PATENT SPECIFICATION

Application Date: April 12, 1932. No. 10,489/32.

" " April 5, 1933. No. 10,170/33.

One Complete Left: April 8, 1933.

Complete Accepted: Jan. 12, 1934.

404,307

PROVISIONAL SPECIFICATION.

No. 10,489, A.D. 1932.

Improvements in Optical Systems for Photography or Kinematography particularly in Colour.

We, ALBERT GEORGE HILLMAN, British Subject, and COLOURGRAVURE LIMITED, a British Company, both of Victoria House, Vernon Place, Southampton Row, London, W.C. 1, do hereby declare the nature of this invention to be as follows:—

The present invention relates to improvements in optical systems for photography or kinematography particularly in colour, of the kind in which branch beams are separated from the entering beam of light by reflectors arranged in intersecting planes, the direct beam passing unobstructed to the focal plane, while the branch beams are reflected by optical flats, which may be of polished steel, to their respective focal planes.

The present invention is particularly applicable for use as a behind lens optical combination in connection with three colour photography.

An aim of the invention is to provide a system designed to work well over a wide range of stops, for example between f/2.5 to f/11 inclusive.

A further aim of the invention is to facilitate the correct apportionment of the divided light beam to the respective focal planes and to obtain even illumination of the images and especially the direct image by facilitating the passage through the system of the more inclined rays, particularly at small aperture.

To this end the present invention broadly comprises a pair of intersecting reflectors which so divide the main beam as to form two reflected images and a direct image, one or both of the reflectors being provided, for the production of the direct image, with multiple perforations whose walls are so inclined with respect to the faces of the reflectors as to present surfaces which converge toward the optical axis on the lens side of the system, and offer the minimum obstruction to the passage through the perforations of the inclined rays.

The perforations may expand rearwardly from the reflecting front surface, and usually only those perforations which lie within the angle of vision at the smaller apertures for which the system is designed, e.g., between f/8 and f/11, have the so converging wall surfaces.

The size and shape of the reflecting surfaces will depend on the plates used, but for rectangular plates a pair of rectangular reflectors may be used in substantially the formation of a blunt wedge directed towards the objective with the edges of the wedge lying substantially perpendicular to and intersecting or lying near to the optical axis. In this arrangement it is convenient for the longer dimension of the reflector to be parallel, or substantially so, with the longer dimension of the plate, the longer dimension of the reflectors thereby taking the larger angle of vision. The system is mounted close to the lens with the meeting edges of the reflectors passing through or lying near the point where the outside rays defining the larger angle of vision of the lens at full aperture intersect on the optical axis behind the lens.

By varying the diameter of the multiple perforations and thereby simultaneously varying the area of reflecting surface a true apportionment of the light for the respective images is facilitated.

A suitable general arrangement of the holes is one in which they progressively increase in diameter in proportion as the distance between the hole and the lens increases. Thus the rows of holes nearest the edge of the wedge will be of the smallest diameter, the successive rows then increasing in each reflector to the back edges thereof.

When the lens is stopped down and the emergent beams for any particular point of view are consequently in the form of fine cones of light, such variably perforated reflectors have the advantage that as the cross sectional area of these cones decreases from the meeting edges of the reflectors to the rear edges thereof the area of the perforations correspondingly increase, thus compensating the reflector factors for the increasing intensity of the converging beams and providing for a larger reflecting surface per total unit area in the region of the reflectors close to the lens from which a greater area of plate has to be covered than from the regions of the reflectors more remote from the lens.

Where the reflectors are of substantially the same shape and size the holes in one may be of relatively greater diameter than corresponding holes in the other so as to conduce to the balance of light necessary as between the two reflected images.

A convenient method of obtaining a satisfactory distribution of the light is to provide multiple evenly spaced like holes in the reflectors and then to enlarge the holes as required so as to compensate for variations of the filter factors and reflection losses.

A suitable lay-out of the holes to ensure an initial even spacing thereof looking perpendicularly on to the surface of the reflector is one in which the holes are so disposed that around any one hole other than the marginal holes a circle may be described which cuts through the equidistant centres of six other holes.

It is convenient to take the smallest stop as a basis for setting out the multiple perforations. Thus with a smallest stop of ½″ diameter, this may be made the diameter of the circles above referred to.

In commencing to mark out the position of the holes a centre line is taken across each reflector surface perpendicular to the meeting edges of the two reflectors and the first hole comes with its centre of this line at a position near to the said meeting edges dependent on the focal length of the lens used. The first ½″ diameter circle is described from this centre and lines are taken, one on each side of the centre line at angle of 30° thereto, which intersect the centre line at the centre of the first hole. The points where these lines intersect the first circle struck provide the centres of further perforations and with these points as centres further circles are described and lines taken parallel to the first two oblique lines to provide the centres of the whole series of perforations.

In forming the perforations in stainless steel reflectors, which are for preference used in the system, it is not convenient so to form the inclined wall surfaces that they meet at a point when produced, but a practicable method of perforating the reflectors which gives an approximation to such an arrangement is as follows:—

The reflector combination is set with the meeting edges lying in a horizontal plane and the reflector surfaces lying at 45° thereto. The holes along the centre lines and those marginal holes which lie outside the angle of vision of the smaller stops, e.g., between $f/11$ and $f/8$, are then formed with the drilling tool horizontal and perpendicular to the vertical plane containing the meeting edges. The combination is then turned through 30° about a vertical axis, first on one side of the original position then on the other, and the holes lying within the aforesaid angle are formed with the tool in the same position as before.

The holes are relieved from the back of the system for example through a total angle of 13°.

The meeting edges of the reflectors may be provided with tongues or extensions. These tongues may be shaped and spaced to provide a series of rectangular spaces or notches which lie in place of what would be the place of a line of perforations if the system were constructed without tongues and with two straight meeting edges. This construction permits the system to be positioned closer to the lens.

The system may be pivotally mounted on a support with the lens as a complete unit with means for adjusting the reflectors relatively to one another and as a unit in multiple directions, including provision for off-setting the system with respect to the optical axis to assist in controlling the balance of light to the respective plates.

The walls of the holes may be blacked or otherwise made non-reflecting.

Dated this 11th day of April, 1932.

HYDE & HEIDE,

2, Broad Street Buildings,

Liverpool Street, London, E.C. 2,

Patent Agents for the Applicants.

PROVISIONAL SPECIFICATION.

No. 10,170, A.D. 1933.

Improvements in Optical Systems for Photography or Kinematography particularly in Colour.

We, ALBERT GEORGE HILLMAN, British Subject, and COLOURGRAVURE LIMITED, a British Company, both of Victoria House, Vernon Place, Southampton Row, London, W.C. 1, do hereby declare the nature of this invention to be as follows:—

The present invention relates to improvements in optical light dividing devices for photography or kinematography particularly in colour.

The present invention comprises certain developments of the invention described in our application No. 10,489 filed 12th April, 1932, in which we have referred more specifically to an arrangement of reflectors in intersecting planes.

According to one aspect of the present invention this consists in the application of certain of the features the subject of our prior application to other types of perforated reflector light dividing systems; whether used before or behind an objective, or with one or more objectives, in connexion with two or three colour photography or kinematography.

Thus a single perforated polished metallic reflector may be used permitting part of the light of the entering beam to pass therethrough to the focal plane and form one image and reflecting part of the light to form another image, the reflected image conveniently being brought to the same focal plane as the direct image by the use of a suitably placed additional reflector, the latter system being especially suitable for cinematography.

In using a light dividing system in connexion with the taking of images for colour work, it is essential for good results that the images simultaneously taken shall be free from "ghost" effects and that the sensitive plates or picture areas shall be substantially uniformly illuminated over the entire effective surface so that a correct blending of the colours shall be realised when the images are superimposed.

The use of polished steel reflectors enable images to be produced free from such ghost effects as are inherently a fault in light-dividing systems involving glass components, but such metallic reflectors must be of a substantial thickness so as to be free from distortion and maintain the high standard of optical accuracy so essential in high class colour work. When such thick metallic reflectors are perforated with tunnel-like holes to permit the passage of direct light to form one of the images, the other or others being formed by reflected light, the perforations, necessarily having walls of substantial dimensions, ordinarily militate against the free passage of the direct light and particularly of the inclined rays entering the system, besides producing flare effects due to the tendency to set up multiple spaced more intensely illuminated areas spotted over the picture area. Moreover if the whole of the perforations were formed with their walls parallel to the optical axis, it would be impracticable to use the system over a desired wide range of stops or apertures, since as the lens aperture becomes smaller the rays are prevented by the walls of the perforations from reaching the marginal portions of the sensitive plate or picture area, and an unevenly illuminated direct image results.

It is an object of the present invention as it is of our aforesaid prior application to overcome the foregoing objections, and to provide a light dividing system which will work well over a range of stops, which will tend towards obtaining an even illumination of the picture areas or plates with any stop within the range for which the system is designed, and which will notably minimise the objectionable effects of parallax.

An object is to facilitate the passage through the system of the more inclined rays, and also to facilitate the design of the reflector or reflectors to attain an even illumination and correct apportionment of light to the sensitive plates or picture areas. It may be here pointed out that the design of the perforated reflector or reflectors must be effected with great precision to realise the proper apportionment of the light, since it is to be remembered that the light is not divided equally. For example in three colour work, the image behind the green filter receives a greater portion of the available light than the image behind either the blue or red filter, while the image behind the red filter must receive more light than that behind the blue. Such an apportionment is on the basis of full day-light or white arc-light, and in such light the ratio of the light division may be taken approximately as follows: 7 units, red; 3 units, blue; 10 units, green. Where half watt lamps are used there will be a preponderance of red actinic rays and it will be generally found satisfactory to reverse the red and blue filters. In two colour work it is also important to obtain the desired correct apportionment of the light.

The invention notably lends itself to this desired distribution.

To the foregoing ends the invention broadly comprises, for taking simultaneously two or more images, a non-refracting optical light dividing reflector device, incorporating one or more reflectors, perforated with multiple holes which diminish locally or generally through the reflector thickness towards the reflecting face.

The attainment of the results aimed at by the present invention is enhanced by inclining the axes, and where necessary differently inclining local portions of the walls, of some or all of the multiple perforations with respect to the optical axis in such a way that inclined rays are free to reach the margins of the picture area despite stopping down of the objective.

The manner of forming such holes will depend on the particular use of the reflector device, whether for photography or kinematography, and on the focus of the objective or objectives employed.

In general for a given class of work the inclination of the axes or general direction of the holes with respect to the optical axis will increase inversely with the focus of the objective. The design of the holes will also depend on the dimensions of the picture area in relation to the reflector device.

In our prior application we have described a vee formation of reflectors in which only a group of holes suitably spaced around the optical axis medially of the system have their axes so inclined, the marginal holes and a central row having their axes substantially parallel to the optical axis and the other holes having their axes intersecting in front of the system a plane which contains the optical axis and bisects the reflector faces, the inclined axes of the holes on either side of such plane being substantially in parallelism.

In a form of reflector device according to the present invention the multiple holes have their axes inclined with respect to the optical axis in the direction of a marginal portion or portions of the direct light receiving picture frame or area and are locally relieved through the reflector thickness without disturbing the reflecting face to permit the passage of light to other marginal portions of the picture frame or area. A single reflector so perforated can be employed in conjunction with a further reflector for producing a direct and a reflected image at the same focal plane. Such a system is well suited for use in two colour cinematography, taking simultaneously two images on a standard size film, in conjunction with lenses of the usual very short focus, two lenses being used arranged behind the system.

Such a single reflector is conveniently formed with three substantially horizontal rows of holes progressively increasing in size and so variably spaced as by computation to obtain even illumination of the reflected image.

Conveniently all the holes are drilled so that their axes are inclined to the optical axis when the reflector is related to its objective. The holes may be drilled, with the tool horizontal, by tilting the reflector through the desired angle.

Such an inclined aspect of the holes with respect to the optical axis will favour the marginal portions of one half of the picture area, and in order to realise an effective and even illumination of the marginal portions of the other half of such picture area, the holes are locally expanded rearwardly such as by a conical tool, without disturbing the reflecting area of the front reflecting face, to produce part conical channels or indentations in the walls of the holes, such channels being variously inclined to control the light to the margins. Thus the inclination of the axes may be such as to favour the top half of the picture area and the holes at one side of the reflector, looking at the front of the system, may have their channels directed towards the marginal portions at and near one bottom and opposite corner of the picture area and the holes at the other side may have their channels directed towards the marginal portions at or near the other bottom corner, while a medial row of holes may each have two channels directing respectively towards or near each bottom corner. By varying the size and inclination of such channels a close control of the distribution of the light is possible without affecting the even illumination predetermined for the reflected image.

The central hole of such a series is itself capable of permitting light to pass to all parts of the picture area. Only a slight channelling of the medial hole in the bottom row is ordinarily necessary.

The lens can be stopped down without causing a lack of effective illumination of the margins of the picture area and the light is caused to reach such margins at the expense of the light which normally tends to concentrate at the medial part of the picture area.

The walls of the holes may be blackened or are otherwise made non-reflecting.

Light dividing reflector devices according to this and our prior application have the advantages that the lens can be stopped down without cutting off light to the margins, that the centre of the picture area is not too strongly illuminated, that the tendency to produce more intensely illuminated local areas spotted over the picture area is countered, and that the apportioning of the light to produce even illumination of the respective picture areas is greatly facilitated.

Dated this 5th day of April, 1933.
HYDE & HEIDE,
2, Broad Street Buildings,
Liverpool Street, London, E.C. 2,
Patent Agents for the Applicants.

COMPLETE SPECIFICATION.

Improvements in Optical Systems for Photography or Kinematography particularly in Colour.

We, ALBERT GEORGE HILLMAN, British Subject, and COLOURGRAVURE LIMITED, a British Company, both of Victoria House, Vernon Place Southampton Row, London, W.C. 1, 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:—

The present invention relates to improvements in optical light dividing devices for photography or kinematography, and is particularly applicable to light dividing devices, used before or behind an objective for two or three colour photography or kinematography, employing a perforated non-refracting reflector or reflectors to divide a main beam into component beams so as to produce images simultaneously from the same point (aspect) of view.

In such devices branch beams may be separated from the entering beam of light by reflectors arranged in intersecting planes, a direct beam passing unobstructed to the focal plane, while the branch beams are reflected by polished metallic optical flats, preferably of optical steel, to their respective focal planes, thus producing three images simultaneously from the same point of view, or a single perforated polished metallic reflector may be used permitting part of the light of the entering beam to pass therethrough to the focal plane and form one image and reflecting part of the light to form another image, the reflected image conveniently being brought to the same focal plane as the direct image by the use of a suitably placed additional reflector.

In using a light dividing system in connexion with the taking of images for colour work, it is essential for good results that the images simultaneously taken shall be free from "ghost" effects and that the sensitive plates or picture areas shall be substantially uniformly illuminated over the entire effective surface so that a correct blending of the colours shall be realised when the images are superimposed.

The use of polished steel reflectors enables images to be produced free from such ghost effects as are inherently a fault in light-dividing systems involving glass components, but such metallic reflectors must be of a substantial thickness so as to be free from distortion and maintain the high standard of optical accuracy so essential in high class colour work. When such thick metallic reflectors are perforated with tunnel-like holes to permit the passage of direct light to form one of the multiple images, the others being formed by reflected light, the perforations, necessarily having walls of substantial dimensions, ordinarily militate against the free passage of the direct light and particularly of the inclined rays entering the system besides producing flare effects due to the tendency to set up multiple spaced more intensely illuminated areas spotted over the picture area. Moreover if the whole of the perforations were formed with their walls parallel to the optical axis, it would be impracticable to use the system over a desired wide range of stops or apertures, since as the lens aperture becomes smaller the rays are prevented by the walls of the perforations from reaching the marginal portions of the sensitive plate, and an unevenly illuminated direct plate results.

It is an object of the present invention to overcome the foregoing objections and to provide a light dividing system which will work well over a range of stops, for example, in the case of the Vee reflector formation for still photography of the order between $f/2.5$ and $f/11$ inclusive, will tend towards obtaining an even illumination of the picture areas or plates with any stop within the range for which the system is designed, will obviate or minimise lens flare and will notably minimise the objectionable effects of parallax.

The invention aims to facilitate the passage through the system of the more inclined rays, particularly with small stops, and also to facilitate the design of the reflector or reflectors to attain an even illumination and correct apportionment of light to the sensitive plates or picture areas. It may be here pointed out that the design of the perforated reflectors must be effected with precision to realise the proper apportionment of the light, since it is to be remembered that the light is not divided equally. For example in three colour work, the image behind the green filter receives a greater portion of the available light than the image behind either the blue or red filter, while the image behind the red filter must receive more light than that behind the blue. Such an apportionment is on the basis of full day-light or white arc-light, and in such light the ratio of the light division may be taken approximately as follows: 7 units, red; 3 units, blue; 10 units, green. Where half watt lamps are used there will be a preponderance of red actinic rays and it will be generally found satisfactory to reverse the red and blue filters. In two colour work it is also important to obtain the desired correct apportionment of the light.

In the case of a behind-lens perforated light dividing system with the reflectors disposed obliquely to the optical axis of the lens, the conical beam of light emerging from the lens of any point in the scene or object is divided by the system into pencils of light converging to the focal plane. If the apertures in the reflectors are formed with their walls parallel to the optical axis, the more inclined pencils, viz., those inclining towards the margins of the picture area or plate, are obstructed by the walls and consequently the medial area of the direct-image receiving surface, already illuminated more than the margins by lens flare, receives considerably more light than the margins of the plate.

It has been proposed to taper the walls of the holes towards the reflecting plane, and obstruction of the more inclined pencils is thereby avoided or minimised and as much light, both of the more inclined and less inclined pencils, is allowed to pass as possible. The result is that there is still a balance of light to the medial area of the direct image.

With a before lens system having the reflector or reflectors obliquely disposed to the optical axis of the objective and the holes formed as above stated, the parallel rays or less inclined pencils of light produced by the reflector device pass more readily than the more inclined pencils and it is not possible to attain even illumination of the direct image.

The present invention is broadly characterised by providing the non-refracting light dividing reflector device with an arrangement of tapered apertures whose non-reflecting walls have portions so inclined to the optical axis towards the margins of the direct image-receiving surface as to facilitate the passage of the light pencils passing to the marginal parts of the direct-image receiving surface and have portions which intrude in the path of and partially obstruct the passage of light pencils to the medial part of such surface.

By this means it is possible, using one or more reflectors computed to provide an even illumination of the reflected image or images, to obtain a uniformly illuminated direct image, the evenly illuminated images and the degree of sharpness permitted by the non-refracting reflectors, resulting in an excellent colour blending and reproduction of the scene or object when the multiple images are superposed.

One important aspect of the present invention consists in a behind lens light-dividing system comprising a Vee formation of non-refracting mirrors having a multiplicity of apertures whereby to form two reflected images and a direct image, the mirrors each having multiple apertures whose walls expand from the reflecting plane and are so differently inclined as to facilitate the passage of the light pencils to the marginal parts of the direct-image receiving surface whilst partially obstructing the passage of the light pencils to the medial part of such surface, the apertures in one mirror leaving a greater reflecting area than those in the other and so varying in size in each mirror as to provide for a progressive decrease in the respective reflecting areas as the distance therefrom to the objective increases the tapering of the walls of the holes being varied in one mirror with respect to the other to compensate the direct image for the difference between the total aperture area in the reflecting plane of one mirror with respect to that in the other for the purposes described.

The attainment of the results aimed at by the present invention is realised by inclining the axes, and where necessary differently inclining local portions of the walls of some or all of the multiple perforations with respect to the optical axis in such a way that inclined rays are free to reach the margins of the picture area despite stopping down of the objective.

The manner of forming such holes will depend on the particular use of the reflector device, whether for photography or kinematography, and on the focus of the objective or objectives employed.

In general for a given class of work the inclination of the axes or general direction of the holes with respect to the optical axis will increase inversely with the focal length of the objective. The design of the holes will also depend on the dimensions of the picture area in relation to the reflector device.

For instance in the case of the vee-mirror formation hereinafter described for three colour photography a group of holes suitably spaced around the optical axis and occupying oblique areas extending to the corners of the system will have their axes inclined towards the corresponding corner of the plate, and it is found that good results are obtained when the holes in either one reflector assume one or other of three directions, the marginal holes and a central row having their axes substantially parallel to a plane which contains the optical axis and bisects the reflector faces and the other holes having their axes intersecting that plane in front of the system, the axes of the holes inclining to the corners of the system on a given side of such plane being substantially in parallelism in any one reflector.

In the hereinafter described system for use in two colour cinematography, in conjunction with which lenses of the usual very short focus will be used, it is found suitable to arrange the whole series of holes with their axes inclined with respect to the optical axis in one direction, local portions of the walls of such holes being appropriately cut away to permit inclined rays to pass to those marginal portions of the plate other than the marginal portions favoured by the general inclination of the holes.

Such a system can be so disposed as to facilitate the passage of ground light by sloping the axes towards the ground, the lower portion of the walls of the holes intruding into the path of the less inclined pencils of light or those parallel to the optical axis and having local enlargements formed in such portions which allow a predetermined amount of bright sky light to reach the picture area. The holes may increase in size as the distance therefrom to the objective increases so as to tend to equalise the unbalancing effect of the different location of the holes from the objective by the angular setting of the reflector with respect to the objective.

In order that the invention may be the more readily understood reference is hereinafter made to the accompanying drawings, in which Fig. 1 to 11 show one form of the invention suitable for three-colour photography, and Figs. 12 to 17 another form of the invention suitable for two colour cinematography.

Fig. 1 is a front elevation with the objective removed, Fig. 2 a side elevation and Fig. 3 a plan of the system mounted on the panel of the objective.

Fig. 4 is a view looking towards the rear of the objective.

Fig. 5 is a detail view of a mounting member for the light divider.

Figs. 6 and 7 show face views of the two reflectors.

Figs. 8 and 9 are face views showing the disposition of the variously drilled groups of holes of one reflector.

Fig. 10 is a part sectional view of the intersecting mirrors, and Fig. 11 an enlarged sectional view of one of the reflectors.

Fig. 12 is a side view and Fig. 13 a front view of a reflector for use in two colour cinematography, the reflector and the optical axis being tilted to show the reflector in a position for drilling the holes.

Figs. 14 and 15 are side and rear views of the same reflector in its normal position.

Fig. 15*a* is a view on an enlarged scale of a picture area or frame of a cinematograph film hereinafter referred to.

Fig. 16 is a part sectional view through one of the holes.

Fig. 17 shows an optical system incorporating a reflector according to Figs. 12 to 16.

Referring to Figs. 1 to 11, the light dividing system here comprises a pair of reflectors 1, 2 in substantially vee or wedge formation, the reflectors having multiple perforations 3. The reflectors are shown positioned behind an objective

4 so as to divide the beam of light coming from the objective, some part of such beam being reflected by the reflector 1 to form one image, another part by the reflector 1 to form one image, another reflector 2 to form a second image, and the remainder passing through the perforations for the production of the direct image.

The reflectors in the example illustrated are of approximately .16″ in thickness.

The multiple perforations 3 are tapered or expanded rearwardly from the polished reflecting front surfaces 5, 6, the medial row of holes 7, 8 of the reflectors and the marginal group of holes 9, 10 (see particularly Fig. 8) being formed with their axes substantially parallel with the horizontal plane containing the optical axis Y—Z, whilst the triangular series of holes 11, 12 are formed with their axes inclined to that plane, the axes of those of the triangular series of holes 11, 12 in a given reflector above the transverse centre line C—D of the reflectors inclining downwardly substantially in parallelism and the axes of the triangular series of holes 11, 12 in a given reflector below such centre line inclining upwardly substantially in parallelism towards the front of the system. Thus if a plane be taken which contains the optical axis Y—Z and the transverse centre line of each mirror, then the axes of all the holes 11 and 12 will intersect such plane in front of the reflectors.

The portions of the walls of the holes 11, 12 nearer to the optical axis are disposed so as to intercept some part of the less inclined pencils of light produced by the system and the disposition of such walls and the amount of light they obstruct can be readily so varied as required to cause a substantially even distribution of the light to the picture area of the direct image.

Usually only those perforations which lie within the angle of vision at the small apertures for which the system is designed, e.g., between $f/8$ and $f/11$, have their axes so inclined, the marginal perforations 9, 10 which have their axes substantially parallel to the aforesaid plane being shut off at such small apertures, except that certain of the apertures at and near the corners of the system have axes inclined to the said plane.

The size and shape of the reflecting surfaces will depend on the sensitive plates used, but for rectangular plates the reflectors 1, 2 are of rectangular form arranged in the formation of a blunt wedge directed towards the objective with the edge of the wedge lying substantially perpendicular to and intersecting or lying near to the optical axis. In this arrangement it is convenient for the longer dimension of the reflector to be vertical and parallel, or substantially so, with the longer dimension of the plate, the longer dimension of the reflectors thereby taking the larger angle of vision. The system 1, 2 is mounted close to the objective 4 with the meeting edges of the reflectors passing through or lying near the point where the outside rays C^1, D^1 defining the larger angle of vision of the lens at full aperture intersect on the optical axis behind the lens. If the system is arranged substantially nearer to the objective 4 than is shown in Fig. 2, inclined rays will be reflected on to the rear face of the objective, whence they will stray on to the plate and produce "ghost" effects; moreover some part of the light from the reflectors would be liable to be obstructed by the lens mount, and the corresponding plates badly illuminated near one edge.

It will be observed that when the aperture of the objective is stopped down, the marginal perforations are excluded from the angle of vision of the objective but the particular formation and disposition of the perforations 11, 12 will permit inclined rays a ready passage through the system to the marginal areas of the directly illuminated sensitive plate.

Apart from this advantage however the particular tapering formation of the perforations has the important additional advantage of facilitating the proportioning of the system to obtain correct division of the light. This will be apparent from the following explanation.

To accommodate for the different filter factors for the two reflected images, the perforations in the reflector 2 e.g., for the green image are somewhat smaller than those in the other reflector, so that a greater reflecting area is provided for the rays which form the green image. But this in itself does not suffice to promote even illumination, for when the lens is stopped down, and the emergent beams for any particular point of view are in the form of fine cones of light, the cross sectional area of these cones decreases from the meeting edges of the reflectors to the rear edges thereof. To allow for this, the perforations are so formed that in each plate they progressively increase in diameter in proportion as the distance between the perforations and the objective increases. Thus the rows of holes nearest the meeting edges will be of the smallest diameter, the successive rows then increasing in each reflector to the back edges thereof.

Thereby compensation is made to the reflector factors for the increasing intensity of the converging beams and a larger reflecting surface per unit area is provided in the region of the reflectors close to the lens from which a greater area of plate has to be covered than from the regions of the reflectors more remote from the lens.

Having obtained an arrangement of holes which will give even illumination of the reflected images, the even illumination of the direct image can be attained by appropriately enlarging or tapering the walls of the perforations without effecting the dimensions of the reflecting areas.

Figs. 6 to 9 show a suitable arrangement of holes, the dimensions of the holes in each row being marked adjacent thereto in Figs. 6 and 7. This arrangement is found to work well using reflectors having a length of 2.25″ and breadth of 1.60″ excluding the prongs and an objective of approximately 6″ focus.

A convenient method of obtaining a satisfactory distribution of the light is first to provide multiple evenly spaced like holes in the reflectors and then to enlarge the holes as required so as to compensate for variations of the filter factors and reflection losses.

A suitable lay-out of the holes to ensure an initial even spacing thereof looking perpendicularly on to the surface of the reflector is one in which the holes are so disposed that around any one hole other than the marginal holes a circle may be described which cuts through the equidistant centres of six other holes, as shown in Fig. 9.

It is convenient to take the smallest stop as a basis for setting out the multiple perforations. Thus with a smallest stop of $\frac{1}{2}$″ diameter, this may be made the diameter of the circles above referred to.

In commencing to mark out the position of the holes a centre line M—N is taken across each reflector surface perpendicular to the meeting edges of the two reflectors and the first hole comes with its centre on this line at a position near to the said meeting edges dependent on the focal length of the lens used. The first $\frac{1}{2}$″ diameter circle is described from this centre and lines are taken, one on each side of the centre line at an angle of 30° thereto, which intersect the centre line at the centre of the first hole. The points where these lines intersect the first circle struck provide the centres of further perforations and with these points as centres further circles are described and lines taken parallel to the first two oblique lines to provide the centres of the whole series of perforations.

In forming the perforations in stainless steel reflectors, which are for preference used in the system, it is not convenient to vary the inclination of the wall, each hole with respect to the wall of each other hole, but a practicable method of perforating the reflectors which satisfactorily transmits the more inclined rays coming from different points around the optical axis is as follows:—

The reflector combination is set with the meeting edges lying in a horizontal plane and the reflector surfaces lying at 45° thereto. The holes 7, 8 along the centre lines and marginal holes 9, 10, which lie outside the angle of vision of the smaller stops, e.g., outside the stops between f/11 and f/8, are then formed with the drilling tool (indicated by the arrow A in Fig. 11) horizontal and perpendicular to the vertical plane containing the meeting edges. The combination is then turned through 30° about an axis C—D (Fig. 1), which lies perpendicular to the meeting edges and in a common plane with the transverse centre lines of the reflectors, first on one side of the original position then on the other, and the holes 11, 12 lying within the aforesaid angle are formed with the tool in the same direction as before. In the above description it is considered for the sake of clarity that the two reflectors are assembled and then perforated.

The holes are relieved from the back towards the margins of the system, for example, through a total angle of approximately 13°, the angle being somewhat greater for the holes in one plate than for those in the other, in order to obtain even illumination of the direct plate despite the fact that the holes in one reflecting face are relatively larger than those in the other.

The meeting edges of the reflectors may be provided with interdigitated tongues or extensions 13 preferably shaped and spaced to provide a series of elongated or rectangular spaces or notches which lie in place of what would be a line of perforations if the system were constructed without tongues and with two straight meeting edges. This construction assists in realising uniform illumination and permits the system to be positioned closer to the lens.

To facilitate drilling the perforations, the reflectors may be suitably stepped to provide a front face perpendicular to the axis of the drilling tool, (see Fig. 11), the steps being subsequently ground off, but the drilling in multiple directions may be effected without such stepping in a suitable jig.

The system may be pivotally mounted on a support with the lens as a complete unit with means for adjusting the reflectors relatively to one another and as a unit in multiple directions, including provision for off-setting the system with respect to the optical axis to assist in controlling the balance of light to the respective plates.

The mirror 1 is rotatably mounted about pivots 14, 15, being rotated and locked in an adjusted position by the screws 16, 17.

The mirror 2 is rotatably mounted about the pivots 18, 19 and controlled and locked by screws 20, 21.

To provide for adjustment of the separation of the pivots 14 and 18 the pivot 18 is mounted on a pivoted arm 22, which, when clamping screws 25 and 26 have been released, can be turned about a pivot 23 and locked by screws 24, 24*a*. A further adjustment of the mirror 2 can be effected by means of an eccentric 27 which is mounted to rotate with the pivot 23, and which, when rotated by the screw 23 after a screw 24 or 24*a* and the clamping screws 25, 26 have been released, acts against a wall of a slot 27*a* in the arm 22 and shifts the arm towards or away from the objective. The clamping screws 25, 26 have sufficient freedom in the holes 28, 29 in the arm to permit this movement.

In order to permit the system to be moved with respect to the optical axis, each reflector can be moved up or down i.e., vertically of Fig. 1, independently of the other by means of adjusting screws 30, 31, the screws 31 in the bottom plate 32 being set in their adjusted position by locking screws 33 which tighten the split clamp portions 35, 37 around the screws 31. The screws 30, 31 form the pivots 14, 15, 18, 19 above described. The system can also be moved bodily in a lateral direction of Fig. 1. For this purpose the bottom plate 32 and the top plate 33 between which the mirrors are held, are provided with shoes 34, sliding in guides 36, the adjustments being effected by screws 38, 39, clamping screws 40, 41 being provided to retain the shoes in the desired adjusted position.

Fig. 17 shows another application of the invention to a system for taking simultaneously two negative images on a standard size cinematograph film.

The system comprises a reflector 42 which is perforated to allow part of the entering beam to pass therethrough and thence through the lens 43 to the focal plane, the other part of the beam being reflected from the reflector 42 on to the reflector 44, and thence through the lens 45 to the focal plane.

Figs. 12 to 16 show a suitable form of reflector 42 made according to this invention.

The reflector is formed with multiple holes 46 the top row (Fig. 13) being of a given diameter and the other rows progressively decreasing in size. The diameter for the three rows in the particular reflector illustrated are indicated in Fig. 13, the length of this reflecting face being $1\frac{1}{4}''$ and the breadth $1\frac{1}{8}''$. the focus of the lenses being 2 inches.

All the holes are drilled so that their axes are inclined to the optical axis when the reflector is related to its objective. The holes may be drilled by tilting the reflector into the position shown in Fig. 12 and drilling with a tool presented horizontally.

Such an inclined aspect of the holes with respect to the optical axis will favour the marginal portions of one half A of the picture area (Fig. 15*a*), e.g., that illuminated by ground light, and in order to realise an effective and even illumination of the marginal portions of the other half B of such picture area e.g., that receiving bright top light, the holes are locally expanded rearwardly such as by a conical tool, without disturbing the reflecting area of the front reflecting face, to produce part conical channels or indentations 47 (*a*, *b*) in the walls of the holes, such channels 47 (*a*, *b*) being variously inclined so as directionally to control the light to the margins.

Thus referring to Figs. 15 and 15*a* the channels 47*a* are suitably inclined to illuminate the marginal portions of the picture area 48 between X, X^2 and Y^2 and the channels 47*b* are suitably inclined to illuminate the marginal portions X, X^1, Y^1 while lower portions of the walls of the holes lie behind the openings in the reflecting plane and partially interrupt the parallel or less inclined rays. Obviously by varing the size and inclination of the holes and the channels a close control on the distribution of the light is possible without affecting the even illumination predetermined for the reflected image.

The central hole of the system is provided with channels 47*a* and 47*b*, as also are the central holes in the top and bottom rows, and such central hole is itself capable of permitting light to pass to all parts of the picture area. Only a very slight channelling of the medial hole in the bottom row is ordinarily necessary.

The lens can be stopped down without causing a lack of effective illumination of the margins of the picture area and the light is caused to reach such margins at the expense of the light which normally tends to concentrate at the medial part of the picture area.

The walls of the holes may be blackened or are otherwise made non-reflecting.

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. An optical light dividing system for taking images by simultaneous exposure from the same point (aspect) of view comprising a non-refracting optical light-dividing reflector device perforated with multiple holes which diminish in size through the reflector thickness towards the reflecting plane or planes, characterised by an arrangement of apertures whose non-reflecting walls have portions so inclined to the optical axis towards the margins of the direct image-receiving surface as to facilitate the passage of the light pencils passing to the marginal parts of the direct-image receiving surface and have portions which intrude in the path of and partially obstruct the passage of light pencils to the medial part of such surface.

2. A behind lens light dividing system for three colour photography or cinematography comprising a Vee formation of non-refracting mirrors having a multiplicity of apertures whereby to form two reflected images and a direct image, the mirrors each having multiple apertures whose walls expand from the reflecting plane and are so differently inclined as to facilitate the passage of the light pencils to the marginal parts of the direct-image receiving surface whilst partially obstructing the passage of the light pencils to the medial part of such surface, the apertures in one mirror leaving a greater reflecting area than those in the other and so varying in size in each mirror as to provide for progressive decrease in the respective reflecting areas as the distance therefrom to the objective increases, the tapering of the walls of the holes being varied in one mirror with respect to the other to compensate the direct image for the difference between the total aperture area in the reflecting plane of one mirror with respect to that in the other for the purposes described.

3. A non-refracting optical light-dividing reflector device as in claim 1 in which the multiple holes have their axes inclined with respect to the optical axis in the direction of a marginal portion or portions of the direct light receiving picture frame or area and are locally relieved through the reflector thickness without disturbing the reflecting face to permit the passage of light to other marginal portions of the picture frame or area for the purposes described.

4. A non-refracting optical light dividing reflector according to claim 1 or 3 used in conjunction with a further reflector for producing a direct and a reflected image at the same focal plane.

5. An optical light-dividing reflector device according to claim 1 or 2, comprising a pair of reflectors disposed in intersecting planes, characterised in that the axes of different perforations intersect in front of the system a plane which contains the optical axis and bisects the reflector faces, the axes of such holes on a given side of such plane being substantially in parallelism in either one reflector.

6. A non-refracting optical light-dividing reflector device as in claim 1 or 3 or 4, in which the openings formed by the holes in the reflector face or faces increase in size as the distance therefrom to the objective increase.

7. A light dividing reflector device as in claim 2 or 5, characterised by the provision of interdigitated prongs at the meeting edges of the reflectors, said prongs leaving elongated openings between them.

8. A light dividing reflector device as in claim 2 or 5 or 7, characterised in that a series of holes are provided whose axes intersect the plane containing the optical axis and bisecting the reflector faces such series occupying obliquely lying areas extending from near the centre towards the corners of the system, and a medial horizontal row and a medial vertical row and marginal series of holes are provided whose axes lie substantially parallel to that plane.

9. A light dividing reflector device as in any preceding claim, in which the reflector or reflectors are adjustable.

10. A light dividing reflector device as in claims 2, and 9, having means for adjusting the reflectors relatively to one another and means for adjusting the system bodily.

11. A light dividing reflector device as in claim 9, or 10, in which the reflector or reflectors are rotatably mounted.

12. A light dividing reflector device substantially as herein described and illustrated in Figs. 1 to 11.

13. A light dividing reflector device substantially as herein described and illustrated in Figs. 12 to 17.

Dated this 8th day of April, 1933.

HYDE & HEIDE,
2, Broad Street Buildings,
Liverpool Street, London, E.C. 2,
Patent Agents for the Applicants.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1934.

Fig. 1.

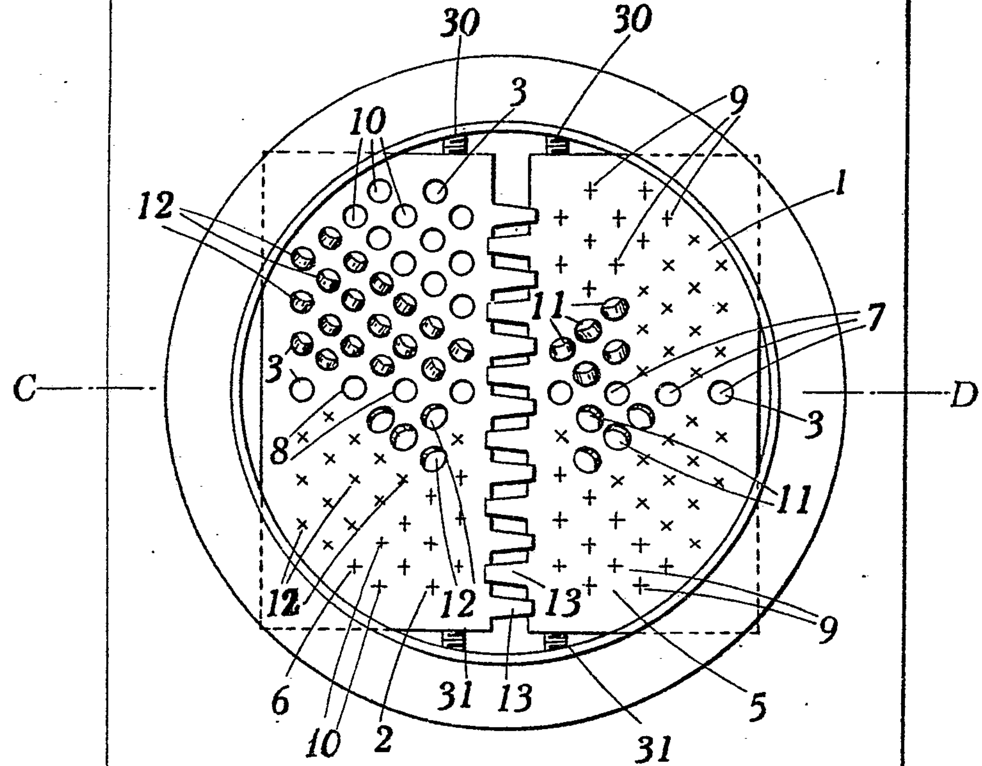
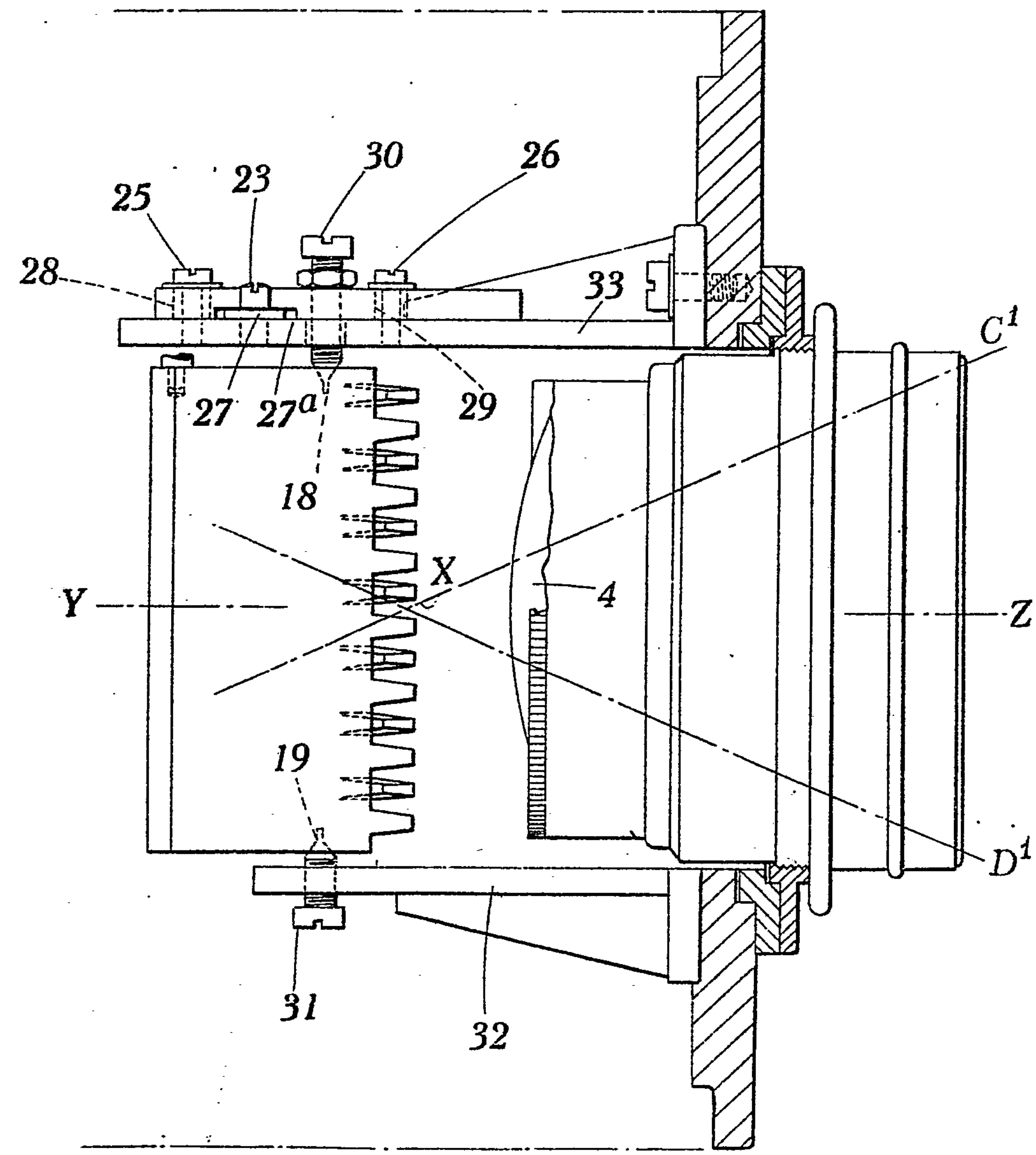


Fig. 2.



Malby & Sons, Photo-Lith.

Fig. 1.

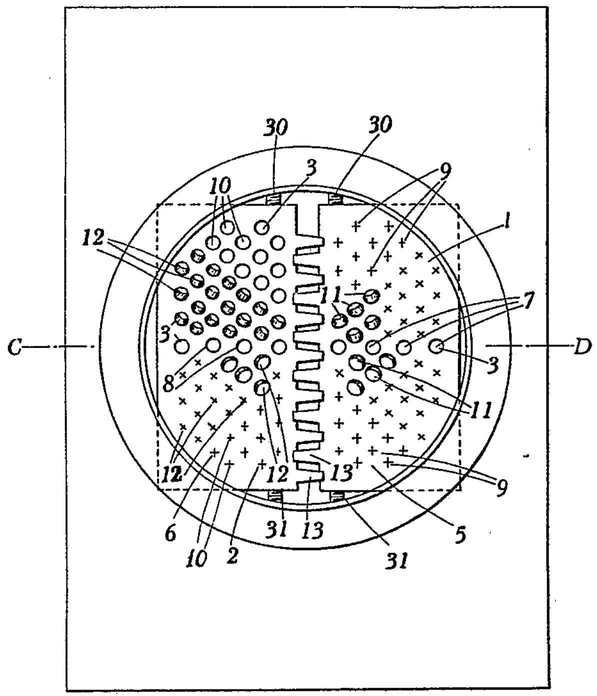
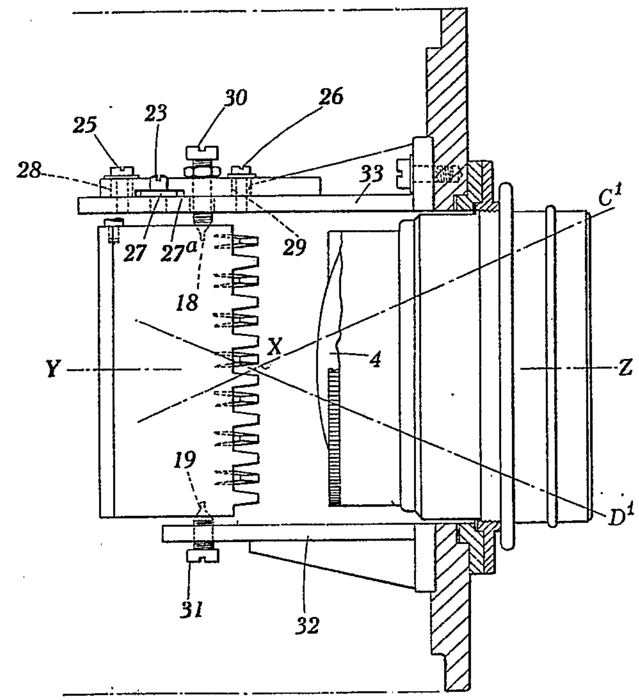


Fig. 2.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 3.

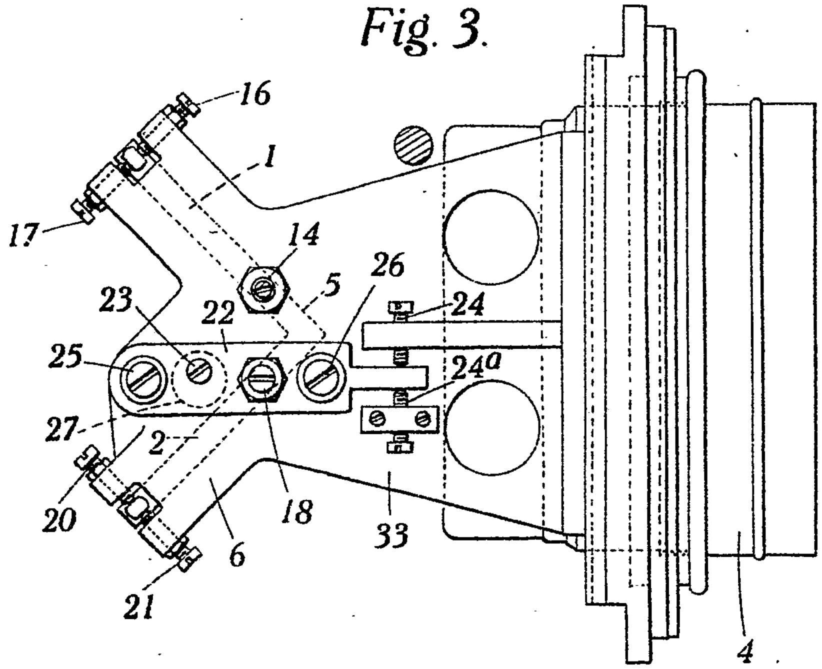


Fig. 5.

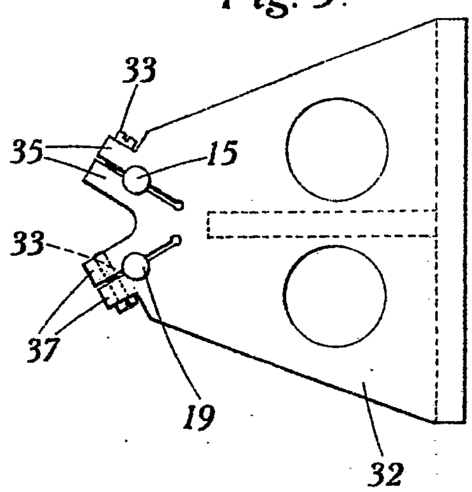
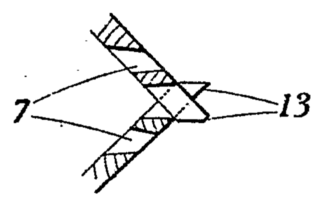


Fig. 10.



Fig

Fig. 4.

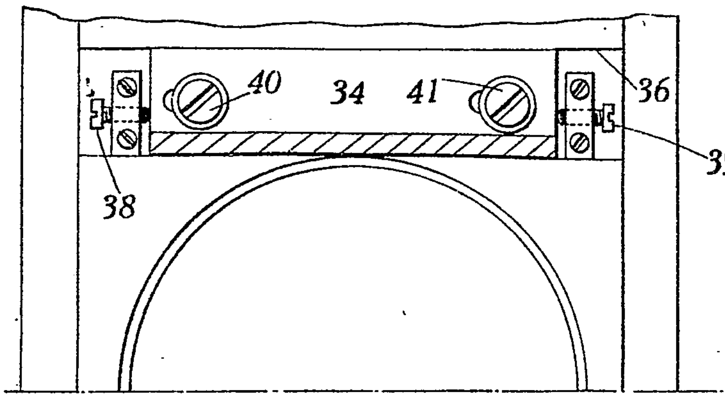


Fig. 6.

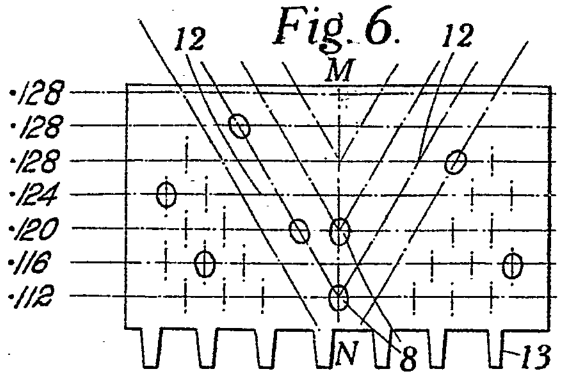


Fig. 8.

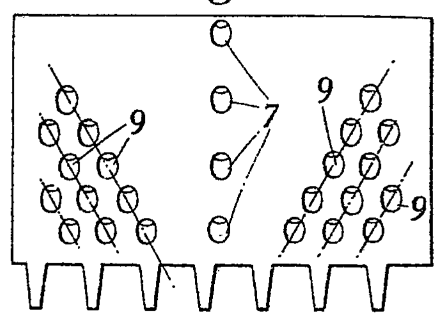


Fig. 7.

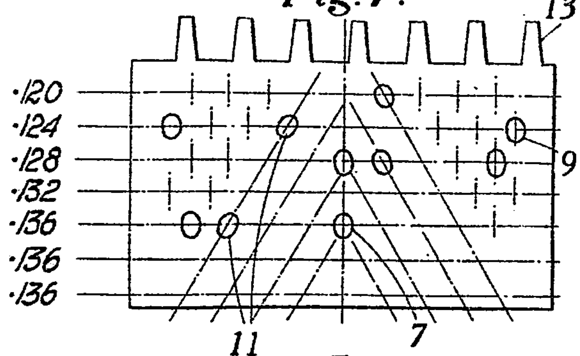
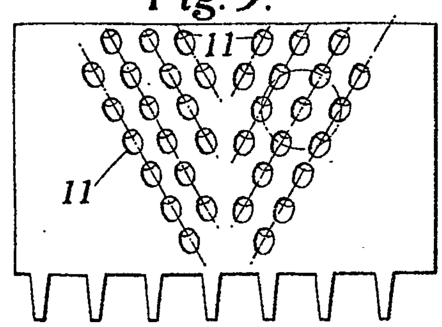


Fig. 9.



=13

Fig. 11.

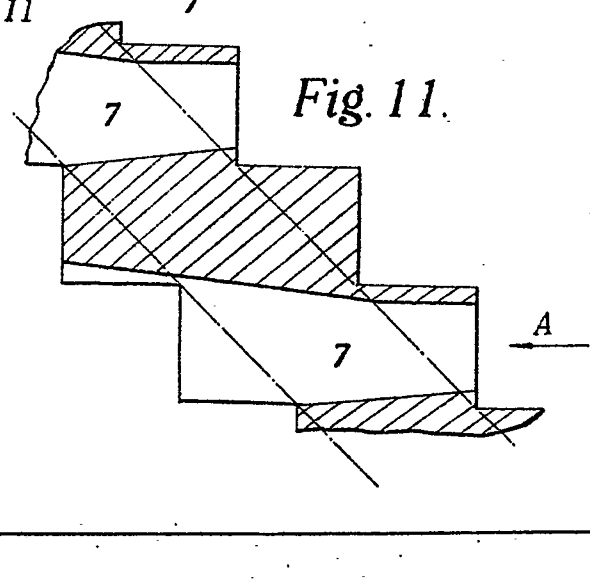


Fig. 3.

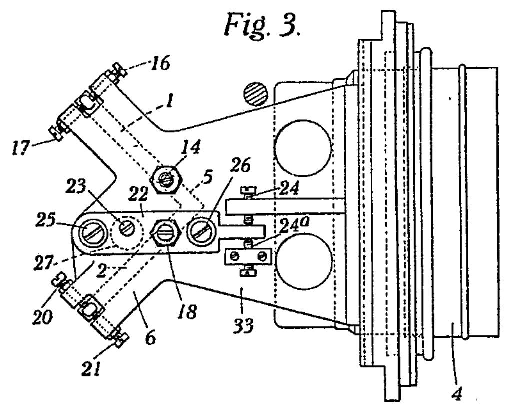


Fig. 5.

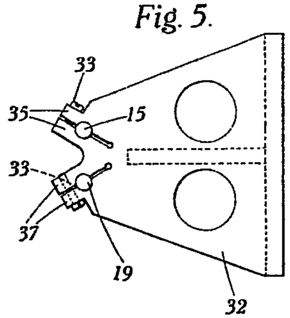


Fig. 10.

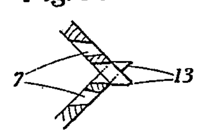


Fig. 4.

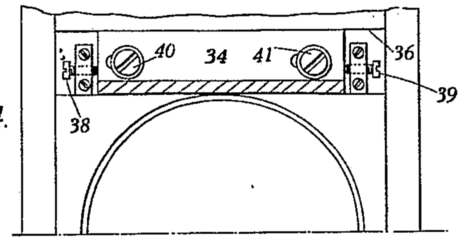


Fig. 6.

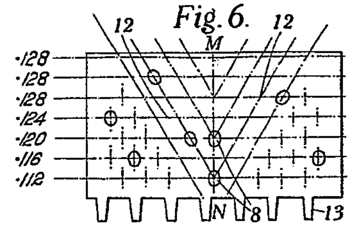


Fig. 8.

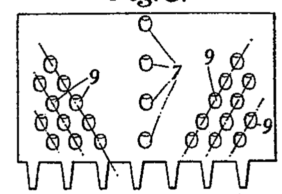


Fig. 7.

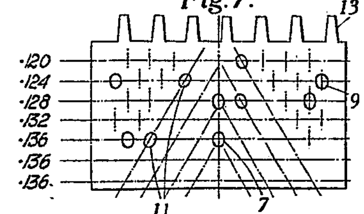


Fig. 9.

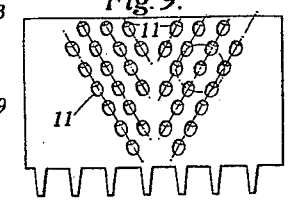
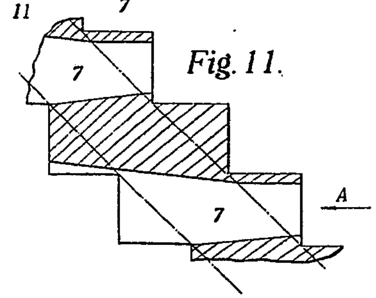


Fig. 11.



[This Drawing is a reproduction of the Original on a reduced scale.]

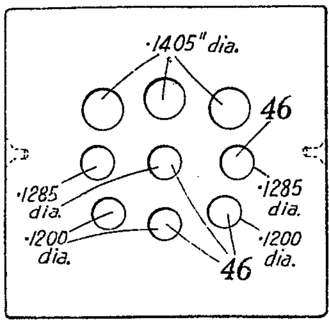


Fig. 13.

Fig. 12.

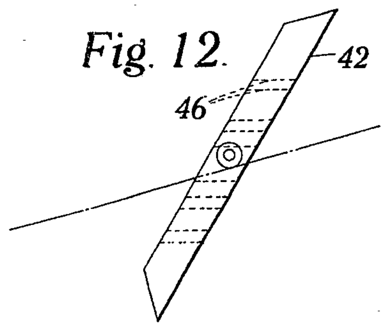


Fig. 14.

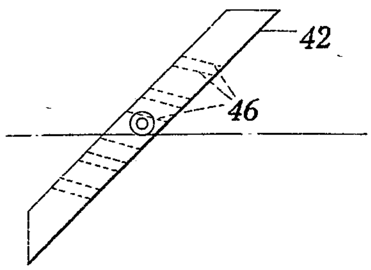


Fig. 15

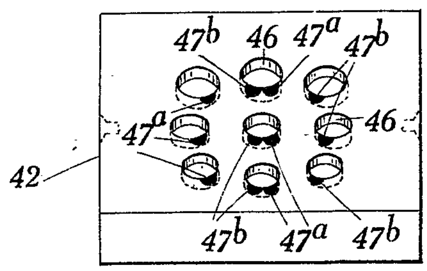


Fig. 15a.

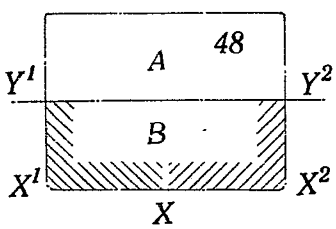


Fig. 16.

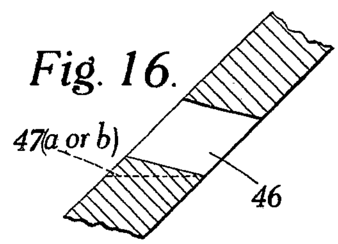


Fig. 17.