March 25, 1958 H. ELION ET AL 2,827,831

LONG RANGE IMAGE PROJECTOR

Filed Aug. 30, 1955 2 Sheets-Sheet 1

FIG. 1.

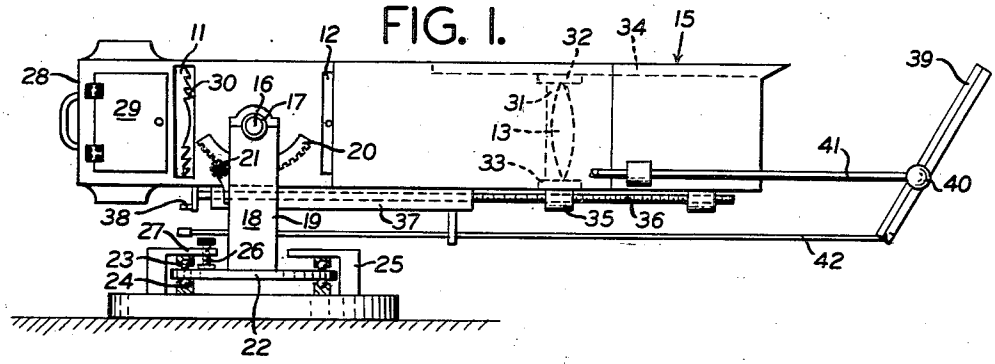


FIG. 2.

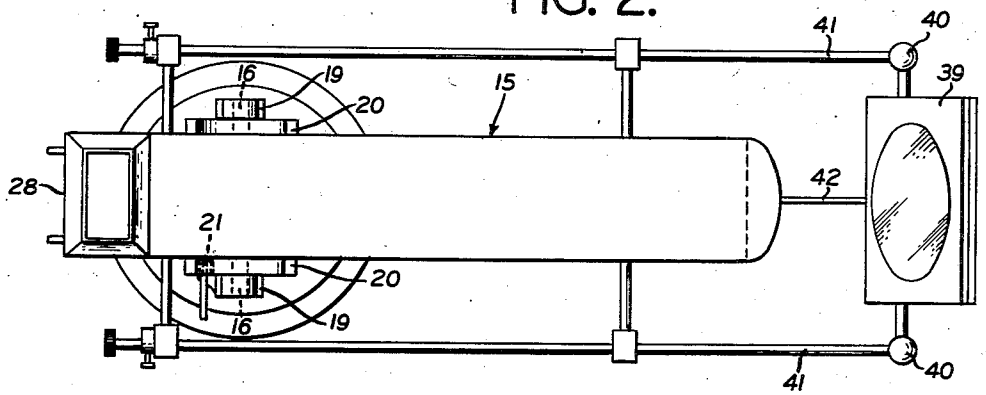


FIG. 3.

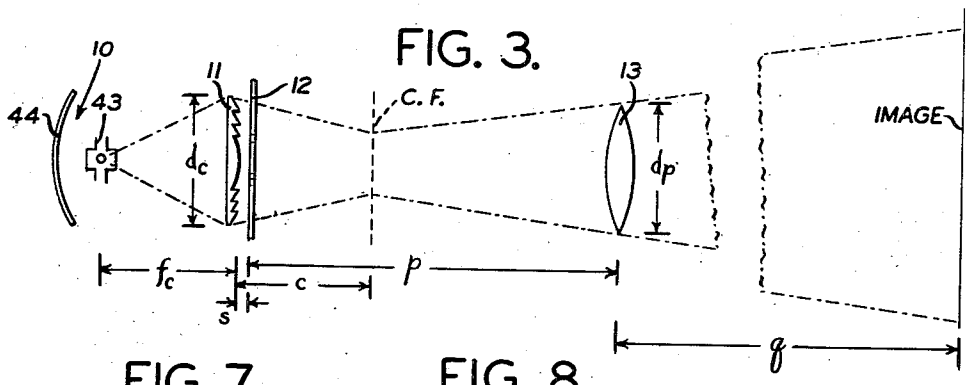


FIG. 7.

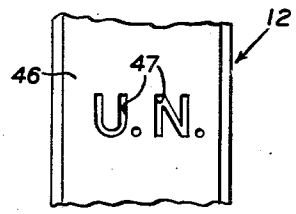
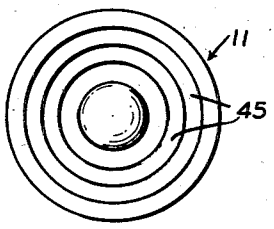


FIG. 8.



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March 25, 1958 H. ELION ET AL 2,827,831

LONG RANGE IMAGE PROJECTOR

Filed Aug. 30, 1955 2 Sheets-Sheet 2

FIG. 4.

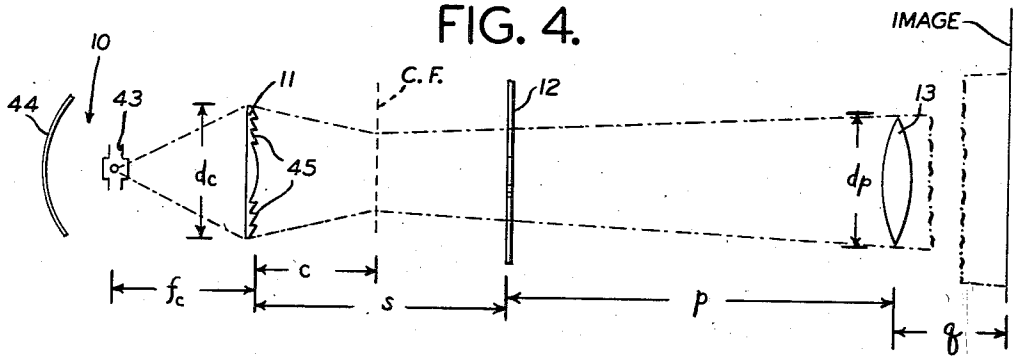


FIG. 5.

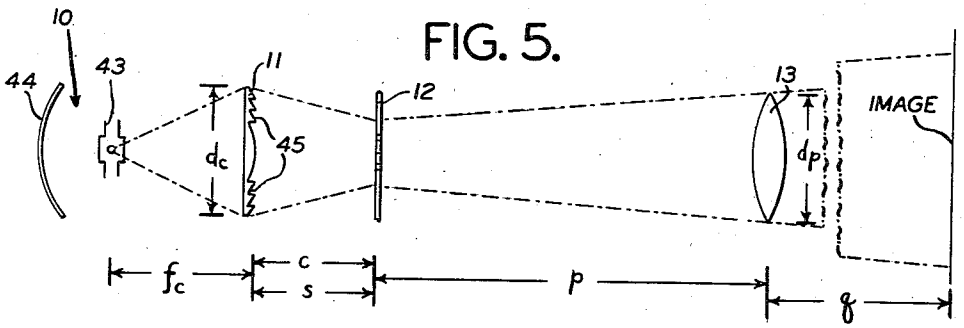
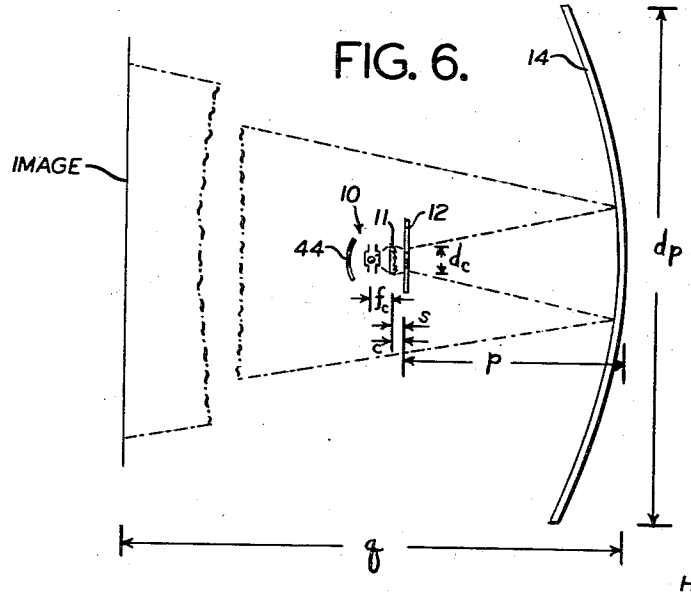


FIG. 6.



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LONG RANGE IMAGE PROJECTOR

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6 Claims. (Cl. 88—24)

This invention relates to the projection of images for observation at relatively great distances from the projector, such as distances of from 1,000 to 18,000 feet—and more particularly to devices for projecting images on clouds, atmosphere-suspended layers of dust, mist, smoke and the like, and on large objects such as buildings and mountainsides or other distant objects of sufficient size and reflectivity.

It is primarily within the contemplation of this invention to provide means for producing an intense beam, for such long-distance projection, of substantially homogeneous luminous intensity throughout the transverse cross-section thereof, and whereby the resultant image is clear-cut and relatively undistorted, with a degree of message resolution not possible with conventional projectors. And it is our objective to accomplish this purpose by means of a long focus projector of relatively small proportions and with a projection lens of relatively small diameter for such a device.

Attempts to accomplish the above-mentioned objectives with conventional projectors have heretofore been without success. In those devices where the conventional condenser lens is eliminated and reliance placed upon a reflecting surface for projecting a beam, it has been found that there is a considerable loss of the light emitted by the energy radiating source resulting in an inefficient device. And in those devices where a conventional condenser is employed, it is invariably of very large proportions, which is not only costly, but also requires the use of special means uniformly to cool the large lens areas adjacent the source of intense heat. Where frosted or opalescent glass is used to prevent the image of the light source from being projected, there is also considerable loss of light, not only because of the translucency of the transmitting medium, but also because the resultant diffusion extends through a range of 180°, some of the rays being scattered to regions outside that of the condenser lens. To overcome this defect, devices have been employed to catch and reflect such scattered rays of diffused light—resulting in an expensive apparatus and one not practically suited for cloud projection.

Another expedient heretofore attempted, with unsatisfactory results, has been the use of a mask or cut-off member in front of the message stencil to encircle the beam, for the purpose of cutting off the image of the light source—such a mask being placed at the conjugate focus of the beam, for most effective masking effects. The use of a mask must necessarily result in a loss of efficiency; and furthermore, because of its placement, the system requires an extremely large diameter, long focus projector lens—which, as aforesaid, is expensive, besides being space-consuming and entails technical difficulties in its maintenance.

To overcome the aforesaid shortcomings attempts have been made to employ various lens systems of different degrees of complexity; but these have proven satisfactory only for short-range projection, being inefficient in the

light-gathering requirements for successful cloud projection.

In most conventional projection systems the message stencil is placed at the conjugate focus of the beam; and since the heat is most intense at that region, the stencil is difficult to handle and is subject to the deteriorating effects of the heat.

It is within the contemplation of our invention to provide a projection system having none of the disadvantages and shortcomings of the conventional projectors hereinabove referred to. Our system employs a novel combination and arrangement of optical and projection components, the preferred form thereof employing, in place of the conventional condenser lens all portions of which have the same focus, a condenser lens with a plurality of zones—adjacent refracting facets—each zone being corrected for spherical aberration, whereby there is no fall-off in brightness at the peripheral margin of the image. The arrangement is such as to enable the use of this type of condenser lens with a low focal-length to diameter ratio, for effective light gathering power, without diffusion losses. The preferred, but not exclusive, embodiment of our novel system is also characterized by the positioning of the message stencil between the conjugate focus and the multi-zoned condenser lens—the stencil being relatively close to the condenser and at a region of the beam of greater cross-sectional area than that of the conjugate focus area. The arrangement is hence such that the stencil is at a locale of comparatively low-heat intensity, thereby eliminating the danger and inconvenience of overheating. Moreover, the projection lens—as well as the message stencil—are relatively close to the light source—thereby resulting in a high-efficiency light system and a clear-cut message image, permitting the use of a smaller projection lens than can be employed with conventional devices, and obviating the use of masks, opalescent or other diffusing media for eliminating the light source image. The novel arrangement above referred to results from a relationship of components not to be found in known devices, with results that are of critical importance in cloud projection.

Other objects, features and advantages will appear from the drawings and the description hereinafter given.

Referring to the drawings,

Fig. 1 is a semi-schematic side elevation of a projector embodying our invention.

Fig. 2 is a top view of Fig. 1.

Fig. 3 is a diagrammatic representation showing a preferred relationship between the main components of our invention.

Fig. 4 is a view like Fig. 3 showing another relationship of the components.

Fig. 5 is a view like Fig. 3 showing still another relationship of the components.

Fig. 6 is a diagrammatic representation of another form of our invention with a concave mirror reflector in place of the projection lens of the device of Figs. 3, 4 and 5, this view also showing the relationship of the main components in accordance with our invention.

Fig. 7 is a front view of a form of message stencil adapted for our invention.

Fig. 8 is a front view of a preferred form of condenser lens adapted for our invention.

The aforesaid main components of our invention as illustrated in Figs. 1–5 are a light source generally designated **10**, condenser means **11**, image stencil **12** and projection element or lens **13**. In the embodiment of Fig. 6, a concave reflecting mirror **14** is employed in place of the said projection element **13**.

As illustrated in Figs. 1 and 2, the said main components are housed within a structure which can be

pivotally moved to change its elevation, and which can also be rotated in a horizontal plane so that it can be swung to the desired azimuth. While Figs. 1 and 2 illustrate one structure of a device embodying our invention, it is understood that other structures for housing said main components and other means for operatively moving the structure may be employed within the scope and intent of this invention.

In the particular form illustrated, a generally cylindrical casing **15** is mounted upon laterally opposite transverse shafts **16**, these being disposed within the bearings **17** at the upper terminal portions of the arms **19** of the yoke **18**. An arcuate gear segment **20** is mounted on casing **15** and is in engagement with gear means **21** on said yoke **18**, whereby the geared means **20** and **21** will be in coactive engagement, in known manner, when the casing **15** is operatively rotated along the horizontal axis extending through the said bearings **17**. The said yoke **18** is mounted on a horizontal plate **22**, the latter being operatively disposed between the upper and lower ball-bearing races **23** and **24**—the base plate **22** and said bearings being disposed within the retainer or housing **25**. The threaded friction stop member **26**, extending through flange **27** of said housing **25**, is adapted to frictionally hold said base plate **22** against movement. By this arrangement, the entire yoke **18**, together with the casing **15** supported thereby, can be horizontally rotated to swing the projector to the desired azimuth.

At the rear portion of the casing **15** is the housing **28** proportioned to contain therein the light source **10** (not shown in Figs. 1 and 2), the door **29** permitting access to the interior of said housing. Disposed forwardly of said housing **28** is a special type of condenser **11**, to be hereinafter specifically referred to, said condenser being contained within a support **30**. Disposed forwardly of said condenser **11** is said message stencil **12**, the position of which can be predetermined by the operator, depending upon particular requirements. At the forward portion of housing **15** is said projection lens **13**, this being mounted within a frame **31** which carries upper and lower slides **32** and **33**. The upper slide **32** is in a slidable engagement, in known manner, with the upper guide rail **34**. The lower slide **33** has affixed thereto the internally threaded collar **35** mounted over the longitudinally disposed screw **36**. The latter is operatively supported by the housing **37**, the rearmost portion of the screw having affixed thereto the crank handle **38**. The arrangement is hence such that, upon a manipulation of crank handle **38**, the screw **36** will revolve and operatively move the projection lens **13** forwardly or rearwardly, as the circumstances require. Disposed in front of casing **15** is the mirror member **39** pivotally mounted at **40** and supported by the rods **41**, the bottom of the mirror having connected thereto the manually movable control rod **42** for swinging the mirror about its said pivotal connection **40**. The mirror arrangement permits azimuth and elevation corrections through the operation of said control rod **42** and the swivel rod **41**.

The light source **10** is of high brilliance, in order to obtain sufficient light energy within a small space, for effective cloud message projection. It has been found that the most favorable type of light source is a cooled, enclosed, high intensity metal vapor discharge lamp, or a combination of such lamps, thereby providing clean, heat-filtered illumination, eliminating vapor gases and such undesirable deposits which commonly result from open arcs and tail flames. The reference numeral **43** identifies such source of illumination—the reflector **44** adjacent the light source being used in combination therewith for directing the beam of light through said condenser **11**. For the purpose of this invention and the limiting relationships embodied therein, as hereinafter set forth, the brilliance of the light source should be greater than 20,000 candles per square centimeter.

The condenser **11** is of the echelon type, comprising a plurality of lenticular zones **45**—each of said zones presenting a refracting facet corrected for spherical aberration. The multi-zone construction may vary in accordance with particular requirements—it being feasible, depending upon the circumstances, to employ concentric portions constituting the lenticular zones (like that of Fig. 8), or adjacent parallel zonal portions—the preferred arrangement being to have the stepped lenticular regions **45** disposed away from the light source. This type of condenser, while used in certain types of searchlights, has never been used in combination with other components in a device for projecting sharp and clear-cut images on clouds. This form of condenser, when used in combination with the other components of our invention, is adapted to attain our said objectives; and when so used, it transmits light without spherical aberration—normally difficult or impossible to attain with ordinary lenses two feet in diameter—enables the collection of relatively large quantities of light in a relatively uniform beam, and gives the required scattering or diffusion of light so as to eliminate the projection of the image of the light source without using masks or other complex mechanisms.

The message stencil **12** is of generally conventional structure as shown in Fig. 7. It contains a plate **46** containing a perforated message portion **47** adapted to permit the passage therethrough of light from the condenser **11**.

We have discovered that there are certain relationships between the main components above-described which enable our various objectives to be attained—and which have not heretofore been obtainable with other devices employing different relationships. In order to define such relationships, the following system of notations will be employed in this specification:

f_c=focal length of condenser system, in the present case of condenser **11**

d_c=diameter of condenser **11**

f_p=focal length of projection lens **13**—or the concave projection mirror **14**

d_p=diameter of projection lens **13** or projection mirror **14**

c=length of the conjugate focus of the system comprising the reflector **44**, light source **43** and condenser **11**

s=distance between condenser **11** and message stencil **12**

p=distance between message stencil **12** and the projection lens **13** or concave mirror **14**

q=distance between projection lens **13** or projector mirror **14** and the image projected by said lens or mirror

The relationships we have discovered to render a device of this class operable for cloud projection are particularly directed to apparatus in which the conjugate focus c is 24" or less, and the distance between the condenser and the message stencil s is 48" or less. Under these conditions, we find that the most effective results are attained (*a*) when the message stencil **12** is disposed between the condenser **11** and the conjugate focus C. F. and (*b*) when the message stencil **12** is disposed closer to the condenser **11** than to the conjugate focus C. F. The lower the value of s the more light energy is available to transmit a clear-cut message through the message stencil **12**. Moreover, the heat at the region close to condenser **11** is much less than that at the C. F., so that undesirable heating of the stencil is eliminated.

We have also ascertained that for most effective operation of the apparatus, the following relationship must prevail, where c and s are of the proportions above indicated:

$s \leqq 2c$—that is, the distance between the message stencil **12** and the condenser **11** is equal to or less than twice the conjugate focal distance c

Where s is greater than $2c$, the light available has been reduced to a point where it is not practical for cloud projection, requiring extremely large projection lens diam-

eters. We have also found that, in addition to the above basic relationship, the distance p between the projection lens 13 (or mirror 14) and the message stencil 12, should be greater than three times the conjugate focal distance c—particularly with a long focal length projection lens or an extremely fast projection mirror (with f value less than 1). Otherwise, compound projection lenses or their equivalent must be employed, with the danger of accumulated aberrations and light losses. We have therefore found that the value $p>3c$ is a necessary relationship, and makes possible the use of a simple lens or mirror system, in conjunction with a relatively fast condenser lens.

Using the multizonal type of condenser, like condenser 11, we have found that such condenser operates efficiently and gives a uniform beam as long as the image distance q between the projector lens and the projected image is greater than 100 times the distance p between the projection lens 13 (or mirror 14) and the message stencil 12. In other words, another important relation is $q>100p$.

As above indicated, the condensing means must be fast—sufficient for effective light collection. The value f_c/d_c must therefore be less than 3—and preferably less than 1—for efficient and satisfactory results.

In addition to the above relationships, the standard projection equation applies both for the arrangement according to Figs. 3–5, and Fig. 6, this equation being

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f_p}$$

With further reference to the device according to Figs. 3, 4 and 5, I have ascertained that effective cloud projection can be obtained not only with the message stencil 12 disposed between the conjugate focus C. F. and the condenser 11, as shown in Fig. 3, but also when the message stencil is disposed forwardly of the conjugate focus as shown at Fig. 4, and at the C. F. as shown in Fig. 5.

The following are specific examples showing these relationships between the main components for the arrangements of Figs. 3–6 inclusive—where c is 24″ or less and s is 48″ or less:

For Fig. 3, where the projection lens diameter (d_p) is 24″ and the focal length f_p of the projection lens is 72″, f_c equals 24″, s equals 2½″, c equals 24″, q equals 5,000′ and d_c equals 24″.

For Fig. 4, where the projection lens diameter (d_p) is 24″ and the focal length f_p of the projection lens is 72″, f_c equals 24″, s equals 48″, c equals 24″, q equals 5,000′ and d_c equals 24″.

For Fig. 5, where the projection lens diameter (d_p) is 24″ and the focal length f_p of the projection lens is 72″, f_c equals 24″, s equals 24″, c equals 24″, q equals 5,000′ and d_c equals 24″.

For Fig. 6, where the diameter (d_p) of concave mirror 14 is 60″, f_c equals 2¼″, s equals 2″, c equals 2″, q equals 1000 to 18000′ and d_c equals 3″.

In each of the four examples hereinabove given, the relationship limitations between the main components of the system as defined by the formulae hereinabove given are maintained. In practice they have enabled the projection of images over distances and with a degree of clarity never heretofore obtained with conventional devices.

In the above description, the invention has been disclosed merely by way of example and in preferred manner; but obviously many variations and modifications may be made therein. It is to be understood, therefore, that the invention is not limited to any specific form or manner of practicing same, except insofar as such limitations are specified in the appended claims.

We claim:

1. In an optical system for the long range projection of images, a high intensity light source, a Fresnel type condenser lens having a low focal length to diameter ratio which is postioned adjacent said light source and which transmits a beam of light from said source to a conjugate focus, a message-bearing stencil disposed forwardly of said Fresnel type lens at a distance no greater than twice said conjugate focus, a projection lens element disposed forwardly of said message-bearing stencil at a distance greater than three times the distance of said conjugate focus, a support for said Fresnel type lens, message-bearing stencil and projection lens element which holds said Fresnel type lens axially in a plane substantially parallel to the plane of the message-bearing stencil, said Fresnel type lens being operatively positioned closer to said message-bearing stencil than to said light source and thereby uniformly illuminating said message-bearing stencil at a location of lower heat intensity in the light beam from said source than exists at locations rearwardly of said Fresnel type condenser lens.

2. An optical system as recited in claim 1 in which said high intensity light source is positioned rearwardly of said Fresnel type lens, said light source being at a distance from the said Fresnel type lens equal to the conjugate focal length thereof and a concave reflector is positioned to the rear of said light source to direct a beam of light from said light source through said Fresnel type lens.

3. An optical system as recited in claim 1 in which said projection lens element includes a reflecting mirror.

4. An optical system as recited in claim 1 in which said message-bearing stencil is positioned between said Fresnel type lens and said conjugate focus.

5. In an optical system for the long range projection of images, a high intensity light source, a Fresnel type condenser lens having a low focal length to diameter ratio which is positioned adjacent said light source and which transmits a beam of light from said source to a conjugate focus, a message-bearing stencil disposed forwardly of said Fresnel type lens at a distance not greater than twice said conjugate focus, a projection lens element disposed forwardly of said message-bearing stencil at a distance greater than three times the distance of said conjugate focus, a support for said Fresnel type lens, message-bearing stencil and projection lens element which holds said Fresnel type lens axially in a plane substantially parallel to the plane of the message bearing stencil, said message-bearing stencil being positioned between said conjugate focus and said projection lens element, whereby said message-bearing stencil is illuminated at a location of lower heat intensity in the light beam from said source than exists at locations rearwardly of said Fresnel type condenser lens.

6. In an optical system for the long range projection of images, a high intensity light source, a Fresnel type condenser lens having a low focal length to diameter ratio which is positioned adjacent said light source and which transmits a beam of light from said source to a conjugate focus, a message-bearing stencil disposed forwardly of said Fresnel type lens at a distance no greater than twice said conjugate focus, a projection lens element disposed forwardly of said message-bearing stencil at a distance greater than three times the distance of said conjugate focus, a support for said Fresnel type lens, message-bearing stencil and projection lens element which holds said Fresnel type lens axially in a plane substantially parallel to the plane of the message-bearing stencil, said message-bearing stencil being positioned at said conjugate focus, whereby said message-bearing stencil is illuminated at a location of lower heat intensity in the light beam from said source than exists at locations rearwardly of said Fresnel type condenser lens.

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