United States Patent

Prouty et al.

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[54] TIME DELAY ELECTROMAGNETIC DEVICE

[72] Inventors: **Robert E. Prouty; John E. Gilman, III; James J. Smith,** all of Logansport, Ind.

[73] Assignee: **Essex International, Inc.**

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[52] **U.S. Cl.**.....**335/240,** 335/245, 335/62

[51] **Int. Cl.**.....**H01f 7/10**

[58] **Field of Search**.....335/59, 60, 61, 62, 63, 64, 335/67, 239, 240, 241, 242, 245; 200/34

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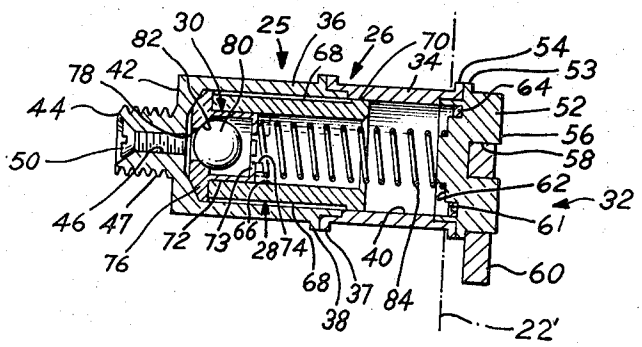
Primary Examiner—George Harris

Attorney—Molinare, Allegretti, Newitt & Witcoff

[57] **ABSTRACT**

A time delay electromagnetic device includes a core for an electromagnetic coil having a tubular sleeve comprising a magnetizable and a non-magnetizable portion which is sealed at one end by a magnetizable pole piece and substantially filled with a damping liquid. A magnetizable plunger is positioned within the sleeve and includes a ball retaining cage and ball check valve positioned in a passage extending through the plunger. The cage is closed at one end and includes an aperture therein. When the plunger is attracted to the pole piece, the ball check valve blocks the flow of the liquid through the passage, causing the liquid to pass through a small space between the plunger and the sleeve to delay the movement of the plunger toward the pole piece.

14 Claims, 4 Drawing Figures



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Fig. 1

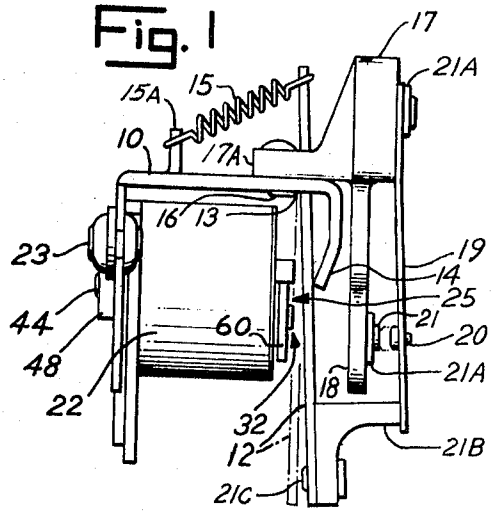


Fig. 2

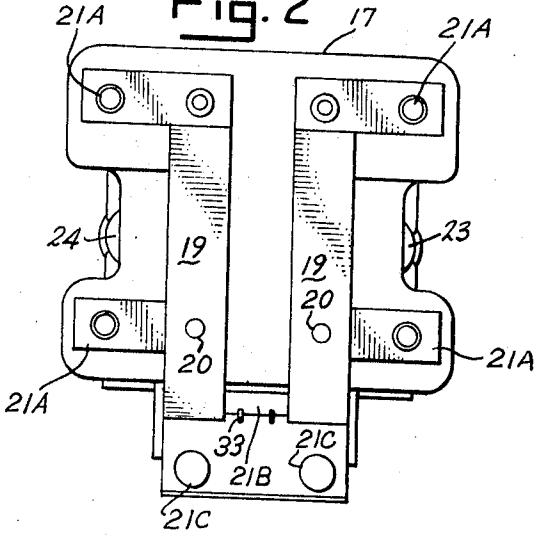


Fig. 3

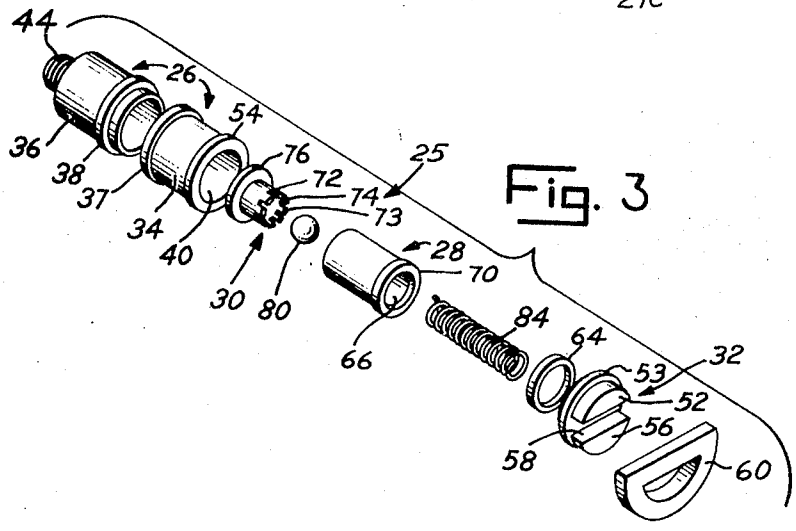
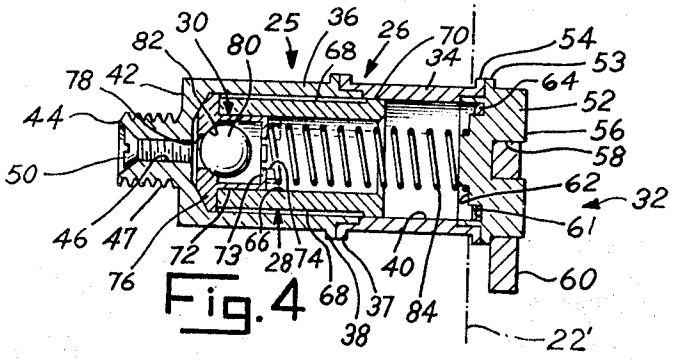


Fig. 4



INVENTORS
ROBERT E. PROUTY,
JOHN E. GILMAN III
BY & JAMES J. SMITH
Bair, Freeman & Molinare
ATTORNEYS

TIME DELAY ELECTROMAGNETIC DEVICE

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a time delay electromagnetic device and, more particularly, to a new and improved coil core for delaying the operation of relay contacts or the like for a predetermined period of time after energization of the coil.

In the past various fluid dampened devices have been employed for delaying the action of relay contacts, solenoid valves and the like for a predetermined time period after the energization of the windings or coil of same. One prior fluid dampened time delay device takes the form of a tubular sleeve which forms part of the core of the wound coil. The sleeve is sealed and filled with a damping fluid and the end of the sleeve toward the contact or the like which is to be actuated is sealed by a magnetizable pole piece which extends into the coil. The pole piece is constructed such that when it is magnetized by the flux field produced upon energization of the coil, the magnetic force exerted by the pole piece on the contact armature is insufficient to, by itself, attract the armature. In order to increase the magnetic force on the armature to a magnitude sufficient to effect actuation, a moveable magnetic plunger is positioned in the sleeve and is normally urged away from the pole piece. However, when the pole piece is magnetized, the plunger is movably attracted to the pole piece by the magnetic force exerted thereby. Actuation of the armature is delayed by an amount of time equal to the time which it takes the plunger to move toward the pole piece to a point at which the magnetic force exerted by the pole piece upon the armature is increased to a magnitude where it is sufficient to actuate the contact armature.

In order to determine the delay time between energization of the coil and the actuation of the contact armature, movement of the plunger toward the pole piece is retarded in these prior devices by way of flow throttling assembly having a valve which partially restricts and throttles the flow of damping fluid from one side of the plunger to the opposite side thereof through the plunger to retard the movement of the plunger toward the pole piece. In the prior devices, such throttling assemblies, along with their associated valves and other components, have necessitated relatively complex plunger and valve constructions. Such complexity results in relay packages which are of substantial size relative to their rated operating capacity and which have a substantial number of component parts. In addition, the complexity of the prior valved devices necessitates an increased number of machining and assembling steps and increases the likelihood of failure.

The time delay electromagnetic device constructed in accordance with the principles of our invention includes a fluid check valve in which the flow of damping fluid from one side of the plunger to the other through the plunger is prevented and the fluid is forced to flow through a small space between the plunger and its sleeve or housing to retard the rate at which the plunger moves toward the pole piece and yet the fluid flows freely past the plunger when it moves in the opposite direction. In the time delay device of our invention, flow through the plunger is blocked by way of a simple one piece ball check valve cage and ball check valve effecting a substantial reduction in the number of components necessary to complete the time delay assembly and obviating the need for complex spring, machined components, or manufacture and assembling steps. The check valve cage of our time delay device, in addition to being simple and functioning to retain and position the check valve, also provides a flow orifice for return movement and forms a bearing surface which guides and assists the movement of the plunger within the sleeve and prevents sticking of the plunger. The time delay device of our invention is extremely quiet in operation, even when subjected to continuous magnetic field conditions, such as encountered during prolonged energization of the coil. Moreover, the plunger may be readily shaded from the magnetic portions of the sleeve to reduce the likelihood of plunger sticking upon initial energization of the coil. In addition to the above advantages of our invention, a time delay electromagnetic device is provided which may be substantially reduced in size relative to the prior known devices and thereby may be substantially completely positioned within the length of the coil. Also the time delay core of our invention may be constructed as an individual item and later be employed in a wide variety of standard coils.

In a principal aspect, the time delay electromagnetic device incorporating the principles of our invention includes an elongated stationary sleeve which is adapted to be positioned in an electromagnetic field and a magnetizable tubular plunger sealed in the sleeve for axial movement therein in response to the condition of the flux field. The sleeve is filled with a damping fluid and a magnetizable pole piece is positioned at one end thereof. The plunger and sleeve are slightly spaced from each other and check means is positioned in the tubular plunger, and the plunger is normally urged toward the end of the sleeve opposite the pole piece. When the plunger is attracted in one direction, the check means blocks the flow of fluid between the ends of the sleeve through the plunger, the fluid flowing through the space between the sleeve and plunger to delay movement of the plunger over a predetermined time period. When the plunger is moved in the other direction the check means is displaced from its fluid flow blocking position to allow the fluid to freely flow through the plunger.

These and other objects, features and advantages of the present invention will be more clearly understood through a consideration of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWING

In the course of this description, reference will frequently be made to the attached drawing in which:

FIG. 1 is a side elevation view of an electromagnetic relay in which the time delay core of our invention is incorporated;

FIG. 2 is a right end elevation view of the relay shown in FIG. 1;

FIG. 3 is an exploded perspective view of the time delay core of our invention; and

FIG. 4 is an assembled cross-sectioned elevation view of the time delay core of our invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 2, an electromagnetic relay is shown which comprises a frame portion 10 and an armature 12 extends through an opening 13 provided in the frame 10 for movement from an unattracted position shown in FIG. 1 to an attracted position shown in dot and dash lines when a coil 22 is energized. In the unattracted position, the armature 12 is biased against a stop 14 integral with the frame 10 by spring 15 which is secured to the extending end of armature 12 and to a lug 15A stamped out of the frame 10.

Secured to the frame 10 by rivets 16 are the feet 17A of an insulating block 17 having a portion 18 extending over the armature 12. Mounted upon the insulating block 17 and extending over the portion 18 are two flexible contact springs 19 carrying movable contacts 20 to engage with and disengage from fixed contacts 21 located on the portion 18. Circuit connections to suitable conductors may be made by means of screws (not shown) threaded into the terminals 21A which are secured to the contact springs 19 and the fixed contacts 21.

The free ends of the contact springs 19 extend beyond the insulating block portion 18 and are engaged by an arm of an insulating bracket or actuator 21B having a base attached to the armature 12 by rivets 21C to disengage the movable and fixed contacts 20 and 21 in the unattracted position. The contact springs 19 are preformed or bent to produce a desired contact force or pressure between the moveable and fixed contacts in the attracted position. In the unattracted position, spring 15 biases the armature 12 against the stop 14 with a greater force than the biasing force of the contact springs 19.

The actuating coil 22 which is of conventional design is also mounted upon the frame 10 and is adapted to be energized and deenergized by way of terminals 23 and 24 which are connected to the windings of the coil. A coil core 25 is positioned within the coil and is adapted to be magnetized and demagnetized in response to the magnetic flux field produced by the coil so as to magnetically attract the armature 12 against the force of spring 15 and thereby move contacts 20 so as to complete the circuit with contacts 21. Although a normally-open multiple pole relay is shown, it will be readily understood that the relay may be of the normally-closed and/or single pole type.

A preferred embodiment of core 25 is shown in FIGS. 3 and 4 for delaying the movement of the armature 12 and the making of the contacts for a predetermined period of time after the coil 22 has been energized. In general, the core 25 comprises an elongated sealed tubular sleeve 26 which is filled with a conventional damping oil, a moveable plunger 28 positioned for axial movement within the sleeve, a throttling va've assembly 30 associated with the plunger 28, and a magnetizable pole piece 32 sealingly positioned in one end of the sleeve adjacent the armature which is to be actuated.

The tubular sleeve 26 is preferably formed into two portions 34 and 36, portion 34 adjacent the pole piece 32 being formed of a non-magnetizable material such as a stainless steel, and the other portion 36 being formed of a magnetizable material. Each of the portions are preferably flanged at 37 and 38, and the flanges are interfitted together, as shown in FIG. 4, to form a continuous elongated sleeve having an axially extending passage 40 therein.

After interfitting the flanges 37 and 38, the coupling so formed may be welded together to form a one-piece sleeve. One end of portion 36 is sealed by an integrally formed wall 42 which includes a bushing 44 having a passage 46 extending into the interior of the sleeve. Bushing 44 is externally threaded at 47 so as to receive a nut 48 for mounting the core 25 and its associated coil 22 to the frame 10 as shown in FIG. 1. A screw 50 is removably threaded into the passage 46 so as to seal the passage, yet provide for a fill opening through which damping liquid may be admitted to the interior of the sleeve.

The other end of the sleeve is sealingly closed by the pole piece 32 which comprises a magnetizable plug 52 which is fitted into the open end of portion 34. An annular flange 53 surrounds the plug and the plug may be firmly brazed or welded at flange 53 to a corresponding flange 54 on the sleeve portion 34. The thickness of the plug 52 is preferably substantially small such that when the core of our invention is positioned within the actuating coil 22, the magnetizable pole piece 32 is positioned substantially entirely beyond the end of the coil nearest the armature. The end of the coil is schematically shown in FIG. 4 by the dot and dash line 22'. By positioning the pole piece beyond the confines of the coil, the magnetic force exerted by the pole piece upon the armature may be substantially reduced in order to insure that an attractive force between the pole piece and the armature does not occur which will move the armature upon initial energization of the coil as will be described in more detail later. In addition, the external face 56 of the plug 52 may be slotted at 58 so as to receive a D-shaped shading ring 60 formed of a non-magnetizable material. Ring 60 further reduces the initial magnetic force exerted by the pole piece 32 on the armature upon energization of the coil.

The internal face of the pole plug 52 is formed into a progressively stepped annular surface having a first annular step 61 and a second annular step 62. A non-magnetizable shading ring 64, preferably formed of copper or the like, is firmly positioned upon the first step 61, such as by press fitting between the internal wall of the passage 40 and the stepped surface of the pole plug 52.

The cylindrical plunger 28 is formed of a magnetizable material and is positioned within the passage 40 of sleeve 26. The plunger takes the form of a tubular cylinder having a passage 66 extending therethrough. The external diameter of the plunger 28 is preferably somewhat smaller at 68 than the diameter of passage 40 over the major portion of the former's length. By slightly reducing the diameter of the plunger, frictional drag and hum may be substantially reduced during operation. The diameter of the plunger 28 is preferably increased somewhat at the end of the plunger nearest the pole piece 32 so as to form an annular flange 70 having a diameter substantially equal to the diameter of the passage 40. Flange 70 acts as a bearing surface to assist in guiding the plunger during movement.

The throttling assembly 30 comprises a cage 72 having a plurality of fingers 73 and 74 formed on one end thereof and having a flange 76 integrally formed at the other end thereof. The cage 72 and flange 76 are formed in one-piece construction of a non-magnetizable material, such as brass or the like, and may be shaped by way of stamping. An aperture 78, having a diameter substantially less than the diameter of passage 66, is formed in the flange end of the cage and provides a fluid flow orifice for the passage of damping fluid from one side of the plunger to the other side of the plunger during movement of the latter. The diameter of the flange 76 is preferably slightly greater than the reduced diameter portion 68 of the plunger. Thereby the flange 76 also acts as a bearing surface to assist in guiding the plunger during axial movement.

A valve ball 80 is positioned within the cage 72 of the throttling assembly. The aperture 78 adjacent the cage side of the flange is preferably tapered at 82 such that the ball 80 tends to seat thereon when a force is exerted on the ball toward the left as viewed in FIG. 4. The ball 80 is retained in the cage by bending over alternate ones 73 of the fingers 73 and 74, as shown in FIG. 4. The remaining fingers 74 are preferably left unbent, such that when the cage part of the throttling assembly is press fitted into the passage 66 of the plunger, the fingers 74 act to receive one end of resilient spring 84. The cage may also be firmly affixed to the plunger and in the end of passage 66 by way of a suitable adhesive, such as epoxy rsein, if desired. The spring acts against the bent fingers 73 at one end and the step 62 of the pole plug 52 at the other end so as to normally urge the plunger 28 away from the pole plug 52, as shown in FIG. 4, when the pole piece 32 is not magnetized. However, when the pole piece is magnetized by way of actuating the coil 22, the magnetic attractive force exerted by the pole piece upon the plunger is sufficient to overcome the force exerted by spring 84 and draw the plunger toward the pole piece.

In operation, when an electrical current is passed through terminals 23 and 24 to the windings of coil 22, a magnetic field is established through the core 25 of the coil. The magnetic flux of the field magnetizes portion 36 of the sleeve 26 the plunger 28 and the pole piece 32. The magnetized pole piece 32 now exerts a magnetic force on the armature 12 tending to draw the lower portion of the armature to the left as viewed in FIG. 1, along with the insulating bracket 21B and contact springs 19 so as to close the contacts 20 and 21. However, due to the construction and position of the pole piece 32 relative both to the coil and the armature, the magnetic force exerted by the pole piece upon the armature at this point is insufficient to move the armature to break the contacts. This force is further reduced by provision of the shading ring 60 to insure that the contacts will not chatter or hum at this point.

However, the magnetic force exerted by the pole piece 32 upon the plunger 28 is sufficient to overcome the force of spring 84 which tends to urge the plunger away from pole piece and the the left as viewed in FIG. 4. Thereby, the plunger 28 begins to move to the right as viewed in FIG. 4 In order to move to the right, the liquid which substantially fills the sleeve 26 must be transferred from the side of the plunger toward the pole piece to the opposite side thereof. However, flow through passage 66 is prevented by the seating of the ball valve 80 and the liquid must flow past the plunger 28 by way of the restricted small annular space between the exterior of the plunger and the inner wall of the sleeve 26. The transfer of

liquid is thereby inhibited so as to restrict the rate of movement of the plunger toward the pole piece.

Movement of the plunger **28** toward the pole piece **32** progressively diminishes the gap between the plunger and pole plug **52** over which the magnetic force must act, progressively increasing the magnetic force exerted by the pole piece upon the armature **12**. When the plunger **28** has moved to a predetermined position adjacent the pole piece, the magnetic force becomes strong enough to move the armature contact spring **19** so as to close the contacts **20** and **21**.

Frictional drag of the plunger **28** during this movement is substantially reduced by the lubricating effect of the liquid being transferred between the plunger and sleeve and by the reduced diameter of the plunger; only flange **70** of the plunger and flange **76** of the throttling assembly contacting the walls of passage **40**. In addition, these flanges guide the plunger so as to substantially reduce chattering or hum during operation. Moreover, the shading ring **64** substantially reduces the likelihood of hum and the likelihood of sticking of the plunger at either end of the sleeve is reduced by flange **76**.

When the coil **22** is deenergized, the sleeve portion **36**, the pole piece **32** and the plunger **28** are all simultaneously demagnetized. Since the pole piece no longer attracts the armature **12**, the armature returns to the position shown in the solid lines in FIG. **1** by virtue of the force exerted by spring **15** and contacts **20** and **21** open. During return, the fluid within the sleeve passes substantially freely from the left side of the plunger, through the passage **66** thereof to the right side of the plunger, as viewed in FIG. **4**, since the ball becomes unseated from the aperture **78** during movement of the plunger in the latter direction.

It will be appreciated that although the time delay electromagnetic construction of our invention hereinabove described is described as employed in an electromagnetic relay construction, the principles of our invention may be employed in other magnetic flux operated devices, such as solenoid valves or overload circuit breaker assemblies. It should also be understood that the embodiment of the present invention which has been described is merely illustrative of an application of the principles of the invention. Numerous modifications may be made by those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed is:

1. A time delayed electromagnetic device of the type which is adapted to be actuated in response to a magnetic flux field, said device including a closed elongated stationary tubular sleeve substantially filled with fluid and adapted to be positioned in said field, magnetizable pole means at one end of said sleeve, a magnetizable tubular plunger positioned in said sleeve for axial movement therein in response to the condition of said flux field, said plunger having a fluid flow passage extending axially therethrough and check means associated therewith for controlling the flow through said passage, the improvement in said check means comprising in combination therewith:

tubular cage means inserted into and fixed in said passage, the end of said cage means opposite said pole means being closed and having an aperture defined therein which communicates said passage with said sleeve,

at least one finger means formed integrally with said cage means and extending in angular relationship to the axis of said tubular cage means, and

ball means loosely positioned in said cage means and movable between said aperture and finger means, whereby when said plunger moves in a direction toward said pole means, said ball means moves into overlying relationship with said aperture to restrict the flow of fluid through said cage means and passage and when said plunger moves in a direction away from said pole means said ball means moves away from said aperture and is retained in said cage means by said finger means.

2. The device of claim **1** wherein said cage means is formed of a non-magnetizable material.

3. The device of claim **1** wherein said cage means is insertably positioned at the end of said passage opposite said pole means.

4. The device of claim **3** wherein said closed end of said cage means comprises flange means formed integrally with said cage means and having a diameter larger than the diameter of said passage, said flange means being positioned between the ends of said plunger and sleeve opposite said pole means.

5. In the device of claim **1** including spring means in said sleeve for moving said plunger in a direction away from said pole means, said spring means bearing against said finger means opposite said ball means.

6. The device of claim **1** including non-magnetizable shading means between said pole means and said plunger.

7. The device of claim **4** wherein the diameter of said flange means is greater than the diameter of said plunger and the diameter of said plunger over a major portion of its length is less than the diameter of said sleeve.

8. The device of claim **1** wherein said elongated sleeve is magnetizable over a portion of its length and non-magnetizable over another portion of its length.

9. A time delayed electromagnetic device comprising:

a plurality of conductive windings forming a coil,

a core positioned within said coil and forming substantially the entire magnetic circuit of said coil, said core comprising,

an elongated sealed sleeve substantially filled with fluid, a portion of said sleeve being non-magnetizable,

a magnetizable pole piece positioned adjacent one end of said sleeve and said coil, said non-magnetizable portion of said sleeve being adjacent said pole piece.

a magnetizable tubular plunger moveably positioned in said sleeve and having a passage extending therethrough,

urging means normally urging said plunger toward the other end of said sleeve with a force insufficient to overcome the magnetic force exerted on said sleeve by said pole piece, and

check means in said plunger comprising

tubular cage means inserted axially into and fixed in said passage, one end of said cage means being closed and having an aperture therethrough which communicates said passage with said sleeve,

ball valve means loosely positioned in said cage means and movable relative to said aperture so as to block the flow of fluid through said aperture and passage when said magnetic force is exerted on said plunger by said pole piece, and

at least one resilient finger bent from said cage means and retaining said ball means in said cage means when said urging means urges said plunger toward said other end of said sleeve.

10. The device of claim **9** wherein said elongated sleeve is positioned substantially entirely within said coil.

11. The device of claim **9** wherein said one end of said cage means is closed by flange means formed integrally with said tubular cage means, said flange means being positioned between said plunger and said other end of said sleeve.

12. The device of claim **9** wherein said plunger is spaced slightly from said sleeve to define a space therebetween, said fluid flowing through said space when said ball valve means blocks the flow of fluid through said aperture.

13. A time delayed electromagnetic device of the type which is adapted to be actuated in response to a magnetic flux field, said device including a closed elongated stationary tubular sleeve substantially filled with fluid and adapted to be positioned in said field, magnetizable pole means at one end of said sleeve, a magnetizable tubular plunger positioned in said sleeve for axial movement therein in response to the condition of said flux field toward and away from said pole means, and check means restraining the movement of said plunger toward said pole means, the improvement comprising in combination therewith:

first shading means positioned on said pole means external of said sleeve, and

second shading means adjacent said pole means internal of said sleeve between said pole means and said plunger.

14. The device of claim 13 wherein said shading means are non-magnetizable and said second shading means comprises a ring on said pole means.

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