

COMPENSATOR SYSTEM FOR DIAPHRAGM CONTROL
IN AN SLR CAMERA OF INTERCHANGEABLE LENS
TYPE

This invention relates to a diaphragm control compensator system in an SLR (single lens reflex) camera of interchangeable lens type.

5 Automatic cameras of this type are generally either of the diaphragm priority (or aperture priority) type, in which a desired aperture setting is preset by the photographer, or of the shutter priority type, in which the exposure time is preset. However, a combination or programmed exposure control may be used in which both aperture setting and shutter speed are automatically determined.

10 For a single-lens reflex camera using interchangeable lenses, the light metering operation can be done within the camera through an interchangeably-mounted lens with the diaphragm of the lens being fully opened. This is known as TTL (through-the-lens) photometry with fully-opened diaphragm or full aperture metering.

15 The resultant value can be used by directly coupling it with an exposure meter or by subjecting said value to an automatic exposure control operation. It is well known, however, that such an arrangement can lead to a great error in the exposure value to be set as derived from the said photometric value, so that a proper exposure
20 would not be obtained.

Such deviation or error is largely classified into (i) that due to the optical characteristics of individual lenses which are interchangeably mounted on the camera and (ii) that due to the specific position at which the light sensing element is located
25 within the camera.

The first of these is caused by the fact that the lens aperture to which the lens is stopped down by a diaphragm adapted to be preset by a diaphragm preset ring (diaphragm priority) at a moment of exposure can not produce a variation of actual illumination intensity in the film plane which accurately corresponds to the
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variation of the preset diaphragm value marked around the diaphragm preset ring. More specifically, individual interchangeable lenses are different in their lens materials, lens arrangements and modes of assembly, so that the illumination intensity in the film plane depends upon the light transmissivity characteristics, the vignetting effect peculiar to each lens, and particularly to the so-called aperture eclipse occurring with the fully opened diaphragm which substantially reduces the effective illumination intensity in the film plane when the lens aperture is held close to its fully opened diaphragm value.

In consequence, the illumination intensity in the film plane is reduced in its effective value and varies in a mode far from the required exponential variation as the lens aperture approaches the fully opened diaphragm value. An illumination intensity which is practically uniform and varies substantially corresponding to the successive steps of preset values marked around the periphery of the diaphragm preset ring can be obtained only within a range of relatively small lens aperture values, for example, apertures smaller than a F-value of 5.6. The effective value of the illumination intensity in the film plane is substantially reduced at the fully opened diaphragm (the maximum lens aperture) and the resultant value of a photometric operation carried out at this fully opened diaphragm can not be used to obtain a proper exposure since it would be impossible, from this resultant value, to produce a variation of the exposure time exactly or acceptably corresponding to the variation of successive preset values within the range of relatively small lens apertures and thereby to obtain an exposure time corresponding to a preset diaphragm value. Such error appearing in the film plane due to variation of illumination intensity depending upon individual interchangeable objectives is referred to herein as the illumination intensity error in the film plane.

Turning now to the second cause of error, the photometric element exposed to the light coming through the lens with fully opened diaphragm is preferably located exactly in the film plane, so that the photometric element may be operatively coupled to an

(17)

5 exposure meter or utilized for automatic exposure control to obtain
a proper exposure. However, if photometric operation is performed
actually in the film plane, the photometric element would be in the
way of the film exposure in photographing. A possible solution
10 is that the photometric element is located not in the film plane
itself but at a position which is equivalent to said film plane or
causes little photometric deviation from the value which would be
obtained from the photometric operation performed exactly in the film
plane. Such a photometric position equivalent to the film plane
15 may be, for example, a position of a focussing plate on which the
light reflected by a mirror is focussed and this position is, in
fact, preferred in that this position is in a conjugate relationship
with the film plane. However, this position would be an obstacle
not only for the photographer viewing through the viewfinder, but
20 also for his focus adjusting operation.

Accordingly, the photometric element has usually been
located, in most cases, on the light exit end surface of a
pentaprism (pentagonal-dachkant-prism) or similar optical system for
reflection and inversion of light which is mounted on the focussing
25 plate, particularly along the periphery of the viewfinder eyepiece
so that viewing therethrough should not be prevented. Even this
position of the photometric element has encountered the problem
that a photometric result is obtained as a value slightly lower or
darker than the illumination intensity actually given in the film
30 plane, since the position of the photometric element is deeper than
the position of the focussing plate, which is practically equivalent
and conjugate to the film plane, by the length of the optical
reflection and inversion path defined by said prism, and there occurs
some light absorption by said prism. Thus such location of the
35 photometric element has never accurately achieved the intended
photometric effect exactly equivalent to that obtained from the
photometric operation performed in the film plane and is necessarily
subject to an error depending upon the focal length of each inter-
changeably mounted lens. The error of this type is referred to
herein as the illumination intensity error due to the position of
the photometric element.

Thus, the respective errors as above mentioned inevitably appear as various amounts of deviation from the actual photometric values which should be obtained through the fully opened diaphragms, even if the objectives have the same value of their fully opened diaphragms or the same focal length. Details of these errors are illustrated and described in the specification of Japanese Patent Application No. 41 (1966)-49771, corresponding United States Patent No. 3,486,434.

With a photographic camera of diaphragm priority type, it is usual to transmit an information signal corresponding to the preset diaphragm value from the lens to a photometric system or its associated circuit, or an exposure control circuit in the camera body. The signal may be transmitted by suitable mechanical means such as a cam (an example of such means is disclosed in Japanese Patent Publication No. 53(1978)-33064), or by suitable electrical compensator means such as a variable resistor control of a special arrangement depending upon the diaphragm value actually preset, so that high precision exposure control can be achieved with an effective compensation of the errors as mentioned above and thereby a proper exposure is given.

The invention is defined in the appended claims to which reference should now be made.

The concept of the invention will be now considered by way of a simplified example. Assuming that, with respect to a reference lens A having a fully opened diaphragm value of F 1.4, a light quantity coming through another lens X having a fully opened diaphragm value of F 1.4 and being incident upon the light receiving element corresponds only to the light quantity which will come through said lens A when the latter is stopped down to a value of F 1.7. Thus the light quantity obtained through the lens X is considered to be lower by 0.5 EV than through the reference lens A. If a relationship of $Av' = Bv' + Sv - Tv$ is established with respect to the reference lens A, application of the Apex computation $Av = Bv + Sv - Tv$ will give a relationship $Av'' = (Bv' - 0.5) + Sv - Tv$ with respect to the lens X.

For example, assume the following conditions:

Brightness of an object to be photographed : $B_v = 8$ (EV),
Film sensitivity : $S_v = 5$ (EV),
Exposure time : $T_v = 8$ (EV), and
 $B_v' = 7$.

(It is assumed here that, also concerning the reference lens A, the effective illumination intensity incident on the light receiving element takes a value lower by approximately 1 EV and, even with the fully opened diaphragm value of F 1.4, not $B_v' = 8$ but $B_v' = 7$.)

Calculation according to the above mentioned formulae based on these values given by way of example gives respective values of A_v , A_v' and A_v'' as the following:

$A_v = 5$, $A_v' = 4$ (EV), $A_v'' = 3.5$ (EV),

wherein $A_v = 5$ indicates that the diaphragm value after the operation of stopping down corresponds to F 5.6.

With respect to the reference lens A, if the amount of displacement of the mechanical system during the stopping down operation is provided with a portion for error compensation corresponding to 1 EV as a preliminary displacement quantity of the diaphragm driving member or the transmission member associated therewith that takes no part in the light intensity quantity control effect, the displacement quantity of said diaphragm driving member that actually takes part in the operation of stopping down will substantially correspond to $A_v' + 1 = 5$ (EV) and thereby a diaphragm value $A_v = 5$ (corresponding to a diaphragm value of F 5.6) will be obtained. The lens X similarly provided with a preliminary displacement corresponding to 1 EV will be stopped down by $A_v'' + 1 = 4.5$ (EV) to $A_v = 4.5$ (corresponding to a diaphragm value of 4.5 after stopped down) with a deviation of 0.5 EV from the reference lens A with respect to the same object to be photographed. To overcome such deviation, the preliminary displacement quantity of

the lens X is set 0.5 EV smaller than that of the lens A (set to a quantity corresponding to 0.5 EV) so that the lens X is stopped down by a quantity of $Av'' + 1 = 4.5$ EV to the position $Av = 5$ (corresponding to the diaphragm value of F 5.6) in coincidence with the case of the reference lens A.

The basic concept of the present invention thus lies in achieving the desired error compensation by providing a part of the mechanical system adapted to transmit movement of the diaphragm driving member operating in the camera body to diaphragm blades in the lens with the displacement quantity that takes no part in the light quantity control through the operation of stopping down in operative association with said transmission so that various errors such as the difference of the fully opened diaphragm values (maximum lens apertures), the illumination intensity errors in the film plane depending upon individual objectives and the illumination intensity errors due to the positions of the respective light receiving elements are properly and reliably compensated with a highly precise diaphragm value as a result of stopping down.

The preferred embodiment of the invention will be described in more detail, by way of example, with reference to the drawings, in which:-

Figure 1 illustrates schematically the relationship between

the resistance value selected by a lever operatively associated with the diaphragm preset ring of respective interchangeable lenses and the starting point from which said preset ring is rotated;

5 Figure 2 is a block diagram illustrating schematically an automatic diaphragm control circuit embodying the present invention;

Figure 3 is a rear elevation view illustrating a diaphragm mechanism in which a diaphragm driving system is provided with a preliminary displacement taking no part in light quantity control effect;

10 Figure 4 is a characteristic diagram showing the delay appearing in operation of a mechanical system during the stopping down process;

Figure 5 is an elevation view illustrating a mount on the camera body for mounting the objective and a mount on the lens
15 along their relative abutting plane; and

Figure 6 illustrates the mechanical connection between the diaphragm control magnet and the diaphragm release plate.

 Before describing the construction of the system in detail, the procedures for the compensation of the said errors will be
20 considered with respect to a photographic camera of diaphragm priority type and the compensator means will be described along these procedures for better comprehension. Referring to Figure 1, R designates a variable resistor provided in the camera body, of which the resistance value is selectively set by a lever operatively
25 associated with a diaphragm preset ring of the respective objectives interchangeably mounted on the camera. Specifically, the resistance value of said variable resistor R peculiar to a given preset diaphragm value is set as said diaphragm preset ring is rotated to said given preset diaphragm value. Even when one
30 objective has the same fully opened diaphragm value as another objective, the respective effective values of illumination intensity in the film plane are different from each other at their fully opened diaphragm values. When they are the same in their fully opened diaphragm values but different in their focal lengths there
35 occurs, in addition to a variation of the illumination intensity error in the film plane, a variation of the illumination intensity error

due to the position of the photometric element. As a result, the exact resistance value of the variable resistor R selected by the lever of each objective at the fully opened diaphragm value is peculiar to this objective.

In view of the fact that the objectives which are interchangeably mounted on the camera may be same both in their fully opened diaphragm values and their focal lengths but different in their lens arrangements, or the same in their focal lengths but different in their fully opened diaphragm values, or same in their fully opened diaphragm values but different in their focal lengths, and so on, one objective which is considered most standard is chosen as the reference lens on the basis of which all the other different objectives are subjected to compensation so that the levers operatively associated with the diaphragm preset rings of the respective interchangeable objectives may select proper resistance values at their fully opened diaphragm values. Also with such reference lens (hereinafter referred to as the reference lense A), the effective illumination intensity in the film plane is lower than the level corresponding to the associated nominal diaphragm value in so far as the fully opened diaphragm value or a range of values adjacent thereto is concerned, while a series of diaphragm values within a range of relatively small diaphragm values bring about substantially proportional variation of illumination intensity in the film plane. The photometric element is influenced not only by such general characteristics but also by the illumination intensity error due to the position of the photometric element.

Based on the illumination intensity error in the film plane and the illumination intensity error due to the position of the photometric element determined with respect to the reference lens A (for example, having a fully opened diaphragm value of F 1.4), the lever operatively associated with the diaphragm of this reference lens A is adapted to be driven and positioned so that respective preset diaphragm values, corresponding to regular intervals graduations on the diaphragm preset ring which are representative of successive proportional diaphragm values, may

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result in proper selection of respective resistance values. These values are utilized for arithmetic operation of the photometric circuit of the automatic exposure control circuit. A relative position relationship is thus provided between the variable resistor R in the camera body of which the resistance value is selected by the lever operatively associated with the diaphragm value preset ring of the reference lens A as a given diaphragm value is preset, on the one hand, and the diaphragm preset ring a adapted to drive said lever operatively associated with the diaphragm value preset ring, on the other hand, as illustrated by (A) of Figure 1. Relative to this position relationship, a lens B being the same in its fully opened diaphragm value F 1.4 but different in other aspects has its diaphragm preset ring b positioned as illustrated by (B) of Figure 1, and another lens C having a fully opened diaphragm value F 4 smaller than said lenses A and B has its diaphragm value preset ring c positioned as illustrated by (C) of Figure 1. It should be noted here that the position relationship has been illustrated in Figure 1 as the relative positions of the respective diaphragm values of the preset ring when the diaphragm values of the respective lens are preset to their fully opened diaphragm values to facilitate understanding.

By adjustably rotating the diaphragm preset ring of the respective lenses A, B and C from such relative position relationship, both the illumination intensity error in the film plane and the illumination intensity error due to the position of the photometric element are compensated, to the extent that not only a photometric signal corresponding to the actual illumination intensity in the film plane produced through the fully opened diaphragm is transmitted to an arithmetic section of the photometric circuit or the exposure control circuit, but also a given diaphragm value preset by rotating the diaphragm preset ring from the respective original position properly brings about a correspondingly value of exposure.

Such method of error compensation may be regarded as being of a type in which the information on diaphragm value applied to the

arithmetic section of the exposure control circuit in the diaphragm value priority mode is replaced by a resistance value selected by a given preset diaphragm value. This method of error compensation can be adapted for the exposure time priority mode, in which an exposure time is set with priority and then the objective is stopped down to a diaphragm value corresponding to a resistance value which will give a proper exposure. The resistance value given as a result of such stopping down already includes an effective compensation of both the illumination intensity error in the film plane and the illumination intensity error due to the position of the photometric element and, accordingly, this resistance value may be utilized as an arithmetic factor for automatic exposure regulation to regulate the amount of actuation for automatic diaphragm control.

On the assumption that the same diaphragm preset ring as used for the diaphragm priority mode is utilized, a preset position for automatic diaphragm control is selected on said diaphragm preset ring at a predetermined angular or rotational distance (corresponding to a_v as illustrated and in this case $a_v \geq 0$) from the rotational position for the fully closed diaphragm value, so that both the illumination intensity error in the film plane and the illumination intensity error due to the position of the photometric element may be effectively taken into account in the operation of stopping down. Such preset position for automatic diaphragm control depends upon individual interchangeable objectives, as illustrated by Figure 1, in which the diaphragm preset ring a of the reference lens A has its automatic diaphragm control marking (Auto) at an angular distance a_v from the marking of the fully closed diaphragm value F 22, while the diaphragm preset ring b of the lens B, which has same fully opened diaphragm value and fully closed diaphragm value as the reference lens A, bears thereon its preset position for automatic diaphragm control (Auto) at an angular distance ΔAvB from the corresponding position for the reference lens A. Similarly, the diaphragm preset ring c of the lens C has its peculiar preset position (Auto) for automatic diaphragm control at an angular distance ΔAvC from the corresponding preset

position for the reference lens A, when the fully closed diaphragm value is at F 32, and at an angular distance $\Delta Av'C$ when the fully closed diaphragm value is at F 22.

As will be readily understood, these angular distances or deviations or ΔAv in general are determined in dependence not only upon the deviations ($-\Delta RvB$ for the lens B and ΔRvC for the lens C) due to different points of starting the operation which are, in turn, determined by different fully opened diaphragms and other characteristics peculiar to the respective objectives interchangeably mounted on the camera but also upon the different fully closed diaphragm values marked on the respective diaphragm preset rings. Thus, the resistance value actually used for the arithmetic operation is selectively obtained between the points P and Q of the variable resistor R. Point or terminal Q of the variable resistor R is adjusted by diaphragm index member on each particular lens in the manner depicted in United States Patent No. 3,486,434 as the lens is installed in the camera body. The position of the index member on each lens establishes the ΔAv value thereof.

Thus, it is seen that the deviation due to different fully closed diaphragm values depending upon the respective interchangeable lenses is transmitted from the lens interchangeably mounted on the camera to the camera body as an information signal for the automatic exposure control in the exposure time priority mode (so-called shutter priority mode) on one hand, and the deviations such as said ΔRvB and ΔRvC (ΔRv in general) which can be known in advance, inclusive of the different fully opened diaphragm values depending upon the respective lenses interchangeably mounted on the camera, the

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illumination intensity errors in the film plane and the illumination intensity errors due to the position of the light receiving element, are replaced by a compensation value as a portion of the displacement quantity occurring in the mechanical system of the respective interchangeable lens functioning from the camera body towards the diaphragm blades on the other hand so that the automatic exposure control can be realized at a high precision.

From the basic concept as mentioned above, an arithmetic expression established when the diaphragm preset ring has been set to the automatic diaphragm control position (Auto) will be considered. This expression is given in the following form in accordance with the exposure time priority mode (or the shutter priority mode). All the units are represented by EV values (in the APEX system, these being logarithmically compressed values).

$$Av = Bv' + Sv - Tv + \Delta Av - \Delta Amin + 1 \dots\dots\dots(I)$$

where:

- Av : diaphragm value;
- 20 Bv' : brightness value of an object to be photographed after transmission through the objective;
- Sv : sensitivity value of the film used for photographing;
- Tv : shutter speed value set with priority;
- ΔAv : deviation from reference lens A;
- 25 $\Delta Amin$: the difference between the fully closed diaphragm value of the reference lens A and the fully closed diaphragm value

of each lens interchangeably mounted on the camera. For the fully closed diaphragm value F 22 of the reference lens A, as illustrated by Figure 1, $\Delta A_{min} = 0$ when the lens to be mounted on the camera has a fully closed diaphragm value of F 22, while $\Delta A_{min} = -1$ when the lens to be mounted on the camera has a fully closed diaphragm value of F 32, and such information is transmitted from the lens to the arithmetic circuit in the camera body simultaneously as the deviation or difference signal when the lens is interchanged.

The value 1 in the equation is the EV value of the fully opened diaphragm value F 1.4 of the reference lens A. The diaphragm value A_v obtained by equation (I) compensates for the illumination intensity error in the film plane and the illumination intensity due to the position of the photometric element. In the case in which the diaphragm value is preset by rotation of the diaphragm preset ring in the diaphragm priority mode, instead of relying upon the automatic diaphragm control (Auto), the shutter speed can be obtained by mutually transferring the terms A_v and T_v in equation (I), namely,

$$T_v = B_v' + S_v - A_v + \Delta A_v - \Delta A_{min} + 1 \dots\dots\dots(II)$$

The exposure control and its value may be used for display within the viewfinder.

The operation of the automatic diaphragm control is accomplished when a member provided in the camera body operatively associated with the shutter release drives a release plate on the lens. Thereupon the release plate is displaced from a position at which the diaphragm mechanism is held fully opened to a position at which said diaphragm mechanism reaches a given EV value. The amount of displacement of said release plate is in a linear proportion to a quantity of stopping down and, therefore, the A_v value obtained from said equation (I) cannot be directly utilized as a control value for the diaphragm. When a value, for example, $A_v = 5$ (corresponding to F 5.6) is used as the arithmetic operation value for the diaphragm control, stopping down by a quantity of 4 EV results in stopping down to F 5.6 for an objective

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having its fully opened diaphragm value of F 1.4 ($A_v = 1$), while stopping down by a quantity of 1 EV results in stopping down to F 5.6 ($A_v = 5$) for an objective having its fully opened diaphragm value of F 4 ($A_v = 4$). Thus, the EV quantity P_v necessary for a desired quantity of stopping down is obtained in the form of a difference or deviation between the EV value as a result of an arithmetic operation and the fully opened diaphragm expressed in EV value, and the P_v expressed in EV value as the control quantity is given by the following formula:

$$P_v = B_v' + S_v - T_v + \Delta A_{min} + 1 - A_{max} = A_v - A_{max} \dots (III)$$

wherein A_{max} represents the EV value at the fully opened diaphragm depending upon the individual lenses.

It will be seen from the above formula that P_v expressed in EV values as the control quantity depends upon the fully opened diaphragm values of the respective lenses which determine the precision of said control quantity P_v . Accordingly, when a particular lens is mounted on the camera it is required to transmit the fully opened diaphragm value peculiar to the lens from the lens to the camera body as a signal which identifies this lens.

Generally, the objective preferably has a large value of its fully opened diaphragm to be used for photographing, since it provides a viewfinder image sufficiently bright to detect an exact focussed point during focus adjustment and enlarges the range of stopping down and thereby enlarges the exposure range that can be photographed. However, this preferable condition is adversely limited by the requirement for various aspects such as optical characteristics and lens size. Thus, it will be practically difficult and even disadvantageous to extract A_{max} signals exactly according to said formula (III) with respect to all the interchangeable lenses over a wide variety and then to transmit them to the camera body in view of factors such as a space for incorporation, a cost therefor and a reliability in operation.

To overcome such problem, the present embodiment proposes that an error in the automatic diaphragm control due to the differences of the fully opened diaphragm values, the illumination intensity error in the film plane which is characteristic of each lens, and the illumination intensity error due to the position of the photometric element, is compen-

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5 sated by a special operation of the member taking part in the diaphragm control, namely, the diaphragm driving member in the camera body or a member operatively associated therewith to bring the diaphragm mechanism to a position corresponding to the desired diaphragm value.

10 The term "a special operation" used herein means a part in the course of operation of an operative system starting from said diaphragm driving member in the camera body and terminating in the diaphragm blades that directly takes no part in stopping said diaphragm blades down to the desired diaphragm value. This operation taking no part directly in stopping down will be referred to hereinafter as a preliminary displacement. The amount of displacement of the members constituting said operative system during said operation taking no part directly in stopping down, namely, before the operation for stopping down the diaphragm blades actually starts to stop the lens aperture down beyond the fully opened diaphragm to the desired value for control of the light quantity will be referred to hereinafter as the amount of preliminary displacement.

20 Substitution of:

$$\Delta Av - \Delta Amin + 1 - Amax = \Delta Rv \dots\dots\dots(IV)$$

25 into said equation (III) and replacement of a value corresponding to ΔRv depending upon the individual lenses by said quantity of preliminary displacement make disappear the $Amax$ signal corresponding to the EV value depending upon the fully opened diaphragm value from said equation (III) and the EV value of Pv as a control quantity is given by:

$$Pv = Bv' + Sv - Tv \dots\dots\dots(V)$$

30 Such aspect will be considered with respect to the lenses C and

5 B of Figure 1. The preliminary displacement quantity of the lens C may be set larger by ΔRvC with respect to the lens A and the preliminary displacement quantity of the lens B may be set smaller by ΔRvB with respect also to the lens A to eliminate the deviation due to different values of the respective fully opened diaphragms, the light intensity error in the film plane depending upon the individual objectives and the light intensity due to the position of the light receiving element.

10 An example of the single-lens reflex camera in which the automatic diaphragm control is effected according to such arithmetic formula is illustrated by Figure 2, wherein CA designates a camera and Bv designates a brightness of an object to be photographed. It has previously been mentioned that the quantity of light coming from an object having its brightness Bv through the objective and to which a photometric element PE is exposed takes an inherent value depending upon the fully opened aperture of this lens, the light absorption coefficient, internal reflection and vignetting effect of this lens, and other factors.

15 The output provided from the photometric element PE is log-compressed by a Bv' generator C_1 , in the form of:

$$Bv' = Bv - (\Delta Av - \Delta Amin + 1) \dots \dots \dots (1)$$

25 and is then applied to an arithmetic circuit C_2 . This circuit C_2 is also supplied with an information signal Tv based on the exposure time (shutter speed) set with priority and another

information signal S_v based on the sensitivity of the film used, from a shutter speed regulating member C_3 and a film sensitivity regulating member C_4 , respectively. The arithmetic circuit C_2 provides a resultant information signal as follows:

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$$B_v' + S_v - T_v \dots\dots\dots(2)$$

When an interchangeable lens is mounted on the camera CA and its diaphragm preset ring is rotated to the automatic diaphragm control position (Auto), a value A_v peculiar to this lens and a constant value 1 added thereto through a circuit processing is:

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$$\Delta A_v + 1 \dots\dots\dots(3)$$

which is output from a compensation signal member C_5 and input to an arithmetic circuit C_7 . On the other hand, the arithmetic circuit C_7 is applied with an information signal:

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$$\Delta A_{min} \dots\dots\dots(4)$$

which corresponds to the deviation of the fully closed diaphragm value peculiar to this lens from the fully closed diaphragm value of the reference lens A, from a minimum aperture signal member C_6 . As a result, the arithmetic circuit C_7 provides a resultant output:

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$$\Delta A_v - \Delta A_{min} + 1 \dots\dots\dots(5)$$

This output is applied together with the output expressed by the equation (2) coming from said arithmetic circuit C_2 to an arithmetic circuit C_8 in which an arithmetic operation $(2) + (5)$ is performed:

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$$B_v' + S_v - T_v + \Delta A_v - \Delta A_{min} + 1 = A_v$$

Substitution of B_v' from the equation (1) gives:

$$B_v + S_v - T_v = A_v \dots\dots\dots(6)$$

and thus it is possible to obtain the Apex quantity A_v of the diaphragm value.

This A_v value can be displayed within a viewfinder by a display circuit C_9 consisting, for example, of a meter. The information signal A_v subjected to this display merely indicates the diaphragm value providing a proper exposure with respect to the exposure time (shutter speed) set with priority, but not the automatic control quantity as it has previously been mentioned. To effect stopping down with the automatic diaphragm control

quantity P_v in operative association with the operation of shutter release, said output (2) provided from the arithmetic circuit C_2 and the diaphragm value signal Av' formed by a diaphragm value signal generator member C_{10} according to the diaphragm value of the lens are applied into a comparator circuit C_{11} so that these two signals are compared to each other in said comparator circuit and, when the output Av' reaches said output Av , the coincidence signal output is applied to a diaphragm control circuit C_{12} and thereby a diaphragm control magnet EE_{mg} is released, with an effective result that the diaphragm value is adjusted to said Av corresponding to the arithmetic result.

A voltage source is connected across variable resistor R and the signal ΔAv is the voltage between points Q and P of resistor R , which is the input to compensation signal member C_5 .

Minimum aperture signal member C_6 could comprise a voltage source and a resistor in the camera body connected through contacts discussed below in connection with Figure 5 in series with a ΔA_{min} representative resistor in the particular lens. The minimum aperture signal is the voltage appearing across the ΔA_{min} representative resistor of the particular lens.

After the shutter release of the camera is actuated, the value of Bv' produced by generator C_1 remains fixed for the rest of the automatic exposure control operation. Thus, generator C_1 produces a static signal. Photometric element PE is also coupled to diaphragm value signal generator C_{10} to produce at the output thereof a dynamic representation of the light striking photometric element PE during the automatic exposure control operation. During the automatic exposure control operation, while the inputs to comparator C_{11} differ, the diaphragm stops down from its maximum value responsive to diaphragm control magnet EEmg. When the inputs to comparator C_{11} are equal, a stop signal is generated to fix the diaphragm value.

Figure 3 illustrates by way of example an arrangement in which said preliminary displacement occurs in a part of the members constituting the operative system interposed between the diaphragm driving member in the camera body and the diaphragm blades on the lens before said diaphragm blades begin to be moved from the fully

opened position to the desired stopped down position for control of light quantity.

Referring to Figure 3, S designates one of diaphragm blades together forming an iris diaphragm, and 11 designates a diaphragm blade actuating ring adapted to rotate a plurality of said diaphragm blades S around associated pivot pins 21. Said diaphragm blade actuating ring 11 itself is adapted to be rotated around the optical axis with respect to a stationary part of the lens barrel. 12 designates a plurality of cam grooves formed in said diaphragm blade actuating ring 11 into which associated driven pins 22 on the respective diaphragm blades S are engaged. The diaphragm blade actuating ring 11 is also provided with a fixed pin 13 adapted to be engaged with a release plate 31 which is, in turn, driven by the diaphragm driving member actuated in the camera body in operative association with the shutter release operation. The diaphragm blade actuating ring 11 is biased by a spring in the direction opposed to the direction indicated by an arrow X in Figure 3 so that said diaphragm blade actuating ring 11 normally tends to open the iris diaphragm towards its fully opened position. The position of the release plate 31 as illustrated corresponds to the starting position of this release plate 31, at which the respective diaphragm blades S take their positions I indicated by broken lines.

The inner edge of each diaphragm blade S is situated inwardly of a circumferential opening which defines the maximum aperture of this lens. From these positions, the respective diaphragm blades S are rotated around the respective pivot pin 21 with its associated driven pin 22 being guided along the associated cam groove 12 as the release plate 31 is urged upward by the diaphragm driving member or a transmission member thereof in the direction indicated by the arrow X, and thereby the diaphragm blade actuating ring 11 is rotated via the pin 13, until the respective diaphragm blades S reach their positions II indicated by broken lines, at which their inner edge are brought into coincidence with said circumferential opening defining the maximum aperture of the lens. The positions II of respective blades S correspond to the positions of

blades in the fully opened diaphragm. Further rotation of the diaphragm blade actuating ring 11 actually begins to stop the lens down beyond the said positions II of the respective diaphragm blades S.

5 Thus, during movement from the position I to the position II, the respective diaphragm blades S have no function of incident light quantity control, and operation of the release plate 31 takes no part in actual operation for stopping down. The operation of
10 said release plate 31 from the starting position to the position illustrated by broken lines corresponds to a preliminary displacement and the amount of such displacement L_v is the amount of preliminary displacement. Although this quantity of preliminary displacement occurs
15 as a relative movement of the release plate 31 and the diaphragm blades S in the embodiment as illustrated in Figure 3, this may be set as a relative movement between the diaphragm driving member in the camera body and said release plate 31, or any other part providing a
20 suitable lost motion connection.

 To provide the individual lenses, for example, the lenses B and C, with respective preliminary displacement quantities L_v , these quantities may be selected so that $L_v = \alpha - \Delta R_v B$ for the lens B while
25 $L_v = \alpha + \Delta R_v C$ for the lens C, as it has previously been

mentioned, when the reference lens A has its quantity of preliminary displacement expressed by:

$$Lv = \alpha.$$

5 However, these quantities of preliminary displacement thus selected are based on the assumption that the operative system provided on the respective interchangeable lens to effect the operation of stopping down is free from a mechanical load during the actual operation of stopping down and there occurs no time
10 delay due to this mechanical system. In fact, it has been found that the mechanical system for stopping down is accompanied by a mechanical time delay particularly during the period from application with a signal for termination of stopping down to the actual termination
15 thereof and such mechanical time delay must be considered in arrangement of said mechanical system.

 Figure 4 illustrates a diaphragm schematically showing such a lag or delay in the mechanical system. A displacement amount of the release plate 31 is given in EV value
20 on the ordinate axis and a time required for stopping down

is given on the abscissa. While a relative linear relationship is given between the displacement quantity of the release plate 31 and the diaphragm value obtained from stopping down by said displacement quantity, the variation in diaphragm values depending upon the displacement quantities of the release plate 31 is not always uniform due to various factors such as a biasing force of the spring normally striving to urge the diaphragm blades back to their fully opened positions, inertia and frictional loads of the respective operative members. Thus the lenses may be classified into three types, i.e., the high speed lens M, average lens N and low speed lens θ . Figure 4 shows the respective characteristic lines of these three types. Strictly, a variation of speed appears in movement of the release plate 31 itself during a period from start to stoppage thereof and particularly the release plate 31 moves at a low speed immediately after its start. However, such variation is negligible relative to the automatic diaphragm control operation by the release plate 31 as a whole, since it is during said preliminary displacement that such speed variation occurs and has little influence upon the control result even when this is approximately looked upon as a linear variation. Therefore, the tendencies of the respective lenses of three types are linearly shown.

Straight lines extending parallel to the abscissa indicate the preliminary displacement quantities L_v of the release plate 31 until the diaphragm blades reach their positions corresponding to the fully opened diaphragm values of the respective lenses. With respect to the lens M in the diaphragm, if the release plate 31 is applied with a stop signal at a moment in time M_1 elapsing after the release plate 31 has started, the diaphragm blades are actually stopped at a later moment M_2 . Similarly, with the lens N, if the release plate 31 is applied with a stop signal at a moment N_1 , the diaphragm blades are stopped at a later moment N_2 and, in the case of the lens θ , the diaphragm blades are stopped at a later moment θ_2 with a stop signal applied to the release plate 31 at a moment θ_1 . Accordingly, no matter which type the lens belongs to, there

occurs a time delay from application of the stop signal to actual stoppage of the diaphragm blades. This means that, to stop the diaphragm blades exactly at a moment corresponding to the desired diaphragm value, said stop signal must be applied to the release plate at a moment earlier than the desired moment of stoppage by such time delay T_d due to the mechanical system or it would result in a stopping down in excess of the extent required for automatic diaphragm control.

Referring again to Figure 4, the amount of stopping down achieved during the time delay T_d due to the mechanical system depends upon the type of lens and such amount can be substituted by the corresponding displacement quantity of the release plate 31 as follows:

Lens M ————— L_{vm} ;
Lens N ————— L_{vn} ; and
Lens θ ————— L_{ve} .

It will be easily understood that higher the speed of operation the lens has, the larger is the amount of stopping down made after application of the stop signal.

Now, setting the circuit in the camera body for generation of the stop signal on the basis of a lens N having the average speed of operation, i.e., so that said circuit generates the stop signal earlier by a quantity L_{vn} with respect to the displacement amount of the release plate 31 would result in actual quantities of stopping down:

excessive by $L_{vn} - L_{ve}$ for the lens θ ; and
insufficient by $L_{vm} - L_{vn}$ for the lens M.

Thus, the corresponding diaphragm control errors would prevent achievement of the proper exposure. Also uniformly setting to $L_v = L_{vn}$ on the basis of said preliminary displacement quantity L_v depending upon the fully opened diaphragm value of the lens N having the average speed of operation would result in diaphragm control errors corresponding to said deviations even when lenses having the same fully opened diaphragm value, so long as their speeds of operation are different due to the mechanical constructions peculiar

to these lenses. Accordingly, the errors in quantities of stopping down corresponding to the respective time delays can be compensated independently of the gradient of characteristic line by setting the preliminary displacement amounts taking consideration of the time delays due to the mechanical systems of the respective types of lens as follows:

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$L_v = L_{vm}$ for the lens M;

$L_v = L_{vn}$ for the lens N; and

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$L_v = L_{ve}$ for the lens θ .

Figure 6 shows the interconnection between the diaphragm control magnet EEmg and release plate 31. Release plate 31 is guided by means not shown to move straight in accordance with movement of the pin 13 working in the camera body side. The position of a stop 40 in the path of release plate 31 varies from lens to lens and determines the LV value of the particular lens. Release plate 31 has teeth that mesh with teeth on a spur gear 41. An annular member having spur gear 41 and a ratchet 42 is guided for rotation by an annular guide member within the lens. The centre of rotation of said annular member is indicated with a reference number 43 in Figure 6. Said annular member having spur gear 41 and a ratchet 42 is provided with a lot of small holes for pulse counting. Said holes are arranged along the circumference with the centre 43 of rotation as its centre. A photo coupler PC consisting of a light emitting diode LED and a photo metric element PE' positioned opposite to each other is mounted and said holes made in an arcuate row pass between the light emitting diode and the photo metric element PE' forming a pair. When the ratchet 42 is moved by rotation of the release plate 31, pulse signals are generated by the rotation of said ratchet 42. Then, signals in proportion to $A_v' - A_{max}$ are taken out from the pulse counter 54, and said signals affect actual diaphragm control action through the comparison circuit. A pawl 44 prevents rotation of ratchet 42 in a counterclockwise direction as viewed in Figure 6 and therefore, also corresponding rotation of spur gear 41 and release plate 31 during the automatic exposure and shutter release operation. When the shutter is reset for the next photograph, pawl 44 is disengaged from ratchet 42 to permit release plate 31 to return to stop 40. Pin 13 and release plate 31 are located in the lens, and spur gear 41, ratchet 42, shaft 43, and pawl 44 are located in

the camera body. A ratchet advancing tooth 45 is located in the camera body with magnet EE_{mg}. Tooth 45 is mounted on the end of a magnetic pivot arm 46 biased into engagement with ratchet 42 by a spring 47. Magnet EE_{mg} is wrapped around an armature 48 in proximity to pivot arm 46. Diaphragm control circuit C₁₄ includes a switch 49 and a battery 50 in series with magnet EE_{mg}. Switch 49 is opened and closed responsive to comparator C₁₄.

When switch 49 closes, as shown in Figure 6, pivot arm 46 is drawn against armature 48, thereby disengaging tooth 45 from ratchet 42. When switch 49 opens, spring 47 pulls pivot arm 46 away from armature 48, thereby driving tooth 45 against ratchet 42 to advance it one increment. Switch 49 is actuated by a relay control 52, such as a solenoid which is driven by a pulse generator 53. Each time a pulse is supplied to relay control 52 by pulse generator 53, switch 49 opens to advance ratchet 42 one increment. Pulse generator 53 begins sending pulses to relay control 52 when shutter release is actuated and stops sending pulses to relay control 52 when comparator C₁₁ indicates equality between the two signals applied to its inputs. A preferred embodiment of the lens mounting arrangement by which the signal characterizing individual lenses are transmitted from the lens to the camera body is illustrated by Figure 5.

Referring to Figure 5, a portion designated by reference symbol CM corresponds to a mount on the camera for mounting of an objective while a portion designated by reference symbol LM corresponds to a mount on the lens. Both the mount CM on the camera and the mount LM on the lens are shown at their surfaces along which they are mutually abutted, namely, the mount CM is shown as seen from the camera front while the mount LM is shown as seen from the rear side of the lens. Both the mounts are provided with a pair of opposed contacts by which ON and OFF signals are transmitted in the form of binary codes, and these contacts are sometimes utilized for carrying of the electric current depending upon various electrical factors such as a resistance value which is, in turn, determined by

the fully closed diaphragm value and other electrical qualities. There are provided a pair of contacts 19 and 91 through which the information on the fully closed diaphragm value depending upon individual interchangeable lens mounted on the camera and on the automatic diaphragm control position (Auto) determined by said fully closed diaphragm value is transmitted from the lens to the camera body. It is through this pair of contacts that the ΔA_{min} signal determined by said fully closed diaphragm value is transmitted from the lens to the camera body. This pair of contacts constitute a part of the fully closed aperture signal member C_6 shown in Figure 2.

As will be seen from the foregoing description in detail, the present system enables an operation of stopping down at the highest precision by the automatic diaphragm control through the operation of stopping down which already includes therein the compensation by a simple mechanism of both the illumination intensity error in the film plane appearing due to the illumination intensity variation depending upon individual interchangeable lenses mounted on the camera and the illumination intensity error due to the position of the photometric element depending on various factors of this lens on one hand, and by providing the mechanism serving for stopping down with a preliminary displacement taking no part in the actual stopping down operation for the interchangeable lenses, on the other hand. Concerning said preliminary displacement amount, a delay occurring in the mechanical operation determined by the different speed of stopping down which depends, in turn, upon the individual lens interchangeably mounted on the camera is also considered and thereby said preliminary displacement amount is

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further finely adjusted so that the automatic exposure control can be achieved with an extremely high precision including therein the effective compensation of the deviations caused by all the factors depending upon the individual lenses.. In spite of achievement

5 of such high precision exposure control the present method advantageously simplifies the mount construction along which the interchangeable lens is coupled to the camera body, since it is unnecessary to transmit the information signal related to the fully opened diaphragm of the respective lens from the

10 latter via the lens mount to the camera body so as to be incorporated into the regulating factors for the exposure control circuit which is also simplified in its construction.. Particularly no means is required to change over the fully opened diaphragm signal in order to compensate the change of F value when a zoom

15 lens accompanied with said change of F value is mounted on the camera. The present method accordingly provides the desired interchangeable lens single-lens reflex camera of automatic exposure control type which is simple as well as compact in its all over construction, obtainable at a low cost and almost trouble-free.



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CLAIMS:

1. A compensation method for diaphragm control in a single-lens reflex camera of interchangeable lens type, said compensating method comprising the step of introducing an amount of preliminary displacement in a part of the mechanical system adapted to transmit the operation of a diaphragm driving member in the camera body occurring under control of an exposure control circuit to diaphragm blades in the lens, and which displacement takes no part in the light quantity control effected by the stopping down operation, the amount of preliminary displacement being dependent upon all of the total deviation of the fully opened diaphragm value depending on an individual interchangeable lens, the light intensity error in the film plane associated with this fully opened diaphragm value, and the light intensity error due to the position of a photometric element.
2. A method according to claim 1, including the step of adding a diaphragm blade stoppage error corresponding to an actuation lag due to a construction of said mechanical system adapted to transmit the operation of said diaphragm driving member to the diaphragm blades to said quantity of preliminary displacement.



3. A single lens reflex camera assembly having an interchangeable lens for use in the method of claim 1, wherein the drive mechanism for the diaphragm of the lens is adapted to transmit to the diaphragm blades a preliminary displacement which takes no part in the light quantity control effected by stopping down, the amount of the preliminary displacement being such as to compensate for errors in illumination intensity in the film plane caused by an individual interchangeable lens, by the deviation of the fully open diaphragm value of the lens from a reference lens and by the specific position of the light receiving element.

4. An assembly according to claim 3 in which compensation is also provided for a diaphragm blade stoppage error corresponding to an actuation lag due to the construction of a mechanical system adapted to transmit an operation of a diaphragm driving member to diaphragm blades, said actuation lag occurring during such transmission.

5. A compensation method for an SLR camera according to claim 1, substantially as herein described with reference to the drawings.

6. An assembly for an SLR camera according to claim 3, substantially as herein described with reference to the drawings.

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