# DIRECT STEREOSCOPIC PROJECTION.

BY

THEODORE BROWN.

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PAPER BY MR. THEODORE BROWN.

*Read before the Optical Society, December 15th, 1904.*

THE opportunity now afforded me of bringing before your notice some of the results of my recent experiments I esteem an honour and one of great responsibility. The kindness you have extended to an outsider, such as myself, gives me confidence in anticipating the unanimous sympathy of this Society; and my only anxiety now is, that the pictures projected may come fully up to your expectations.

We shall look at pictures that have been produced at various stages during the development of this new system, and I ask for your kind allowances for varying imperfections, in the earlier productions. Euclid, and other philosophers of old, observed the dissimilarity of the two retinal images in binocular vision, but they do not appear to have conceived the idea of reproducing such phases for inspection in a stereoscope. Thanks, however, to the researches and ingenuity of such men as Elliott, Wheatstone, Brewster, and others, we now have this instrument, the means whereby the pleasing sensations of natural phenomena, may be imitated; nay, copied with such precision, that the keenest intelligence, the most alert observer, is deluded by so perfect illusions.

But despite the existence of this ready means for demonstrating the true nature of stereoscopic effects, misconceptions still persist as to what actually constitutes the term involved. Hence it will be as well for us to refresh our minds with the qualification demanded.

We are told that the word "stereoscope" is derived from two Greek words, signifying "solid" and "to see." So that we understand that to see an object stereoscopically, that object should be perceived not merely in relief of its surroundings, but also invested with the still more important property of "solidity." Any subject rendered with this two-fold qualification can truly be termed "stereoscopic."

This effect, which arises in the process of binocular perception, is also appreciated in dissimilar pictures in the stereoscope; but the limitations of that instrument have induced experimenters to look for some system of lantern projections that will enable a large audience to see the results simultaneously. Those of you who are acquainted with the excellent series of articles on this subject, contributed to the 'Magic Lantern Journal,' by Mr. Thomas Bolas, will remember that all the systems therein described depended for their final results on some sort of intermediate aids to be used by each person in the auditorium, such aids being composed either of coloured glasses, revolving shutters, refracting, reflecting, or polarising media.

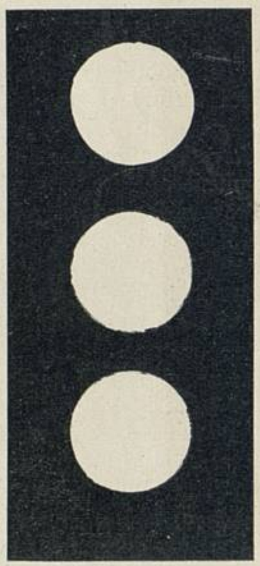


FIG. 1.

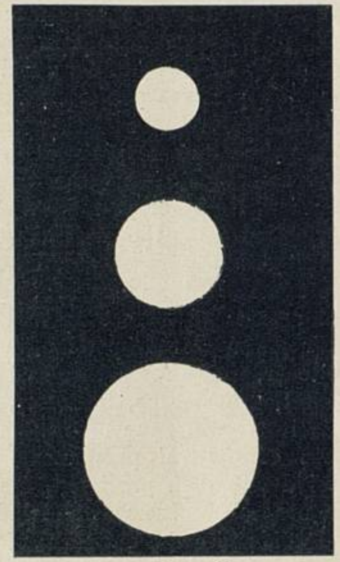


FIG. 2.

These necessities in the old systems were obvious drawbacks to success, and it is, therefore, with a certain degree of satisfaction that I am able to bring before your notice this evening, a system in which no intermediate aids are required; trusting that the degree of success the invention has as yet attained may be supplemented and strengthened by your kind approval.



Before we proceed to consider how stereoscopic effects are to be "directly" projected upon a lantern screen, I wish to draw your attention to some of the conditions of light and shade, that are calculated to suggest distance and solidity, which, however, are not stereoscopic effects. If we place three discs of white paper, fig. 1, equal in size and one above the other, there will be absolutely no illusion of relief, they will all appear to be situated at one distance from the eye.

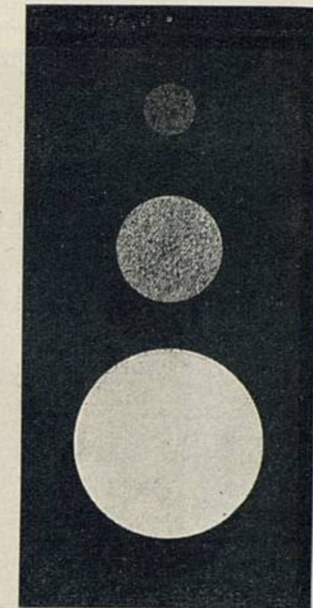


FIG. 3.

To perceive the illusion, hold this diagram at arm's length, and view with one eye only.

If, however, we vary the relative sizes of such discs, in the manner shown in fig. 2, we shall embrace the laws of proportion and perspective, and by so doing create in the observer's mind an idea that the smallest disc is the one farthest from the eye; the middle-sized disc at the intermediate plane, and the largest disc in the immediate foreground. But the illusion is weak, being somewhat unnatural; for if in nature we place three discs of equal size at varying distances from the observer, a close analysis of the retinal images will show that they not only vary in size, according to their respective distances, but that they will also vary as regards tone or luminosity.

Thus nature gives us the hint, that to suggest dissimilarity of distance, the largest of the three discs should be made the most brilliant, the middle size one less so, and the smallest one of the weakest tone. We will, therefore, take this hint and note the effect obtained (see fig. 3).

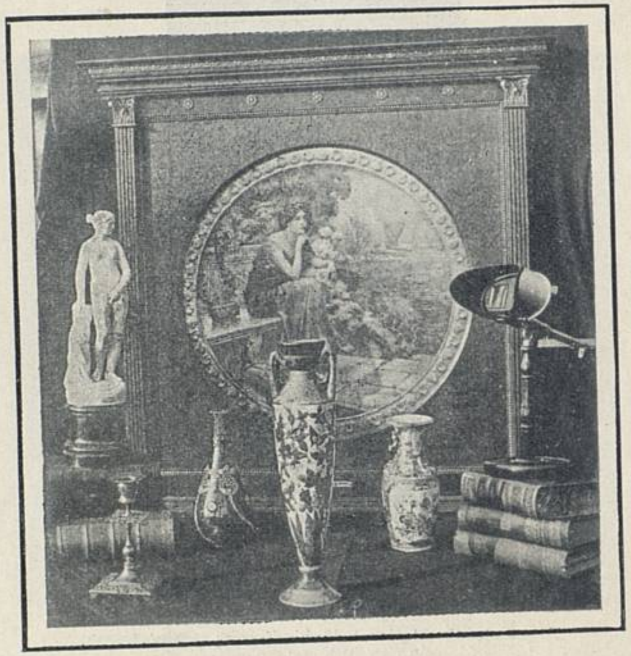


FIG. 4.

I think you will agree with me that it requires no extravagant imagination to enable us to appreciate the three discs here presented, as being located at different distances from the eye. This, then, is an example of an arrangement of light and shade capable of creating an illusion of relief, similar, yet not identical, with stereoscopic effect. We may now turn our attention to a second condition of light and shade which, in this instance, will



suggest solidity, namely, *local gradation of tone,* by which we mean the shading up of each individual object in a collection of objects. If we make a drawing of a group of models, such, for instance, as a cube—a vase—and a ball; the drawing may be perfect as regards its proportions and lineal perspective, but the absence of light and shade robs it of its power to delude.

Immediately we add this additional criterion, our drawing at once assumes solidity, and to the casual observer the subject may appear as real objects in space.

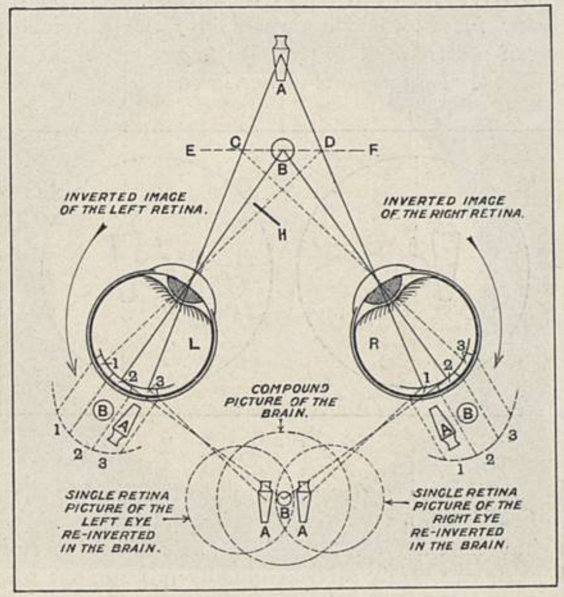



FIG. 5.

Subjects that lend themselves to this illusion are those that are already known to be solid, such as statuary, vases, etc., an example of which is shown in fig. 4. But this illusion also ceases to deceive under mathematical analysis.

We have looked at two conditions of light and shade, the first one capable of suggesting distance, whilst the second suggests solidity. A combination of the two, giving to us both solidity and relief, must not be confused with the solidity and relief of the stereoscope. We shall omit to mention the conditions of colour, insomuch that we know the stereoscope to depend on no such agencies for its peculiar results. Doubtless, we are all, more or less, acquainted with the causes of apparent solidity obtainable in the stereoscope; but it is not enough for us to know that because nature paints upon the two retinæ of the eyes images that are not precisely alike, and that, therefore, it is necessary that our pictures in the stereoscope should be correspondingly dissimilar. No! if we wish to strengthen our views on this subject it will be necessary for us to look deeper into the physical provisions of nature, and in practice to anticipate, as far as possible, the requirements of her laws.

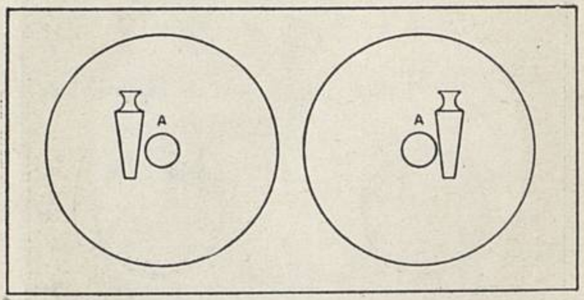



Fig. 6.

Let us, then, turn our attention to the diagram or section of the human eyes (fig. 5). The first fact to be observed is that there are corresponding parts in the two retinæ. Such parts are really microscopically minute, but for the sake of simplicity we shall suppose the little divisions marked 1, 2, and 3, to represent the parts referred to. When light emanates from any object and strikes corresponding parts in the two eyes, there will be a single impression produced in the mind, though that impression has a duplicate origin. Thus light emanating from the object B, which falls on part 2 in each eye, gives rise to a single image in the mind.

The axes of the eyes, an imaginary line drawn through the centre of the pupil to the retina, is always directed to the object of immediate attention, and will meet therein. Any object such as D, situated in the same



plane with the object of immediate attention, will also be projected upon corresponding parts of the two retinæ 1—1, and will also give rise to a single impression in the mind. An object such as the vase A, removed from the plane of immediate attention, will give rise to a double impression in the mind, two images of the single object being noticable.

This duplication of images is due to the light striking *contrary* parts of the two retinæ, 3 in the left eye, 1 in

Fig. 7.

the right. Perhaps this phenomenon is more clearly demonstrated (but in a reverse order) if we hold a single finger before the face and then gaze at a remote object. Two fingers are seen, one on either side of the distant object. If, now, we turn the attention away from the distant object, and centre the axes upon the near finger a single impression from the latter will arise, whilst the remote object, that hitherto appeared single, will now be duplicated.

This compound effect in the mind, when looking at a ball and vase, is represented within the large dotted circle of our diagram, whilst the compositions within the two smaller circles represent the respective images of the retinæ. If we placed photographic cameras, in the positions of the eyes, the dissimilar pictures of the vase and ball will be as indicated within the small dotted circles, and when mounted for the stereoscope would be as shown in fig. 6.

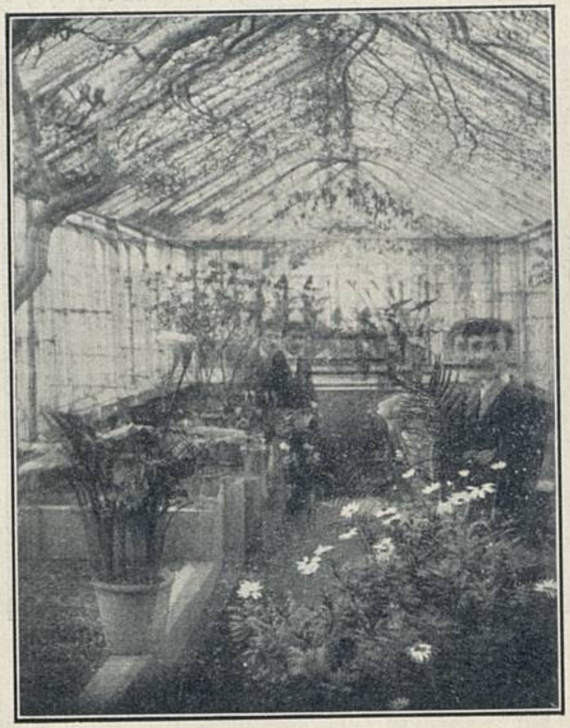


Fig. 8.

On examining these pictures in the stereoscope, it is possible to blend either the pictures of the ball or of the vase into one, but not both these objects may be seen singly at one adjustment of the axes. If we turn the attention particularly to the ball, we shall see a dim image of a vase on either side of it; and if we look more especially at the vase, then a single vase will be seen with



a dim image of a ball on either side of it, as shown in our next diagram (fig. 7).

From these considerations it is evident that in binocular vision no two planes can be absolutely superimposed at one moment, the cause being due to the dissimilarity of the retinal images obtained from separate view points. These facts are so vital to the remarks I have to make later, that I must venture to illustrate the truth in another way (fig. 8). Suppose we make a pair of transparencies from negatives obtained in a stereoscopic camera, these may be taken to represent the dissimilar images in binocular vision. If we superimpose the nearest object, *i.e.*, the white flower, we shall find it impossible to make the dissimilar images of the remote plane coincide. Hence, two images of the man in the background is seen, as in fig. 8. If we superimpose the remote images, then foreground objects will be duplicated.

Thus we find that the full and complete appreciation of a landscape involves a constant variation in the direction of the eyes' axes; and we may add, a constant readjustment of their refractive humours. These facts should suffice to dismiss from our minds the slightest entertainment of the erroneous idea that a single picture can, under any circumstances, produce stereoscopic effects. We have already stated that the limitations of the hand stereoscope induced experimenters to seek for the means whereby stereoscopic effects could be shown on the lantern screen. A review of all the methods devised would show that each inventor in his turn assumed that the only way of creating the desired result was to present the dissimilar pictures of the stereogram to the respective retinæ, so that each eye saw its proper element.

This assumption, which we shall endeavour to dispel, brought each inventor face to face with the awkward fact that the conditions of binocular vision made it necessary that each eye must not only see its proper element, but also that each must *not* see the element belonging to its companion. Under conditions of binocular vision, therefore, intermediate aids became the necessary nuisances. As far as scientific research has yet arrived, no system has been suggested that dispenses with the need of intermediate aids, and at the same time complies with the laws of binocular perception.

Seeing the hopelessness of ever solving the problem under binocular conditions, we were led to ask ourselves the question, "Is it not possible, in virtue of the sympathetic nature of the two retinæ, to transmit through a single eye mental impressions not differing very substantially from those gained during the use of both eyes?" In turning our attention to this new phase of the subject, we did not know at the time that we were about to propound a new theory, and do somewhat towards the development of a unique invention, namely, "Monocular Stereoscopy."

Many of the optical illusions to which our eyes are subject may be explained by the circumstance that the retentive power of the memory is superior, as regards duration of impression, to that of the retinæ of the eyes; and to this inequality of physical and mental persistence we attribute the possibility of "direct stereoscopic projection," or as we have otherwise termed it, "monocular stereoscopy." We have the united support of eminent philosophers, together with practical and ready proofs, that an image projected upon the retina persists but only ⅛th part of a second, whilst numerous examples could be supplied to show that such an impression will be retained in the mind for a very much longer period of time. It seems to have escaped the notice of all experimenters, that in virtue of the fact that there are corresponding parts in the two retinæ, we may use both or only one set of nerves for the transmission of pulsations to the brain; the result in the mind, under both circumstances, being substantially the same, though not minutely identical.

Referring again to the sectional diagram of the binocular system (fig. 5), let 1, 2, 3, in each eye represent the corresponding parts referred to. If we place two vases on the line E—F, at points C and D, respectively, cancelling the vase A, the image in the mind will be similar to that shown within the large dotted circle. This is with the axes still centred at B, as shown. What will happen if a shutter H is allowed to intercept the rays from D to the left eye L? Will any noticeable change take place in the compound image of the brain?

The answer is in the negative, because, although point 1 in the eye L is not stimulated as before, its corresponding point 1 in the companion eye R *is* stimulated, being uninterrupted by the shutter H. Hence whilst the vase on



the left in the compound image (within the larger dotted circle) will be transmitted thereto by companion nerves from point 3—and, therefore, will be a compound or binocular impression—the vase on the right within the large dotted circle will be a simple or monocular impression, because it is transmitted thereto only through one set of nerves, emanating from but one point, 1 in the right eye.

But whilst this is the case there will not have been any noticeable change in the mind by the interposition of the shutter H—the observer would not be conscious of any reduction of stimulus, unless his attention was particularly directed to the fact; and even then it would be with difficulty that he could determine from which eye the light had been excluded.

These facts seem to justify the conclusion that it is possible to fully convey to the mind the nature of a flat sur-

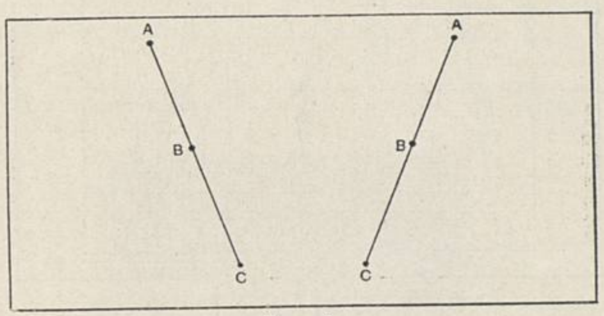
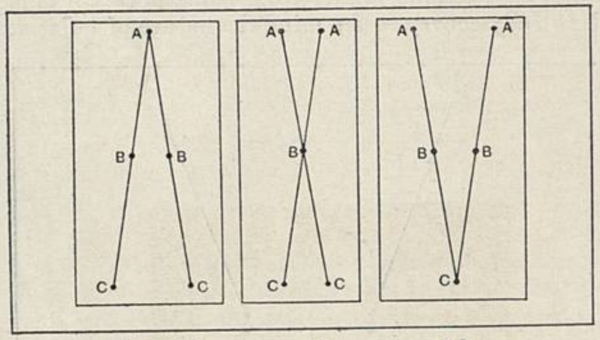



Fig. 9.

face, through both or only one set of the optic nerves, without substantial differences in the total effect produced, so that we are led to ask the question, "May we not go further and by some means transmit the sensations of depth also through both or a single eye?" Before we proceed to show how such results are to be brought about, we must observe that, as binocular vision consists more or less in an incessant modification in convergence and divergence of the axes to various planes, there must be a lateral displacement upon the retina of images of external objects as different ones are successively observed.

Thus, referring to figure 9, which represents the two elements of a stereoscopic picture of a long bar with knobs, when superimposed by the stereoscope, we may look successively at points A, B, C. Looking fixedly at A, we shall notice by oblique rays that C, C, do not coincide, and the impression in the mind will be similar to that shown at fig. 10. Sliding the axes along the bar and looking fixedly at C, the image in the mind will then be as 12, whilst if we look fixedly at B, we shall observe the effect shown at 11, *i.e.*, a **X.**

As we have already intimated, the sensation of relief in binocular vision arises during the active progress of the axes from one plane to another, and now we observe further, that the images of objects situated at varying distances from the observer traverse the retina laterally, crossing and recrossing the axes, as the latter concen-




FIGS. 10. 11. 12.

trates its attention upon various planes. Thus in looking from A to C (fig. 9 combined in the stereoscope) A first occupies the axial centre of the eyes, and then, as the attention is turned to C, A becomes doubled, and moves to the right and left of the axes simultaneously. This circumstance gives us the hint that if we oscillate to certain degrees different parts of a picture within a given time and in a proper manner, we shall at once create an artificial axial accommodation.

In our next diagram, fig. 13, we have the binocular or stereoscopic phases of a cone with its base farthest from the eyes, but these two figures show only the *extreme* phases, the most central intermediate phase being as indicated by figure 14. If, now, we present to the eyes or eye, not merely extreme phases (fig. 13), and a central



phase (fig. 14), but also a large number of intermediate phases coming between these, we shall then create in the mind a sensation of relief. A primitive method of carrying this experiment into practice is by using a disc (fig. 15).

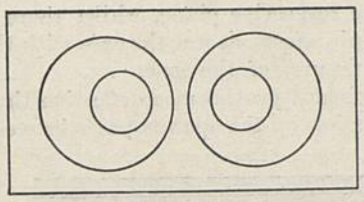


FIG. 13.

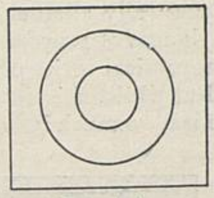


FIG. 14.

On close examination it will be found that the inner circle of 32 diagrams represents the dissimilar phases of a cone. On revolving the disc on its axis, and in front of a mirror, we may look through the slits from behind, thus viewing the successive diagrams by reflection in the mirror; this will give an impression of all the diagrams combined, resulting in an image in stereoscopic relief.

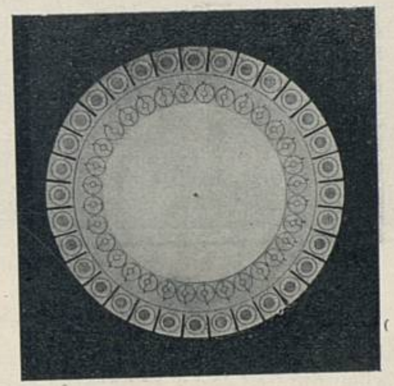


FIG. 15.

We thus demonstrate, though somewhat imperfectly, *persistence of vision* and *mental retention*, the apparent continuity of physical impression having to do with the first law, and the effects of relief with the second.

But to carry the same experiment to greater perfection we require photographic images. For this purpose we arrange a group of articles and take a number of phases by means of a camera. These pictures we arrange on a similar disc, fig. 16. On inspecting them in the same manner as we did the cone, we have the additional quality of tone to aid the senses, with the result that each article is naturally allotted its respective plane, whilst there is no danger of pseudoscopic effects, as was the case with the diagramical series of pictures of the cone.

But whilst this experiment proved more effective than the last, so much light is lost by the opaque parts between

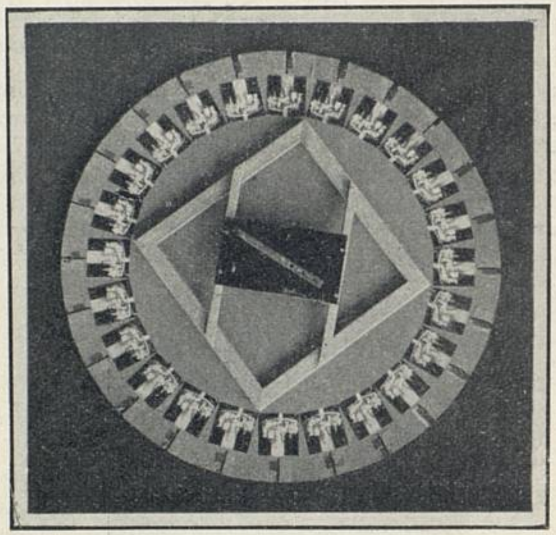


FIG. 16.

the slits that we found the series of pictures could be better seen when applied to an apparatus similar to the praxinoscope (fig. 17). In this instrument the illumination of the subject is continuous. The principle of monocular stereoscopic projection, which we hope is now made clear, naturally suggested calling into use different types of kinematograph cameras, whether for the production of stationary or animated subjects. For the latter it is absolutely necessary that such cameras should be used, and that the bioscope or kinematograph



projector should be employed for their exhibition upon a lantern screen.

Time will not permit us to dwell upon the possibilities of adapting monocular stereoscopy to the ordinary lantern. We first used the kinematograph camera in the manner indicated in fig. 18. A supplementary piece of mechanism was used, capable of operating the camera and at the same time, by means of a connecting rod, of oscillating a shelf or table upon which the subject was arranged. We will now look at a picture so obtained.

PROJECTION OF PICTURES BY MEANS OF A BIOSCOPE.—You will notice that whilst there is a pronounced stereoscopic effect produced, the results are somewhat discounted by the very apparent oscillation of the foreground objects. This movement is due to the fact that sufficient intermediate phases of the subject were not included; in other words, the number of dissimilar pictures contained in the complete cycle were too few. Recognising this, we proceed to increase the number of pictures in the cycle; and by so doing the oscillation is correspondingly r e d u c e d; and although there is a slight reduction in the stereoscopic effect, the result obtained is more agreeable to the observer.

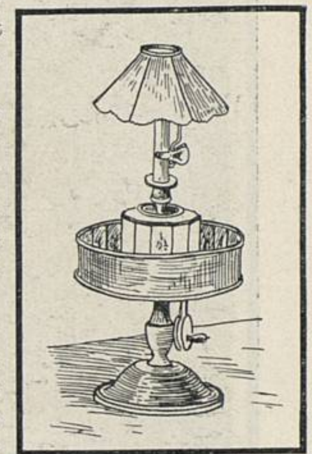


FIG. 17.

PROJECTION OF PICTURE BY BIOSCOPE, ILLUSTRATIVE OF THE LAST REMARKS.—It should be mentioned that the oscillation may be reduced in several ways; we may mention two here, viz., by enlarging the number of pictures in the cycle, or by decreasing the distance of displacement of the subject.

But the apparatus with which the picture of the vases was obtained could only be used for inanimate subjects, or for such small subjects as would permit of being placed upon a table; so that for animated subjects of any kind whatsoever, we devised the supplementary mechanism now shown upon the screen (fig. 19). On turning the handle, the camera is operated, and by means of a crank (not visible in the picture) the camera was reciprocated whilst resting upon a bed, and sliding on parallel bars. The displacement of the camera could be regulated to suit the subject in hand. The series of pictures obtained were not merely dissimilar as regards successive phases of motion, as in an ordinary kinematograph film, but also dissimilar along a horizontal plane at right angles to the subject. We will first look at some

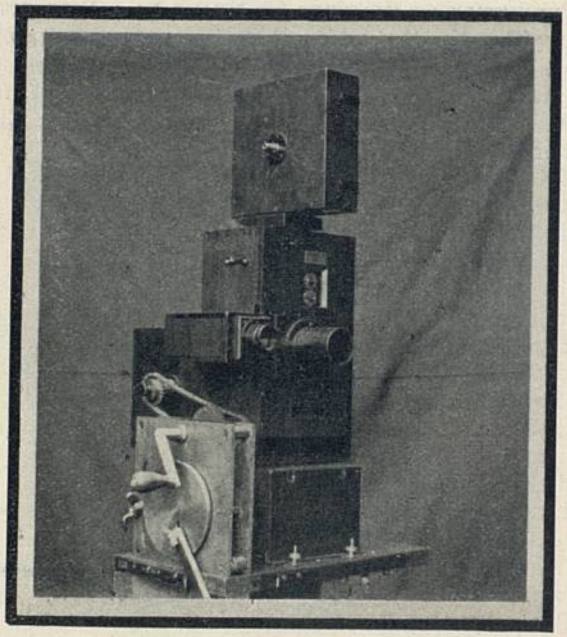


Fig. 18.

still-life subjects, taken by means of this apparatus. [Demonstrations with bioscope followed.]

Now, it was found that whilst the camera was allowed to oscillate, parallel to the subject, or with its axis at right angles to the subject, the side-swing of foreground objects proved somewhat disagreeable to the eye. To avoid this as much as possible concentricity of the axis of the lens was adopted. Thus, in reference to the figure upon the screen (fig. 20), as the camera (marked C) was



made to oscillate, the parallel bars upon which the camera bed reciprocated were curved, so that the axis of the lens concentrated upon a suitable or middle plane of the subject, radiating to a point A. By this means the oscillation of objects was distributed throughout the entire depth of the subject; thus dismissing to a very large extent all objectionable movements, as will be seen from the next two series of pictures shown. [Bioscope projections followed.]

Our next series is illustrative of Farm Scenes—commencing with the cows being driven home to the farm,

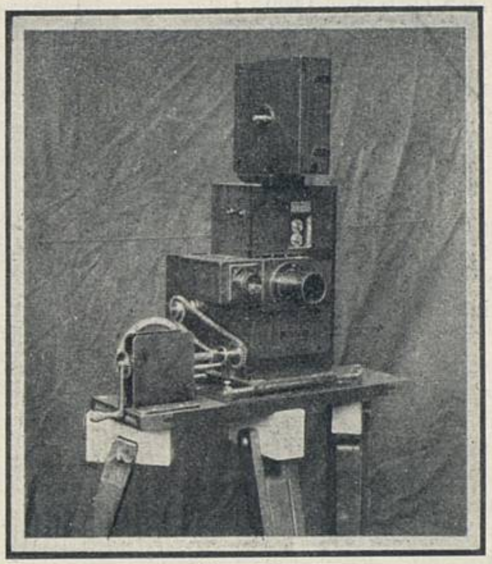


Fig. 19.

cows being milked, and finally, the process of making the butter. For these pictures, which were taken by the special stereoscopic apparatus already described, we are indebted to Mr. R. W. Paul, who is doubtless well known to most of you; and it is gratifying to be able to say that we have the co-operation of that gentleman in the work of producing stereoscopic living pictures. Mr. Paul is making extensive preparations to supply the market, and in view of the fact that, since these pictures were taken, improvements have been made in the patent apparatus, we can promise even better results in the future than as yet have been obtained. We will now proceed to take a peep into the country. [Bioscope projections again followed.]

The next picture we have to show (fig. 21) is of the still-life type. Here the axis of the lens radiated to a point six feet distant from the camera, and as the lady shown occupied the radiant point, you will note that she is absolutely stationary. [Bioscope projections of fig. 21 were then given.] It has been suggested by your worthy Vice-President, Mr. Charles Hyatt-Woolf, that to give a fair opportunity for judging the differences between these stereoscopic pictures and the ordinary cinematograph productions, the ordinary pictures should be shown, immediately followed with stereoscopic ones, and for this purpose we have taken the same subject, under both systems, and made one continuous band of the two. We do not know which will happen to be projected first, and we shall leave the audience to decide for themselves the distinction. [Bioscope projections followed.]

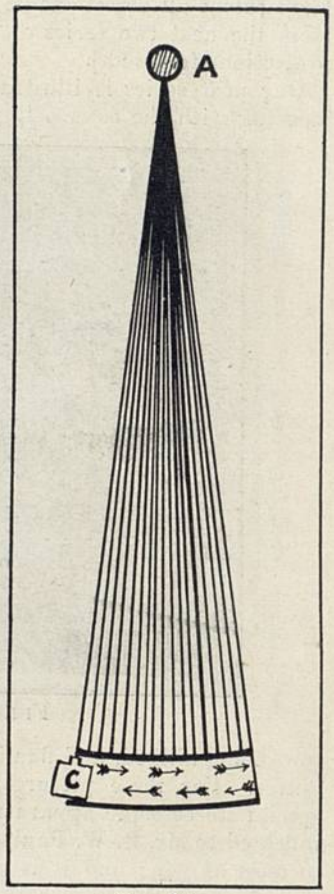


Fig. 20.

For the next series of pictures we have to thank Mr. Collier, of Messrs. Pathé Freres, who has been kind enough to allow us to include this subject in our programme to-night. Before looking at fig. 22, we may refer for a moment to the diagram upon the screen (fig. 23). If we use only one eye when looking



from a railway carriage window in motion, that eye will be carried in panoramic order, as indicated by the successive dotted circles. In viewing this external landscape, composed of objects at A, A 1, B, etc., let us sup-

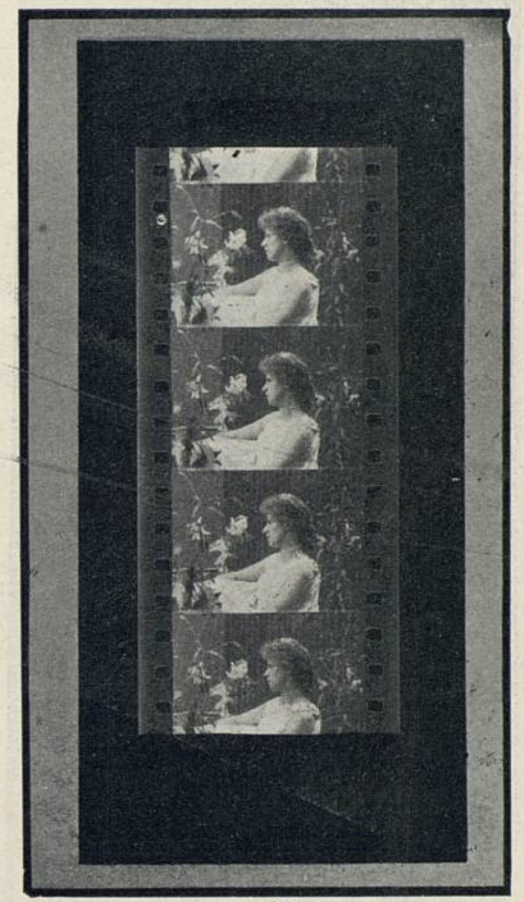


Fig. 21.

pose the attention to be directed to the remote object A. Whilst watching this, the eye, carried from C to D, will turn in its socket, with the motion of the train, so that the image of A, though viewed from successive positions, remains stationary upon the retina.

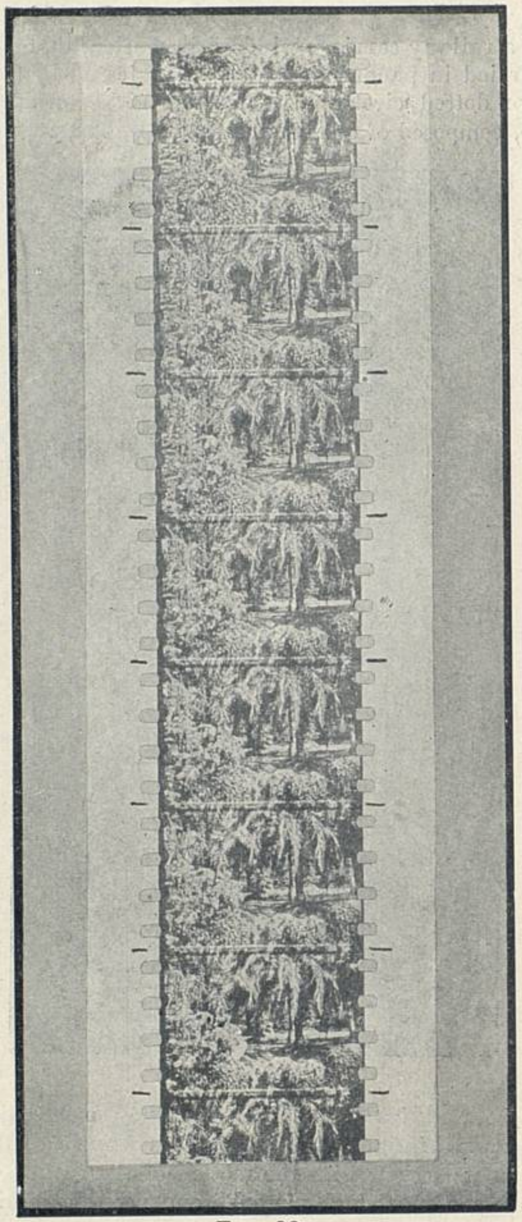


Fig. 22.



When it has reached D, by reason of inconvenience to continue its gaze, through the altered position of the train, it will suddenly turn to another object, A 1. This constant re-adjustment of the eye can be seen by looking at our companion on the opposite seat in the train, as he or she watches external things. The result is stereoscopic effect in the mind, which may be reproduced by placing a camera in the successive positions, C, D, E, etc., and photographing the landscape.

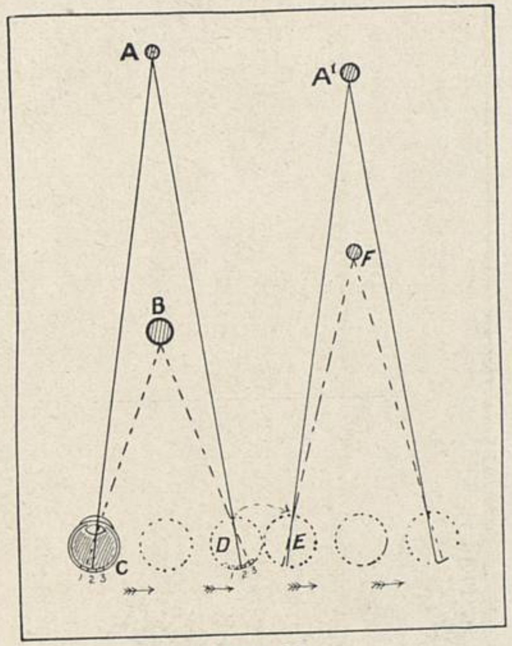



Fig. 23.

This may be done by means of a cinematograph camera operated upon any moving vehicle, and when a positive film, made from a negative so obtained, is projected in the usual manner upon a screen, stereoscopic effects will be the result. It is evident, however, that this panoramic and progressive movement cannot be applied to all subjects without interruption at short intervals; so that what we are endeavouring to do is to recroprocate the camera, or subject, in such a way that an equal stereoscopic effect may be retained, and this without pronounced oscillation of various parts. I think we may say that the pictures we have been looking at this evening justify the conclusion that "Direct Stereoscopic Projection" is no longer the dream of inventors, but a tangible and present reality.

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Printed by The Optician and Photographic Trades Review,
123-4-5, Fleet Street, London, E.C.