Stereoscopy in the Cinema to-day and to-morrow

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Summary.

Of the various known systems of stereoscopic cinematography, polarized light processes are most widely used today. They have, moreover, been adopted for the majority of the public demonstrations of stereoscopic cinematography which have been given during the past decade or so, and a system of this type is at present in successful and regular operation at the Festival of Britain Telekinema. It is considered justifiable, therefore, to devote a considerable portion of this paper to descriptions of some recent developments in polarized light processes and of the actual apparatus used for the Festival of Britain stereoscopic films. In addition, a new anaglyphic process will be described, and some of the author's work in the field of autostereoscopic cinematography will be briefly surveyed.

Polarized Light Processes.

Some years ago a convenient single-film polarized light process was evolved by Zeiss-Ikon, but those familiar with the process will be aware that it suffers from the disadvantage of involving a serious reduction in the illumination available from the projector. More than half of this loss of light is due to the fact that the bi-prism used for producing superimposition of the two components of the stereogram is arranged in close proximity to the projection lens. As a result of this arrangement, but for the use of two pairs of polarizing filters (one pair in the film gate and the other pair close to the bi-prism), there would be two pairs of images, of substantially equal brightness, at the screen surface. One pair of filters is required for polarization of the superimposed stereoscopic pair of images, and the other pair of filters is required for suppression of the two unwanted images which would otherwise be visible, one at each side of the superimposed pair.

A new single-film Polarized Light Process.

During the past few years the author has developed a single-film system which can be regarded as a considerable advance as, for an illuminant of the same output, the screen brightness is approximately 2 1/2 times that available with the Zeiss-Ikon system. Moreover, the system is immediately applicable to any existing projector, without alteration, as the single pair of polarizing filters used is incorporated, together with the image-converging device, in one unit arranged in front of the lens.

The principle underlying the process, which is the subject of various British and foreign patents, may be described briefly as follows. Considering one-half of the field of, say, a projection lens, it is readily demonstrable that, at the plane of the lens, the image-forming rays consist of rays from both halves of the object field in equal proportions. This condition may be referred to as that of zero segregation. At the other extreme, that is to say, at the image plane, the image-forming rays in any half of the image field consist entirely of rays emanating from the appropriate part of the object field. This condition may be referred to as that of total segregation. It can be shown further that, between these two extreme positions, segregation varies from zero to total (infinity) according to a function:

$$f\left(\frac{d\,tan\frac{\theta}{2}}{a}\right)$$

where d denotes the distance from the lens, a the maximum effective aperture (measured in the same units as d) of the lens, and the angular field of the lens.

We are concerned with- determining the minimum value of d at which segregation will be sufficiently far advanced for the purpose in view, that is, the minimum distance from the lens at which we may position the converging and polarizing unit. When it is desired to segregate, to their appropriate halves of the lens field, the two images of a stereoscopic pair, it is not possible to specify precisely a minimum value for d which will give an acceptable result, because the minimum value is inevitably governed to some extent by the amount of image overlap which can be regarded as tolerable in a particular case. It is, on the other hand, a simple matter to specify a definite, sufficiently small value for d which will yield an intolerable result for any stereoscopic purpose. This value is given by:

$$d = \frac{a}{tan\frac{\theta}{2}} \qquad (1)$$

at which distance there is still serious overlapping across approximately the « middle third » of the cross-section of the lens field.

By introducing a constant k into equation (1) we obtain a satisfactory formula for design purposes, thus:

$$d = \frac{ka}{tan\frac{\theta}{2}} \qquad (2)$$

Empirical methods have shown that a value of k in the region of 2 is satisfactory for most purposes. (Values of k odapted by Stereoptics, Ltd., range from 1.7 up to 4.0 according to the precise nature and purpore of the apparatus concerned).

Application of New Process.

In producing cinematograph films for projection in accordance with the principle outlined above, the author prefers the arrangement of images shown in Fig. 1. The « left-eye » and « right-eye » views, denoted in the sketch by respectively L and R, are recorded side by side, but each image is rotated in the same direction through an angle of 90". In this way the stereoscopic pair, each component of which is of the same proportions as a standard motion picture frame, is caused to occupy practically the whole area of the frame. Filming in accordance with this method can he carried out with any existing camera,

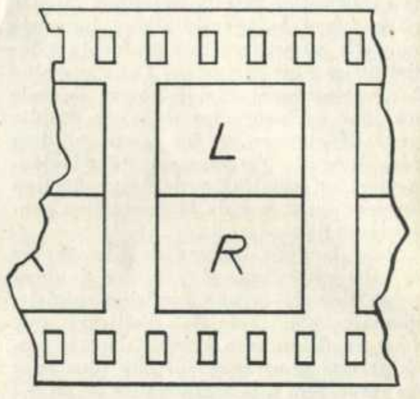

Fig. 1.
Arrangement of images on film for projection by single-film polarized light process

without alteration, the necessary stereoscopic optical system being attached externally.

Serious consideration was given to the possibility of employing this process for the Festival of Britain stereoscopic films. It seems likely that the process would have been adopted but for the fact that, at the time the Festival authorities wished to place the contract for supply of the apparatus, no camera attachment incorporating the imagerotating feature was available for demonstration.

Examples of apparatus embodying the for egoing principles, recently supplied by Stereoptics, Ltd., to one of the Government research establishments, are shown in the photographs Figs. 2. and 3. The camera attachment is illustrated in Fig. 2., and the auxiliary optical apparatus for use with the projector is shown in Fig. 3. The actual apparatus illustrated was designed for use with 16 mm. equipment.

Referring to Fig. 3., P denotes a 90° erecting prism, and C the converging and polarizing unit. For stereoscopic projection the projector is placed on the baseboard with its lens immediately behind the erecting prism, that is, to the right of the prism as viewed in the photograph. The beam then passes, first through the erecting prism, and then through the converging and polarizing unit.

Of the many polarized light processes with which the author has had experience, including those which he himself has developed, that described above is, in his opinion, by far the most satisfactory. The ease with which the system can be put into operation with any existing camera and projector is a point which should commend it to the motion picture industry in the event of a decision to exploit the polarized light principle a time, pending the eventual change to autostereoscopy.

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Picture Definition.

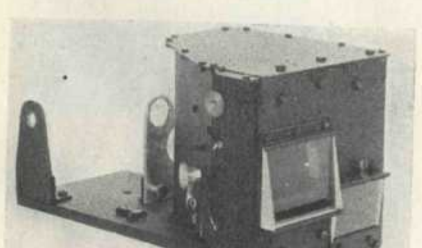
It seems opportune here to correct an erroneous belief, held in some quarters,- concerning the picture definition available with systems of this type. Some who are not fully conversant with such systems are under the impression that if, for example, the area of a 35mm. frame be arranged to contain the two components of a stereogram, each component occupying one-half of the area, the available definition with the two components fused binocularly will be only 50 per cent of that obtainable witli a single, planoscopic picture occupying the whole frame.

This is a topic which the author has had cause to examine with some thoroughness, and it is to be emphasized that if the two components of the stereogram be projected and viewed as a three-dimensional image of given size, then the definition will be almost precisely equal to that of the image of the planoscopic picture projected the same size. The word *almost* is used because there will be a very small, imperceptible reduction in definition attributable to the stereoscopic image, which reduction varies inversely as the total area of emulsion occupied by the component pictures, and directly in accordance witli a very complex function of the number (two in the present case) of such pictures. The complexity of the direct function is due in part to the fact that the homologous views with which we are concerned in stereoscopy are not precisely the same except when the object is at infinity, the dissimilarity increasing with decreasing distance of the object.

For all practical purposes, however, the definition available with a simple stereogram can be taken as dependent on the combined area of the two views - not on the area of a single component.

An interesting series of tests was carried out some time ago to determine the number of identical pictures which could be recorded satisfactorily in a single 35mm. frame, these images being projected in accurate superimposition. The superimposed images were compared with a single image, projected to the same dimensions, of the same subject photographed full-frame size. For reasons which need not concern us here, these comparative tests were made witli frames so divided that the number of pictures was successively, 2, 2^2, 2^3, 2^4 . . . and so on. It was found that even with 2^6 (i. e. sixty-four) pictures per frame the reduction in definition was surprisingly small.

Fig. 2.
Stereoscopic camera attachment for single-film polarized light process.



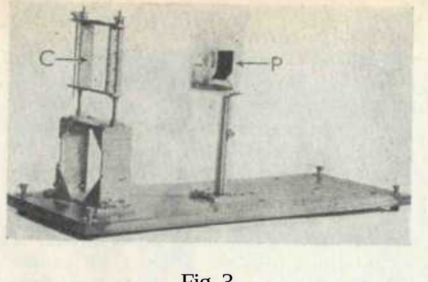


Fig. 3.
Stereoscope projection apparatus for single-film polarized light process.

Telekinema Two-film System.

The apparatus specified by the Festival of Britain for the Telekinema stereoscopic films is the well-known polarized light process involving the use of two cameras and two projectors. It is not without interest to note that this method was proposed as long ago as 1390 by Anderton, but the development of a practical process was delayed for nearly half a century by the high cost of natural polarizing crystals and the difficulty of obtaining them in sufficiently large sizes. E. H. Land, in 1934, went a long way towards overcoming these obstacles by his invention of the synllietic polarizing material which, of course, we know as Polaroid.

The Festival of Britain, when placing the contract with Stereoptics, Ltd., for supply of the necessary stereo photographic apparatus, laid down a rigid specification as to not only the precision with which the equipment must be manufactured, but also the functional characteristics of the apparatus. The more important of the functional requirements are listed below:

1) The complete apparatus, including two Newman Sinclair Model G auto Kine cameras[4] privided for the purpose, to he sufficiently light to be supported by a single Vinten tripod.

2) The apparatus to be suitable for use with matched pairs of Cooke lenses ranging in focal length from 28mm. to 100mm.

3) The effective stereoscopic base of the apparatus to be adjustable from a maximum value of not less than about 8 ins. down to a minimum value rather less than the normal interocular distance.

4) The angle of convergence of the optical system to be adjustable independently of the stereoscopic base.

5) The camera mechanisms to be operated synchronously.

6) Focusing of each pair of lenses to be coupled and synchronized, so that adjustment of the focus of either one of a pair of lenses produces a corresponding adjustment of the focus of the other.

Stereoscopic Camera Equipment.

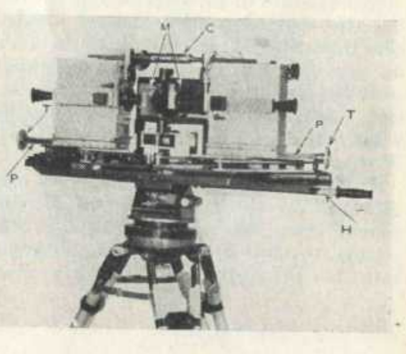
The apparatus developed in order to meet the above requirements is illustrated in the photographs Figs. 4. and 5., which shows respectively front and rear views of the equipment. The principle involved, which is the subject of the author's Provisional Patent No. 17,086/50, is shown diagrammatically in the sketches Figs. 6. and 7.

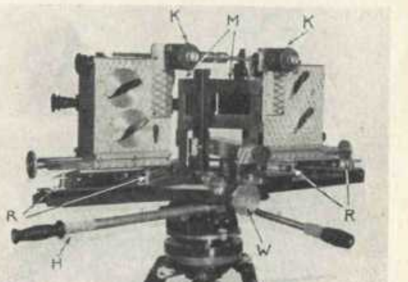
Feferrring first to Fig. 6., L and R denote the two cameras, the former heing employed for recording the « left-eye » view and the latter the « right-eye » view. Light rays, such as the axial ray l from the subject, reach the camera L after reflection through an angle of 90° by a front-aluminized mirror M_1. Likewise, light rays, such as the axial ray r, reach the camera R after reflection from a similar mirror M_2. In this diagram the apparatus is represented as being adjusted for filming a very distant subject. Accordingly, matters are so arranged that the stereoscopic base D is of comparatively large value, and the axial rays l and r are substantially parallel, the latter condition being secured by adjustment of the angle 0 between the mirrors to a figure approaching its minimum value of 90°.

In Fig. 7. the apparatus is represented as having been adjusted for filming the subject from a reduced distance. Such adjustment is effected by two main operations: (1) The two cameras are moved in the directions indicated by the arrows to new positions so that the stereoscopic base D is reduced to an appropriate value. (2) The angle 0 between the mirrors is increased so that the rays l and r still originate in some common preselected point p in the field of view.

Figs. 6. and 7. arc, it is considered, adequate to illustrate the general principle of operation, although it should be noted that it is possible to adopt any combination of D and 0 within the limits laid down in the specification. It is one of the mechanical features of the stereoscopic mounting that the angle a between the optical axis of each camera and its associated mirror is maintained constant and equal to 45° for all settings of the apparatus.

Fig. 4. 5.
Two-film stereophotographic appartus
Front view.





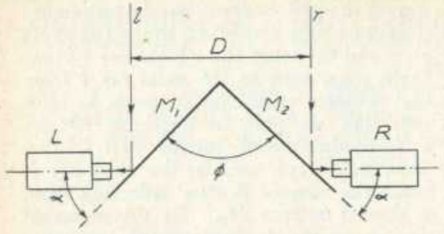


Fig. 6.
Two-film stereoscopic apparatus set for distant shots.

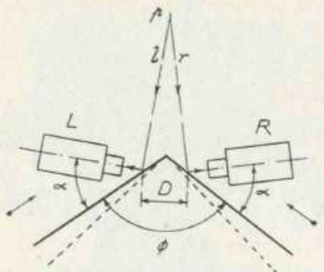
Adjustment of the stereoscopic base D is effected by forward or backward movement of the lever H in the photographs Figs. 4. and 5. Movement of this lever causes the cameras to move in the required direction, parallel to the surfaces of the mirrors K, along the rails indicated in Fig. 5. by R. The angle of convergence is adjusted by turning the handwheel W wich can be seen in the same photograph. Two further small handwheels are provided, and are indicated by T in Fig. 4. Rotation of these two handwheels produces movement of the cameras along the platforms P. In this way it is possible to adjust the positions of the cameras so that lens fronts are always in close proximity to the mirrors, whatever the focal length of the particular lenses in use. As can be seen in Fig. 4., the focusing rings of the two lenses are interconnected via gears and the universally-jointed coupling C.

The camera mechanisms are driven synchronously by two 12-volt electric motors, shown at K in Fig. 5,, coupled by a flexible shaft. Since the present photographs were taken, however, the motors have been re-mounted nearer the camera bases in order to eliminate trouble due to vibration which occurred with the motors mounted as shown.

Manufacture of the stereoscopic mounting was carried out by Messrs. Multiple Industries, Ltd. Other work, such as provision of the electro-mechanical coupling for the cameras, synchronisation and coupling of the lens focusing rings, etc., was undertaken by Messrs. Newman & Sinclair, Ltd.

Projection in the Telekinema is carried out by the usual method of employing two synchronously driven projectors. A full description of the apparatus has been given by the makers else-

Fig. 7.
Two-film stereoscopie apparatus set for close-ups.



where [5], but a few words on this subject may be of interest.

Synchronisation of the two SUPA projectors employed is maintained by the use of selsyn motors.

The two projectors are mounted side by side and slightly « off centre », in opposite directions, with respect to the screen. In order to avoir the keystone distortion which would othermise result, the projectors have been modified so that the lenses are slightly off centre witH the gate apertures. This modification would cause some waste of light from the arcs, so these, in turn, have been displaced slightly sideways in their housings by an amount corresponding with the displacement of the lenses.

The projection screen is of the aluminized type, specially developed by J. L. Stableford [6].

A new polychromatic anaglyphic process.

Synchronous eclipse and monochromatic anaglyphic processes must be regarded as impractical in the case of the former and obsolescent in the case of the latter. Consequently, it is not proposed to discuss processes in either of these categories. A new polychromatic anaglyphic process is available, however, which represents a considerable advance on earlier processes of similar type. A full description will be found in the author's British Patent Specification No. 634,890.

The essential feature of the system is an optical attachment for use with an ordinary still or cinematograph camera. Colour stock, such as « Kodachrome », is used, and the arrangement is such that stereoscopic pairs of images are superposed on the film to form anaglyphs direct in natural colour. Several different optical arrangements are possible, one of the most simple being that shown diagrammatically in Fig. 8.

Parallax is produced by a pair of laterally spaced prisms P_1 and P_2. The former is a simple 45° prism, and the latter is of composite form consisting of two 45° prisms cemented together at the hypotenuse faces with Canada balsam. One of the hypotenuse faces is partially silvered, rendering the junction of the two surfaces partially light-transmitting and partially light-reflecting. Complementary colour filters, F_1 and F_2 are arranged in front of the prisms, the distance between the centres of the filters being approximately equal to the normal interocular separation.

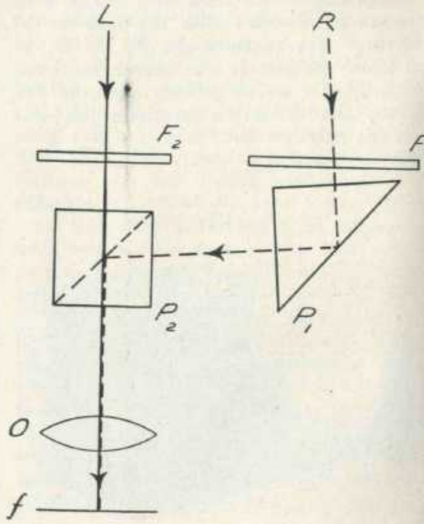
During exposure, a « left-eye » image is formed on the film / by the camera lens O as a result of rays such as L passing through the filter F_2 and direct through the partially light-transmitting surface of the prism P_2. On this image a « right-eye » image is superposed as a result of rays such as R which, after passing through the filter F_1 are reflecter through approximately 90°, first at the hypotenuse surface on the prism P_1, and then at the partially light-reflecting surface of the prism P_2. Each of the images occupies the whole of the available film area, that is to say, the entire frame in the case of cine film.

The colour filters are so chosen that each passes light covering a comparatively wide band of wavelengths, the two bands being complementary to one another. Consequently, after processing, one of the two images contains the yellow, orange and so on of the original scene, and the other cotains the blue, geen, etc. When the anaglyph is viewed through spectacles having appropriate colour filters, therefore, binocular fusion of the two images results in blending of the colours contained in the separate views. Accordingly the scene is reconstituted not only three-dimensionally but also in a very fair reproduction of its original colours.

In manufacturing the prism P_2 careful attention is devoted to production of the partially silvered surface. The density of the metallic deposit must be accurately controlled so that the light reaching the camera lens is composed of the correct proportions of transmitted and reflected light. It might at first be thought that the transmitting and reflecting properties of the surface should be exactly equal. Such is not the case in practice, however, owing to the fact that colour films do not possess exactly the same sensitivity to all colours. But it is necessary that the two images costituting the anaglyph should be of substantially the same density; accordingly we must compensate for the unequal colour-sensitivity of the film by suitably balancing the relative intensity of the light forming the « left-eye » and « right-eye » images. For example, let us suppose that the film is more sensitive to the light transmitter by the filter F_1 than to that transmitted by the filter F_2. Then the density of the partially silvered surface must be made such that the intensity of the transmitted light exceeds that of the reflected light by an appropriate amount.

It will be noted from Fig. 8. that the reflecting surface of P_1 is not exactly parallel to the partially silvered surface of P_2. The prism P_1 is inclined slightly inwards towards P_2 so that corresponding rays such as L and R emanate from a common point about thirty feet away instead of from a point a t infinity. As a result, the two views comprising the anaglyph are superposed in such a way that those parts of the images which are in coincidence represent a plane of the suhject distant about thirty feet from the camera. Hence, on viewing the projected anaglyph, it is this plane of the subject which appears to lie in the plane of the screen. This arrangement has the effect of minimising the effort of convergence required to achieve binocular fusion under average filming and viewing conditions.

Fig. 8.
Optical System for produetion of polychromatic anaglyphs.



A camera attachment embodying the foregoing principle is shown fitted to a 16 mm. camera in the photograph Fig. 9. This particular model is suitable for use with either the Bell & Howell *Filmo*, as shown, or the Cine-Kodak *Special*.

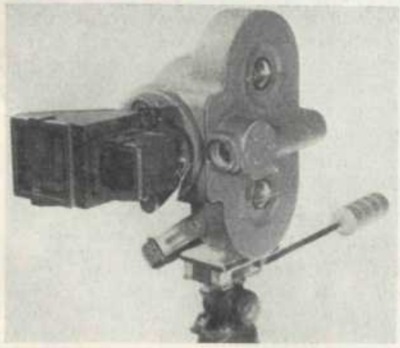
The type of anaglyphic process just described is very satisfactory from the point of view of illumination efficiency. If the colour film is correctly exposed, the average density after processing is substantially the same as that of a similar piece of film exposed in the normal manner without the camera attachment. Hence, as no filters are employed in the path of the projector beam, the only loss of light on projection is that due to absorption by the viewing spectables.

Auto-stereoscopy.

Stereoptics, Ltd. were asked by the Festival Authorities whether it would be possible to provide an auto-stereoscopic system for the Telekinema. As was stated at the time, the provision of a system of this type would have been technically practicable. Serious consideration of the proposal was, however, out of the question owing to the short time available in which to produce the equipment and to the very considerable expenditure which would have been entailed in production of the necessary special screen and other apparatus.

The author ventures, nevertheless, to express his personal opinion that expenditure in this direction might well have proved an investment yielding a handsome dividend to the British film industry. The cost involved would, in any case, have been comparatively small when considered in relation to the sums expended on certain other Festival projects which are unlikely to result in any permanent benefit to industry.

Fig. 9.
Polychromatic anaglyphic attachment fitted to Bell & Howell *Filmo*



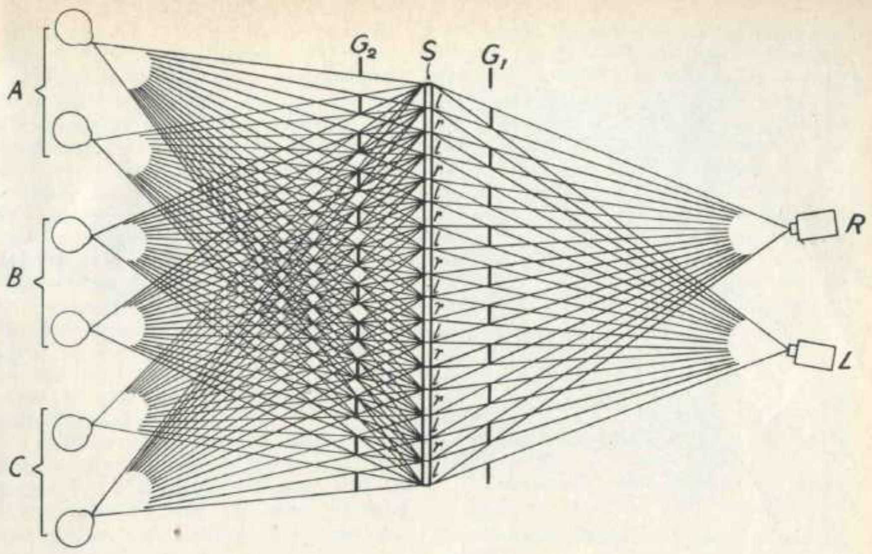


Fig. 10.
Projection of parallax stereograms with two projectors.

Parallax Stereogram Principle.

As far back as 1935 the author successfully demonstrated autostereoscopic cinematography by means of the parallax stereogram principle [2], which principle was adopted several years later by Sergei Ivanov in Moscow [3].

Two synchronised cameras, mounted side by side, were used for filming the scene. Thus, one for the two film records represented a « left-eye » view of the scene and the other a « right-eye » view.

The arrangement adopted for projection is shown diagrammatically in Fig. 10. Two synchronised projectors, carrying the « left-eye » and « right-eye » films respectively, are arranged at L and R. The projector beams pass through the transparent gaps in a line grid G_1 to form images on a translucent screen S. The relative positions of L, R, Gi and S are so chosen that the images on the screen are in the form of alternate « left-eye » and « right-eye » vertical strips as denoted by *l*, *r*, *l*, . . . etc.; that is to say, the picture is in the form of a parallax stereogram. The spectators view the screen through a second, suitably positioned grid G_2. For the sake of clarity in the drawing, the positions of only three spectators A, B and C, have been shown.

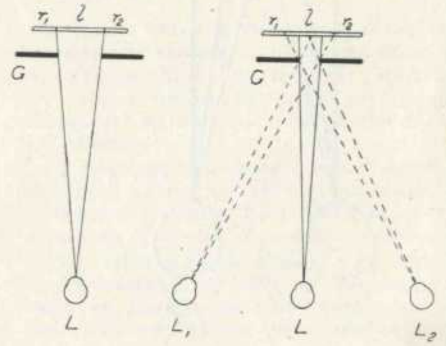
It will be observed that, owing to the presence of the grid G_2, each spectator sees with his left eye only the «left-eye » strips, and with his hight eye only the « right-eyes » strips. Hence, each sees the. projected scene in stereoscopie relief. In practice there are many laterally spaced positions, such as A, B and C, from which a parallax stereogram can be seen in stereoscopic relief, and the stereoscopic viewing zones extend back for a considerable distance from the screen. Unfortunately, as will he evident from examination of Fig. 10., these zones are inevitably interleaved between pseudoscopic viewing zones of the same width.

Grid Aperture Ratio.

In Fig. 10., again for the sake of clarity, the opaque and transparent strips of the viewing grid are represented as being of equal width, whereas it is customary for the transparent strips to be made somewhat narrower than the opaque ones. The reason for this can be seen from Fig. 11. Refening first to Fig. lla., L represents the left eye of an observer viewing a « left-eye » element *l* of a parallax stereogram through a gap in a grid G having a 1/1 opaque/transparent ratio. Portions of the « right-eye » elements adjacent the « left-eye » element *l* are denoted by r_1 and r_2. Clearly, the slightest lateral movement of the observer's head will cause him to see a double image. Thus, if the observer moves his head to the left, his left eye will see a portion of r_2 in addition to a portion of *l*. If he moves his head to the right, his left eye will see portions of both r_1 and *l*.

Referring, now, to Fig. 11b., in this case opaque/transparent ratio of the grid has been increased to approximately 2/1. As a result, the observer has now been accorded some degree of freedom of movement. He can move mis head leftwards so far that his left eye L reaches the position L , or right-

Fig. 11.
Effect of varying parallax stereogram grid ratio.



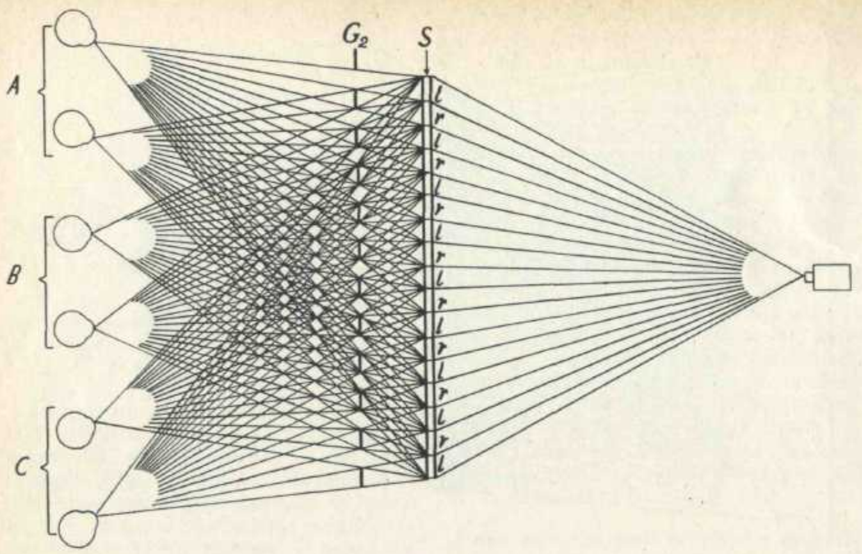
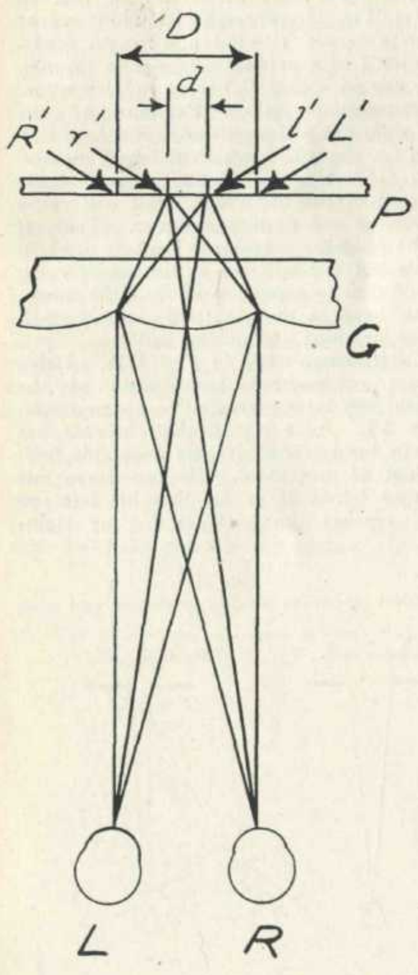


Fig. 12.
Projection of parallax stereograms with single projector.

wards so far that his left eye reaches the position L , without seeing a double image.

Whilst increasing the grid ratio has the desired effect of increasing the width of the orthoscopic viewing zones, thereby providing some freedom of movement within each such zone, the same increase in width is imparted to each intermediate pseudoscopic viewing zone. This means that if a cinema be equipped for the projection of simple parallax stereograms, the seating capacity of the auditorium is inevitably reduced to about 50 per cent. of the normal. It has been found in practice that the grid ratio should be 3/1 or more, and this naturally entails a serious reduction in the amount of light transmitted. This difficulty can be overcome by the use of cylindrically lenticulated grids, for such grids are optically equivalent to line grids of high ratio, with the advantage of good light-transmitting properties. Moreover, with a suitable lenticular grid, front projection becomes a practical proposition, the pictures being projected and viewed through the same grid.

Fig. 13.
Viewing panoramic parallax stereogram.



Parallax Stereograms with Single Projector.

In 1939, British Patent No. 514,624 was granted the author, the specification covering the construction of a stereoscopic camera suitable for recording parallax stereogram images direct on cinematograph film. The use of such an instrument results in several advantages. As only a single camera and single projector are required, there are no synchronisation problems. Further, as the image on the fils itself is in the form of a parallax stereogram, the grid G_1 in Fig. 10. is no longer necessary. Hence, the projection arrangement is simplified to that shown in Fig. 12.

Some preliminary work was done in connection witli this modified arrangement, but the project was abandoned owing to the outbreak of war. The author did not, moreover, subsequently resume work in this direction owing to his conviction that the disadvantages of the parallax stereogram, discussed briefly above, render this type of autostereoscopic picture insuitable for general adoption in the cinema. It is, nevertheless, of interest to note that an auto-stereoseopic system, at least as satisfactory as that now in use in Russia, was available in England no less than sixteen years ago.

Parallax Panoramagram Principle.

Towards the end of the war, when it became possible for the author to resume research into auto-stereoscopic film processes, his attention was devoted first to the possibility of utilising the principle of the parallax panoramagram. His investigations left him with little doubt that it would be possible to develop a cinematograph system embodying this principle which would be satisfactory from the point of view of the cinema patron. Film technicians and exhibitors, on the other hand, might take a different view, as research tends to indicate that the necessary photographic and projection equipment would almost inevitably be both cumbersome and complex.

In view of these considerations, therefore, the author commenced an investigation into the possibility of developing a new type of autostereoscopic photograph which would be capable of meeting the following requirements:

First, as in the case of the parallax stereogram, the constitution of the image to be such that all parts can be recorded simultaneously, thus obviating any « time parallax » when such images are produced cinematographically;

Secondly, as in the case of the parallax panoramagram, the orthoscopic viewing zones to be much wider than the pseudoscopic viewing zones.

By the end of 1946 it was found possible to lay down a precise specification for a photograph possessing the above characteristics. Early in 1947, however, work on auto-stereoscopic films had, once again, to be postponed in order that attention coul be given to the development of certain stereoscopic processes to meet existing demands in advertising and other fields. Work on the auto-stereoscopic film project was again resumed, at a low priority, about two years ago, and it can now be stated that, for some time past, production of the necessary type of photographic image has been an accomplished fact. The author is unable, at the present time, to disclose full details of the process, but a few brief particulars will no doubt be of interest.

Panoramic Parallax Stereogram.

The new type of photograph, known as the *panoramic parallax stereogram,* consists of a number of vertical picture elements which are viewed through a lenticular or line grid. Each pitch-distance of the image, unlike the parallax stereogram, does not contain a pair of homologous elements. The arrangement is such that each pitch-distance contains a view of a particular element of the scene, the aspect portrayer ranging from extreme « leftwards » at the right-hand edge to extreme « rightwards » at the left-hand edge. The disparity in aspect represented by these two extremes corresponds to a stereoscopic base of considerable magnitude. In this respect, j therefore, the image construction may be said to resemble that of the parallax panoramagram.

In the sketch, Fig. 13., P represents, to a greatly exaggerated scale, an element of a panoramic parallax stereogram being viewed through a single lenticulation of a grid G. The observer's left and right eyes respectively are denoted by L and R. The aspects represented by the element, the width of whoch is D, vary from extreme « rightwards » at R' to extreme « leftwards » at L'. Now, the points r' and V on the element which are visible to respectively the right and left eyes of the observer, are separated by a much smaller distance *d*. Further, matters are so arranged that, from the average viewing distance, the value of *d* approximates to $\frac{DE}{S}$ where E is the normal interocular distance, and S the effective stereoscopic base of the photographic apparatus, all dimensions being in the same units. As a result, the disparity between the aspects presented by the points r' and V is appropriates for the production of correct stereoscopic relief.

I can readily be shown that with a system of the type under discussion the orthoscopic viewing zones are approximately $(\frac{S}{E} - 1)$ times as wide as the pseudoscopic viewing zones. For cinematographic purposes a convenient value for S is in the neighbourhood of 20 ins., this resulting, as will' be evident, in an orthoscopic/pseudoscopic ratio of about 7/1, which may be regarded as a satisfactory value.

That then motion picture industry will eventually change over to auto-stereoscopy is beyond doubt, although, naturally, it is impossible to predict the precise nature of the various evolutionary stages through which it will pass. It seems, nevertheless, reasonable to believe that a system based on the principle of the panoramic parallax stereogram, preferably alied to a four-track stereophonic system such at that now in use at the Telekinema, would meet the industry's requirements for a good many years.

Small-scale projection tests with the panoramic parallax stereogram have already proved completely successful, and no unforeseen difficulty is likely to arise in adapting the system for projection on en full-size cinema screen. The manufacture of the necessary large lenticular grids need not be regarded as a major problem for two main reasons. First, as only a single layer of lenticulations is required, the composition of the grids is basically of a simple nature. Second, owing to the nature of the panoramic parallax stereogram image, the pitch of the lenticulations can be comparatively coarse, this factor contributing further towards simplicity of manufacture. A method of producing suitable large grids from a number of small units is at present being devised.

In connection with this matter generally, it is fo interest to note the following comments by Mr. R. Howard Cricks in the issue of the « Ideal Kinema » dated 16th August, 1951:

« Mr. Dudley has now demonstrated to me on a small scale that this » (i. e., projection of panoramic parallax stereograms) « is possible, by the projection of a three-dimensional image on a small screen... Advance details of this system have been given me by him, and my opinion is chat it could be adapted just as easily as the present polarized light system to any cinema, with a certain adjustment of the seating. In the Russian Ivanoff system probably one-third of the seating area is unusable; in the new system the only requirement is that the gangways should he suitably positioned.

« Further details of the system cannot be divulged until the patents are accepted. I do feel, however, that in this system we have the first practical and commercial method of cinema stereoscopy ».

From the foregoing it will be evident that the major obstacles to general adoption of auto-stereoscopy in the cinema have at last been overcome. It now remains for the industry to take advantage of the vast potentialities of the ney technique and to transform them into reality.

Much of the material contained in the present paper is based on information from the author's article « Stereoscopy in the Telekinema and in the Future » which appeared in the June, 1951 issue of « British Kinematography ». The author is, therefore, indebted to the British Kinematograph Society for their courtesy in permitting this material to be re-published herein. He also wishes to thank Messrs. Macdonal & Co. (Publishers) Ltd. for their permission to include some data from his recently publisher book, « STEREOPTICS ».

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Le "Cyclostéréoscope", procédé de cinéma en relief à vision collective directe sans lunettes

par Fr. SAVOYE
Inventeur

On sait que la perception du relief est due à l'observation d'un point situé dans l'espace, observé simultanément sous un angle différent par chacun des deux yeux du spectateur, la base de cet angle étant constituée par l'écart oculaire. L'exploration successive par chacun des yeux de points différents situés dans l'espace permet d'apprécier leur relief et leurs distances relatives dans l'espace considéré.

La stéréoscopie permet de reconstituer, par l'intermédiaire de la photographie, la sensation d'espace et de relief par l'observation simultanée de deux vues prises suivant une base convenable, chaque œil n'observant que la vue qui lui est destinée, à l'aide d'un stéréoscope.

LES PROJECTIONS EN RELIEF

Il existe actuellement deux méthodes:

1er - *les filtres individuels.*

Ces filtres sélectionnent les images projetées, afin que chaque œil ne voie que l'image qui lui est destinée. On a eu recours à des filtres utilisant des couleurs complémentaires dans les anaglyphes, (orange et vert, et bleu et jaune), mais ces procédés ont l'inconvénient d'exclure les projections d'images en couleurs; de plus, ils fatiguent la vue et interdisent de ce fait les projections de longue durée.

Actuellement on cherche à vulgariser un procédé qui utilise des filtres pour lumière polarisée, mais en dépit des perfectionnements apportés, l'absorption de lumière est trop considérable, et la fatigue de la vue qu'ils entraînent empêchent des projections de longue durée. C'est pourquoi il n'a jamais été possible de réaliser des films stéréoscopiques de long métrage. Signalons, en outre, que les spectateurs dans leur ensemble répugnent à porter des lunettes qu'ils jugent incommodes.

Pour conclure, nous dirons que les procédés à filtres individuels de sélection, si ingénieux soient-ils, ne peuvent être utilisés pour la vulgarisation du cinéma en relief.

2ème - *Le cinéma en relief à vision collective directe.*

Après les filtres individuels, la deuxième méthode consiste à utiliser *un système d'écran muni d'un sélecteur collectif* à travers lequel chacun des yeux des spectateurs ne voit que l'image qui lui est destinée.

De nombreux inventeurs ont d'abord cherché à utiliser le système des *trames à réseaux statiques* dont l'origine remonte au Français BERTHIER, en 1896.

Des variantes furent réalisées par IVES de Philadelphie en 1903, et par ESTANAVE, en France, en 1906. Ces trames étaient constituées par un réseau de li-