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Fahlenberg et al.

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[45] **Apr. 11, 1972**

[54] PHOTOGRAPHIC SHUTTER WITH ELECTRO-MAGNETIC DRIVE MEANS

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[51] **Int. Cl.**.....**G03b 9/08**
[58] **Field of Search**.....95/53, 53 E, 53 EA, 53 EB, 95/58, 59

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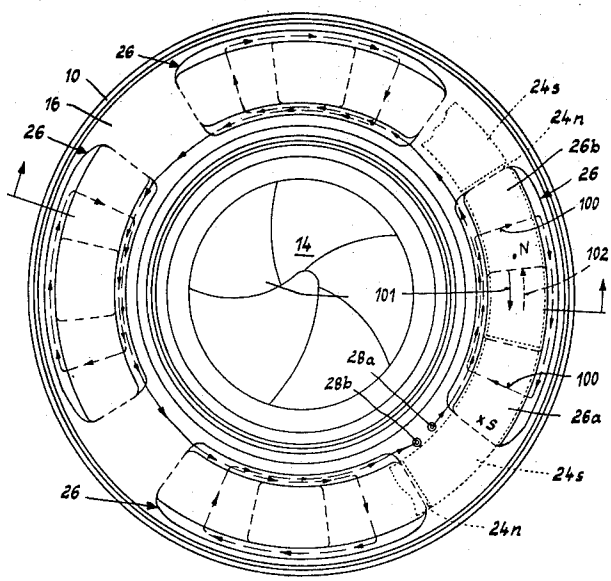
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Assistant Examiner—Monroe H. Hayes
Attorney—Charles Shepard and Stonebraker & Shepard

[57] **ABSTRACT**

A photographic shutter having a shutter blade drive ring provided with magnetic coils disposed in the magnetic field of a magnet which is fixed in the housing. When the coils are energized, they react with the magnetic field of the magnet to cause the drive ring to turn, to open and close the shutter blades. An electronic circuit provides the pulses which energize the coils to operate the shutter.

10 Claims, 9 Drawing Figures



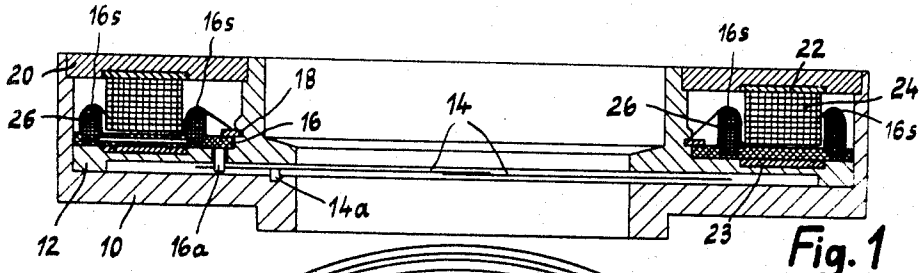


Fig. 1

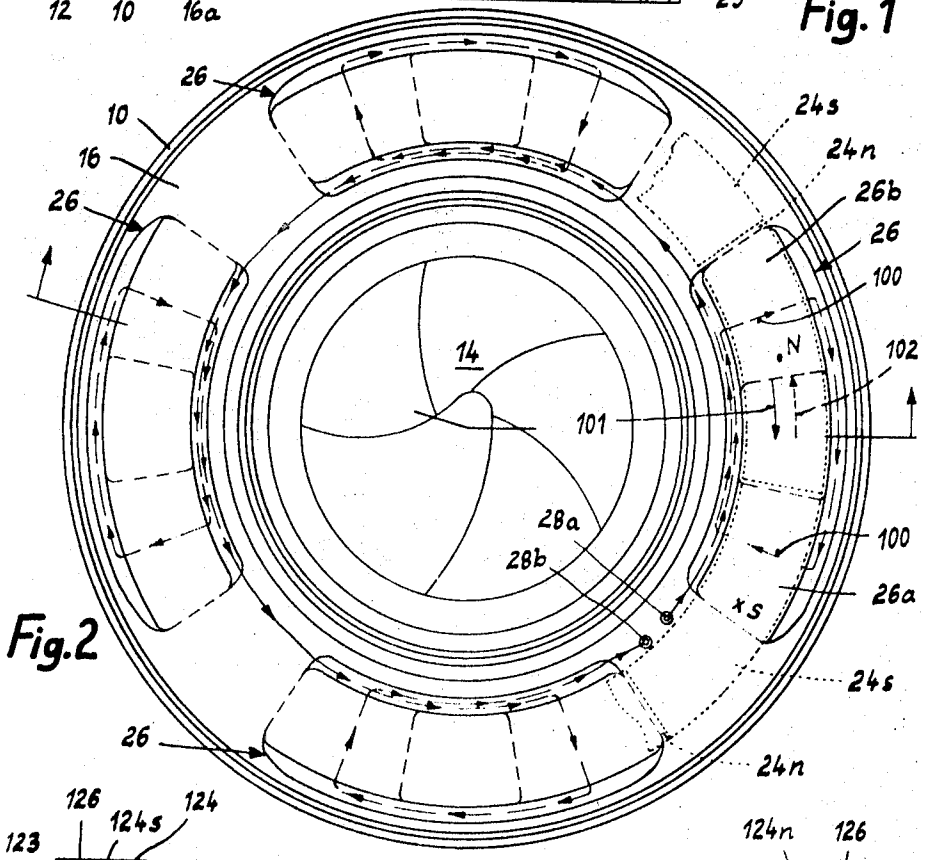


Fig.2

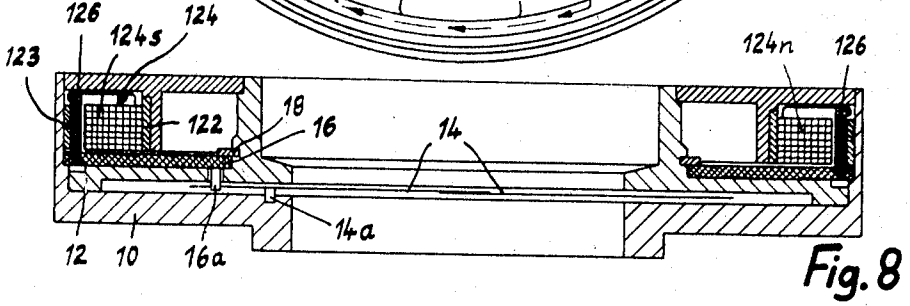


Fig. 8

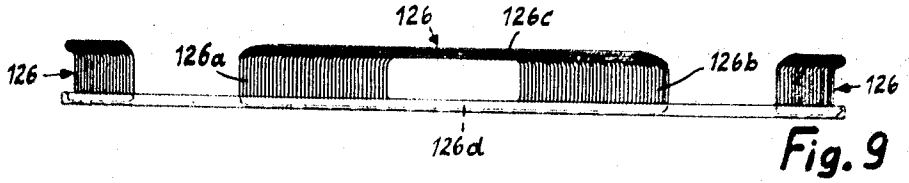
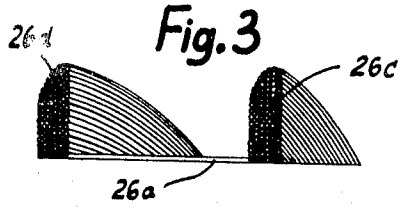


Fig. 9

Fig. 3



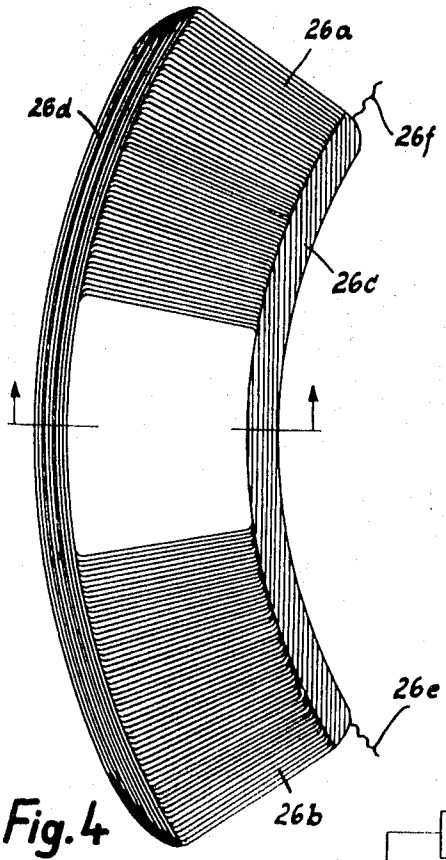


Fig. 4

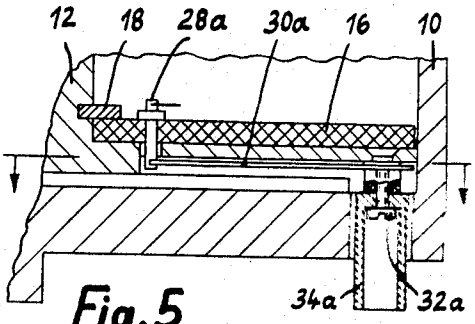


Fig. 5

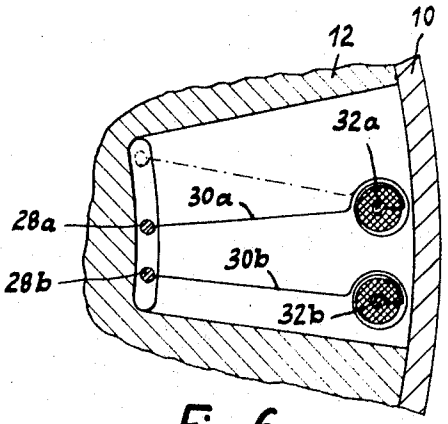


Fig. 6

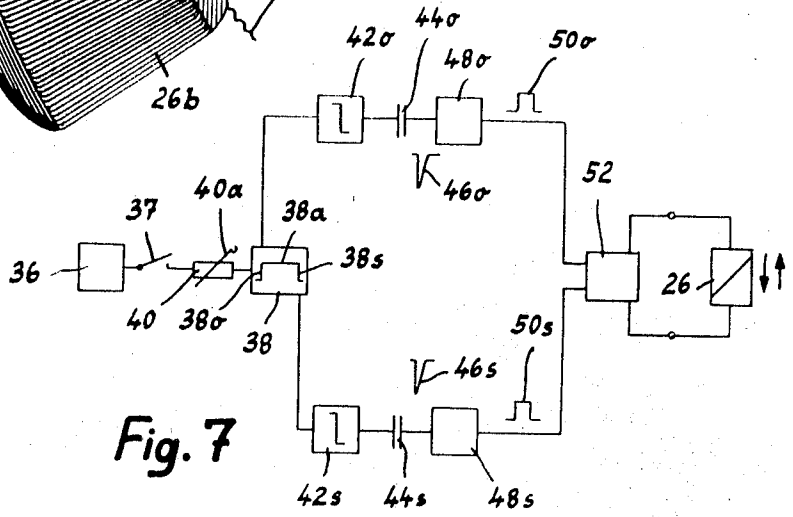


Fig. 7

PHOTOGRAPHIC SHUTTER WITH ELECTRO-MAGNETIC DRIVE MEANS

BACKGROUND OF THE INVENTION

The invention relates to photographic shutters such as are used on various types of photographic apparatus, especially on cameras. Such shutters are generally in the form of an annular housing with a central aperture for admitting light into the camera, and there are usually several shutter blades pivoted in the annular housing to swing from overlapping closed positions preventing passage of light through the central exposure aperture, to open positions permitting passage of light. The respective blades are usually pivotally connected to a blade driving ring (sometimes called merely a blade ring) which rotates concentrically with the optical axis (that is, concentrically with the center of the exposure aperture) so that rotation of the ring in one direction will move the various shutter blades to their respective open positions, and rotation of the ring in the opposite direction will swing the blades to their closed positions, terminating the exposure.

These above mentioned features, commonly found in modern photographic shutters are retained in the shutter of the present invention, and these parts of the present construction may be regarded as conventional. The novelty of the present invention is in the manner in which the blade ring is driven to cause the opening and closing movements of the blades. According to the present invention, a permanent magnet is mounted in stationary position in the shutter housing, and a magnetic coil is attached to the blade driving ring to move therewith. The magnetic coil is within the magnetic field of the permanent magnet. When current flows through the magnetic coil, this produces a force tending to cause the coil to move relative to the stationary magnet, and since the coil is mounted on the blade driving ring, this causes a rotation of the blade driving ring, to open or close the shutter blades, as the case may be.

An object of the invention is the provision of a generally improved and more satisfactory photographic shutter, and particularly one in which the movement of the shutter blades is caused by flow of current through a coil in the field of a permanent magnet.

Another object is the provision of such an arrangement so devised as to give optimun utilization of the magnetic field for a given size of magnet, to insure a high degree of effectiveness of the electromagnetic or electrodynamic driving means.

Still another object is the provision of such a construction in which the coil is so arranged with relation to the magnet, that the coil elements or components which are actively concerned with the movement of the coil are always disposed within the magnetic field of the magnet, while other elements or components of the coil, used only to complete the circuit, are disposed externally of the magnetic field of the magnet.

A further object is the provision of an electromagnetically driven shutter, so designed that it is simple in construction, easy and inexpensive to manufacture, sturdy in use, and not likely to get out of order.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial cross section through a shutter in accordance with a preferred embodiment of the invention, the section being taken approximately on the line 1—1 of FIG. 2;

FIG. 2 is a plan or face view of the shutter, with the cover plate and certain other parts removed in order to show parts beneath, and with some parts shown schematically;

FIG. 3 is a cross section, on an enlarged scale, of a magnetic coil constituting part of the structure, the section being taken approximately on the line 3—3 of FIG. 4;

FIG. 4 is a plan of the same coil shown partially in FIG. 3;

FIG. 5 is an axial section through a fragment of the shutter, illustrating particularly certain electrical connections;

FIG. 6 is a transverse section substantially on the line 6—6 of FIG. 5;

FIG. 7 is a wiring diagram of the electric circuit arrangement for controlling the current flowing in the magnetic coils;

FIG. 8 is a view similar to FIG. 1, illustrating a modification of the construction; and

FIG. 9 is an edge view of the magnetic coils used in the embodiment illustrated in FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The first embodiment of the shutter structure, illustrated in FIGS. 1–6, comprises the usual cylindrical or annular shutter housing or casing **10**, having a central aperture as shown, the optical axis extending through the center of this aperture in the conventional manner. Mounted in the housing is an annular base plate or mounting plate **12** suitably fastened therein as by screws. A flat space is provided between the parts **10** and **12** to accommodate the shutter blades **14**, of any desired number, five blades being here illustrated. Each blade **14** is rotatably mounted by a pin **14***a* in the housing, and has a slot engaged by a driving pin **16***a* on the blade driving ring **16**, which is made of non-magnetic material and preferably of synthetic plastic material. This ring is mounted for rotation about the optical axis as a center, and rotates on a suitable bearing surface on the plate **12**. It is held against axial movement away from the plate **12** by a spring ring or clip **18** seated in a circumferential slot in the forwardly extending lens tube which forms part of the member **12**. When the blade ring **16** turns in one direction, the blades **14** are swung to their open positions, and when the ring **16** turns in the opposite direction, the blades are closed to the closed position shown in FIGS. **1** and **2**. The shutter housing is provided with a front plate **20**.

An annular permanent magnet **24** is secured, by cement or otherwise, to the inner face or side of the front plate **20** A return flow ring **22** is interposed between the magnet **24** and the plate **20**, as illustrated, This ring **22** serves to complete the magnetic circuit and provides for return flow of the magnetic flux from the permanent magnet **24**.

This permanent magnet **24** is preferably made of a plurality of equal-sized magnet segments. In the preferred form, there are eight such segments, each of arcuate form, the ends of the segments abutting tightly against each other in a circumferential direction, with no space between them. Alternate segments are of alternate polarity, four segments **24***n* being magnetized completely as north poles, interspersed with four segments **24***s* magnetized completely as south poles. The eight segments together thus constitute a complete ring which is continuous in a circumferential direction and which has alternating north pole and south pole portions. The housing portions **10**, **12**, and **20** are made of non-magnetic material, preferably aluminum, while the magnetic circuit return flow plate **222** above mentioned, and also a further magnetic circuit return flow plate **23** set in a groove in the mounting plate **12**, are of ferrous material.

Associated with the permanent magnets are magnetic coils **26** shown in FIGS. **1** and **2**, and illustrated on a larger scale in FIGS. **3** and **4**. There are four of these coils **26**, each occupying somewhat more than a quarter of the complete circle, with gaps of somewhat less than a quarter of the complete circle between the ends of adjacent coils, as will be seen especially from FIG. **2**. These coils are secured to the previously mentioned blade driving ring **16**, and move therewith as a unit when the ring turns in one direction or the other.

Each coil is made of a great number of fine conductor wires, illustrated schematically. In the portions shown at **26***a* and **26***b* (FIG. **4**) the conductor wires extend in a direction radially with respect to the optical axis of the shutter, or in other words perpendicular to a line which is tangent to the blade driving ring **16** at the point where any particular coil conductor is located. The conductors in these portions **26***a* and **26***b* form a very flat coil, with minimum thickness in the direction of the optical axis of the shutter, the coil being only one wire thick in this direction. To complete the circuit through these flat portions of the coil, the conductor wires extend through what may be called the coupling portions **26***c* and **26***d* of the windings, the conductors in these portions **26***c* and **26***d* extending in a generally circumferential direction to couple each individual

wire in the flat coil portion 26*a* to a corresponding individual wire in the flat coil portion 26*b*. it will be understood that the various conductors in these portions 26*a*, 26*b*, 26*c*, and 26*d* form one continuous conducting circuit, the ends of the winding being shown schematically at 26*e* and 26*f*. In other words, if the terminals 26*e* and 26*f* of the coil 26 are connected to a source of current, current will flow first through one of the radially extending or flat coil conductors in the portion 26*a*, then circumferentially through one of the conductos in the portion 26*c* to the first one of the radially extending conductors in the portion 26*b*, thence circumferentially through one of the connecting or coupling conductors in the portion 26*d* to a second one of the radial conductors in the portion 26*a*, thence back through one of the conductors in the portion 26*c* to a second one of the radial conductors in the flat coil portion 26*b*, and so on.

It is seen from FIG. 3 that the connecting or coupling portions 26*c* and 26*d* appear to be much higher, in the direction of the optical axis, midway of the length of the coil, as compared with the ends of the coil. This is true, and is caused by the fact that many more conductors must be present midway of the length of the coil, than at its ends. At the mid-point, each portion 26*c* and 26*d* must contain enough wires or conductors to connect each individual crosswise or radial conductor in the portion 26*a* to a corresponding crosswise or radial conductor in the portion 26*b*. But a constantly decreasing number of conductors is necessary, in the portions 26*c* and 26*d*, as one approaches the ends of the coil.

Each coil 26 is wound in an appropriate shape. It is then heated in an oven until the thermoplastic sheath or insulating covering on each turn of the wire is softened enough to become bonded to the next adjacent sheath or sheaths, whereby the overall shape of the formed coil will be retained when the coil is cooled to room temperature, the thermoplastic insulation becoming hard or firm. The connecting portions or coupling portions 26*c* and 26*d* of each winding constitute upstanding lateral ribs, and they are curved (when viewed in plan as in FIG. 4) appropriately to the shape of the shutter, to lie on either side of the permanent magnet 24 (as seen in FIG. 1) close to but not actually making contact with the permanent magnet.

The four individual coils 26, after being pre-formed to the desired shape as above mentioned, are conductively coupled to each other, in series, and are then placed in an injection mold so shaped that when the synthetic plastic material is forced into the cavity of the mold, the plastic material will form the blade driving ring 16 against the lower face of the flat coil portions 26*a* and 26*b* of the respective coil windings 26. Also, the injection mold cavity is so formed that a thin coating 16*s* of the plastic material will be deposed over the remaining parts of the coil, to increase the rigidity of the latter and to guard the fine conductor wires of the coil against damage. Upon completion of the injection molding operation, the blade driving ring 16 and the coils 26 have the form illustrated in FIGS. 1 and 2.

The connection of the coils 26 to a source of current and to a control circuit is illustrated in FIGS. 5 and 6. The coils are all connected in series with each other, and the terminal conductors are connected to axial contact pins 28*a* and 28*b*, respectively, firmly set in and moving with the blade driving ring 16. One end of each of these contact pins carries a radially yielding contact spring 30*a* and 30*b*, respectively, which in turn is conductively connected to a screw 32*a* and 32*b*, respectively, which joins the connection nipple 34*a* and 34*b*, respectively, mounted on and suitably insulated from the base plate or mounting plate 12. The conductors 30*a* and 30*b* are flexible in a direction circumferentially of the shutter, and also have a sufficient degree of flexibility in a direction radially of the shutter, on account of the outer ends of these conductors having loops where they are connected to the screws 32*a* and 32*b*, as shown in FIG. 6. In view of this radial and circumferential flexibility of the conductors, the blade driving ring 16 together with the contact pins 28*a* and 28*b* thereon can perform its turning motion without impairing the electrical connections and can easily move through the necessary circumferential distance from one extreme position to the other, as indicated schematically in broken lines in FIG. 6.

The coils 26 are electrically connected through the above mentioned nipples 34*a* and 34*b* with a control circuit illustrated in FIG. 7, which circuit may be installed in a special switch box which may be either close to the shutter, or at some distance therefrom, if remote control of the shutter is desired.

A current source, such for example as a battery 36, may be provided in the switch box, and can be connected at will to the electronic shutter arrangement through a switch 37. A control impulse generator is shown at 38. This produces electrical pulses of rectangular form. The duration or length of these rectangular control pulses (diagrammatically illustrated at 38*a*) can be modified at will by a variable resistance 40. The hand setting member of the resistance 40 is schematically shown at 40*a*, and can be adjusted manually to set the mechanism to the exposure period value or shutter speed which is required at any particular time, using a fixed exposure time or shutter speed scale, and a marker or pointer connected to the setting member 40*a*.

The rising flank 38*o* of the control pulse 38*a* is converted by a reversing amplifier 42*o* and a differentiating member 44*o* into a negative needle pulse which is diagrammatically depicted at 46*o* in FIG. 7. This needle pulse 46*o* is converted into a rectangular pulse of, for example, 5 microseconds duration or length, by a pulse former 48*o*. This pulse is diagrammatically indicated at 50*o* and is conducted by the end amplifier 52 in equiphase condition to the magnetic coil 26. Similarly, the descending flank 38*s* of the control pulse 38*a* will produce a needle pulse 46*s* through a non-reversing amplifier 42*s* and a differentiating member 44*s*. This pulse is converted by the pulse former 48*s* into a rectangular pulse 50*s* and passed through the end amplifier 52 in antiphase condition to the magnetic coil 26.

The shutter operates as follows: When the shutter is in the rest position, the coils 26 occupy the position relative to the various segments of the magnet 24 as illustrated in FIG. 2. The component 26*a* of each coil 26 is located beneath a south pole portion 24*s* of the magnet, and each coil component 26*b* is located beneath a north pole segment 24*n* of the magnet. When the release trip or trigger on the switch box is operated to close the switch contact 37, the pulse 50*o* invoked by the rising flank 38*o* is conducted to the magnet coil 26 and produces a temporary excitation thereof. This first pulse of current through the coils 26 is indicated schematically by the arrow 100 in FIG. 2.

The coils 26, together with the blade driving ring 16 on which they are mounted, are moved in the magnetic field of the permanent magnet 24 in the direction indicated by the arrow 101, through a predetermined angular distance the length of which approximately corresponds to the length of the arrow 101, and the blades 14 are thereby opened. After a period of time determined by the setting of the member 40*a*, the pulse 50*s* produced by the descending flank 38*s* comes into effect. The end amplifier 52 then produces a pole current reversal, so that the current then runs through the coils 26 in the reverse direction. The coils 26 and the blade driving ring 16 are then moved reversely, in the direction of the arrow 102 in FIG. 2, to close the blades 14. This completes the exposure operation.

In the construction illustrated, the active components or portions 26*a* and 26*b* of the coils 26 are always disposed in the field of force of the magnetic poles 24*n* or 24*s* respectively, both in the rest position and in the open position of the driving ring. The non-active coil components or parts 26*c* and 26*d*, which are only used for completing the connections between the active portions or components 26*a* and 26*b*, are outside of the magnetic field. This therefore represents optimum use of the magnetic field, with the dimensions of the magnet 24 determined by those of the shutter. A very high degree of efficiency of the electromagnetic or electrodynamic shutter

operating means is thus achieved in accordance with the invention

DESCRIPTION OF A SECOND EMBODIMENT

A second embodiment of the invention, illustrated in FIGS. **8** and **9**, is similar in general to the first embodiment above described, the differences being in the coils and in the magnet. The annular permanent magnet **124** is formed, as before, with four north pole segments **124***n* alternating with four south pole segments **124***s*. Here, the magnet is magnetized radially, and is connected to and supported from the return flow ring **122** which is fixed to a depending flange on the cover plate, as shown. A second return flow ring **123** extends around the inside face of the outer cylindrical wall of the shutter housing.

In this embodiment, the active part of the coil, constituting the components **126***a* and **126***b*, is in the form of a flange upstanding from the blade driving ring **16** near the outer edge thereof, instead of lying flat on the ring as in the previous embodiment. This upstanding part of each coil lies between the magnet **124** and the return flow ring **123**, and is freely movable circumferentially between them. The inactive parts of the coils, serving merely to complete the circuit through the active parts **126***a* and **126***b*, are shown at **126***c* and **126***d*. The rest of the construction is essentially the same as the first embodiment previously described, and operates in the same way.

The manner in which the coils **26** or **126** are mounted on the blade driving ring **16**, by molding the pre-formed coils and the driving ring together in an injection mold as above described, enables these parts to be formed very accurately to close tolerances, so that there is an exact operational positioning of the movable elements of the shutter in relation to the fixed elements. The desired operational positioning can be maintained even if the air gap between the coils and the magnet is made very narrow. The synthetic material coating the coil components **26***c* and **26***d* or **126***c* and **126***d* promotes the rigidity of these parts and thereby prevents deformation or wear of the wire windings.

What is claimed is:

1. A photographic shutter having an optical axis and a housing, shutter blades arranged in said housing and movable between shutter closed and opened positions, a driving ring for moving said shutter blades, at least one magnetic coil fixed on said driving ring and having current input and output circuit connections, at least one ring shaped magnet fixed within said housing coaxially with respect to said optical axis and being magnetized in an axial direction with respect to said optical axis, said magnetic coil having a winding portion arranged in the magnetic field of said magnet and movable in common with said driving ring when a current flows through said magnetic coil, the winding portion (26*a*, 26*b*) of the magnetic coil (26) lying within the magnetic field being a flat shaped winding coil, the windings thereof running radially with respect to said optical axis and perpendicular with respect to a tangent of said driving ring, (16).

2. A shutter as defined in claim **1**, wherein said driving ring is formed of molded synthetic plastic material and said coil is preformed to the desired shape and bonded to said driving ring during the molding thereof.

3. A shutter as defined in claim **2**, wherein a part of the winding of the preformed coil is rigidly molded on said driving ring and another part of the winding is provided with a thin coating of the same plastic material from which said driving ring is formed.

4. A shutter as defined in claim **1**, wherein said coil is mounted on and rotates with said driving ring, characterized by the fact that input and output circuit connections for said coil are conductively connected through tangentially yielding conducting connections with coupling connections arranged in fixed position of said housing.

5. A shutter as defined in claim **4**, wherein said circuit connections yield radially as well as tangentially.

6. A photographic shutter having an optical axis and a housing, shutter blades arranged in said housing and movable between shutter closed and opened positions, a driving ring for moving said shutter blades, at least one magnetic coil fixed on said driving ring and having current input and output circuit connections, at least one ring shaped magnet fixed within said housing coaxially with respect to said optical axis and being magnetized in a radial direction with respect to said optical axis, said magnetic coil having a winding portion arranged in the magnetic field of said magnet and movable in common with said driving ring when a current flows through said magnetic coil, the winding portion (**126***a*, **126***b*) of the magnetic coil (**126**) lying within the magnetic field being a ring shaped winding coil, the windings thereof running axially with respect to said optical axis and perpendicular with respect to a tangent of said driving ring (**16**).

7. A shutter as defined in claim **6**, wherein said driving ring is formed of molded synthetic plastic material and said coil is preformed to the desired shape and bonded to said driving ring during the molding thereof.

8. A shutter as defined in claim **7**, wherein a part of the winding of the preformed coil is rigidly mounted on said driving ring and another part of the winding is provided with a thin coating of the same plastic material from which said driving ring is formed.

9. A shutter as defined in claim **6**, wherein said coil is mounted on and rotates with said driving ring, characterized by the fact that input and output circuit connections for said coil are conductively connected through tangentially yielding conducting connections with coupling connections arranged in fixed position on said housing.

10. A shutter as defined in claim **9**, wherein said circuit connections yield radially as well as tangentially.

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