becomes conducting the induced voltage in the drive coils **12** and **13** exactly equals the power cell **11** voltage, no current would flow, since the two voltages are opposite in polarity and would cancel each other. The design of the mass or core magnet **10** and coil system is of the essence in the operation of the amplitude control system and is arranged so that at the proper amplitude of its oscillation, the voltage, induced in the drive coils **12** and **13**, has a peak value about 10% less than the voltage of the power cell **11**. Because of this, a 10% increase in amplitude, resulting from a disturbance caused by the rotating projectile, would cause the driving current pulses to be reduced to zero and the oscillating mass would rapidly return to its proper amplitude. Further, a 10% decrease in amplitude would cause the driving current pulses to double and again return the oscillator very rapidly to the proper amplitude. From the foregoing it is understood that the amplitude is controlled by converting it into a voltage, which is maintained at a value about 10% below the power cell voltage. In view of this, the

power cell must be designed to provide a very constant voltage for approximately 99% of its useful life, or in its application as an electromechanical timer to the short time period during which the shell moves along its trajectory; hence, the amplitude remains at its proper value or returns to this value within a very small fraction of a second after any disturbance or deviation. By varying the oscillation of the slug **10** to correct for the deviations caused by the rotating projectile to control the ratchet drive **15** which actuates the setting ring **16** through the gear **23** and when the contact **17** is reached the fuze is set and as setting ring **16** moves to contact **18**, the arm **19** completes the circuit to the squib **20** which is fired by the current supplied by the power cell **11**. This electromechanical fuze timer when in a rotating projectile is subject to deviations or forces, caused by the excessive rotation while in flight, which are reflected in the flexing of the leaf springs or corrugated diaphragm **21** which is connected to the oscillating core **10** and this flexing of the elastic elements **21** varies the amplitude of the oscillations of the core **10** for the purpose of compensating the operation of the timer for the deviations in such a manner that the effect of the deviations, which are Coriolis and centrifugal forces, is reduced to a negligible minimum;

FIGURE 4 shows the oscillating slug **10** mounted coaxially with the axis A of the projectile **1** and driven by the coils **12** and **13**, with radially disposed leaf springs **21** secured to the interior of the projectile **1** and connected at the center to the oscillating slug **10**. The flexing of the springs **21** will vary the amplitude of the oscillations of the slug **10**. This arrangement is an example of linear oscillation;

FIGURE 5 is a section taken on the **5—5** line of FIGURE 4, showing particularly the radial disposition of the leaf springs **21**;

FIGURE 6 is another example of linear oscillation, wherein the slug **10** mounted coaxially in the projectile and is suspended between helical springs **22** to restrain the movement imparted to the slug **10** by the deviating forces;

FIGURE 7 is an enlarged schematic view of the electromechanical oscillator showing the arrangement of parts in which the housing for the electronic circuits **2** for the conversion of the oscillation to the unidirectional drive of the rachet **15** which drives the gear **23** and the setting ring **16** while the slug **10**, oscillating coaxially with the rotation axis between the coils **12** and **13**, is adjusted for the deviations by the leaf springs **21**. Since the inner ends of the leaf springs have only a very small radial component of motion, Coriolis forces affecting the frequency and amplitude of the springs (or diaphragm) and so the accuracy of the timing systems can be reduced to a very small or practically negligible magnitude; by the rachet drive **15** the oscillations of the central slug **10** are converted into a unidirectional and intermittent rotation of the setting ring **16**.

FIGURE 8 is a top plan view of FIGURE 7 showing particularly the sector shaped house **2** of the electronic circuits;

FIGURE 9 shows the principle of the torsion element **24** with the cross bar **25** attached in the center at **26** and provided at either end with a concentrically oscillating slug; this arrangement is an example of angular oscillation;

FIGURE 10 is a horizontal section of the oscillating element **10** of FIGURE 9 taken on the **10—10** line;

FIGURE 11 shows the entire assembly employing angular oscillation in which radial flexural pivot **27** is coaxially mounted carrying the cross bar **25** with the oscillating elements **10** at either end and the amplitude of oscillation varied by the flexing of the leaf springs **21** to twist the pivot **27**;

FIGURE 12 is a cross section of FIGURE 11 taken on the **12—12** line, showing the flexing of the leaf springs **21** being in a direction perpendicular to the oscillation of slug **10** with the leaf springs so arranged that their flat sides are in the plane of the axis of rotation and clamped near this axis to a common mount; the drive coils force the outer ends of the springs to oscillate practically concentric to the axis of rotation; by this arrangement, Coriolis forces affecting the frequency, amplitude and accuracy of the system are reduced to a negligible magnitude or practically avoided; the aim of both systems shown in FIGURES 7 to 12 is to reduce considerably or even suppress the effects of Coriolis forces on the frequency and amplitude constancy of such electromechanical timers and in this manner improve their accuracy.

FIGURE 13 shows another modification of angular oscillation in which the common bar or cross bar **25** supporting the oscillating elements **10** is twisted by the double bifilar elastic elements **28**;

FIGURE 14 is a view taken on the **14—14** line of FIGURE 13 showing the particular arrangement of the elastic elements **28** for compensating for the deviations caused by excessive rotation;

FIGURE 15 is another modification of angular oscillation in which the pivot member **27** is secured to prevent rotation and the common bar **25** is connected to the pivot **27** by spiral springs **29**, with the dotted lines showing the direction of centrifugal forces and the springs **29** acting to restrain the cross bar **25** from the twisting movement imparted by the centrifugal force, and since there is no measurable mass, there are no Coriolis forces to affect the regulation of the oscillating elements; and

FIGURE 16 is a table showing the various oscillating systems with respect to the axis A of the projectile and the resulting forces on the vibrating element; the oscillating systems are the tuning fork, cantilever leaf spring, the angular or torsion system and the linear system (spring retained mass); the positions used for these oscillating elements, are position #1 oscillation in a plane through axis A termed radial oscillation system (ROS, position #2 oscillation in a plane perpendicular to axis A termed angular oscillation system (AOS), and oscillation approximately parallel or exactly colinear with axis A termed linear oscillating system (LOS).

FIGURE 17 shows the principle of the magneto-elastic element for linear oscillation utilizing the outside oscillating element **10** with the drive coils **12** and **13**, for transmitting the oscillation to the axial drive bar **14**; alternately, there is also shown that proper oscillation and regulation may be obtained by eliminating the outside oscillating element and utilizing the principle shown in FIGURE 2, wherein the drive coils **12** and **13** are represented by the dotted lines, to drive the oscillating element **3**, the alnico or ceramic magnet rings **4** and the cylindrical housing **5** with a soft steel base and acting as a mantle for flux return; the oscillating element **3** is keyed to the axial bar **14** connected to the rachet drive **15** as shown;

FIGURE 18 shows a longitudinal section of an assembly employing the principle of angular oscillation with magneto-elastic elements arranged as described in the alternate construction of FIGURE 17, wherein the cross bar **25** is keyed to the coaxial flexural member **27**, has oscillating elements at either end and a fork **30** at the end of the cross bar **25** attached to the oscillating element and oscillating therewith as shown by the arrows; and

FIGURE 19 is a top plan view of FIGURE 18 showing the magnetoelastic elements in the housing **5** attached to the cross bar **25** having at each end a fork **30** which is connected to the oscillating element of housing **5** and oscillates therewith with the oscillation transmitted to the cross bar **25** as indicated by the arrows.

The following table is a qualitative comparison between material-elastic and magneto-elastic oscillatory systems with respect to Coriolis f_{co} and centrifugal f_{cr} effects on the systems.

Effect	Angular oscillation		Linear oscillation	
	Material-elastic	Magneto-elastic	Material-elastic	Magneto-elastic
f_{co}	By an appropriate selection of type and geometrical arrangement of the elastic element, f_{co} can either be decreased to a negligible magnitude or completely suppressed.	None	Similar to effect on f_{co} on angular systems.	None.
f_{cr}	To minimize f_{cr}, the geometrical arrangement of the elastic element must be so that a small as possible f_{cr} acts at the spot where the elastic elements has the greatest amplitude.	Essentially none since mass of the energy content of the energy content of the magnetic field is practically zero (not measurable).	Similar to angular system.	Essentially none similar to angular system.

What is claimed is:

1. An electromechanical fuze timer for a rotating projectile, comprising an elastic system utilizing the quasi-elastic properties of magnetic fields by employing a permanent magnetic oscillating slug suspended between two permanent magnetic pole pieces and actuated by said pole pieces, said slug oscillating coaxially with the axis of rotation of the projectile, elastic elements attached to said slug and adapted to flex in the same direction as the oscillating slug, said elastic elements responsive to the effects of the deviating forces created by the rotation of the projectile to vary the amplitude of oscillation of the slug to compensate for said deviations, a driving ratchet for the timer and said slug connected to the driving ratchet in such a manner as to convert the oscillation of the slug into an intermittent and unidirectional actuation of said ratchet for correcting the timer for deviations due to Coriolis and centrifugal forces generated by the rotating projectile.

2. An electromechanical fuze timer as claimed in claim 1, in which the elastic elements are flat leaf springs radially disposed within a circular body, the outer ends of the leaf springs securely clamped to said circular body, the inner ends of the leaf springs connected to the slug and free to flex coaxially with the slug and said springs responsive to the effects of said deviating forces and compensating therefor, wherein the mass of repellant quasi-electric magnetic fields is not measurable and the deviating effects caused by Coriolis and centrifugal forces are completely avoided.

3. An electromechanical fuze timer as claimed in claim 1, in which the elastic elements are coaxial helical springs conected to the oscillating slug at each end, said springs responsive to the deviating effects caused by the rotating projectile and dampening the twisting action imparted to the oscillating slug to vary in a direction parallel to the axis the amplitude of oscillation of the slug to properly compensate for the deviation due to centrifugal force and the elimination of Coriolis forces.

4. An electromechanical fuze timer as claimed in claim 1, in which the elastic elements are a torsional member mounted coaxially with the oscillating slug and connected therewith and said torsion member responsive to the deviating effects in a rotating projectile to impart a twisting action to said slug to vary the amplitude of oscillation and compensate for the deviations created by the rotating projectile.

5. An electromechanical fuze timer as claimed in claim 1, in which the elastic elements are a corugated diaphragm.

6. An electromechanical fuze timer as claimed in claim 1, in which the elastic elements are double bifilar elements.

7. An electromechanical fuze timer as claimed in claim 2, in which the flexing of the leaf springs and the oscillation of the attached slug are as close as possible to axis of rotation of the projectile for the purpose of reducing to a minimum the effect of centrifugal force on the oscillating slug and improving the accuracy of said timer.

8. An electromechanical fuze timer of the magneto-elastic type for a rotating projectile, comprising a magneto-elastic system having a central magnetic slug therein oscillating coaxially with the axis of projectile during flight of the projectile, means for driving said timer, and said slug being operatively connected to said driving means to regulate the driving means to compensate for the deviating effects of Coriolis and centrifugal forces resulting from the projectile rotation in flight, due to the immeasurability of the mass of repellant quasi-elastic magnetic fields acting upon the slug.

9. An electromechanical fuze timer for a rotating projectile, comprising as oscillating and time giving elastic elements, a projectile having an axial member disposed therein, an oscillating slug coaxial with said axial member suspended between drive coils and actuated thereby, a plurality of flat leaf springs radially arranged with respect to the axis of rotation of the projectile, said leaf springs clamped at the outer ends to the projectile and attached at the common center to the oscillating slug to impart the flexing movement of the springs thereto, and a driving system for the timer connected to the oscillating slug to convert the slug oscillation into an intermittent and unidirectional rotation by regulating the amplitude of the oscillation for varying the frequency of the driving system.

10. An electromechanical fuze timer for a rotating projectile, comprising two magneto-elastic oscillation systems connected by a common bar, a coaxial torsion member attached to said bar in the center thereof and adapted to actuate the bar and said systems in a plane perpendicular to the axis of the projectile, said torsion element responsive to the deviating effects of rotation to regulate the movement of the common bar and oscillation system wherein the timer avoids the effects of Coriolis forces due to the immeasurabliity of the mass of repellant quasi-elastic magnetic fields.

11. An electromechanical fuze timer for a rotating projectile, comprising elastic elements utilizing the quasi-elastic properties of magnetic fields by employing two magneto-elastic oscillating systems each having a central magnetic oscillating slug suspended between two permanent magnetic pole pieces and actuated by said pole pieces, said slugs oscillating concentrically with the axis of rotation of the projectile, a coaxial flexural pivot adapted to twist in a direction perpendicular to said axis, a common bar having an osciallating slug at each end attached in the center to said flexural pivot and adapted to twist therewith, the elastic elements being flat leaf springs radially disposed in the projectile with the outer ends securely clamped to the projectile and the inner ends connected to the flexural pivot for imparting the flexing movement thereto, said springs responsive to the deviating effects of rotation to flex in a direction perpendicular to the axis of rotation, the flexing movement of the springs adapted to twist the flexible pivot and the attached common bar to vary simultaneously the amplitude of oscillation of both slugs attached to said bar, a driving rachet for the timer and said slugs connected to the driving rachet in such a manner as to convert the oscillations of the slugs into an intermittent and unidi-

rectional actuation of said ratchet for a balanced correction of the timer for deviating effects due to Coriolis and centrifigal forces generated by the rotating projectile.

12. An electromechanical fuze timer for a rotating projectile, comprising an elastic mechanism utilizing the quasi-elastic properties of magnetic fields by employing two magneto-elastic oscillating systems each having a central magnetic oscillating slug suspended between two permanent magnetic pole pieces and actuated by said pole pieces, said slugs oscillating concentrically with the axis of rotation of the projectile, a coaxial torsional member mounted to twist in a direction perpendicular to said axis of rotation, the oscillating slugs being secured to the torsional member in spaced relation on opposite sides of said axis of rotation, said torsional member being responsive to the deviating effects of rotation of the projectile to vary the amplitude of oscillation of the slugs to compensate for deviations due to centrifugal and Coriolis forces, and timer driving means operated by the oscillations of the slugs.

13. An electromechanical fuze timer for a rotating projectile, comprising an elastic mechanism utilizing the quasi-elastic properties of magnetic fields by employing two magneto-elastic oscillating systems each having a central magnetic oscillating slug suspended between two permanent magnetic pole pieces and actuated by said pole pieces, said slugs oscillating concentrically with the axis of rotation of the projectile, a coaxial flexural pivot adapted to twist in a direction perpendicular to said axis, a common bar attached at its center to the flexural pivot and adapted to twist therewith, said bar having each of its ends attached to one of the slugs, double bifilar elastic elements supporting the flexural pivot coaxially within the projectile, the bifilar elastic elements being disposed in parallel relation to the axis of rotation and adjacent thereto, said bifilar elastic elements being responsive to the deviating effects of projectile rotation to flex in a direction perpendicular to the axis of rotation, the flexing movement of the elastic elements operating to twist the flexural pivot and the attached common bar to vary simultaneously the amplitude of oscillation of both slugs attached to the common bar, a driving rachet for the timer and said slugs connected to the driving rachet in such manner as to convert the oscillations of the slugs into an intermittent and unidirectional actuation of said rachet for a balanced correction of the timer for deviating effects due to Coriolis and centrifugal forces generated by the rotating projectile.

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