United States Patent

[11] 3,587,430

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[21] Appl. No. **760,771**
[22] Filed **Sept. 19, 1968**
[45] Patented **June 28, 1971**
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[32] Priority **Sept. 29, 1967**
[33] **Japan**
[31] **42/62808**

[54] **MULTIPHOTOGRAPHIC DEVICE**
5 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **95/37,** 355/33
[51] **Int. Cl.** **G03b 19/18**
[50] **Field of Search** 95/36, 37; 355/33

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ABSTRACT: A multiphotographic device is provided having a first lens with an associated movable aperture adapted to record a plurality of images by means of a movable aperture and a plurality of microlenses. The movable aperture is formed by superimposing a slot in a vertically moving belt on a slot in a horizontally movable plate. The vertical belt is moved in increments slightly larger than the size of the aperture, and the horizontal plate is moved in increments equal to $1/n$ where n is the quotient obtained by dividing the length of the slot by the length of one side of the aperture.

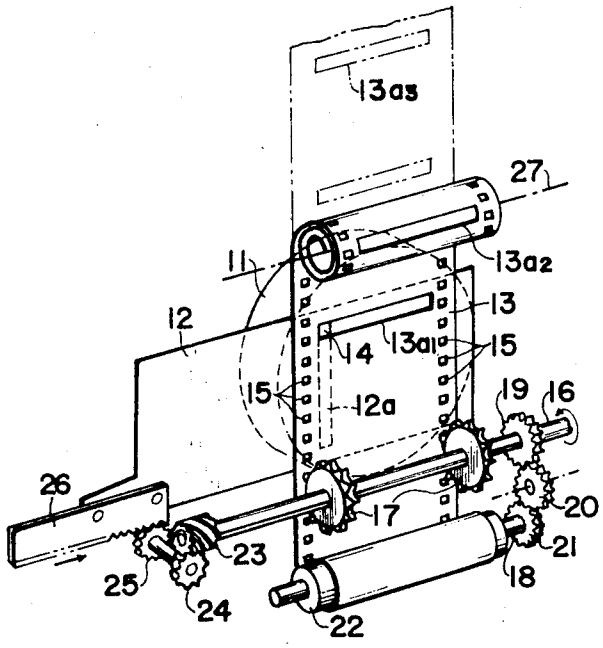


FIG. 1

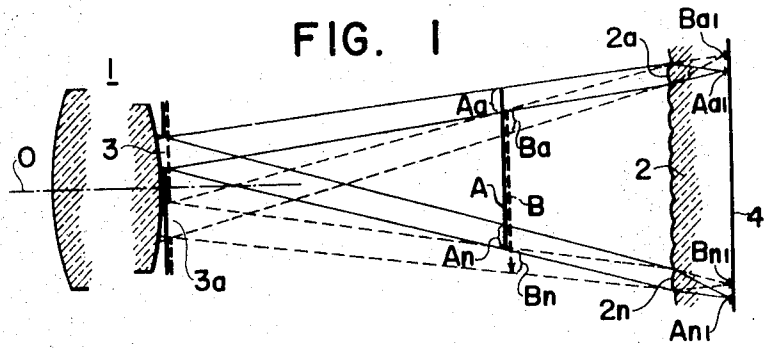


FIG. 2

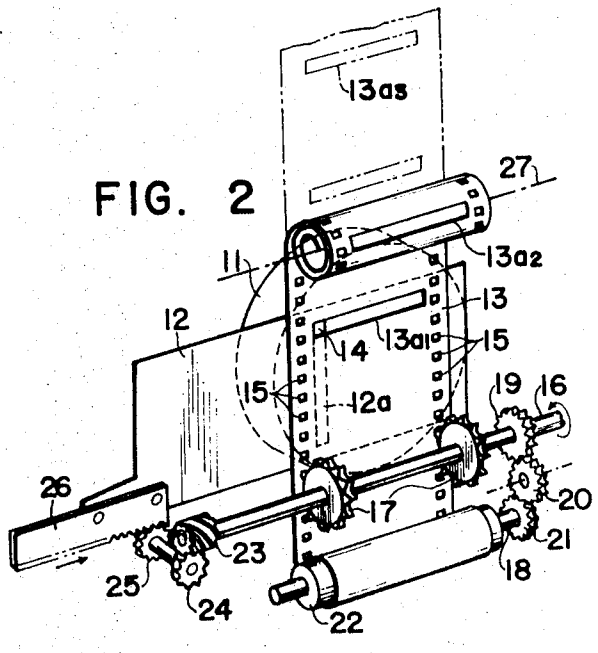


FIG. 4

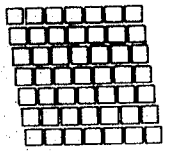


FIG. 3A

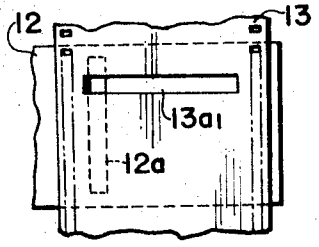
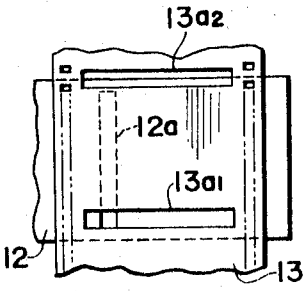


FIG. 3B



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MULTIPHOTOGRAPHIC DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a multiphotographic device in general and more particularly a multiphotographic device of the type in which one image of an object to be photographed is finely split into small portions which in turn are recorded upon a single sensitive material at predetermined positions thereof as a plurality of split images. Furthermore another image of another object to be photographed is split into small portions in a similar manner as described above, said split images being recorded upon said single sensitive material in such a manner that the second mentioned split images are not superposed upon the first mentioned split images which have been previously recorded upon said sensitive material. Still another image of a still another object is recorded upon said single sensitive material in the similar manner as described above, and so on.

In the photographic device of the type described, an image produced by a relatively large diameter first photographic or objective lens and an aperture disposed within, forwardly or backwardly of said first lens is projected as a plurality of split images upon a sensitive material or plate disposed backwardly of a second lens comprising a microlens group. The positions of the split images to be recorded upon the sensitive material are dependent upon the positions of the aperture. Therefore, a plurality of objects can be recorded photographically upon a single sensitive material when the positions of the aperture are suitably selected. In this case, it is impossible to read or view the split images thus recorded upon the single sensitive material. In order to produce the images recorded in the single sensitive material, the optical system similar to that used in effecting a multiphotographing must be used in such a manner that the images are projected by the lights whose direction is opposite to that of the lights used in photographing. In this case, the most essential factor is that the position of the aperture relative to the first lens when the images are reproduced must coincide exactly to the position of the aperture when the images are recorded. It is also required that the positioning of the aperture must be effected successively in a simple stepwise manner. The present invention was made to meet the requirements described above.

SUMMARY OF THE INVENTION

According to one preferred embodiment of the present invention, one movable plate provided with a plurality of elongated slots and another movable plate provided with only one elongated slot are utilized in such a manner they move in the directions at right angles with respect to each other. Both of said plurality of elongated slots and the elongated slot of said other movable plate are so arranged and disposed that they are at right angles with respect to the directions of the movements of said movable plates respectively. An aperture is formed by one of said plurality of elongated slots and said elongated slot provided in said other movable plate. The movements of said movable plates are interconnected drivingly to each other in such a manner that when one of said plurality of elongated slots moves by a distance equal to the length of one side of an aperture, said other movable plate is caused to move by a distance of $1/n$ of said first mentioned distance (n being the quotient obtained by dividing the length of each of said plurality of elongated slots by said length of one side of an aperture). Therefore, the position of the aperture formed when said one movable plate having said plurality of elongated slots is displaced by a distance equivalent to the length of one side of the aperture is displaced from the preceding position of the aperture by a distance of $1/n$ of the length of one side of the aperture in the direction of the displacement of said another movable plate (having only one elongated slot). As soon as one of said plurality of elongated slots has passed beyond one end of said elongated slot of said other movable plate, the next one of said plurality of elongated slots comes to a position so as to overlap with said elongated slot of said another movable plate and to form the uppermost or lowermost aperture with said elongated slot of said another movable plate. Thus, a number of n^2 apertures are defined and formed by the relative movements of said pair of movable plates.

One of the objects of the present invention is to provide a multiphotographic device provided with an aperture positioning means adapted to ensure the correct positioning of an aperture to the next position thereof whenever photographing is made, by imparting to a pair of elongated slots which are adapted to define and form an aperture by overlapping one upon another predetermined relative displacements respectively, said pair of elongated slots being arranged so as to be perpendicular with respect to each other.

The above and other objects and advantages of the present invention become apparent from the following description, taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an explanatory view of a multiphotographic device according to the present invention;

FIG. 2 is a perspective view illustrating only the essential part of one embodiment of the present invention;

FIG. 3A and 3B are rear views for explaining the movements of a pair of movable plates looking at the rear of FIG. 2; and

FIG. 4 is an explanatory view illustrating the positions of the apertures selected whenever photographing is made.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The optical system of the multiphotographic device according to the present invention is comprising, as shown in FIG. 1, a relatively large diameter lens 1, a second lens 2 and 2 and an aperture 3 disposed immediately behind the first lens 1. The second lens 2 is consisting of an integrally formed microlens group in which a plurality of microlenses are arrayed in row and column into a form of a grating. The second lens 2 serves to split finely into small parts the inverted image produced by the first lens 1 so that these finely split images are focused upon a sensitive material 4 as erect images. The aperture 3 is so disposed that it may be moved vertically and transversely in the plane perpendicular to the optical axis O of the first lens, and serves to determine upon what position of the sensitive material 4 is focused each of the minute split images corresponding to each of limited parts of the image produced by the first lens through each of the microlenses of the second lens 2. The same effect can be attained when the aperture 3 is disposed immediately in front of or within the first lens 1. As to the sensitive material 4 which is shown as being disposed backwardly of the second lens 2, the sensitive material may be located at the back surface of the second lens or in a spaced-apart relation therewith as long as the images through microlenses of the second lens 2 are sharply focused upon the sensitive material 4.

Now when an inverted image A is produced by the first lens 1 between the first and second lenses 1 and 2, one portion A*a* of the image A included in the light ray incident upon one 2*a* of the microlenses of the second lens 2 through the aperture 3 is focused as an erect split image A*a*1 upon the sensitive material 4. In a similar manner as described above, another portion A*n* of the image A included in the light ray incident upon another microlens element 2*n* through the aperture 3 is focused as an erect split image A*n*1 upon the sensitive material 4.

Next when the aperture 3 is displaced to a position designated by 3*a* and the taking lens or first lens 1 is directed to another object or scene, then the image B of that object or scene is produced in a similar manner as described above. One portion B*a* of the image B included in the light ray incident upon the above-described microlens element 2*a* through the aperture 3*a* is focused upon the sensitive material 4 as an erect split image B*a*1 through the microlens element 2*a*. In a quite

similar manner, another portion B*n* of the image B included in the light ray incident upon the element **2***n* through the aperture **3***a* is focused upon the sensitive material **4** as a split image B*n*1.

Furthermore, when the aperture **3** is displaced to a position intermediate the positions **3** and **3***a*, the split images of the image produced by the first lens **1** with the aperture **3** being in that position, will be focused upon the unexposed portions of the sensitive material **4**, that is the portions intermediate the portions where the above-described split images of the images A and B have been focused. It is of course required that whenever the aperture **3** id displaced upon photographing, the newly displaced aperture position must not coincide with the previous position of the aperture **3**. The split images of the image produced by the first lens **1** are therefore distributed over the whole surface of the sensitive material **4** and are prevented from being superposed upon the other focused or exposed image upon the sensitive layer **4**.

The number of pictures photographed by the device with the construction described above is dependent upon the ratio of the exposure area when the shielding plate provided with the aperture **3** is moved about on the exposure area when the aperture **3** is inserted. That is, the number of pictures to be photographed is dependent upon the ratio of the effective area of the first lens **1** when disposed at the position of the aperture **3** to the size of the opening of the aperture. For example, let it be assumed that the effective diameter of the first lens when disposed at the position of the aperture be 30 mm.; the focal length, 95 mm.; the distance between the aperture **3** and the image produced by the first lens, 80 mm.; the distance between the aperture and the second lens **2**, 40 mm.; the opening of the aperture, 2 mm.×2 mm.; and the pitch of the stepwise displacement of the aperture in both of the vertical and transverse directions, 3 mm., then 49 pictures can be photographed upon a single sensitive layer by displacing the aperture **3** in **7** steps in both of the vertical and transverse directions.

Since the image of an object photographed by the multiphotographic device of the present invention is distributed as minute split images over a single sensitive material, it is impossible to distinguish what kind of an object or objects are recorded upon the sensitive material when the sensitive material is viewed in an ordinary manner. However, when the optical system used when the photographing is made is used and only the direction of the light rays is reversed, that is when the images recorded in the sensitive material are projected by the lights from a light source disposed at the back of the sensitive material and the same optical system as described above is used, then the photographed image or images can be reproduced.

The aperture must be located at a correct position whenever photographing is made in order to correctly determine the angle of incidence upon the second lens **2** of the light rays which split the image produced by the first lens **1**. When the position of the aperture **3** should be slightly displaced from its correct position, especially when the position of the aperture when photographed is different from the position of the aperture when the image is reproduced, the perfect reproduction of the photographed image can not be made. Furthermore, the aperture **3** must be displaced vertically and transversely within the plane perpendicular to the optical axis of the first lens to a new position whenever photographing is made, regardless of the sequence of the steps to that new position in the vertical or transverse direction.

Now reference is made to FIG. **2** where schematically one embodiment of the present invention is illustrated comprising a first lens **11**, an opaque movable plate **12** having an elongated slot **12***a* whose width is equal to the length of one side of a square aperture and a moving beltlike opaque plate **13** provided with a plurality of elongated slots **13***a*1, **13***a*2, and so on each of which is adapted to intersect with the elongated slot **12***a* so as to form an aperture in the form of a regular square as shown at **14**. With perforations **15** provided on both sides of the moving beltlike plate **13** (hereinafter referred to as "moving belt" for brevity) engage the teeth of a sprocket wheel **17** carried by a driving shaft **16** which in turn is drivingly interconnected to a winding shaft **18** of the moving belt **13** through gears **19**, **20** and **21**. When the driving shaft **16** rotates in the direction indicated by the arrow, a winding cylinder or drum **22** which is friction-fitted over the winding shaft **18** takes up the moving belt **13** therearound.

When a worm **23** fixedly secured at one end of the shaft **16** rotates in the direction as indicated by the arrow, a rack **26** is caused to move in the direction indicated by the arrow through a worm gear **24** and a pinion **25**. The driving shaft **16** is adapted to rotate in the direction indicated by the arrow in such a manner that whenever one photographing is made, the moving belt **13** is moved downwardly by a distance slightly longer than the length of one side of the aperture to be formed. At the same time, the movable plate **12** is displaced only a little distance toward the right as the movable plate **12** is coordinated with the moving belt **13**. The displacement of the movable plate **12** is dependent upon the number of apertures defined along the elongated slot **12***a* by the elongated slot **13***a* of the moving belt **13** which intersects with the elongated slot **12***a* when the elongated slot **13***a* moves from the uppermost aperture forming portion to the lowermost aperture forming portion of the elongated slot **12***a*. Let it be assumed for example that a number of *n* apertures are defined in the elongated slot **12***a* in a manner as described above, then the ratio of the displacement of the elongated slot of the moving belt **13** to that of the elongated slot **12***a* will become *n*: 1. FIG. **3**–A illustrates the state wherein the elongated slot **13***a*1 is moved one step downwardly while the elongated slot **12***a* is moved toward the right by the distance equivalent to $1/n$ in the second photographing. In FIG. **3**–B, the state is shown where the elongated slot **13***a*1 has been moved downwardly in stepwise manner from the position shown in FIG. **2** in a number of times equal to $(n-1)$ each time as the photographing is made while the elongated slot **12***a* has been moved toward the right by a distance equal to $(1-d)$, where $d=1/n$. When the elongated **13***a*1 is further moved downwardly by one step from the position illustrated in FIG. **3**–B, thus completing the downward stepwise movement in *n* steps, the elongated slot **13***a*1 will not intersect with the elongated slot **12***a* any longer, but simultaneously the next elongated slot **13***a*2 comes to intersect with the uppermost aperture forming portion of the elongated slot **12***a* so as to form the uppermost aperture in the second column. In this case, the elongated slot **12***a* has moved from the position shown in FIG. **2** to a position spaced-apart therefrom by a distance equal to the length of one side of the aperture to be formed.

FIG. **4** illustrates schematically the arrangement of the apertures which have been sequentially defined and positioned as described above by the elongated slot **12***a* and the slots of the moving belt **13**. In this case, it is assumed that the number of apertures to be formed along the elongated slot **12***a* by one elongated slot of the moving belt **13** when the belt moves from the uppermost to the lowermost aperture forming portions of the elongated slot **12***a* are **7** while tee elongated slot **12***a* advances by a distance equal to **7** times as much as the length of the side of the aperture to be formed when seven elongated slots of the moving belt **13** move downwardly. As clearly seen from FIG. **4**, the row of the apertures immediately below the uppermost row is displaced in the transverse direction by a distance of $1/n$ relative to the uppermost row and so on. When the single sensitive material is completely exposed, the moving belt **13** is rewound by means of a rewinding shaft **27** so that the aperture is returned to its first position as shown in FIG. **1** (that is, the position **14** in FIG. **2**).

According to the present invention wherein a pair of elongated slots which are adapted to form an aperture at the intersection thereof are driven in a predetermined relationship with respect to each other, thereby forming the apertures in different positions sequentially, the correct position of the aperture which must be disposed to the next position when-

ever one photographing is made can be ensured with high accuracy whereby a very high precision multiphotographic device can be provided.

The present invention has been described in detail with particular reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the present invention as described hereinabove and as defined in the appended claim.

I claim:

1. In a multiphotographic device comprising:
a first lens for producing images;
a movable aperture associated with said first lens;
a second group of lenses comprising a plurality of microlenses; and
a sensitive material associated with said second lens group for recording the images;
the improvement comprising forming and moving the aperture by:
a pair of overlapping flat elements relatively movable with respect to each other, one element including a series of spaced-apart horizontal elongated slots, said one element movable vertically in increments slightly greater than the size of the aperture, the other element including a vertical slot, said other element movable horizontally in increments equal to $1/n$ where n is the number of apertures in a horizontal row, and the aperture being formed by part of said horizontal slot overlapping part of a said vertical slot.

2. A device according to claim 1, in which the width of said vertical slot determines the width of the aperture.

3. A device according to claim 1, in which the horizontal slots are spaced-apart sufficiently so that only one horizontal slot overlaps any part of a vertical slot at one time, and the height of the horizontal slot determines the height of the aperture.

4. A device according to claim 1, in which said one element comprises a flexible belt, and spaced-apart roller means are provided to roll and unroll said belt.

5. A device according to claim 4, in which the other element is a plate, and drive means are provided to move said plate in said increments, said drive means being coordinated to move simultaneously with said roller means.