Dec. 14, 1937. J. EGGERT ET AL 2,101,932

EXPOSURE CONTROL

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Fig. 1

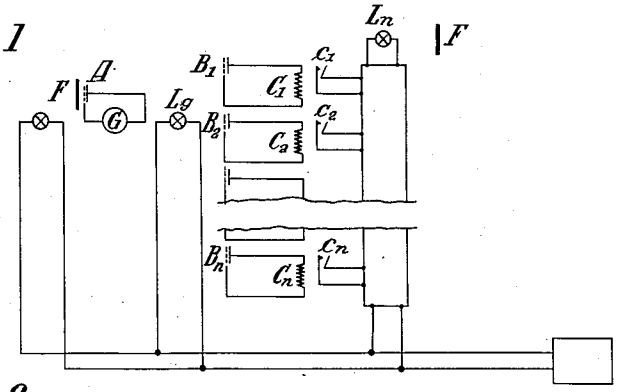


Fig. 2

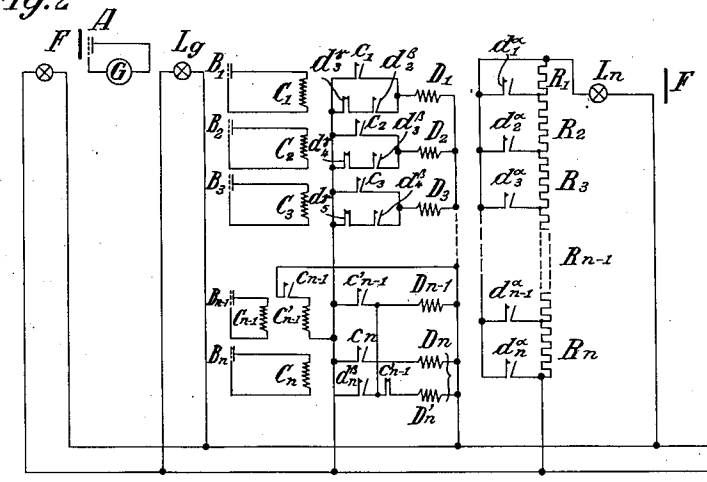
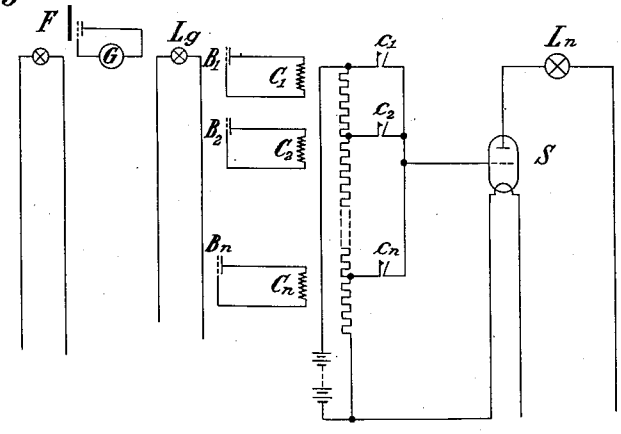


Fig. 3



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Fig. 4

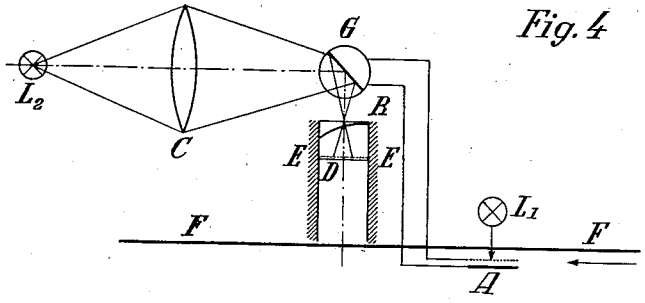


Fig. 5

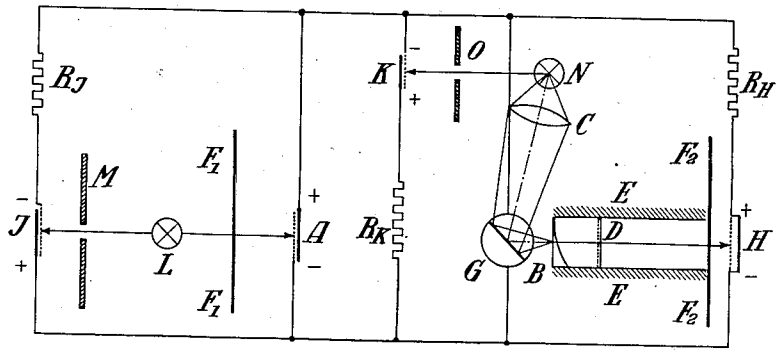


Fig. 6

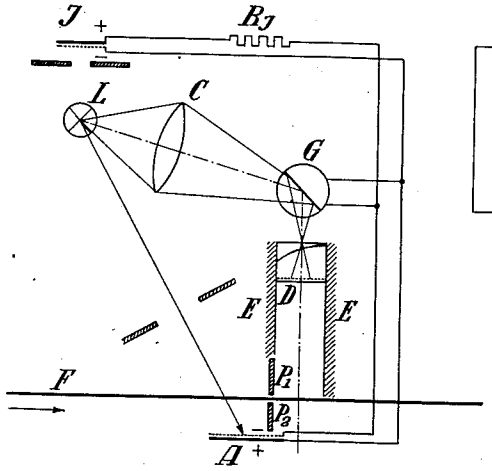
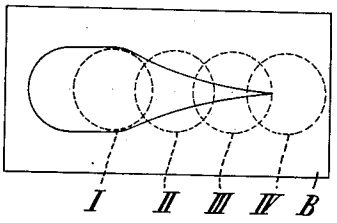


Fig. 7



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EXPOSURE CONTROL

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In Germany April 20, 1934

1 Claim. (Cl. 95—75)

Our present invention relates to exposure control and more particularly to an apparatus for the application of a dosed exposure in the photographic reversal process and in the photographic printing process.

One of its objects is to provide an improved apparatus for exposure control. Another object is an apparatus of this kind which is more efficient than those hitherto known. A further object is an apparatus for exposure control which is operated exclusively optically and electrically and is therefore operated with a minimum of inertness. Further objects will be seen from the detailed specification following hereafter. Reference is made to the accompanying drawings in which:

Fig. 1 shows a diagram of the connections of an apparatus according to this invention,

Fig. 2 shows a diagram of the connections of an apparatus according to this invention as shown in Fig. 1 with the difference that a special relay has been provided for holding the required contacts closed when the galvanometer has a too great deflection,

Fig. 3 shows a diagram of the connections of an apparatus according to this invention in which the intensity of the printing light is regulated over a heavy current valve,

Fig. 4 shows a modified apparatus according to this invention,

Fig. 5 shows an apparatus as shown in Fig. 4 but provided with a back coupling,

Fig. 6 shows an apparatus as shown in Fig. 5 with a modified back coupling, and

Fig. 7 shows a diaphragm as used in the apparatus shown in Figs. 4 to 6.

In the second exposure in the production of a reversed film it is necessary to adjust the quantity of light projected on the film in accordance with the density of the photographic image. So also in the printing process the illumination must be selected in dependence on the density of the negative.

A known arrangement for producing an automatic adjustment of the light consists in placing on the other side of the film to be illuminated a device whereby the transmitted light excites a photo-electric cell the current from which moves directly or indirectly a diaphragm in the path of the rays from the illuminating lamp. These devices have the drawback that they are comparatively slow because considerable masses have to be moved, with the disadvantage that in the majority of cases the film or a greater part of it is incorrectly exposed.

According to this invention the exposure of the film is regulated exclusively electrically and optically. With the apparatus herein described it is not only possible to control the intensity of the printing light in any desired proportion, but it is also possible to adjust the intensity of the printing light according to the density of the film to be exposed while having regard to the special properties of the used film and the used photocell. A particular advantage of the apparatus according to this invention is its little inertness which guarantees a rapid adjustment of the intensity. Photo-electric cells of the regenerative type that is to say such which are capable to convert light into electric energy are preferred, for instance, photo-electric cells in which a layer of a finely subdivided semi-conductor is in contact with a layer of a conductor, as in the cuprous oxide cells. However, also the other photo-electric cells may be used. The use of non-regenerative photo-electric cells that is to say such in which only the resistance to an electric current is changed by the influence of light are less practical because they need a special source of electric current and an amplifier.

In using the apparatus for dosing the intensity of the source of light in the second exposure of a reversal film it is not necessary to scan the whole breadth of the pictures. The desired width which must, however, not include the perforation row, is blocked out by a mask. In order to obtain correct density of the print at least one picture length must be scanned, preferably there are scanned 4 to 5 picture lengths.

The modifications of an apparatus for exposure control according to this invention have the common feature that the light projected, for instance, through the bleached reversal film excites a photo-electric cell. The current of the photo-electric cell actuates a galvanometer provided with a mirror. According to the variations of power of the current the galvanometer is more or less deflected and, therefore, the beam of light projected from a source of light on the mirror. This beam of light may be used directly or indirectly for exposing the film. For using it directly the beam of light falls on a fixed mask having a suitable aperture which according to the degree of deflection transmits more or less light which is evenly distributed on the film plane to be exposed. When using the beam of light indirectly it falls on photo-electric cells which by means of relays switches-in or cuts out resistance in the circuit of the source of light.

In printing from a finished negative or posi-

tive an optional source of light may be used and it must only be adapted to excite the photo-electric cell correctly. When scanning a bleached reversal film for a dosed second exposure the source of light is adjusted so that only little blackening of the film is produced. Therefore, in this case a source of light is selected of as small a photographic activity as possible, for instance, a source of yellow light.

The principle of the indirect method will now be explained with reference to the accompanying drawings. The indices of the switches are the same as those of relays by which they are actuated. The reversal film F which is to be exposed is passed between a source of light and a photo-electric device in such a manner that the photo-electric cell is excited by the light passing through the film. The current produced by the light in the photo-electric cell actuates a galvanometer G provided with a mirror. The mirror reflects a light ray of the source of light L_g. The position of the mirror determines the direction of the reflected light ray. Thus the direction of the light ray is dependent on the density of the scanned picture. With a certain deflection of the mirror of the galvanometer the light is projected on a photo-electric device B_1, which actuates a relay C_1. The relay initiates the adjustment of the required intensity of the source of light which serves for the second exposure of the film. There are arranged several photo-electric devices B_1, B_2 . . . B_n directly side by side or at suitable distances, each photo-electric device actuating a special relay. In accordance with the relay which is actuated a certain intensity of the source of light for exposing the film is produced.

The arrangement represented in Fig. 2 shows one of the many possibilities. If the relay C_1 is actuated by light projected on B_1, a second relay D_1 is energized so that it closes the switch d_1^α, Hereby the resistance R_1 is short-circuited so that the current supplied to the source of light L_n is increased and the intensity of the source of light likewise is increased. If the relay C_2 is actuated R_2 is short circuited over $c_2 D_2 d_2^\alpha$. The intensity of the source of light L_m is further increased. Thus, the intensity of the source of light may be regulated to different values which are determined by the value of the resistance R.

In the following manner the effectiveness may be further increased. The pencil of light projected on the photo-electric devices B_1, B_2 and so on is made so large that when the pencil of light passes from one photo-electric device to the next two adjacent relays are actuated (apart from the first and the last photo-electric device). By closing the switch d_2^β with the actuation of the relay D_1 the relay is kept in action also when c_1 is not actuated by C_1. This involves the advantage that when the pencil of light emanating from the mirror in moving back from B_2 to B_1 the switch c_1 is closed without being under tension. Furthermore d_1^α is closed, so that on actuation of d_1^α only the partial resistance R_2 is switched on or switched off. This would not be the case if, for instance, the galvanometer G is operated so quickly that the relay cannot follow immediately. This involves a steady operation, little wear, and increased reliability in service. It is not desired that all relays are in operation; the switches d^γ which are actuated by the relays D having the corresponding indices switch off all relays except two which are in operation.

If the galvanometer G has no abutment which prevents deflection of the pencil of light so that it passes beyond B_n it is possible to provide a device which retains the relay D_n in its operative position when the pencil of light is deflected beyond B_n. For this purpose that relay has a coil D_n' which is actuated over a switch d_n^β of the relay D_n and an open circuit contact c'_{n-1} of the relay C'_{n-1}. If the pencil of light wanders from B_n to B_{n-1}, B_{n-2} . . . the relay D_n must be switched off. If it wanders in the opposite direction the relay D_n must remain in operation. Thus, the maximum intensity of the source of light L_m which may be required cannot be surpassed.

Another possibility of control consists in applying different grid voltages to the grid of a heavy-current control valve by means of the relays C_1 . . . C_n. The switching on of different voltages may be obtained in different manners, for instance, by means of a potentiometer, a battery from which different voltages can be taken, a transformer from which different voltages can be taken or an apparatus by which a phase lead or a phase lag is produced. The alternating current which flows through the heavy-current control valve is directly or after transformation conducted to the lamp which serves for the exposure of the sensitive film.

The direct method provides a rapid adjustment by using a stationary diaphragm and changing the direction of the light rays so that more or less light is projected upon the diaphragm.

The accompanying diagrams of Figs. 4, 5, and 6, illustrate three arrangements in accordance with the invention.

Referring to Fig. 4, the film F is illuminated by the source of light L_1. The transmitted light excites the photo-electric cell A, the current from which actuates a mirror galvanometer G. This mirror reflects the cone of rays from the lamp L_2. In the path of this reflected light is the diaphragm B, the form of which is preferably such that a certain ratio between the density curve of the image and the gradation of the strength of illumination is obtained. The diaphragm B may, for instance, have the form shown in Fig. 7.

The circles 1, 2, 3 and 4 drawn in this figure show different positions of the cone of rays which are projected from different positions of the mirror on the diaphragm B. By the diaphragm the required pencil of light is cut out from the cone projected by the mirror.

The diaphragm may be exchanged for another or the aperture may be changed according to requirement. Instead of a diaphragm of particular form there may be used a diaphragm with the interposition of a suitable grey wedge or there may be used a grey wedge alone. The diaphragm is advantageously placed at a position in the path of the rays where the diameter of the cross section of the cone of light corresponds with about the greatest breadth of the diaphragm.

If the current passing through the galvanometer becomes stronger in consequence of a smaller density of the image, the cone of rays moves gradually behind the diaphragm, the reverse being the case when the density of the image becomes greater. The galvanometer mirror may be so adjusted that there is always a certain minimum quantity of light passing through the diaphragm.

There can, however, be provided a separate passage for the light. Advantageously, the lamp L_1, which serves for providing the transmitted light, may have such photographic activity that it produces the smallest necessary illumination. The light passing through the diaphragm falls upon the ground glass screen D by which the film is illuminated. The loss of light which occurs at the ground glass must be taken into account in selecting the intensity of the source of light. In order to avoid loss of light the path of the light between the ground glass screen and the film is surrounded by reflecting surfaces E.

Fig. 5 shows an arrangement for increasing the sensitiveness of the device by means of an auxiliary current. On the left hand side is the lamp L that provides the light rays to be transmitted by the film, and on the right the illuminating lamp N. In parallel with the photo-electric cell A, which actuates the galvanometer G, there is inserted a second photo-electric cell H, which is excited by the illuminating lamp N. The light necessary for the actuation of the photo-electric cell H may be taken from the trace of the rays of the printing light N at any place behind the diaphragm B. This may be done by introducing a suitably inclined mirror into the trace of the rays. The photo-electric cell H may, as shown in Fig. 5 be arranged behind the film and a too great intensity of the light passed through the film may be reduced by the insertion of a suitable mask. The regulation of the additional energy obtained from the cell H may also be achieved by the resistance R_H.

For regulating any fluctuations in the illumination of the lamp L or of the lamp N the following devices are provided:—In series with the photo-electric cells A and H, which serve for regulating the illumination, are inserted two like cells J and K with interposition of resistances R_J and R_K; these are directly illuminated by the lamps L and N. When, for example, the candle power of the lamp diminishes, the countercurrent from the cell J or K through the galvanometer diminishes. The device has still another advantage. According to experience the density of a film which is to receive a second exposure varies very little. Correspondingly the light falling on the photo-electric cell A changes only in small degree; so also does the current from the photo-electric cell which actuates the galvanometer. One can think of these currents together as a constant and one which changes with the density of the image. This constant current is a disturbing factor and is advantageously removed by an equal, opposed current in the galvanometer. This is derived from the photo-electric cell J or K. A correct magnitude of the current is secured by a diaphragm N or O or by the resistance R_J or R_K.

A further possibility for producing the auxiliary energy is shown in Fig. 6. Here the light that is transmitted through the film and the illuminating light are so close to each other that they in part overlap, whereby the auxiliary energy is produced. The current is adjustable by a diaphragm P placed in front of or behind the film F. For this purpose the diaphragm can be laterally displaced. Advantageously the diaphragm has reflecting faces. This illuminating device has the advantage that it is very simple and operates very quickly. Obviously instead of a single source of light for producing the transmitted rays and for the illumination there may also be used two sources of light.

What we claim is:

An apparatus for exposure control comprising in combination a source of light for scanning a picture, a photo-electric device which receives the light varying in intensity with the density of said picture thereby causing a variation of an electric current, a galvanometer deflected in accordance with said variations of electric current, a mirror provided on said galvanometer, a second source of light projecting a pencil of light on said mirror, said pencil of light being reflected by said mirror, a series of photo-electric devices arranged one beside the other within the reach of said reflected pencil of light at a distance smaller than the breadth of the reflected pencil, relays arranged in a circuit with said photo-electric devices, a further series of relays actuated by said first named relays, a source of light for exposing a photographic layer, a resistance arranged in a circuit with said source of light and switches actuated by said relays for switching on and switching off parts of said resistance for varying the intensity of said source of light for exposing said layer in accordance with said variations of electric currrent, a wire coil arranged on the relay situated farthest towards the end of the reach of said reflected pencil of light when said mirror is most deflected, and switches actuated by said wire coil for keeping switched off the whole resistance in the circuit of said source of light for exposing said layer when said reflected pencil of light passes beyond the last photo-electric device of said series.

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