PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to the Printing of Copies from Lenticulated Film Bearing Colour Component Images

We, KODAK LIMITED, a Company registered under the Laws of Great Britain, of Kodak House, Kingsway, London, W.C.2, (Assignees of FORDYCE EDDY TUTTLE, Citizen of the United States of America, of 343, State Street, Rochester, New York, United States of America), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the printing of copies from an " original " lenticular photographic film, that is to say, a film having a picture recorded thereon in colour component images, on to another lenticular film or " copy ".

For the purpose of printing from one lenticular film on to another lenticular film it has been proposed separately and successively to illuminate the colour component images on the original film and to project these images separately on to the copy by successively unmasking different portions of the pupil of the printing objective. Only a part of the pupil of the objective is thus unmasked for the printing of each colour component thus entailing the use of an objective of large aperture.

According to the present invention the original film is illuminated by a point or linear light source the light from which is incident on the lenticular surface of the original film, and the apparent position of the light source with respect to the original film for the several colour component images is adjusted by light-deflecting means between the original film and the light source thereby separately and successively illuminating the colour component images, the axis of the printing light pencil passing, for each colour component image, through the centre of the curved lenticular surface and through the centre of the said colour component image. The images are projected on to the copy film by means of a printing objective with the axis of the projected light pencil for each colour component passing approximately through the optical centre of the objective the apparent position of which with respect to the copy film is adjusted for the several colour component images by light-deflecting means between the objective and the copy film thereby separately and successively recording the colour component images on the copy film in positions corresponding respectively to those occupied by the colour component images on the original film, the axis of the light incident on the lenticular surface of the copy film from the objective, for each colour component image, passing through the centre of the curved lenticular surface on the copy film and through the centre of the image area.

Conveniently adjustment of the apparent position of the light source with respect to the original film and the adjustment of the apparent position of the objective with respect to the copy film is effected by a series of thin wedge-shaped light-refracting prisms which are successively moved into the optical axis between the original film and the source of light and between the copy film and the objective. The said apparent positions of the light source and objective are in this way adjusted by refraction as opposed to the reflection obtained when reflecting prisms or mirrors are employed.

In the accompanying drawings,

Figure 1 illustrates diagrammatically one optical arrangement for printing the central colour component, in accordance with the invention,

Figure 2 is a similar view of an optical arrangement for printing one of the off-axis components,

Figure 3 shows in perspective and on an enlarged scale three prisms which are successively employed when printing the three colour components respectively,

Figure 4 illustrates a mask suitable for use with the printing objective when an $f/2$ objective is used,

Figure 5 is a view at right angles to the optical axis of optical apparatus for printing successive frames of an original film on to successive frames of a copy,

Figure 6 shows the prism carrier and shutter viewed in the direction of the optical axis, and

[*Price* 1/-]

Figure 7 is a vertical section showing a modified construction of the prism carrier associated with the copy film.

For the purpose of illustrating the underlying principle of the invention Figures 1 and 2 separately illustrate the optical arrangement for printing the central and an off-axis colour component respectively. The apparatus illustrated in Figure 1 for printing the central colour component, usually the green component, comprises a linear light source 10 the light from which is concentrated by condenser lenses 11 on the original film 12 carrying a developed image 13 and provided with cylindrical lenticulations 14. The illuminated image in the layer 13 is imaged, by an objective 15, on a virgin or " copy " film 16 having a light sensitive layer 17 and cylindrical lenticulations 18. The lenticulations 14 and 18 lie parallel to the linear light source 10, as is necessary with cylindrical lenticulations. The lenticulated surfaces of both films face the light incident from the light source 10, and a window 19 of suitable dimensions is provided for framing the image on the sensitive film 16, a compensating lens 20 being arranged in close proximity to the window 19 so that the light rays incident on the film 16 are parallel. If a cylindrical compensating lens is used the axis of curvature of the lens should be parallel to the axes of the lenticulations 18. A plane parallel glass plate 21 is arranged between the condenser 11 and the original film 12, and a second plane parallel glass plate 22 is arranged in front of the compensating lens 20 as shown, the optical path being thus shortened for the purpose hereinafter described.

The width of the light source 10 and the joint length of the condenser 11 are so chosen in relation to one another that the image of the light source in the silver image layer is of less width than the width of the central (i.e. green) image band therein. In this way it is ensured that only the central or green colour component behind each lenticulation 14 of the original film 12 is illuminated so that light passes to the objective 15 only from the central colour component. The printing objective 15 subtends an angle equal to the apparent angle, usually $f/8$, subtended by a single area of the colour filter which is to be used in projecting the copy film 16. With the arrangement shown in Figure 1 therefore the objective 15 will subtend on the copy film 16 an angle corresponding to the central filter band so that only the central colour component will be printed on the copy film 16.

For printing an off-axis component, i.e. the red or the blue, of an original film which has been recorded through a three colour filter, the optical arrangement is modified as shown in Figure 2 to illuminate the off-axis component. In this arrangement a thin refracting prism 23 is arranged between the condenser 11 and the original film 12, this prism causing the apparent position of the linear light source 10 with respect to the original film 12 to be at 10^1, that is to say above the optical axis of the apparatus. The angle of the prism 23 must be such that the light therefrom incident on each lenticulation 14 will be directed on to one of the off-axis colour components, say the red, lying immediately behind that lenticulation. An angle of 14 degrees for the prism 23 has been found suitable in practice. It will therefore be seen that the red colour component only is illuminated so that the light collected by the objective 15 will represent the red component only and, if properly directed upon the sensitive layer 17 of the copy film 16, will print the red component alone.

In order that the light should be suitably directed on the sensitive layer of the copy film, a thin refracting prism 24 is positioned between the compensating lens 20 and the film 16, the prism 24 being inverted, as shown, relatively to the prism 23. In this way the portion of the sensitive layer 17 of the copy film to which light will pass will have the same relative position in the image as a whole and as inverted by the objective 15, as its relative position in the image on the original film 12. The introduction of the refracting prism 24 tends to displace the image formed on the copy film 16 and in order to compensate for this displacement an equal and opposite displacement is introduced by inserting a plane parallel glass plate 25 in front of the compensating lens 20, the plate 25 being slightly inclined out of the vertical as shown. The degree of this inclination will depend on the thickness and refractive index of the glass used for the plate 25. The prisms 23, 24 and the plate 25 will alter the effective length of the optical path and, in order that the length of this path should be the same when printing the central colour component (Figure 1) as when printing the off-axis component, the apparatus shown in Figure 1 is provided with the two plane parallel glass plates 21 and 22.

The second off-axis component, that is to say the blue component is printed in the same manner as that described with reference to Figure 2 but with each of

the prisms 23 and 24 and the plate 25 inverted relatively to the position shown in Figure 2.

For successively printing the three colour components two refracting prisms 23, 26 and a plane glass plate 21 arranged as shown in Figure 3 are successively brought into position in front of the original film 12 during the printing of each frame as hereinafter described, two similar refracting prisms and a glass plate being simultaneously moved but in the reverse order in front of the gate 19. Each of the prisms associated with the copy film 16 will be accompanied by an inclined glass plate, such as the plate 25, to compensate for the image displacement due to the associated prism.

Instead of employing an $f/8$ objective, a larger objective, say, $f/2$ may be used by providing a mask, such as that shown in Fig. 4, having an opening 28 the length of which is parallel to the lenticulations 18 and of such width that the angle subtended by the opening at the film 16 does not exceed the angle to be subtended by a single filter band during projection of the copy 16. The width of the opening 28 is the effective diameter of the objective, that is to say, with the arrangement above described, the diameter as measured in a direction at right angles to the length of the lenticulations on the copy film.

If the smaller printing objective is used the quality of the print may be improved by inserting between the original film 12 and the objective 15 a weak negative cylindrical lens 29 such, for example, as an ordinary spectacle lens of sufficient power to cause the light passing from the emulsion behind one lenticulation of the original film 12 to be incident on two lenticulations simultaneously of the copy film 16. In this way a tendency for a moire pattern to be produced in the printed image will be reduced. The same beneficial result could be obtained by using a lens 29 with a larger objective such as $f/2$ but most objectives of large aperture are so poorly corrected as to render their use in this manner unsatisfactory.

Figure 5 illustrates one construction of printing apparatus whereby the steps above separately described can be carried out when printing from an original lenticulated motion picture film, upon which a picture has been recorded through a three colour filter, on to a virgin lenticular film or copy. In this apparatus the original film 12 is fed through a gate 30 by claw-feed mechanism 31 whilst the copy film 16 is fed through a gate 32 by claw-feed mechanism 33. The two films are fed in opposite directions so that the inversion of the image by the objective 15 will not affect the correct arrangement of the images in successive frames of the copy film 16.

A shutter 34 is rotated by a shaft 35 driven through gearing 36, 37 by an electric motor 38. the claw-feed mechanisms 31, 33 being driven by the shaft 35. The shutter 34 is so positioned that upon being rotated it periodically interrupts illumination of the original film 12 in the gate 30 and is synchronised with the claw-feed mechanisms 31 and 33 in such a manner that the films 12 and 16 are advanced one frame for each complete revolution of the shutter 34. The prisms 23 and 26 and the associated glass plate 21 for controlling the direction of the light illuminating the film 12 are mounted on a carrier 39 pivoted at 40 on a fixed part 41 of the base or frame of the apparatus. A coiled spring 42 tends to turn the carrier 39 in the clockwise direction as viewed in Figure 6 so that a follower 43 on the carrier 39 is held in engagement with a cam 44 secured to the shaft 35 so as to rotate with the shutter 34.

The cam 44 comprises three segments each of which is an arc concentric with the axis of rotation of the cam 44, the segments being so angularly spaced apart that no movement of the arm 39 occurs when any one of the openings of the shutter is in alignment with one of the prisms 23, 26 or the plate 21. Thus, the successive movements of the carrier 39 caused by engagement of the follower 43 with one of the non-concentric portions of the cam 44 occur during a period when the light is interrupted by the shutter 34. In this way, for one complete revolution of the shaft 35 a single frame of the original film 12 will be illuminated successively through the prism 23, plate 21 and prism 26, the light transmission to the original film being interrupted by one blade of the shutter 34 between each such successive illumination during which interruption the carrier 39 is moved to bring the next succeeding element 23, 21 or 26 into its operative position between the light source 10 and the gate 30.

A similar arrangement is provided in respect of the copy film. To this end a carrier 45 for the prisms and plate is biased by a spring (not shown) which tends to maintain a follower 46 on the carrier 45 in engagement with a cam 47 rotated by the shaft 35 and having a contour corresponding to that of the cam 44. The carrier 45 is furnished with

three elements comprising respectively a prism and associated inclined glass plate such as the prism 24 and plate 25, a plane glass plate such as the plate 22, and a second prism and associated inclined plate similar to the prism and plate 24, 25 but inverted relatively thereto. The arrangement is such that when the prism 23 is in its operative position and is unmasked by the shutter 34 the prism 24 and associated plate 25, as shown in Figure 2, lie on the optical axis so that one off-axis colour component is printed. When the plate 21 is in its operative position the plate 22 lies on the optical axis so that the central colour component is printed, and when the prism 26 is in its operative position the prism and plate which are inverted relatively to the prism 24 and plate 25 in Figure 2 lie on the optical axis so that the second off-axis colour component is printed. The two films are next advanced by one frame and the process repeated. A compensating lens 20 may be arranged between each associated plate 25 and prism 24 on the carrier 45 but, if desired the prism 24 and compensating lens 20 may in each case be replaced by a decentered compensating lens 48 as shown in Figure 7.

From an examination of the particular arrangement illustrated by way of example in Figure 2, it will be seen that the central ray of the light cone emerging from the image layer behind each lenticulation of the original film 12 does not reach the objective 15 in the same manner as the central ray in printing the central component (Figure 1). In printing the central component therefore a greater proportion of the light is collected by the objective 15 than in printing an off-axis component. To compensate for this difference in intensity the exposure time in printing the central component is made less than for the off-axis components by suitably reducing the width of the open sector of the shutter 34 which unmasks the glass plate 21 for printing the central component.

When it is desired to print from an original film having transverse lenticulations on to a film having longitudinal lenticulations or vice versa it is only necessary to ensure that the refracting prism and inclined plate or the like associated with each film deflect the light (incident from the light source and from the objective) in planes at right angles to the length of the lenticulations on the original film or on the copy film. For example, if one imagines the lenticulations of either of the films shown in Figures 1 and 2 to be revolved, say 90°, about the optical axis, of the whole system, then the adjacent refracting prism or like unit should be revolved to the same extent.

It will therefore be seen that not only is each colour component image printed separately but the angle subtended by the filter during exposure of the original film in the camera is independent of the angle subtended in projecting the copy film. This being true, all that is necessary in order to print on an altered scale, is to adjust the position of the printing objective, adjust the gate to gate distance, and to select compensating lenses having the proper focal length for directing the light on to the virgin or copy film. Another advantage arising from the independence of the filter angles in taking the original film and projecting the copy film is that it renders possible the use of a lens of small aperture for exposure of the original film in the camera. Again, as will be seen from Figures 1 and 2, the axis of the printing light pencil passes, for each colour component image, through the centre of the curved surface of the corresponding lenticulation 14 and through the centre of the said colour component image, whilst the axis of the light pencil from the objective 15, for each colour component image, passes through the centre of the curved surface of the corresponding lenticulation 18 and through the centre of the corresponding image area on the copy film. Further, the axis of the projected light pencil for each colour component passes substantially through the optical centre of the objective so that the position of the effective part of the pupil remains on the optical axis and a printing objective of small aperture may be employed.

Though the invention has been described as applied to the printing of lenticulated film bearing three colour component images, the invention is also applicable to the printing of lenticulated film bearing two colour component images, these images corresponding either to two stereoscopic views or to two colour separation images of a two colour process.

It will be understood that the method and apparatus described above are given by way of example only and may be modified.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. The method of printing from a lenticular film having colour component images on to another lenticular film or copy, which comprises illuminating the original film by a point or linear light

source the light from which is incident on the lenticular surface of the original film, adjusting the apparent position of the light source with respect to the original film for the several colour component images by light-deflecting means between the original film and the light source thereby separately and successively illuminating the said colour component images, the axis of the printing light pencil passing, for each colour component image through the centre of the curved lenticular surface and through the centre of the said colour component image, projecting the images on to the copy film by means of a printing objective with the axis of the projected light pencil for each colour component passing approximately through the optical centre of the objective, and adjusting the apparent position of the objective with respect to the copy film for the several colour component images by light-deflecting means between the objective and the copy film thereby separately and successively recording the colour component images on the copy film in positions corresponding respectively to those occupied by the colour component images on the original film, the axis of the light incident on the lenticular surface of the copy film from the objective, for each colour component image, passing through the centre of the curved lenticular surface on the copy film and through the centre of the image area.

2. In optical apparatus for printing from an original lenticular film bearing colour component images on to another lenticular film or copy, the combination with a point or linear light source from which light is incident on the lenticular surface of the original film, light-deflecting means between the original film and the light source whereby the apparent position of the latter with respect to the original film is adjusted for the several colour component images thereby separately and successively illuminating the said colour component images, the axis of the printing light pencil, for each colour component image, passing through the centre of the curved lenticular surface and through the centre of the said colour component image, of a printing objective through the optical centre of which passes the axis of the light pencil projected from each colour component image on the original film, and light-deflecting means between the objective and copy film whereby the apparent position of the objective with respect to the copy film is adjusted for the several colour component images which are thus separately and successively recorded on the copy film in positions corresponding respectively to those occupied by the colour component images on the original film, the axis of the light incident on the lenticulated surface of the copy film from the objective, for each colour component image, passing through the centre of the corresponding curved lenticular surface on the copy film and through the centre of the corresponding image area.

3. Optical apparatus as claimed in Claim 2 in which means are provided whereby the illumination of each colour component strip behind each lenticulation on the original film does not extend over the whole width of such strip.

4. In optical apparatus for printing from an original lenticular film bearing colour component images, on to another lenticular film or copy, the combination with means for supporting the two films with their lenticulations facing a point or linear source of light, of a condenser between the said light source and the original film for giving the source an apparent width, as viewed from the original film, not greater than the apparent width of a single filter band of the filter used in taking the original, light-deflecting devices for adjusting the apparent position of the light source with respect to the original film so as successively to illuminate the individual colour component images thereon, the axis of the printing light pencil passing, for each colour component image, through the centre of the curved lenticular surface and through the centre of the said colour component image, an objective positioned to collect the light transmitted from the original film and through the optical centre of which objective passes the axis of the projected light pencil for each colour component, and light-deflecting devices for adjusting the apparent position of the exit pupil of the objective as viewed from the copy film for the several colour component images thereby separately and successively recording the colour component images on the copy film in positions corresponding respectively to those occupied by the colour component images of the original film, the axis of the light incident on the lenticular surface of the copy film from the objective, for each colour component image, passing through the centre of the curved lenticular surface on the copy film and through the centre of the image area.

5. Optical apparatus as claimed in Claim 3 or Claim 4 in which adjustment

of the apparent position of the light source with respect to the original film and the adjustment of the apparent position of the objective with respect to the copy film is effected by a series of thin wedge-shaped light-refracting prisms which are successively moved into the optical axis between the original film and the source of light and between the copy film and the objective.

6. Optical apparatus as claimed in Claim 4 in which a weak negative lens is disposed between the original film and the printing objective so that the light emergent from behind each lenticulation of the original film is spread over two lenticulations of the copy film.

7. The optical apparatus for printing from an original lenticular film on to another lenticular film or copy as described with reference to Figures 1, 2 and 3 and Figures 5, 6 and 7.

8. The optical apparatus for printing from an original lenticular film on to another lenticular film or copy as described with reference to Figures 1, 2 and 3 and Figures 5, 6 and 7 and having a printing objective the aperture of which is restricted as described with reference to Figure 4, of the accompanying drawings.

Dated this 5th day of November, 1934.
KILBURN & STRODE,
Agents for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1936.

Fig. 1.

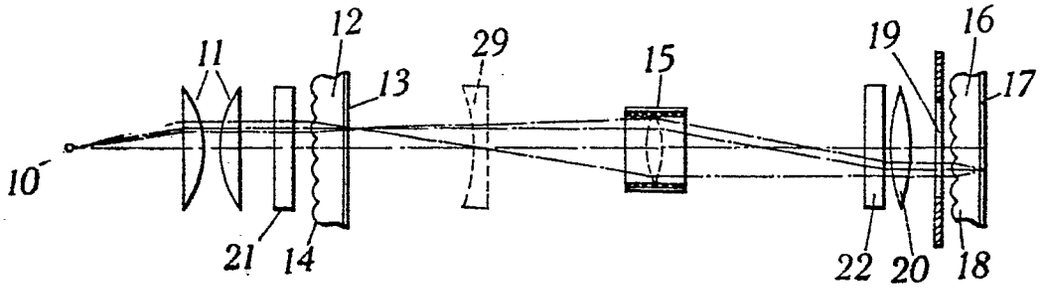


Fig. 2.

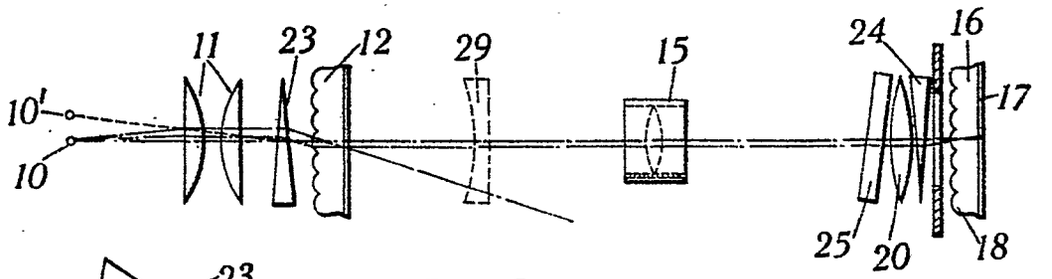


Fig. 3.

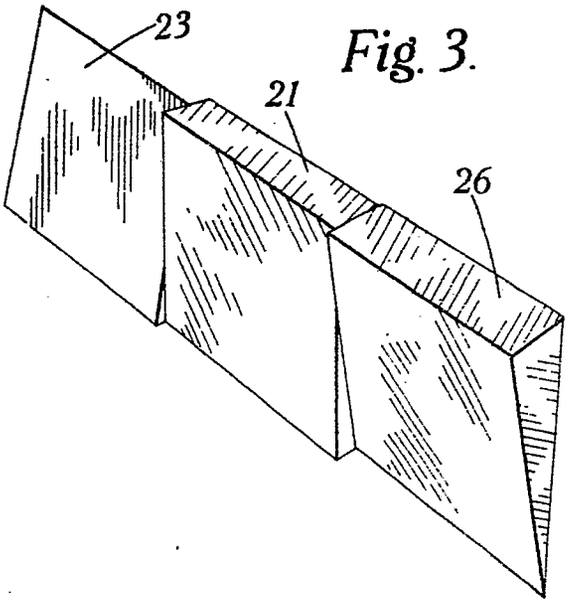


Fig. 4.

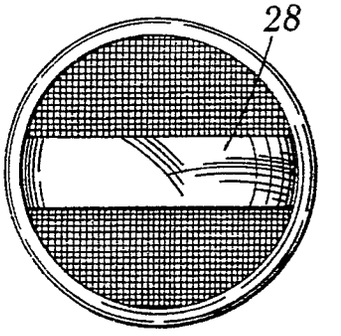
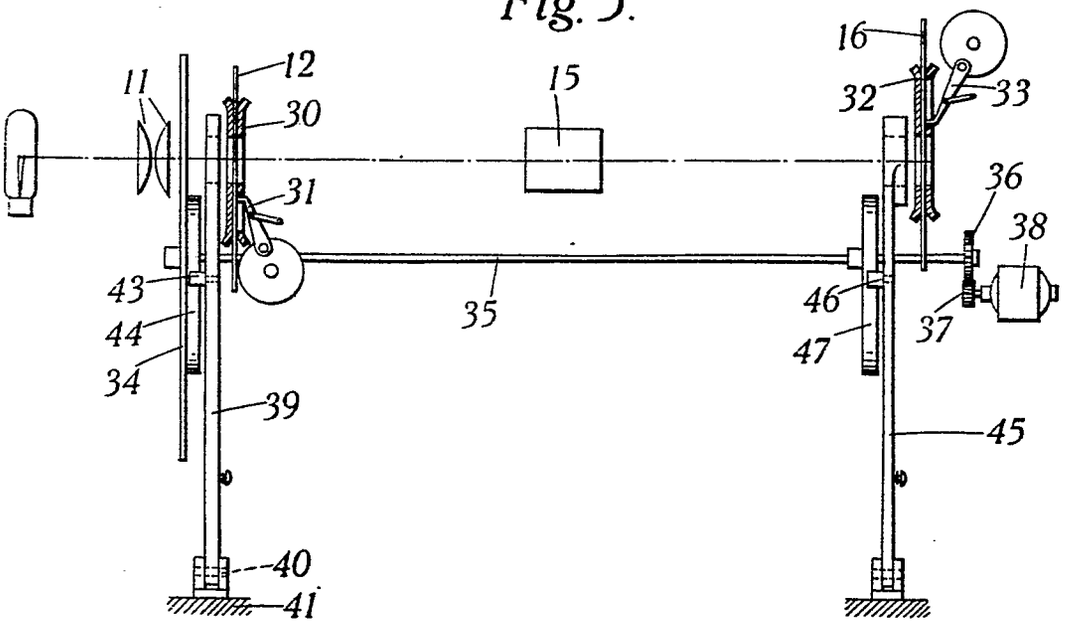
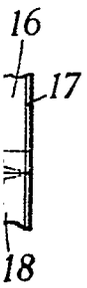


Fig. 5.





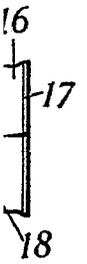


Fig. 6.

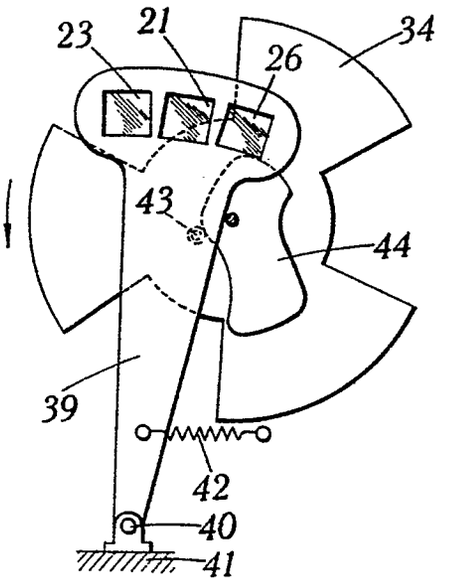


Fig. 7.

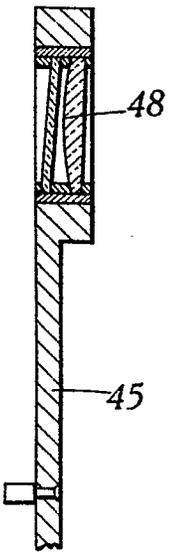


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Fig. 1.

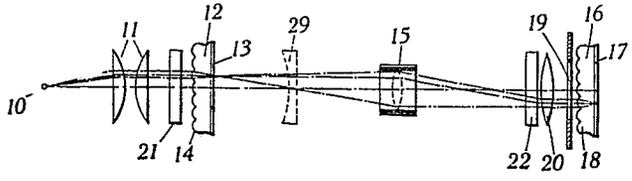


Fig. 2.

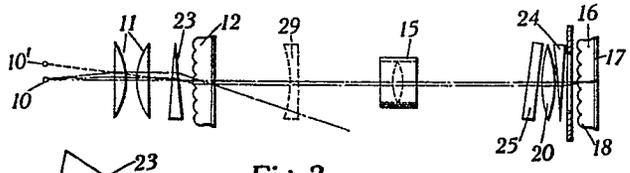


Fig. 3.

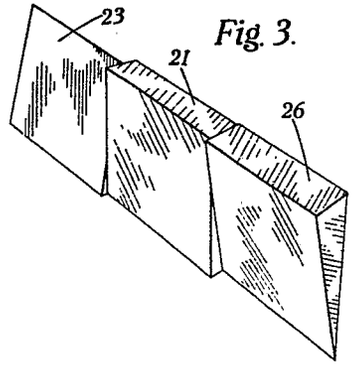


Fig. 4.

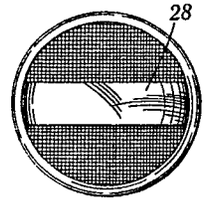


Fig. 5.

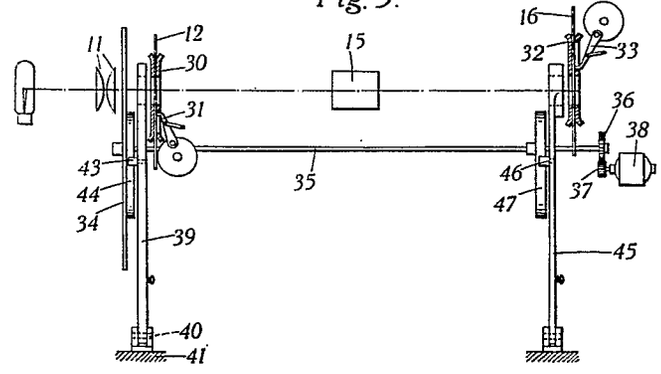


Fig. 6.

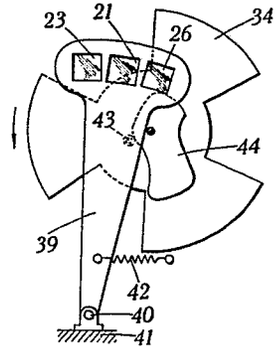
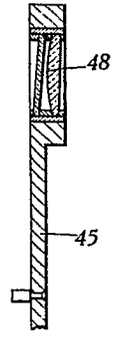


Fig. 7.



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