May 28, 1963 E. R. BRANDT 3,091,164

PHOTOGRAPHIC APPARATUS

Filed Sept. 26, 1960

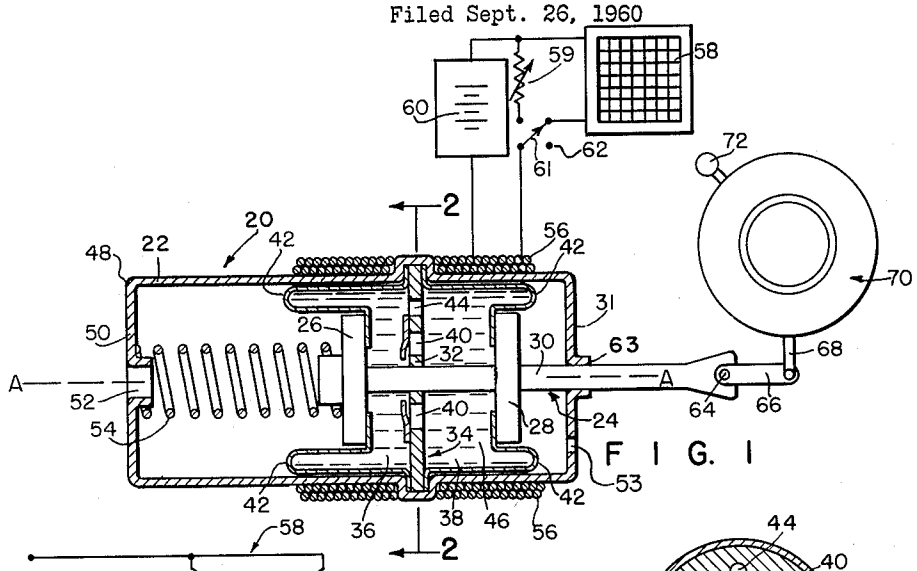



FIG. 1

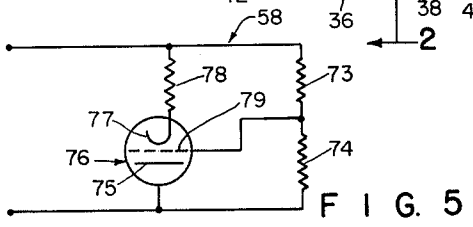



FIG. 5

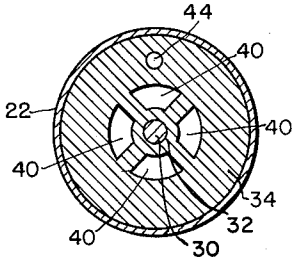



FIG. 2

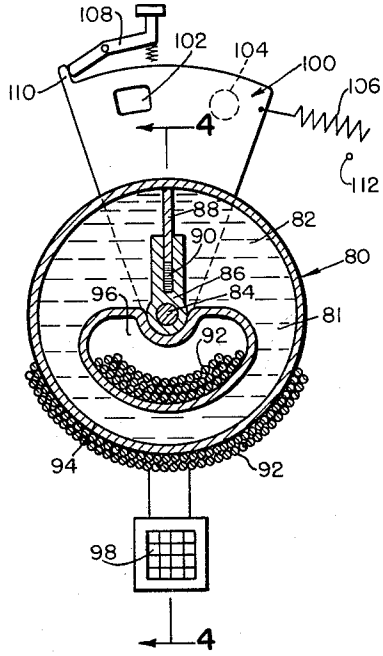



FIG. 3

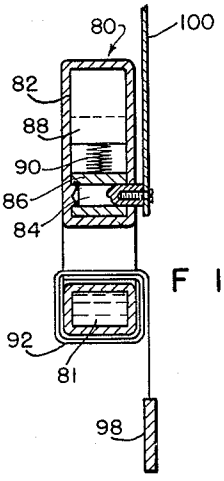



FIG. 4

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3,091,164

# PHOTOGRAPHIC APPARATUS

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This invention concerns timing devices and more particularly photoelectrically controlled mechanisms for determining time intervals of photographic exposures.

Since the discovery of the photoelectric effect, efforts have been made to employ photocells, in one form or another, for controlling exposure parameters of photographic devices. Largely due to the meager power available, the applications of photoelectric devices to photography, particularly in the field of portable cameras, have employed galvanometers as a means for converting photocurrent to a mechanical displacement for controlling an exposure parameter. However, this usage created a group of problems which arose out of the delicate mechanical construction and nonlinearity of galvanometers. For instance, the bulk of mechanisms in which an exposure time interval was determined as a function of the equilibrium position of a galvanometer needle necessarily included mechanical interconnections, with all of the problems inherent in mechanical systems, between the galvanometer needle and the speed control system.

The present invention comprises a timing device which is particularly well adapted for control of exposure time interval in photographic devices, and because no galvanometric mechanism is employed, is unusually dependable, rugged, and substantially free of perturbation from contamination, adverse frictional and thermal effects.

The principal object of the present invention is to provide a timing device for use with a photographic mechanism in which the exposure time interval provided by the device is a function of the viscosity of fluid in a hydraulic element, the viscosity being variable in accordance with a magnetic field established responsively to the determination of ambient illumination by a photoelectric element.

In its most general form, the present invention is characterized by a hydraulic mechanism which controls the exposure time interval of a photographic device. The hydraulic mechanism comprises, in one form, a hydraulic dashpot formed of the usual cylinder and piston, and a field-responsive hydraulic fluid. The speed of movement of the piston, when under a substantially constant force, is controlled by the resistance or obstruction to the flow of the hydraulic fluid, for example, to passage thereof through an aperture, and, therefore, is a function of the viscosity of the fluid. The hydraulic fluid employed is characterized in that its apparent viscosity is a function of an applied magnetic or electric field or both. Means are included for creating a field, either magnetic or electrical, in the vicinity of the hydraulic fluid and this field in turn, by magnetizing substances within the fluid, changes the apparent viscosity of the fluid, thereby causing an increase in resistance of the passage of the fluid through the aperture. In recognition of the fact that, in cases of mixtures, the viscosity of the fluid per se does not change but only the binding force between magnetized particles opposes the flow, the term "apparent viscosity" is employed herein to indicate the viscosity of the total combination as well as that of the fluid alone when the latter is magnetizable. Because the means for creating the field are coupled with a photoelectric device having an output inversely responsive to the intensity of illumination incident thereon, the field and therefore the resistance to the fluid flow are both functions of the ambient illumination. The time interval of the type of



photographic device with which the fluid-retarding mechanism is preferably employed is characterized in having a shutter including a moving member, the time interval provided by the shutter being a function of the speed of movement of the moving member.

A particularly attractive feature of the present invention is its almost complete immunity to positional instability. This is quite important in instances where the invention is incorporated into a hand-held camera inasmuch as variation in exposure time intervals resulting from different camera positions is intolerable.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIGURE 1 is a schematic side-elevational view, partly in section, of one embodiment of the invention, showing the shutter mechanism in an uncocked position;

FIG. 2 is a cross-section of a portion of the embodiment of FIGURE 1 taken along the line 2—2;

FIG. 3 is a schematic, front-elevational view, partly in section, of another embodiment of the invention;

FIG. 4 is a cross-section of a portion of the embodiment of FIG. 3, taken along the line 4—4; and

FIG. 5 is a schematic circuit diagram of one form of a photoelectric mechanism forming a portion of the embodiment of FIGURE 1.

Referring now to the accompanying drawings, in FIGURE 1 there is shown a timing device indicated generally by the reference numeral **20** and comprising an elongated cylindrical element **22** and a piston element **24** disposed within the bore of element **22** and movable substantially along the cylindrical axis A—A of element **22**. Element **24** comprises a double-ended piston having a first circular plate **26** disposed substantially perpendicularly to the cylindrical axis of element **22** and a second circular plate **28** similarly disposed. Both plates have diameters substantially lesser than the diameter of the bore so that they fit quite loosely within element **22**. Connecting plate **26** and **28** and adapted to be positioned substantially along the cylindrical axis of element **22** is a piston rod **30** which extends substantially perpendicularly from plate **26** to plate **28** and thence outwardly of the one cylindrical end **31** of element **22**. The portion of piston rod **30** which extends between the two plates is adapted to ride in a central aperture or bearing **32** provided in a rigid diaphragm means **34** which substantially separates cylindrical element **22** into two chambers **36** and **38**. In an alternative embodiment the piston plates may be connected together externally of the cylinder, thereby eliminating possible leakage at bearing **32**.

Symmetrically disposed in diaphragm means **34** about bearing **32** are fluid control means such as one-way valves **40** which, in the form shown in both FIGS. 1 and 2, are simple flap-type valves. As a means for providing a fluid-proof seal between the interior surface of the bore of element **22** and the peripheries of the respective plates, there is provided in the preferred embodiment, a positive flexible seal **42** which allows piston element **24** susbtantial freedom of movement from one end to the other of cylindrical element **22** while yet allowing of no leakage whatever due to lack of proper sliding clearance between the diameter or bore of element **22** and the plate diameters. Such a seal is that manufactured by The Bellofram Company of Massachusetts

and described more fully in U.S. Patent No. 2,849,026. Such a sealing device is preferred because it substantially reduce starting friction, provides a really complete fluid seal, and considerably reduces the costs of construction by abolition of the need for critical tolerances.

It will therefore be seen that the piston plates, the seal and the cylinder all together form a pair of substantially fluid-tight chambers 36 and 38 having communication with one another through valves 40 and through fixed aperture 44 or plurality thereof provided in diaphragm means 34 adjacent one of the valves. These chambers are preferably filled with a viscous fluid 46 comprising a mixture of paramagnetic or ferromagnetic particles such as carbonyl-iron powders, a dispersing agent such as a detergent, and a suspensory medium such as a fluid silicone which is substantially inert chemically and possesses a comparatively small temperature coefficient of expansion. The structure here described is thus a virtually maintenance-free structure in that, being sealed it cannot readily be contaminated and is substantially moisture proof, the frictional effects are controlled and predictable, and it is relatively immune to thermal effects within a reasonable range of temperatures.

One end 48 of element 22 is preferably partly closed by an annular flange 50 which extends substantially inwardly from the cylinder towards its cylindrical axis A—A, an opening 52 being provided in the flange to allow for ready venting of air in and out of the space between end 48 of the cylinder and plate 26. Another vent such as hole 53 is provided at the opposite end of element 22 to permit movement of air in and out of the space between end 31 and plate 28. As a means for providing a substantially constant force for biasing piston element 24 for movement along the cylindrical axis, there is provided a spring means such as coil spring 54 disposed substantially coaxially within the cylindrical element 22. One end of coil spring 54 is mounted upon flange 50, the other end of the spring being engaged with plate 26. Spring 54 is so dimensioned that when plate 26 is immediately adjacent diaphragm means 34, the spring is substantially relaxed, spring 54 being in a compressed and therefore torsional state when plate 26 is displaced any substantial distance from the diaphragm means.

The invention includes means such as coil 56 for providing a magnetic field in which hydraulic fluid 46 is positioned. Coil 56, in the form shown, is wound about the external arcuate periphery of cylindrical element 22 so as to be substantially coaxial therewith. The coil may be formed of any of the electrically conducting substances known in the art such as copper, silver or the like and, of course, is preferably electrically insulated from element 22. For energizing coil 56 to create a magnetic field, the coil is fed from a source of electromotive power, which in one form of the invention, comprises a photoelectric device or photocell 58. It is to be understood that the term "photocell" as used herein includes the concepts of photoemissive, photoconductive and photovoltaic devices either as individual units, or combination of units, or as a plurality of stages, with or without amplification or inversion as the case may be. Under some circumstances manual control may be desired in place of photoelectric control. Consequently the invention includes means for bypassing photocell 58, which means comprises, in one form, a potentiometer or manually controlled rheostat 59 connected to one lead from battery 60 to photocell 58. Switch means, such as switch 61, are provided in the other lead from the coil to the photocell, and is movable between a first position (as shown in FIG. 1) wherein the photocell is in circuit and the rheostat out of circuit, and a second position wherein the switch connects the rheostat to the battery while disconnecting the photocell from the circuit. In the form shown, in order to avoid unnecessary drain on the battery when the invention is not in use, switch 61 has a third position 62 in which the photocell and battery are disconnected from coil 56. In embodiments where photocell 58 is of the photovoltaic type, battery 60 is preferably placed in parallel rather than in series circuit relation therewith as shown.



The end of piston rod 30 which extends outwardly of end 31 of cylindrical element 22 is preferably supported thereat by appropriate bearing means 63 in which the piston rod is slidably mounted. The extremity of the piston rod which extends beyond bearing 63 is provided with connecting means such as an eye and pivot 64 upon which one end of a linking means such as lever 66 is mounted. The other end of lever 66 is pivotally connected to a moving member such as tensioning lever 68 of a camera shutter 70, the shutter being of the well-known type wherein the exposure time provided by the shutter is a function of the speed of movement of the moving member. Shutter 70 is illustrated as being of the central or Prontor type such as is disclosed in U.S. Patents Nos. 2,531,034, 2,663,235 and many others. The timing device may be connected through the piston linkage to moving members of many other types of shutters wherein the exposure time is a function of the speed of movement of the moving member, such as so-called rotary-disc shutters and many blade and cover blind types of shutters.

The operation of a Prontor-type shutter is well known; typically in its operation, tensioning lever 68 is moved into a cocked position by manual pressure thereon and when the shutter is thus cocked, actuation of release lever 72 thereof trips the shutter allowing the shutter mechanism to open. The time interval during which the shutter remains open is a function of the speed of movement of tensioning lever 68 from its tensioned or cocked position to an uncocked position. In the usual Prontor shutter, the speed of movement of lever 68 is determined by a gear train. This train is preferably removed in shutters of this type when employed with this invention, or the shutter is set for the shortest exposure time interval, thereby essentially by-passing the timing gears. The movement of the tensioning lever is transmitted through lever 66 to piston 30, compressing spring 54 during the cocking motion (clockwise as seen in FIGURE 1) of lever 68. Upon actuation of lever 72, the speed of the return motion of lever 68 to uncovered position is retarded by the resistance to the flow of fluid 46 through aperture 44. Thus the time interval during which the shutter is open for exposure is directly proportionate to the speed of movement of the piston as determined by the resistance presented to fluid flow.

Photocell 58, which is preferably directed toward the field of view of the shutter 70 and therefore is illuminated with light from the subject matter which is observable through shutter 70 when the latter is open, produces (i.e., either generates, controls or modifies) an electrical current which, upon passage through coil 56 sets up a magnetic field in which hydraulic fluid 46 is disposed. Because fluid 46 comprises magnetic materials, the viscosity of the fluid varies with variations in the intensity of the magnetic field. Therefore the speed of movement of piston 24 within cylindrical element 22 is a function of the intensity of ambient illumination determined by the photocell.

The electrical current produced by photocell 58 is a direct function of the intensity of light incident upon the photosensiitve portion of the photocell. If the dependency of photocurrent upon light intensity is allowed to directly control the apparent viscosity of fluid 46, then the longer exposure-time intervals will occur at the higher light intensities, and the shorter exposure-time intervals will occur at the lower illumination levels. However, for photographic purposes, it is desired that the dependency of the magnetic field and thus the viscosity upon the light level be in inverse relationship, and means are provided to this end. One form of photocell 58 which includes an exam-

ple of inversion means is shown in FIG. 5, wherein is provided a photoconductive element **73** having a resistance which varies inversely as the intensity of the light incident thereon. Element **73** is connected in series with a ballast resistor **74** and with battery **60** and coil **56**. Coil **56** is also in the circuit of plate **75** of triode **76**, the cathode **77** of the triode being connected to battery **60** through a resistor **78**. Light falling on element **73** will increase its conductivity thus creating an increase in the potential impressed upon grid **79** of the triode, the grid being tapped into the circuit between photoconductive element **73** and ballast resistor **74**. With proper polarity of battery **60**, the potential of the grid will tend to become negative and this will give rise to a decreased plate circuit current. Thus, increases in light intensity are accompanied by decreased current flow through coil **56** and a lowering of the viscosity of fluid **46**. It is apparent that the limiting speeds of movement of the piston are determined (assuming a constant force from spring **54**) by the maximum and minimum viscosities provided by the hydraulic fluid including its magnetizable component. The resistance to fluid flow during return movement of the piston (i.e., during cocking movement of lever **68**) is reduced considerably by the action of valves **40**, thereby offering little impediment to easy setting of the device even when the fluid is very viscous.

In FIGS. 3 and 4 there is shown an alternative arrangement wherein is included a substantially hollow, approximately doughnut shaped element **80** filled with a magnetizable hydraulic fluid composition **81** similar to that previously described herein in connection with the embodiment of FIGURE 1. Pivotally mounted in element **80** at its center upon pivot **84** and keyed thereto is a movable support means such as scabbard **86** which slidingly supports a piston element such as vane **88**. The latter is spring loaded by spring **90** disposed within scabbard **86** and is biased thereby into contact with at least a portion of the inside wall of the external periphery of element **80**. Upon rotation thereof about pivot **84**, the arrangement of vane and scabbard is intended to have a limited travel or stroke through portion **82** of element **80**, portion **82** having a substantially uniform internal cross-section, as shown in FIG. 4. Both scabbard **86** and vane **88** are dimensioned to fit the uniform internal contour of portion **82** with a minimum tolerance to prevent leakage of hydraulic fluid between the vane and scabbard on the one hand and the internal walls of element **80** on the other. In order to prevent or minimize friction at the sliding juncture of the internal walls of element **80** with the moving parts, the hydraulic fluid per se is a lubricant or comprises a lubricant such as a miscible oil.

Means are provided such as coil **92** for generating a magnetic field, variations in which create corresponding changes in the viscosity of fluid **81**. Coil **92**, in the form shown, is wound about another portion **94** of element **80**, passing from the outside of the latter through central aperture **96** provided somewhat off center in the doughnut shape of element **80**. Coil **92** is electrically coupled by appropriate means to photocell means shown schematically at **98**, the magnetic field generated by the coil being a direct function of the current produced by the photocell means.

Mounted upon pivot **84**, externally of element **80**, is a shutter element such as blade **100** which in the form shown includes an opening **102** therein adjacent the unpivoted end thereof. Blade **100** is positioned for movement between a first position wherein opening **102** is to one side of exposure aperture **104** through which an exposure is intended to be made, to a second or displaced position at the opposite side of aperture **104**. Opening **102** is adapted to pass over aperture **104**, substantially in registration with the latter, during movement of the blade from one of the positions to the other. Means such as spring **106** is coupled with blade **100** for providing the force necessary to move the blade, in the form shown, from the first position of the latter, wherein spring **106** is tensioned, to the second position of the blade. Spring-loaded, pivotable latch means **108** is shown engaged with extending portion **110** of blade **100** for releasably retaining the latter in its first position. When in either the first or the second position, blade **100**, being opaque to the radiation intended to be employed for exposure purposes, occludes exposure aperture **104**.

In operation, rotation of latch **108** releases blade **100** for movement from its first position under the impetus of spring **106**, the resulting traverse of opening **102** across aperture **104** affording exposure through the latter. The time interval of such exposure is obviously determined by the speed of movement of blade **100**, at least during transit of opening **102** across aperture **104**. The motion of blade **100** under the bias of spring **106** continues until blade **100** is arrested in its second position by limit stop **112**. It is apparent that the return movement of the blade from its second to first position (for instance, under manual pressure) will also afford exposure through aperture **104**, hence the shutter mechanism will be understood to include an auxiliary device such as a cover blind which prevents exposure during this return movement. For the sake of clarity, such a cover blind, well known in the art, has been omitted from the drawing.

The speed of movement of the shutter blade is controlled by the retardation offered to the movement of fluid **81** around the inside of element **80** by the force exerted thereon by vane **88** and scabbard **86**. Where the viscosity of fluid **81** is minimal, the resistance to fluid flow is also minimal and the speed of movement of the vane and scabbard and the coupled shutter blade is maximal; conversely, where the viscosity of the fluid is at its greatest, the speed of movement of the shutter blade is slowest, thereby providing the longest time intervals of exposure. Because the relative viscosity of fluid **81** is controlled by the intensity of illumination determined by photocell means **98**, the exposure time intervals provided by the mechanism are thereby determined responsively to the light intensity.

It will be seen that the embodiment shown in FIGS. 3 and 4 is particularly well adapted for timing control of rotary movement, while the embodiment of FIGS. 1 and 2 is particularly useful for control of the timing of more nearly linearly movable devices. However, known mechanisms for converting linear to rotary motion and vice versa may be employed with either embodiment to adapt them for particular applications.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a shutter mechanism in which the exposure time interval is a function of the speed of movement of a moveable member forming a portion of said shutter mechanism, a device for controlling the exposure time intervals comprising, in combination, a displaceable fluid the apparent viscosity of which is variable in accordance with the degree of magnetization thereof, movable means coupled with said movable member for moving said fluid, the speed of movement of said movable means being a function of said viscosity, and means for predeterminedly magnetizing said fluid for controlling the viscosity thereof so as to effect changes in said exposure time intervals.

2. A control device as defined in claim 1 including manually controlled means for varying said degree of magnetization.

3. A control device for a shutter mechanism in which the exposure time interval is a function of the speed of movement of a movable member forming a portion of said shutter mechanism, said control device comprising photoelectric means for producing electrical signals in accordance with the intensity of illumination thereon,

means for generating a magnetic field responsively to said signals, a fluid having at least a portion thereof disposed within said field, the apparent viscosity of said fluid being variable by said field responsively to changes in the latter, and a movable element for moving said fluid, the speed of movement of said element being a function of said viscosity, said element being couplable with said movable member for controlling said exposure time interval in accordance with said illumination intensity.

4. A control device as defined in claim 3 wherein said fluid includes a magnetizable substance.

5. A control device as defined in claim 3 including container means for holding said fluid, said movable element comprising a piston device movable within said container means.

6. A control device as defined in claim 5 wherein said container means is approximately doughnut shaped and said piston device is pivotally mounted for movement within said container.

7. A control device as defined in claim 5 wherein said container means comprises a cylindrically shaped container, said piston device being movable substantially linearly therein along the cylindrical axis thereof, and including flexible sealing means coupling both said piston device and said container so as to prevent leakage of said fluid between said piston device and said container.

8. A control device as defined in claim 7 wherein said piston device comprises a double-ended piston, said fluid being confined within the space defined by the ends of said piston and the internal walls of said container and said seal, said control device including a diaphragm positioned transversely of said container between the ends of said piston and having an aperture therein through which said piston is adapted to move said fluid.

9. A shutter mechanism comprising, in combination, a movable member, the exposure time interval provided by said shutter mechanism being a function of the speed of movement of said movable member, retarding means including a movable element couplable with said member, a magnetizable fluid movable by said movable element, means for moving said movable element, the speed of movement of said movable element being a function of the apparent viscosity of said fluid, means for producing a predeterminedly variable electrical current, and means for magnetizing said fluid for varying the viscosity thereof in accordance with variations of said electrical current.

10. A shutter mechanism as defined in claim 9 wherein said means for producing a variable electrical current comprises photoelectric means for producing said current in accordance with the intensity of illumination thereon.

11. A shutter mechanism as defined in claim 9 wherein said means for producing a variable electrical current comprises a manually controllable rheostat.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,159,169 | Brown | Nov. 2, 1915 |
| 2,507,182 | Young | May 9, 1950 |
| 2,661,596 | Winslow | Dec. 8, 1953 |
| 2,667,237 | Rabinow | Jan. 26, 1954 |