N° 13,042 A.D. 1915

Date of Application, 11th Sept., 1915

Complete Specification Left, 13th Mar., 1916—Accepted, 7th Sept., 1916

PROVISIONAL SPECIFICATION.

Compound Cross-reflecting and Transmitting Prism-block, and the Use thereof in Cameras and like Optical Devices.

I, HAROLD WORKMAN, of 12, University Gardens, Kelvinside, Glasgow, North Britain, Engineer, do hereby declare the nature of this invention to be as follows:—

This invention relates to compound optical prisms for dividing a bundle of light into three separate portions in such manner that each of these portions comprises some light from all parts of the bundles; and in particular the present invention relates to three colour photographic and kinematographic cameras of the type in which three separate colour record images are taken at one exposure from one point of view; the incident light rays from the subject being divided into three portions or beams by two angled partially reflecting surfaces placed in the light path, these surfaces directing two portions of the divided light rays directly or indirectly towards two of the focal or sensitive surfaces at or on which the images are to be formed, and the remaining portion or beam passes by direct transmission through the two partial reflecting surfaces towards the focal or sensitive surface on which the third image is to be formed. In certain cases by a second reflection the reflected portions of the divided light form images on the same focal or sensitive surface as that which receives the directly transmitted image.

An object of the present invention is to provide new and improved means and arrangements for so dividing a beam of light into three beams that photographic or kinematographic cameras can be adapted for producing three identical or practically identical images, taken at one exposure from the same point of view, with a lens (or lenses) of large aperture.

With this object in apparatus as indicated above the invention consists in the provision of two flat partially reflecting and partially transmitting surfaces arranged at suitable and convenient angles to the axis of the incident cone of light rays; which surfaces cross one another on a line which passes through or near to and at right angles to the axis of the incident cone of light rays, both partially reflecting surfaces being formed at junction surfaces of a built up glass prism block in which they are contained as defined above, the faces through which the light enters and leaves the built up block being in every case similarly angularly disposed to and preferably normal; or nearly normal to the axis of the cone of light rays entering or leaving the block.

The four internal reflecting surfaces of the built up or compound prism block may be made partially reflecting by the coating or deposition all over of a thin partially reflecting and partially transmitting layer of silver, platinum or other suitable metal or substance, or by the coating or deposition all over of a fully reflecting layer of silver, platinum or other suitable metal or substance, and the subsequent removal of narrow lines or small areas of such coating over the whole reflecting surface, so that the light is reflected from and transmitted through the surfaces in the desired proportions.

The light may be equally distributed among the three sensitive surfaces or

[*Price 6d.*]

may be divided among them in desired unequal proportions to suit the light filters and colour sensitiveness of the plates or films used, by suitably proportioning and adjusting the reflecting and transmitting powers of the four partially reflecting surfaces.

Where the surfaces are made partially reflecting by fully reflecting lines distributed over them the two aspects of the crossing surfaces towards the scene have their lines preferably disposed at right angles to each other and the two back aspects have their lines similarly disposed but towards opposite sides of the prism block, as more particularly defined below.

The compound prism block is preferably a rectangular or nearly rectangular block made up of four equal sided rectangular prisms or Newton's prisms cemented together apex to apex, the contacting or cemented surfaces being made partially reflecting so as to form a square ended block or cube in which one reflection transmission plane extends from one edge of the cube to the diagonally opposite edge and the other reflection transmission plane extends from an edge parallel to the first mentioned edge to a diagonally opposite edge. Thus the two reflection transmission planes intersect so that the aspect of the intersection forms a saltire cross. This cube is preferably placed so that the axis of the cone of light rays entering the block passes normally through it without deflection, the axis of the cones of the two partially reflected light rays being reflected in opposite directions at right angles or nearly so to the axis of the incident cone of light rays and leaving the two side faces of the compound block normally without deflection.

In some cases the line of intersection of the cross reflecting surfaces may with advantage be made nearer to or further from the front or back surfaces of the compound block. Also in some cases it may be desirable that the partially reflecting surfaces should be arranged at other angles than 45° to the axis of the incident beam such angles being equal or otherwise but preferably not far removed from 45° and such a compound block may be used provided the necessary conditions as to the angles of the faces by which the light enters and leaves the block are observed.

The built up or compound prism block so arranged and constructed may either be placed in front of three lenses, behind one lens, between the combinations of a lens system, or one or more of its surfaces may be worked with a spherical curvature so that it may be utilized to form part of the lens system itself.

In the case in which the compound prism block is used in front of three lenses the surfaces by which the light enters and leaves the built up block must be plain flat surfaces but the lengths of the light paths of the three light rays in the built up block need not necessarily be equal provided that the lenses are placed so that their optical centres are equidistant optically from the front surface by which the light enters the built up double reflection prism. In the case in which the compound prism block is used behind a single lens the surfaces by which the light enters and leaves the built up block must be plain flat surfaces but the light paths in the compound block in the three cases (*i.e.*, the two partially reflected beams and the directly transmitted beam) need not be equal as such inequality only affects the position of the focal plane on which the image is formed and not its size.

In the case in which the compound prism block is used between a lens combination (*i.e.*, with part of the combination in front of the face of the prism block by which the light enters and three similar parts (each of which virtually completes the combination) behind the faces at which the light leaves the built up prism block the surfaces by which the light enters and leaves the prism block must be plain flat surfaces and preferably arranged so that the light paths in the prism block are of equal length in the three cases.

In the case in which the cube or prism block forms part of the lens combination the face by which the light enters the prism block, or the three faces by which it leaves it or all faces may have suitable spherical curvatures

worked upon them, but the three surfaces by which the light leaves should have similarly worked surfaces and the three light paths in the prism block should be of equal length.

A compound cross reflecting and transmitting prism block substantially as herein described provides a firm and compact optical device for dividing a beam of light into three beams each of which shall or may include in itself the potential image or aspect of the scene from which the original beam comes. This optical device may be placed in appropriate position for dividing the beam received through a single objective, as the objective of a telescope, a microscope or a camera obscura so that the interfitting or registering images may be observed or projected, or formed in appropriate focal planes.

Alternatively the beam from the object or scene may be received directly by the above mentioned optical device and directed through a multiplicity of objectives or image-forming lenses, the resulting images being interfitting or registering.

Otherwise the image forming lens system or objective may be divided, so that part is in front of the above mentioned optical device and other part is behind. By way of example a portion or front combination of the objective may be in front of the new optical device and each branch of the divided beam may pass through a back combination of the objective, this back part being three-folded or triplicated.

It is in certain cases desirable to bring the images for three-part heliochromy to or on the same focal plane and to effect this certain additions are made to the reflection transmission cube as described above; these additions being, in essence, two Newton's reflecting prisms, one against each of those sides from which a reflected beam emerges. Thus the three beams are brought into parallelism but as the images would not in all cases be formed at the same plane, optical correctors of plane parallel glass may be used.

While the primary object of this invention is to provide means which enable three identical images to be produced simultaneously from precisely the same point of view the present invention includes a utilization of the cross reflecting compound prism so as to produce the two reflected images from two separate points of view situated more or less closely together and the directly transmitted image from a point of view situated between them or similar to one of them. For example, the distance of the line of intersection of the cross-reflecting surfaces from the front of the compound prism block may be made to differ somewhat from the distance between such line and the back of the block; and to the block additions may be made which in essence are two Newton's reflecting prisms one against each of those sides from which a reflected beam emerges.

Dated this 11th day of September, 1915.

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

COMPLETE SPECIFICATION.

Compound Cross-reflecting and Transmitting Prism-block, and the Use thereof in Cameras and like Optical Devices.

I, HAROLD WORKMAN, of 12, University Gardens, Kelvinside, Glasgow, North Britain, Engineer, 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 improvements in compound optical prisms of the type wherein a bundle of light is divided into three separate portions in such manner that each of these portions comprises some light from all parts of the bundle, or *vice versa*, and in particular the present invention is applicable to three colour photographic and cinematographic cameras of the type in which three separate colour-record images are taken at one exposure from one point of view; the incident light rays from the subject being divided into three portions or beams by two partially reflecting surfaces placed at an angle in the light path, these surfaces directing two portions of the divided light rays directly or indirectly towards two of the focal or sensitive surfaces at or on which the images are to be formed, and the remaining portion or beam passing by direct transmission through the two partial reflecting surfaces towards the focal or sensitive surface on which the third image is to be formed. In certain cases by a second reflection the reflected portions of the divided light form images on the same focal or sensitive surface as that which receives the directly transmitted image.

The object of the present invention is to provide a new and improved optical device of the kind described.

The invention consists in an optical device of the kind described for dividing a bundle or cone of light rays into three separate portions or *vice versa* comprising a compound optical prism having two flat partially transmitting and partially reflecting surfaces oppositely angularly disposed to the axis of the incident cone of light rays which surfaces cross one another on a line which passes through and at right angles to the axis of the incident cone of light rays such partially transmitting and partially reflecting surfaces being formed at optically contacting surfaces of a sectionally built up compound prism block in which they are thus combined, the front face through which the light enters the compound block and the two side and back faces through which the light leaves it being similarly angularly disposed normally or nearly normally to the axis of the entering or emerging cone of light rays.

The four internal reflecting surfaces of the built up or compound prism block may be made partially reflecting by the coating or deposition all over of a thin partially reflecting and partially transmitting layer of silver, platinum or other suitable metal or substance, or by the coating or deposition all over of a fully reflecting layer of silver, platinum or other suitable metal or substance, and the subsequent removal of narrow lines or small areas of such coating over the whole reflecting surface, so that the light is reflected from and transmitted through the surfaces in the desired proportions.

The light may be equally distributed among the three sensitive surfaces or may be divided among them in desired unequal proportions to suit the light filters and colour sensitiveness of the plates or films used, by suitably proportioning and adjusting the reflecting and transmitting powers of the four partially reflecting surfaces.

Where the surfaces are made partially reflecting by fully reflecting lines distributed over them the two aspects of the crossing surfaces towards the scene have their lines preferably disposed at right angles to each other and the two back aspects have their lines similarly disposed but towards opposite sides of the prism block, as more particularly defined below.

The compound prism block is preferably a rectangular or nearly rectangular block made up of four triangular prisms of equal size cemented together apex to apex, the contacting or cemented surfaces being made partially reflecting so as to form a square ended block or cube or an approximation to a cube, in which one reflection transmission plane extends internally from one edge of the cube to the diagonally opposite edge and the other reflection transmission plane extends from an edge parallel to the first mentioned edge to a diagonally

opposite edge. Thus the two reflection transmission planes intersect so that the aspect of the intersection forms a saltire cross. This cube is preferably placed so that the axis of the beam or cone of light rays entering the block passes normally through it without deflection, the axes of the cone of the two partially reflected light beams being reflected in opposite directions at right angles or nearly so to the axis of the incident cone of light rays and leaving the two side faces of the compound block normally without deflection.

In some cases the line of intersection of the cross reflecting surfaces may with advantage be made nearer to or further from the front or back surfaces of the compound block. Also in some cases it may be desirable that the partially reflecting surfaces should be arranged at other angles than 45° to the axis of the incident beam such angles being equal or otherwise but preferably not far removed from 45° and such a compound block may be used provided the necessary conditions as to the angles of the faces by which the light enters and leaves the block are observed.

The built up or compound prism block so arranged and constructed may either be placed in front of three lenses, behind one lens, between the combination of a lens system, or one or more of its surfaces may be worked with a spherical curvature so that the prism block may be utilised to form part of the lens system.

In the case in which the compound prism block is used in front of three lenses, the surfaces by which the light enters and leaves the built up block being plain flat surfaces, the lengths of the light paths of the three light rays in the built up block need not necessarily be equal provided that the lenses are placed so that their optical centres are equidistant optically from the front surface by which the light enters the built up double reflection prism.

In the case in which the compound prism block is used behind a single lens, the surfaces by which the light enters and leaves the built up block being plain flat surfaces, the light paths in the compound block in the three cases (*i.e.*, the two partially reflected beams and the directly transmitted beam) need not be equal as such inequality only affects the position of the focal plane on which the image is formed and not its size.

In the case in which the compound prism block is used between a lens combination, *i.e.*, with part of the combination in front of the face of the prism block by which the light enters and three similar parts (each of which virtually completes the combination) behind the faces at which the light leaves the built up prism block, the surfaces by which the light enters and leaves the prism block, being plain flat surfaces, are preferably arranged so that the light paths in the prism block are of equal length in the three cases.

In the case in which the cube or prism block forms part of the lens combination the face by which the light enters the prism block, or the three faces by which it leaves it or all faces may have suitable spherical curvatures worked upon them, but the three surfaces by which the light leaves should have similarly worked surfaces and the three light paths in the prism block should be of equal length, unless for any special reason or in any particular aim special focal variations or adjustments are required.

A compound cross-reflecting and transmitting prism block substantially as herein described provides a firm and compact optical device for dividing an image forming beam of light into three beams each of which includes in itself the image forming potentiality of the original beam without the introduction of any distortion in the resulting images.

It is in certain cases desirable to bring the images for three-part heliochromy to or on the same focal plane and to effect this certain additions are made to the reflection transmission cube as described above; these additions being, in essence, two right-angled reflecting prisms, one against each of those sides from which a reflected beam emerges. Thus the three beams are brought into parallelism but if it is desired that the images shall be formed at the same plane, special provision may be made.

As illustrating the invention I have appended two sheets of drawings in which convenient and advantageous constructions of the sectional compound optical prism are illustrated together with some examples of recording systems in which the sectional compound optical prism in each and every case forms an integral part of the optical recording system these being depicted in particular relation to three colour photographic and cinematographic cameras.

In Fig. 1: 1, 2, 3, and 4 depict right-angled reflecting prisms which are cemented or optically contacted together apex to apex to constitute the compound optical prism, the aspect in the drawing being towards the inoperative faces or ends of the respective reflecting prisms. A beam of light from the scene entering towards 1 or as indicated by the arrow *a*, is trifurcated at the contact surfaces 5, 7, and 6, 8 of the cube, these surfaces being shewn in Figs. 3 and 4 as made partially transmitting and partially reflecting by fully reflecting lines 9 and 10 distributed over them in interspaced relation the lines on the faces 5 and 7 being disposed at right angles to the lines on the faces 6 and 8.

Fig. 2 is a side elevation of the compound optical prism depicted in Fig. 1 looking in the direction of the arrow *b*, the dash line 11 denoting the line of intersection of the cross reflecting and transmitting surfaces 5, 7 and 6, 8 respectively.

Such a prism block may be conveniently and advantageously constructed as shewn in Fig. 5 in which the reflecting prism 1 has two junction faces 12 and 13 furnished with the reflected rulings, the former being lined as shewn in Fig. 3 and the latter being lined as shewn in Fig. 4, the prism 2 has one junction face 14 lined as shewn in Fig. 4, the junction faces 13 and 14 co-acting to form the partially reflecting surface 5, 7, Fig. 1; the prism 3 has the junction faces left clear, while the prism 4 has the junction face 15 lined as shewn in Fig. 3 to co-act with the face 12 of the prism 1 to form the partially reflecting surface 6, 8 (Fig. 1). The respective prisms 1, 2, 3, and 4 are illustrated in Fig. 5 as spaced apart for a better understanding, but it will be understood that these four equal sided rectangular prisms will be cemented or optically contacted together to form a square-ended block or cube as shewn in Fig. 1 and as hereinabove described.

Certain structural modes as defined below are to be regarded as within the scope of the present invention. For example, in constructing the prism block or assembling the parts, it may be desirable to interpose a plate of plane parallel glass as denoted by 16, Fig. 6, such plate being used to secure accuracy of position and ease in adjusting the prismatic parts. Thus in Fig. 6, two prisms 1 and 2 of the system are cemented or balsamed to a plane parallel glass 16 and their position having been fixed and the balsam or cement having hardened two more prisms 3 and 4 may be attached to the plane parallel glass 16 to complete the cube (or approximately a cube).

In such an arrangement the reflection rulings of the faces 13 and 14 of the prisms 1 and 2 may be transferred to the plane parallel glass 16 as shewn in Fig. 6 if desired.

For avoiding reflections from the emerging surfaces of the side prisms 2 and 4 there may be thin extensions 2^a and 4^a of the prisms 2 and 4 as shewn in Fig. 6.

Figs. 7, 8, 9, and 10, depict arrangements of a three colour photographic or cinematographic camera in which three cameras are disposed at right angles or approximately so to each other and in which a compound optical prism as hereinabove described forms an integral part of the optical system.

In Fig. 7 the compound optical prism is disposed as depicted, behind a single lens, the lens being against that face of the prism block at which the beam coming from the scene enters, the beam through this objective being trifurcated so as to form three images at 17, 18, and 19 respectively.

In Fig. 8 the compound optical prism is disposed, in front of three lenses,

the centres of the lenses being equidistant optically from the face through which light enters the prism block, and as in Fig. 7 the beam through this system will be trifurcated to form three images at 17, 18 and 19 respectively.

Fig. 9 shows a compound prism block disposed between the compound parts of a lens system, the front element being designated 20, and the back portion being triplicated, the back elements of the lens system being designated 21, 22, and 23 respectively, and the images being formed as before at 17, 18, 19 respectively.

Fig. 10 shows the compound prism block with a front element 24 of an objective lens against that face of the prism block at which the beam coming from the scene enters and the completing or correcting elements, to the front element, formed as spherically worked surfaces 25, 26, and 27 on those faces of the prism block which are respectively on each trifurcation of the beam, the images being formed as before at 17, 18, and 19 respectively.

Fig. 11 shows the compound optical prism block with a right-angled prism cemented or integrally formed as a lateral extension of the block on the line of the emergence of each of the reflected beams, the two added prisms being designated 28 and 29, this device being arranged, as shewn, in front of three lenses and serving to bring the three images to or near one focal plane and if desired on one and the same receiving surface. In this arrangement air distance correction may be introduced as illustrated and in accordance with the principles laid down or defined in a Specification of the present applicant and others numbered 16,811 of 1915 for the purpose of bringing equi-sized images at one and the same plane; thus the medial lens is set back in air in relation to the side lenses and plane parallel blocks of glass or other suitable medium 30 and 31 are fitted between the side lenses and the common focal plane 32 so as to cause all three images to be brought to a sharp focus on this plane.

Fig. 12 shows an arrangement similar to Fig. 11 except that the compound optical prism with the two added right-angled reflecting prisms are employed behind a single lens, the three images being brought by plane parallel correctors 33 and 34 to a sharp focus and to the same size at one and the same plane, the numeral 32 designating this plane in Figs. 11 and 12.

The herein described improvements in compound prism blocks may be applied to optical observing apparatus and systems.

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

1. An optical device of the kind described for dividing a bundle or cone of light rays into three separate portions or *vice versa*, comprising a compound optical prism having two flat partially transmitting and partially reflecting surfaces oppositely angularly disposed to the axis of the incident cone of light rays which surfaces cross one another on a line which passes through and at right angles to the axis of the incident cone of light rays, such partially transmitting and partially reflecting surfaces being formed at optically contacting surfaces of a sectionally built up compound prism block in which they are contained, the front face through which the light enters the compound block and the two side and back faces through which the light leaves it being similarly angularly disposed normally or nearly normally to the axis of the entering or emerging cone of light rays.

2. A three colour photographic or kinematographic camera of the kind referred to provided with an optical device as claimed in Claim 1 hereof in which the partially reflecting and partially transmitting surfaces are formed and proportioned so as to divide the light in desired unequal proportion among the three sensitive surfaces and to distribute equally over each such surface its portion of light.

3. A compound optical prism as claimed in Claim 1 or Claim 2 hereof having interposed therein a plane parallel plate of glass extending over the whole of one of the cross reflecting and transmitting surfaces and having the partially reflecting and partially transmitting surface formed upon one of its surfaces or upon those surfaces of two of the prisms with which it is in optical contact.

4. A three colour photographic or kinematographic camera provided with a compound prism block according to Claim 1 or Claim 2 or Claim 3 hereof, in front of three lenses and three cameras disposed at right angles or approximately so to each other, the centres of the lenses being equidistant optically from the face through which light enters the prism block.

5. A three colour photographic or kinematographic camera provided with a compound prism block according to Claim 1 or Claim 2 or Claim 3 hereof, behind one lens.

6. A three colour photographic or kinematographic camera according to Claim 5 hereof, in which the side prisms have thin extension pieces formed with or added to them to avoid reflection from the emerging surfaces of such side prisms onto the surface on which the directly transmitted image is formed.

7. A three colour photographic or kinematographic camera provided with a compound prism block according to Claim 1 or Claim 2 or Claim 3 hereof, which is disposed between the component parts of a lens system, the back portion of which is triplicated.

8. A three colour photographic or kinematographic camera provided with a compound prism block according to Claim 1 or Claim 2 or Claim 3 hereof, and having one or more of its surfaces spherically worked so that the prism block may be utilised to form part of the lens system.

9. The compound prism block according to Claim 1 or Claim 2 or Claim 3 hereof, having side additions of reflecting prisms whereby the axes of the reflected beams are redirected and brought into parallelism with the axis of the direct beam.

10. A three colour photographic or kinematographic camera provided with a compound prism block and side additions according to Claim 9 hereof, which is placed in front of three lenses and in which means are provided to produce equal sized images exactly at one and the same plane substantially as described and shewn by Fig. 11.

11. A three colour photographic or kinematographic camera provided with a compound prism block and side additions according to Claim 9 hereof, which is placed behind one lens and in which means are provided to produce equal sized images exactly at one and the same plane substantially as described and shewn by Fig. 12.

12. The herein described improvements in compound prism blocks for optical observing or recording instruments and systems substantially as set forth or illustrated.

Dated this 13th day of March, 1916.

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

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1916

ERRATUM.

SPECIFICATION No. 13,042. A.D. 1915.

Page 6, line 23, *for* "reflected" *read* "reflecting."

PATENT OFFICE,
May 17th, 1917.

A.D. 1915. Sep. 11. № 13,042.
WORKMAN'S Complete Specification.

(2 SHEETS)

SHEET 1.

Fig. 1.

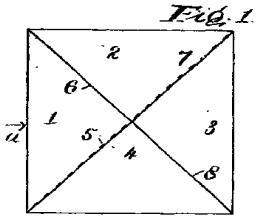


Fig. 2.

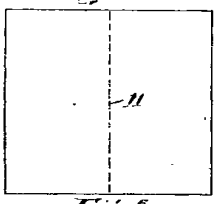


Fig. 3.

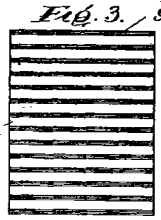


Fig. 4.

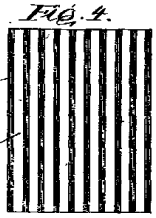


Fig. 5.

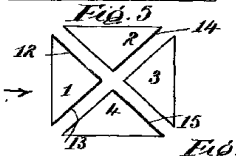


Fig. 7.

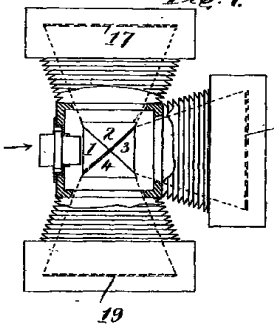
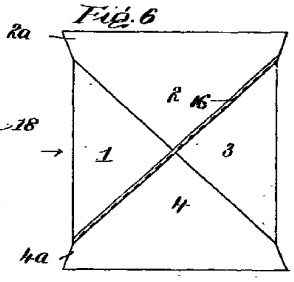


Fig. 6.



SHEET 2.

Fig. 8.

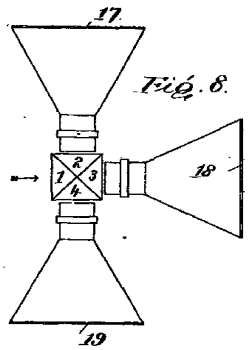


Fig. 9.

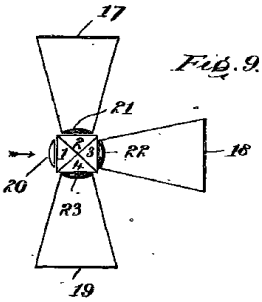


Fig. 10.

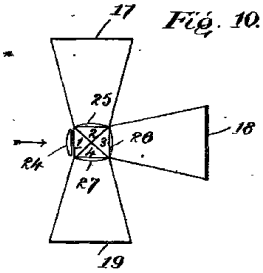


Fig. 11.

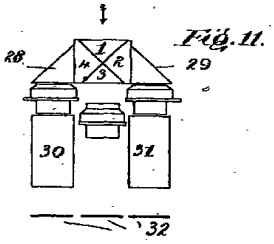
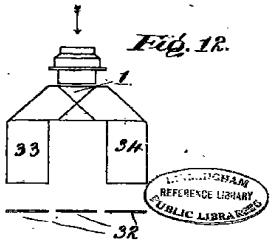


Fig. 12.



Malbyle Sons, Photo-Litho

A.D. 1915. Sep. 11. № 13,043.
WORKMAN'S Complete Specification.

SHEET 1.

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

Fig. 1.

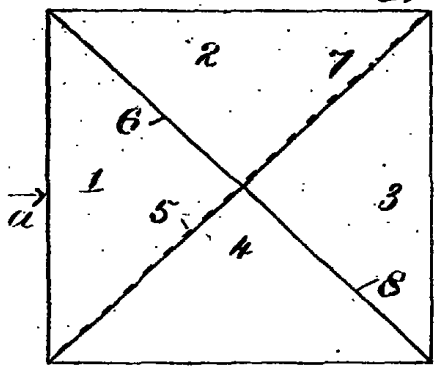


Fig. 2.

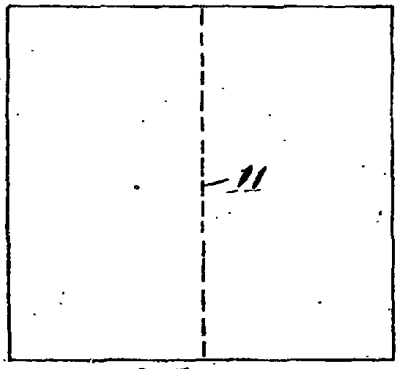


Fig. 3.

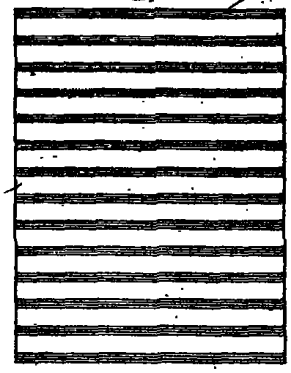


Fig. 4.

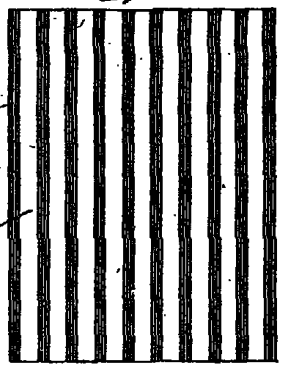
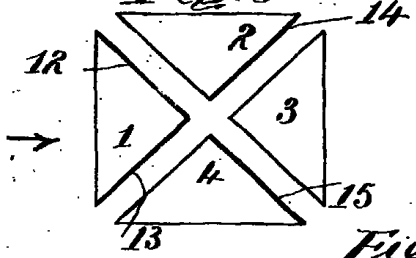


Fig. 5



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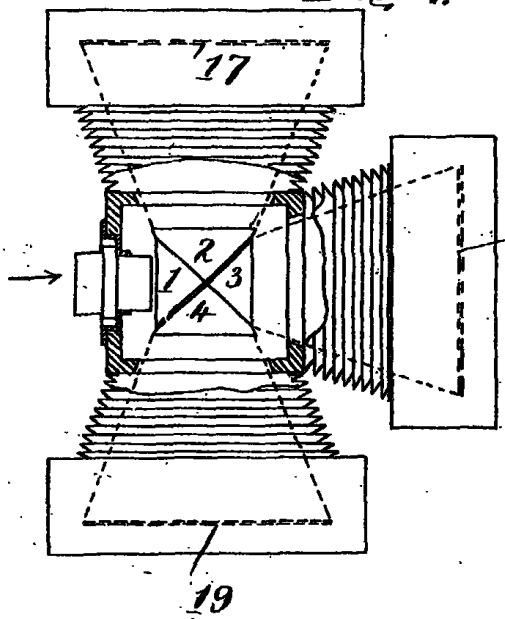
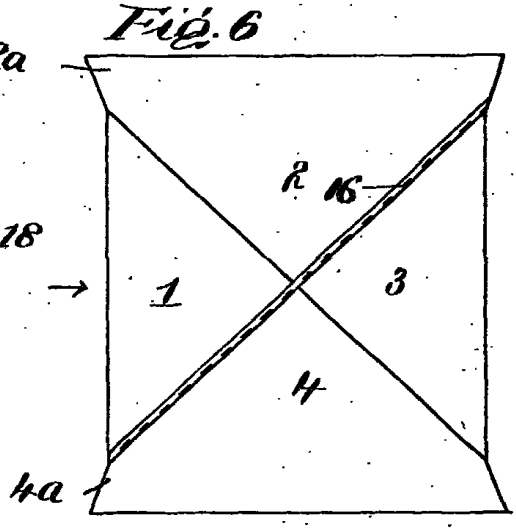
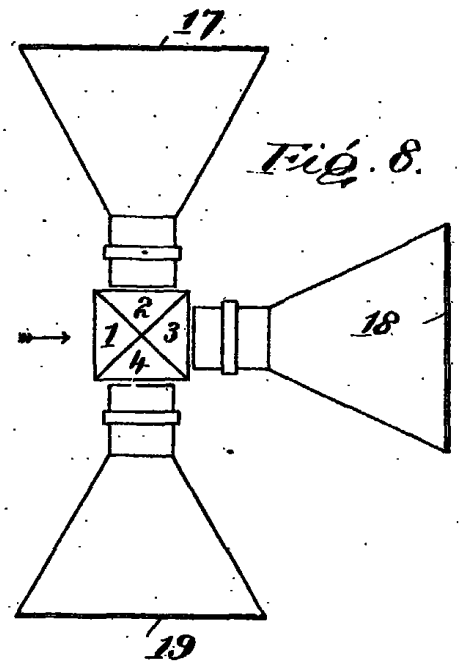


Fig. 6





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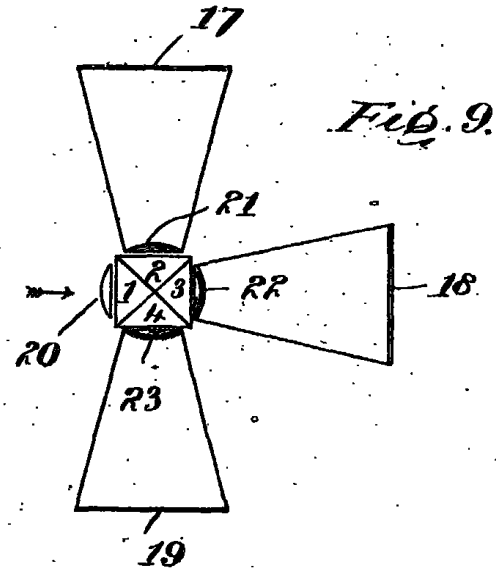

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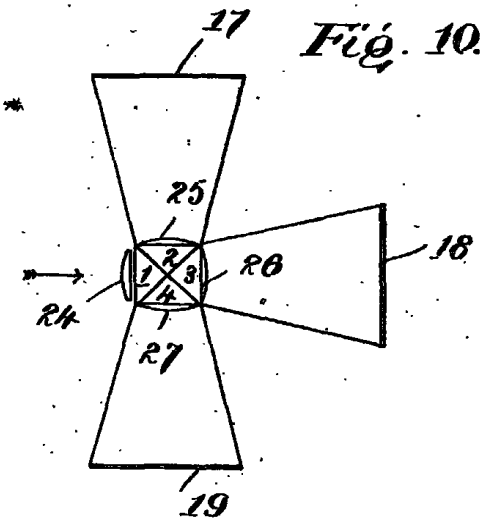

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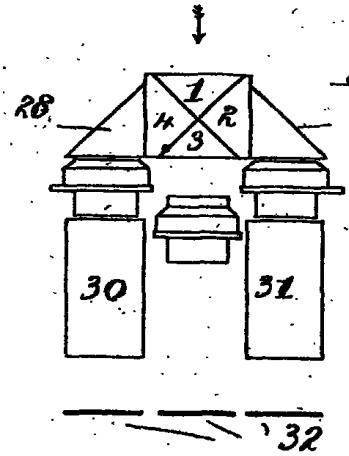

Fig. 11.

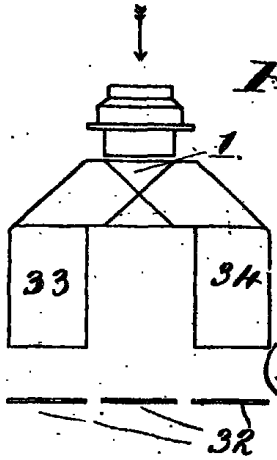

Fig. 12.

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