PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Production of Cinematographic Effects in Colour and Means therefor

We, ALBERT GEORGE HILLMAN, British Subject, of The Cottage, Braywick Road, Maidenhead, and GEORGE HARMER JOHNSON, British Subject, of Harlequin Avenue, Great West Road, Brentford, Middlesex, do hereby declare the nature of this invention to be as follows:—

This invention relates to a method of and means for producing negative bands containing a single series of colour constituent images (hereinafter termed negatives) which are suitable for producing corresponding positive constituents (hereinafter called positives) and to a method of projecting the positives on the screen in such a way as to give pictures in substantially natural colours.

The invention deals in particular with the production of cinematographic effects by the three or more colour process.

The invention aims at a process which will not involve departing from the standard single picture pull in the projector, and which will reduce objectionable colour fringing when the positives are projected.

In cameras as usually constructed for taking silent black and white pictures, the length of exposure of each negative is approximately 1/36 second, and the time between successive exposures approximately 1/29 second, the pictures being taken and projected at the rate of sixteen pictures per second. With the advent of sound films the speed was increased to twentyfour pictures per second, each exposure period occupying approximately 1/51 second, and the time between successive exposures approximately 1/45 second. It is undesirable to give each negative an exposure substantially longer than that during which each negative of a silent film would be exposed, or the movement in the scene would cause undue blurring in the negative. The same applies to each negative of a film of colour constituent negatives.

In the production of cinematographic effects in colour the taking of a single colour constituent negative at each stationary period of the film is unsatisfactory, for when dealing with fairly rapid motion in the scene being photographed, the time between exposures is sufficiently great to cause such lack of registration between the complementary negatives as to give rise to considerable colour fringing when the positives are projected. If on the other hand three constituent negatives are taken simultaneously with a time of exposure limited as aforesaid, then an excessive length of film is required which does not conform to the commercial requirements of the sound synchronization with the pictures; furthermore great strain would be imposed on the camera mechanism, and a three picture pull projector would be required.

One object of the invention is to obviate the foregoing difficulties in the taking of the negatives and to do this in such a manner that the postives produced from the negatives can be projected with a projector employing the standard single picture pull.

To these ends in accordance with this invention the individual negatives of a group of constituent negatives, say one taken through a red filter, one through a green filter and one through a blue filter, are taken in quick succession at one stationary period of the film with, if desired, some overlapping in the time of exposure of adjacent negatives, a succession of similarly taken groups being produced along the film, and the number of film shifts per second is so reduced that each of the successively taken negatives can be given a predetermined sufficient time of exposure equalling or approximating for example the time of exposure of an ordinary silent film negative. The negatives of each group are preferably taken by exposure to parts of the same main beam.

The method of projecting the positives produced from such a negative film is to maintain the single picture pull but to project two adjacent images in superposition at each projection, that is at each stationary period of the film, so that each constituent will be projected twice viz., with a constituent preceding it at one projection and with a constituent following it at another projection, these

projections succeeding one another, and persistence of vision being relied upon to blend the colours.

Although persistence of vision is relied upon to blend the colours, that fatigue to the eye of the spectator, due to colour pulsation, which is incidental to two colour processes relying on persistence of vision for this purpose is reduced or avoided, as the colours reflected by the screen are the relatively high transparency complementary colours formed by combining at each projection beams of two of the primary colours. Thus, assuming the sequence of projection of the beams is (1) red plus green, (2) green plus blue-violet and (3) blue-violet plus red, the beams forming the combination (1) tend to produce pale yellow, the beams (2) to produce a light blue and the beams (3) to produce magenta.

At two out of every three projections therefore constituents will be superposed which have been produced as a result of exposures with only a very short, if any interval between them. Moreover by suitably arranging the filters in the camera such a negative film can be produced that when the positives are projected the red constituent is never projected with a positive which has been obtained from a negative whose exposure was separated from the exposure of the red constituent by a film shift period, but on the contrary at each third projection when the positives of two such time-separated negatives are in the gate, it can be ensured that green and blue positives are projected so that any fringing resulting from lack of registration between time separated images is not so apparent as that which would occur if the highly contrasting red fringe were permitted. Moreover, the fringing effect of this lack of registration can be reduced or avoided by arranging that at every such third projection the two images are projected in super-position through the appropriate green and blue filters but a phase or phases is or are intermitted during which the images being superposed are for a part of their exhibition projected through filters which unbalance the colour reconstitution and set up temporary colour confusion which is not such as to be detected by the observer, yet breaks up the persistence of the fringing colours. Confusion filters may be used which retain the resultant light blue complementary reflected rays during this period of projection. For example a green filter phase can be interposed in the projection of the image taken through the blue filter and a blue filter phase during the projection of the image resulting from exposure through the green filter.

A camera suitable for taking the negatives in the case of three colour work is arranged to operate a film shift of three picture frames in one pull, the time for the complete operation of, (1) cover, (2) pull, and (3) exposures occupying 1/8 second, the exposures being made through three apertures preferably to branch beams of an optical system having a single main entering beam so that each negative is taken from substantially the same aspect. A suitable stationary system of filters may be used. The exposures can be controlled by a shutter which allows three picture frames of the film to be exposed successively whilst the film is at rest, and these exposures can be timed to overlap somewhat, i.e., for the exposure of one frame to commence before the exposure of the preceding frame finishes so as to produce a dissolving effect between successive images recorded on the three frames, or a very short time gap can be introduced, say from as short as 1/1000 of a second between the successive exposures.

One form of rotating shutter comprises three arcuate apertures at different radial distance from the axis of rotation and arranged in such circumferential displacement as successively to expose the windows of a triple windowed gate. The circumferential dimension of the apertures may be appropriately increased in accordance with the distance of the aperture from the axis of rotation so that the time of exposure of each window is equal, but it may be found convenient so to proportion the apertures that the exposure through the red filter is of greater duration than the exposures through the blue and green filters, and it is preferred to associate the red filter with the middle window of the vertical group of three windows.

The angular layout of the apertures and of the cover sector of the shutter may be so proportioned that if the film is moved down eight times per second, the cover period (including picture pull period) occupies 1/28.8 second, the exposure in the lowest window (e.g., exposing the green filter) 1/36 second, the exposure in the middle window 1/28.8 second and the exposure in the top window 1/36 second.

As the film is at rest during the period of the three exposures, it is possible to vary these exposures one with another for the purpose for example of adjusting for the different transmission powers or other factors of the different filters.

It will be observed that the positives

obtained from negatives exposed at the same rest period in the lower and top windows are never projected together, consequently there is no time factor or substantial time factor or loss of movement between any two frames within each group of three and therefore lack of registration of moving objects in adjacent images of the group will not be very pronounced.

The form of shutter described has to be of comparatively large diameter but other more compact shuttering systems may be used.

For example, a pair of rotary shutter discs may be arranged to rotate in opposite directions, there being an arcuate aperture and an arcuate marginal notch in one disc which respectively expose an end window and a middle window, and the other disc having a marginal notch or aperture to expose the other end window, the apertures and notches being arranged to come into action successively in proper timed relationship.

In another shutter device a pair of shutter discs each provided with a marginal exposure notch rotate in opposite directions and each expose an end window at the predetermined time, whilst an oscillating or reciprocating shutter, e.g., actuated by suitable cam mechanism may be used for exposing the middle window in proper timed relationship with the exposures of the end windows.

Alternativeley a shutter for the middle window may work with a horizontal reciprocatory motion by being connected to a crank arm rotating at half the speed of two disc shutters controlling exposures in the top and bottom windows, e.g., at four revolutions per second so that when the lower disc shutter is about to commence to close the lower window the crank starts to rise and when it has risen 45° the middle window (preferably exposing through a red filter) is just beginning to be exposed to a vertical slit like aperture in the reciprocatory shutter, this aperture moving across the window during the next 90° of crank movement, whilst during the next 45° of crank movement the top window is exposed so that three pictures are exposed in 180° of crank movement.

In another form of shutter employing oppositely rotating discs, each disc may have an arcuate aperture registering with an end window and also a marginal notch which registers with a marginal notch in the other disc for exposing the middle window.

In still another form of shuttering device, an oscillating sector may be employed having three apertures at different radial distances from the rocking axis, and appropriately circumferentially displaced or stepped so as to come into line successively with the vertical axis through the three windows. The sector is geared or linked to expose the windows when moved in one direction, while during the return stroke a common pivoted shutter sector swings across all the windows to allow the film to be shifted. The aperture sector may be linked up to a lever carrying a roller which is actuated by a peripheral edge cam to rock the sector, and the common shutter sector may be geared to the cam shaft.

There may be some circumferential overlap of adjacent apertures and/or notches so that the exposure of one picture frame is commenced before the exposure of the adjacent frame, or some small angular separation, e.g., 10° may sometimes be left between the apertures.

Any well known accelerated film shift mechanism may be employed so as to keep the cover period short while the film is being moved through three picture frames. The cover period can be safely reduced to say 1/36 second if desired. For example the time factors may be as follows:—

Cover and pull	80	degrees	1/36. sec.
1st exposure	85	,,	1/33.8823 sec.
Time gap	10	,,	1/288 sec.
2nd exposure	90	,,	1/32 sec.
Time gap	10	,,	1/288 sec.
Third exposure	85	,,	1/33.8823 sec.

Or if there is no angular separation between the apertures or notches:—

Cover and pull	80	degrees	1/36 sec.
1st exposure	91	,,	1/31.648 sec.
2nd exposure	98	,,	1/29.285 sec.
3rd exposure	91	,,	1/31.648 sec.

The choice of optical system employed in the camera is important in order to ensure that the picture pitch, i.e., the spacing of the images along the film is maintained constant. For this purpose any one of the optical systems described in our co-pending application No. 11114 filed 17th April, 1936 (Serial No. 478,500) could be used, or in front of each lens a reflector can be set at about 45° and the said reflectors spaced at different distances from the lenses so that one or more reflectors receiving an entering beam can be positioned below or at one side of the three reflectors for the purpose of reflecting the beam on to such reflectors. In any of these systems the reflectors should be appropriately adjustable, e.g., rotatably mounted under fine

screw control, for attaining accuracy of picture pitch. It is preferred to use plane reflectors of optical steel.

Each gate can be suitably notched to indicate its particular colour record so as to facilitate correct splicing of different film lengths.

Dated this 25th day of July, 1936.

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COMPLETE SPECIFICATION

Production of Cinematographic Effects in Colour and Means therefor

We, ALBERT GEORGE HILLMAN, a British Subject, of "The Cottage," Braywick Road, Maidenhead, Berkshire, and GEORGE HARMER JOHNSON, a British Subject, of Harlequin Avenue, Great West Road, Brentford, Middlesex, 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 improved methods of and means for producing cinematographic negative bands containing a single series of colour constituent images (hereinafter termed negatives) which are suitable for producing corresponding positive constituents (hereinafter called positives) and to a method of projecting the positives so made on the screen in such a way as to minimise eye strain and to obtain improved multi-colour effects.

The main object of the invention is the production of constituent images in three or more colours in a single series, which can be subsequently projected without departing from the standard single picture pull, and which will reduce eye strain and colour fringing on the screen.

In cameras as usually constructed for taking silent black and white pictures, the length of exposure of each negative is approximately 1/36 second, and the time between successive exposures approximately 1/29 second, the pictures being taken and projected at the rate of sixteen pictures per second. With the advent of sound films the speed was increased to twenty-four pictures a second for such films, each exposure period occupying approximately 1/51 second, and the time between successive exposures approximately 1/45 second. It is undesirable to give each negative an exposure substantially longer than that during which each negative of silent film would be exposed since in such case the movement in the scene would cause undue blurring in the negative, and this applies also to each negative of a film of colour constituent negatives.

In the production of cinematographic effects in colour the taking of a single colour constituent negative at each stationary period of the film is unsatisfactory, for when dealing with fairly rapid motion in the scene being photographed, the time between exposures is sufficiently great to cause such lack of registration between the complementary negatives as to give rise to considerable colour fringing when the positives are projected.

If on the other hand three constituent negatives are taken simultaneously at each such stationary period then, if visual continuity is to be preserved in reproduction, three times the normal number of image areas must be taken involving an excessive length of film, which does not conform to commercial requirements or to sound synchronisation of the picture and the use of a three picture pull would be required on the projector.

Furthermore a very rapid film shift which would be required would impose great strain both on the camera and the film itself.

An object of the present invention is therefore to reduce the number of projections of images which are out of phase with the previous image by a time represented by a film shift period and also to avoid the alternate projection of images which are alike and register and images which are out of phase by a shift period of the film; and to cause the motion analysis between a series of projected images to exhibit itself more gradually or in other words to obtain a merging of the motion from one picture to the next so that whilst each picture represents a different motion analysis from the next, the difference of two out of every three projections is less than that resulting from a time separation incident to a shift of the film.

According to the present invention the individual images of a group of three colour constituent images are taken in quick succession at one period of rest of the film by exposure of the image areas to different colour beams so that the exposure of one image area is completed

before the exposure of the next begins, each image area receiving its full exposure during the one period of rest of the band.

The images of each group are taken of the normal size following one after the other along the band, and a succession of groups are produced along the band so as to form a single series of images, and accordingly the invention is not to be regarded as extending to or including methods in which, on an area corresponding to the usual size of picture, two or more small pictures are produced, either following each other, or side by side, or as a triangular series, or to any method in which the film is shifted laterally between longitudinal shifts. We also exclude methods in which moving mirrors or prisms are employed, since these involve great difficulties in ensuring accurate registration of the images. In order to obtain a full exposure of each image at one stationary period of the film, despite the fact that a plurality of images are taken during such period, such factors as the rapidity with which the emulsion on the band is responsive to the image-carrying beams, the density of the colour filters and the lens apertures selected must all be considered, but providing the camera is so constructed as to permit the necessary time of exposure, as is the camera hereinafter described, the experienced cinematographer will have no difficulty in obtaining a correct exposure. In general the camera would be constructed so as to give a fixed time of exposure for each image area, interchangeable filters and/or variations of the lens apertures being resorted to for accommodating different photographing lights.

As an alternative to completing the exposure of each of the three image areas taken at the same stationary period of the band before the exposure of the next begins, there may be overlapping in the exposures of adjacent image areas but not of the first and third.

In designing the camera hereinafter described, the aim has been to make the taking of the images conform to the requirements of present day projection, i.e., so as to enable the positive film to be projected by the standard pull mechanism in which the film is advanced at the rate of twenty four pictures per second and by single picture shifts. The camera as hereinafter described is intended for the three colour process and is arranged to operate a film shift of three image areas in one pull, the time for the complete operation of (1) cover, (2) pull and (3) exposures occupying 1/8 second. Consequently the film is only pulled eight times a second and at the time which the remaining sixteen shifts and the corresponding covering operations would occupy, or a substantial part of such time is saved, the necessary time for the exposure of each image is readily obtained. Even if there is no overlap of the exposure of any adjacent two of the images of each group, the time of exposure can be made substantially greater than that given to each image of an ordinary black and white sound film so as to allow for the loss of light due to the interposition in the beam of (a) colour filters and (b) means for splitting up the entering beam where such means are used. On the other hand, if any lengthening of the time of exposure is needed, the exposure of the second image of a group could commence before the exposure of the first is completed, and the exposure of the third before the exposure of the second is completed.

If, as is preferred, a beam splitting system is used the images taken at one period of rest of the film will have been exposed from the same aspect. A suitable stationary system of filters may be used in the camera. The exposure can be controlled by a shutter which allows three picture frames of the film to be exposed successively whilst the film is at rest, and these exposures can be timed to overlap somewhat, i.e., for the exposure of one frame to commence before the exposure of the preceding frame finishes so as to produce a dissolving effect between successive images recorded on the three frames, or a short time gap can be introduced between the successive exposures.

The preferred method of projecting the positives produced from such a negative film is to maintain the single picture pull but to project two adjacent images in super-position at each projection, that is at each stationary period of the film, so that each constituent will be projected twice, viz., with the constituent preceding it at one projection and with the constituent following it at another projection, these projections succeeding one another, and persistence of vision being relied upon to blend the colours.

Although persistence of vision is relied upon to blend the colours, that fatigue to the eye of the spectator, due to colour pulsation, which is troublesome in two colour processes relying on persistence of vision for this purpose, is reduced or avoided, as the colours thrown on to the screen are the relatively high transparency complementary colours formed by combining at each projection beams of two of the primary colours. Thus, assuming the sequence of projection of

the beams is (1) red plus green, (2) green plus blue-violet and (3) blue-violet plus red, the beams forming the combination (1) tend to produce pale yellow, the beams (2) to produce a light blue and the beams (3) to produce magenta.

At two out of every three projections therefore constituents will be superposed which have been produced as a result of exposures with only a very short, if any, interval between them. Moreover by suitably arranging the filters in the camera, such a negative film can be produced that when the positives are projected, the red constituent is never projected with a positive which has been obtained from a negative whose exposure was separated from the exposure of the red constituent by a film shift period, but on the contrary at each third projection when the positives of two such time-separated negatives are in the gate, green and blue positives are projected so that any fringing resulting from lack of registration between time separated images is not so apparent as that which would occur if the highly contrasting red fringe were permitted.

The fringing effect due to lack of registration can be also reduced or avoided by arranging that while at every such third projection the two images are projected in super-position through the appropriate green and blue filters, the images being superposed are for a part of their exhibition projected through filters which unbalance the colour re-constitution and set up temporary colour confusion which is not such as to be detected by the observer, yet breaks up the persistence of the fringing colours. For example, a green filter can be interposed in the projection of the image taken through the blue filter and a blue filter during the projection of the image resulting from exposure through the green filter.

Similar temporary confusion can also be introduced where the images being shewn have been taken during the same rest period of the film, though this is in general less necessary. In some cases two or more conflicting filters can be so introduced, e.g., a blue and a red in a green phase and the confusion colours introduced need not necessarily be the same as those of the other phases.

In some cases more than two frames may be simultaneously exposed in the projector but we consider that generally this is not desirable.

In order that the present invention may be the more readily understood, reference is made to the accompanying drawings in which a camera suitable for taking pictures according to the present process, and a filter system suited for the projection of the positive film are illustrated, but this is by way of example only and to illustrate the best methods known to us, as the main features of the process are not dependent on the particular apparatus employed.

Fig. 1 is a front view of the camera with the light-dividing system and the lenses removed to show the shutters and the gearing therefor.

Fig. 2 is a general view of the shutters in another position.

Fig. 3 is a similar view of the shutters in still a further position.

Fig. 4 shows a side view of one form of optical light dividing system used for carrying out the invention.

Fig. 5 is a front view of the camera similar to Fig. 2 but having the shutters removed and the gate and filter carrier mounted in position.

Figs. 6, 7, 8 and 9 show variant forms of shutters.

Fig. 10 shows a filter suitable for use in the projection of the positive band.

The camera comprises three objectives 65, 66, 67, in front of which is a light dividing and directing system. Behind the lenses is a partition containing three openings 8, 9 and 10, one opening being behind each objective, these openings allowing light to pass to three exposure windows. Before the windows is a filter carrier 11 (Fig. 5) containing a red filter 12, a green filter 11*a* and a blue-violet filter 13, and the exposures in the windows are controlled by a pair of shutters 15 and 16.

The shutters are driven from a helical pinion 17 on the main shaft 18 of the camera, the shutter 15 deriving drive from the pinion 17 through gears 19 and 20 and the shutter 16 through gear 21, idler wheel 22 and gear 23. The main shaft of the camera is driven for example by an electric motor in any convenient or usual manner.

The shutter 15 is provided with an aperture 24 through which the upper window 8 is exposed, and the shutter 16 has an aperture 25 for exposing the lower window 10, whilst each shutter is provided with a marginal notch 26, which notches are so situated and the drive of the shutters so timed that the notches will pass the middle window at the same time and together expose the whole of such window.

The shutter apertures and the shutter drive are so arranged that the windows are exposed successively, as can be seen by reference to Figs. 1 to 3. In Fig. 1 the shutter aperture 25 is just commencing the exposure of the lower window, the

bottom shutter rotating in a clockwise direction and the upper shutter in an anti-clockwise direction as shown by the arrows. Almost immediately after the exposure of the bottom window has been completed, or if desired before or simultaneously with the end of such exposure, the notches 26 commence to expose the middle window, Fig. 2 showing the middle window completely exposed, whilst soon after the exposure of the middle window has been completed, or before or simultaneously with the end of such exposure, the aperture 24 in the upper shutter commences to expose the upper window. Fig. 3 shows the aperture 24 in a position at which the exposure has nearly been completed.

Three images taken successively through the respective windows are produced at each stationary position of the film. The film is then moved down by a distance of three picture frames during the time that the opaque sectors 27, 28, in front of the aperture 25 and behind the aperture 24 in the direction of rotation of the shutters, are passing across the window.

The mechanism preferred for moving the film the aforesaid distance is that described and claimed in our co-pending application No. 23659/36 (Serial No. 483,819) the mechanism preferably being constructed to permit of an accelerated film shift.

It is preferred to take the successive images through an appropriate light-dividing system so as to avoid as far as possible the effects of parallax. A suitable light dividing and directing system for this purpose, as shown in Fig. 4, is used in conjunction with the three matched lenses 65, 66, 67, one to each window. In front of the middle objective lens are arranged a pair of reflectors 68, 69 lying in intersecting planes and of such a character as to permit part of the incoming beam to pass therethrough and through the middle objective to form one constituent image, another part of the beam to be reflected by the back reflector 69 on to a reflecting prism 70 arranged before the top objective so as to reflect such part therethrough to form the image in the top window, and another part to be reflected from the front reflector 68 to a prism 71 arranged before the lower objective so as to reflect this part through such objective to form the third image. This prism system 71 comprises reflecting surfaces 72, 73, 74 which reflect light received from reflector 68 to the lower objective.

No claim is however made to this special light dividing system, as any suitable light dividing system may be used e.g., those shewn in Figures 9 and 10 of Patent Application 478,500.

The camera may be advantageously constructed with a focussing system as described and claimed in our concurrent application No. 24614/36 (Serial No. 483,820).

Figs. 6 to 9 show variant forms of shutters. In the form shown in Fig. 6, the pair of shutters is replaced by a single rotating shutter comprising three arcuate apertures 100, 101, 102 at different radial distances from the axis of rotation and arranged in such circumferential displacement as successively to expose the windows of the triple windowed gate. The circumferential dimension of the apertures may be appropriately increased in accordance with the distance of the aperture from the axis of rotation so that the time of exposure of each window is equal, but in this and the other forms of shutter described it may be found advisable so to proportion the apertures that the exposure through the red filter is of greater duration than the exposures through the blue and green filters, and it is preferred in all cases to associate the red filter with the middle window of the vertical group of three windows.

The last mentioned form of shutter described has to be of comparatively large diameter, and is therefore not so compact as the first form described. Other shuttering systems may however be used.

For example, as in Fig. 7 a pair of rotary shutter discs 103, 104 may be arranged to rotate in opposite directions, there being an arcuate aperture 105 and an arcuate marginal notch 106 in one disc which respectively expose an end window and a middle window, and the other disc having a marginal notch 107 or aperture to expose the other end window, the apertures and notches being arranged to come into action successively in proper timed relationship.

In the shutter device illustrated in Fig. 8 a pair of shutter discs, each provided with a marginal exposure notch 109, 109 rotate in opposite directions and each expose an end window at the predetermined time, whilst an oscillating shutter 110, e.g., actuated by suitable cam mechanism 111 may be used for exposing the middle window in proper timed relationship with the exposures of the end windows. The cam rocks the arm 111*a* carrying the shutter 10 when the bottom and top windows are covered. A spring 111*b* returns the arm 111*a* when the cam so permits. The arm carries a roller 111*c* which is engaged by the wide part of the cam when the arm is to be rocked.

Alternatively a shutter for the middle window may work with a horizontal reciprocatory motion by being connected to a crank arm rotating at half the speed of two disc shutters controlling exposures in the top and bottom windows, e.g., at four revolutions per second so that when the lower disc shutter is about to commence to close the lower window the crank starts to rise and when it has risen 45° the middle window (preferably exposing through a red filter) is just beginning to be exposed to a vertical slit like aperture in the reciprocatory shutter, this aperture moving across the window during the next 90° of crank movement, whilst during the next 45° of crank movement the top window is exposed so that three pictures are exposed in 180° of crank movement.

In the form of shuttering device shown in Fig. 9, an oscillating sector 112 may be employed having three apertures 113, 114, 115 at different radial distances from the rocking axis, and appropriately circumferentially displaced or stepped so as to come into line successively with the vertical axis through the three windows. The sector is geared or linked to expose the windows when moved in one direction, while during the return stroke a common pivoted shutter sector 116 swings across all the windows to allow the film to be shifted. The aperture sector may be linked up to a lever 117 carrying a roller 118 which is actuated by a peripheral edge cam 119 to rock the sector, and the common shutter sector may be geared to the cam shaft through gears 120, 121.

The angular layout of the apertures and of the cover sector of the shutter may be so proportioned that if the film is moved down eight times per second, the cover period (including picture pull period) occupies 1/28.8 second, the exposure in the lowest window (e.g., exposing the green filter) 1/36 second, the exposure in the middle window 1/28.8 second and the exposure in the top window 1/36 second.

As the film is at rest during the period of the three exposures, it is possible to vary these exposures one with another for the purpose of example of adjusting for the different transmission powers or other factors of the different filters.

There may be some circumferential overlap of adjacent apertures and/or notches so that the exposure of one picture frame is commenced before the exposure of the adjacent frame, or some small angular separation, e.g., 10° may some times be left between the apertures.

With the aid of the accelerated film shift mechanism employed in the intermittent mechanism according to our said co-pending application No. 23659/36 (Serial No. 483,819) the cover period can be kept short while the film is being moved through three picture frames. The cover period can be safely reduced to say 1/36 second if desired. For example, the time factors may be as follows:

Cover and pull	80	degrees	1/36. sec.
1st exposure	85	,,	1/33.8823 sec.
Time gap	10	,,	1/288 sec.
2nd exposure	90	,,	1/32 sec.
Time gap	10	,,	1/288 sec.
Third exposure	85	,,	1/33.8823 sec.

Or if there is no angular separation between the apertures or notches:—

Cover and pull	80	degrees	1/36 sec.
1st exposure	91	,,	1/31.648 sec.
2nd exposure	98	,,	1/29.285 sec.
3rd exposure	91	,,	1/31.648 sec.

Each gate can be suitably notched to indicate its particular colour record so as to facilitate correct splicing of different film lengths.

This invention deals with the method of taking different constituent frames and also with the method of their production on the screen and not with the choice of particular colour filters.

The character of the colour filters used depends on the conditions under which the negative film is to be taken; for example, filters which are suitable for full daylight (external scenes) have to be varied somewhat for white arc light or half-watt light (internal scenes), there being usually a preponderance of red actinic rays in the half watt light which makes it desirable to restrict the amount of light passing to form the red image and to increase the amount of light which is passed by the blue filter. Moreover, filters of less density should be used for morning or evening light than would be used for full daylight. The light dividing system is computed according to well known methods to give a suitable apportionment of the main entering beam of light to the respective filters, and it is readily possible for the skilled person in the art knowing the apportionment of the light to select the filters suitable for such an apportionment. By way of example, a system designed for outdoor use in good average daylight, would be satisfactory if the light were apportioned in the following manner; 45% Green, 25% Red and 30% Blue, and if with such a system the filters sold under the Wratten Nos. 58 (Green), 25 (Red) and 47 (Blue) be used.

In a system designed especially for indoor work, i.e., for use with incandescent lighting, it would be satisfactory to divide the main beam as follows: 35% Green 14% Red and 51% Blue, employing Wratten filters of the same numbers as before, i.e., 58 (Green) 25 (Red) and 47 (Blue). These figures are suitable for an Eastman-Kodak supersensitive panchromatic film.

The same light apportionment and filters as are used for good average daylight will also serve for photographing in arc light. This light apportionment will also serve for morning and evening or dull or bright outdoor light provided the filters and the lens apertures are properly chosen. This can be done by the photographer with the aid of a visual spectroscope if he carries a suitable supply of filters. For projecting the positive film from either of the negatives obtained by means of such systems, the following filters could be used, viz., Wratten Nos. 24 (Red), 59 (Green) and 47 (Blue). To facilitate the changing of the filters to suit different conditions, the filters are preferably arranged on a carrier 120 (Fig. 5) which carries two or more sets of filters of different shades the carrier being slidable by rack and pinion means 121, 122 so that a fresh set of filters can be brought to the gate, and the filters are preferably detachably mounted in the carrier so that one or more sets can be exchanged for others, depending upon the conditions under which photographing is going to take place. The filter device is described more fully in our concurrent application No. 24613/36 (Serial No. 483,079).

From the negative band, a monotone positive transparency film is made for use in the cinematograph projecting apparatus, which may be of the standard type except that provision is made for interchanging the standard lens with a pair of lenses having appropriate adjustment for accurately superposing the alternating colour sensations on the screen and for interposing the appropriate colour filters in the path of the beams, the successive projections of each colour sensation as it passes through the gate being arranged to be made through its corresponding colour filter. Such a projector comprises a double-windowed gate and the film is moved down by one picture frame at each shift period.

In a variant method of producing cinematographic effects in colour from a negative band obtained under the present invention, a positive band may be produced therefrom, in which each picture is a complete heliochrome, such heliochrome reconstitution from the negative band being made by any selective printing process in which the colour analysis elements are mechanically selected from the negative band and the positive prints thus selected brought to correct colours.

Fig. 10 shows a form of filter device which could be used in the projector. The filters are mounted in concentric bands interrupted by narrow radial sectors 95. Three groups of such bands may be used, the outer band 89 in one group A being blue, and the inner band 90 red, pair B comprising an outer band 91 which is green and an inner band 92 of blue, and the pair C comprising an outer red band 93 and an inner green band 94 so that the second projection of each picture area is made through the proper filter after the filter disc has been turned through 120° whilst the film is shifted. The film is moved down at the usual rate i.e., twenty-four pictures each second, and the pictures are of the usual size. The two parts 96, 97 of the sectors 95 may be light transmitting but of different colour from the two adjacent filtering bands. The film is shifted whilst these sectors 95 cover the gate and no opaque shutter is employed. For example, between each pair of bands, say green and red, a sector part of the third colour, in this example, blue, can be introduced. These sectors could however be replaced by opaque sectors if desired.

The band of blue in the group B is however interrupted by a small portion or portions 98 of green and the band green in the same group is interrupted by a small portion or portions 99 of blue, this for a purpose which will be hereinafter described.

It will be observed that the positives obtained from negatives exposed at the same rest period in the lower and top windows of the camera are never projected together. Consequently there is no time factor or substantial time factor or loss of movement between any two frames within each group of three and therefore lack of registration of moving objects in adjacent images of the group will not be very pronounced. However, if desired, suitable confusion filtering elements could be introduced during the projection of these images also.

Moreover, where the negatives have been so taken in the camera that where any two adjacent images have been interrupted by a shift of the film, these two images were taken through the green and blue filters, then when these two images are projected through corresponding colour filters and superimposed on the screen the lack of registration is much less

noticeable in terms of colour fringing than if an image taken through the red filter formed one of the pair. In order however further to minimise the effect of such lack of registration, these pairs of green and blue images are projected through the group of filters B which include the filter sections 98, 99 which have the effect of momentarily unbalancing the colour reconstitution whereby to set up temporary colour confusion which is not such as to be detected by the observer yet breaks up the persistence of the fringing colours.

No claim is made herein to the method of projection without opaque shutters as hereindescribed or to the method of unbalancing the colour reconstitution.

Although we have described the invention as applied to a three colour process, it is also applicable to a process in which four or more colours are used, but we do not consider that such a number of colours is in general necessary and their use would render it necessary to arrange a four pull shift in the camera which would impose an additional strain on the mechanism, and also it would in general be necessary in order to give sufficient exposure that very rapid film should be used.

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

1. A process for the production on a negative band of a single series of constituent images in three colours, in which at each stationary period of the band three image-receiving areas, formed one after the other along the band, are exposed in succession to different colour beams so that the exposure of one image area is completed before the exposure of the next begins and each image-area receives its full exposure during a single period of rest of the band.

2. A process according to claim 1, in which there is a small time interval between the successive exposures of the frames of each group exposed at the same stationary period of the film.

3. A process according to claim 1, in which the second and/or each subsequent exposure in each group exposed at the same stationary period of the film commences simultaneously with the completion of the preceding exposure.

4. A process according to claim 1, in which the film is shifted at the rate of eight shifts a second.

5. A modification of the process according to claim 1, in which there is an overlap of the exposure of the first and second image areas and/or of the second and third image areas but not of the first and third.

6. A process according to any of the preceding claims 1 to 5, which consists in taking the first and last of the successive exposures through a blue filter and a green filter, or *vice versa*.

7. A process according to any preceding claim 1, 2, 3, 5 or 6, in which a four or more colour process is employed in lieu of a three colour process.

8. A process according to any preceding claim 1 to 6 characterised by the use therein of an accelerated film shifting mechanism.

9. A process according to any preceding claim, in which the successive images taken at one stationary period of the band are produced by the aid of a light divider.

10. A camera adapted for producing a negative band of colour constituent images in a single series comprising a film shift mechanism constructed so as to pull three image areas at each pull and a shutter or shutters so constructed and driven in relation to the film shifting mechanism that at each stationary period of the film the three image areas are exposed in succession the exposure of each image area commencing after the previous one has ended.

11. A camera according to claim 10, in which the shutter means are so arranged that the second or following exposure commences simultaneously with the end of the previous exposure.

12. A camera according to claim 10, save that the shutter means are so arranged that the exposure of the first and second image areas and the exposure of the second and third image areas overlap but not the exposure of the first and third.

13. A camera as in claim 10, 11 or 12, having a single shutter provided with three separate exposure apertures so arranged that the exposure apertures come into effect successively.

14. A camera as in any preceding claim 10 to 12, having two co-operating rotary shutters each of which has a shutter opening formed therein and a marginal notch, these marginal notches mating to form the third exposure aperture, the three apertures being so arranged as to come into effect successively.

15. A camera as in any preceding claim 10 to 12, having two co-operating rotary shutters, one of which has an opening formed therein to form one exposure aperture and also a marginal notch to form a second exposure aperture, whilst the other shutter is marginally notched to form the third exposure aperture, the shutter being so arranged and driven that

the exposure apertures come into effect successively.

16. A camera as in any preceding claim 10 to 12, having two rotary shutters each marginally notched to form an exposure aperture for exposing the outside windows and a reciprocating shutter which exposes the central window, the parts being so controlled that the three exposure apertures come into effect in succession.

17. A camera according to any preceding claim 10 to 13, in which the shutter is in the form of a continuously rotating disc having arcuate slots at different radial distances from the axis of rotation and circumferentially displaced.

18. A camera according to any preceding claim 10 to 13, in which the shutter is in the form of an ocillating sector having slots at different radial distances from the axis of oscillation and displaced circumferentially.

19. A camera according to any preceding claim 10 to 18, embodying a stationary system of colour filters.

20. A camera according to any preceding claim 10 to 19, having a light dividing and directing system and a plurality of objectives through which the succession of images taken at each stationary period are produced.

21. A camera according to any preceding claim 10 to 20 having accelerated film shifting mechanism.

22. A process for producing a negative band of colour constituent images substantially as herein described.

23. A negative band of colour constituent images when prepared by any of the proceses herein claimed.

24. A positive band of colour constituent images when prepared from a negative according to claim 23.

25. A positive film wherein each picture is in the form of a complete heliochrome, such positive film being produced from a negative band according to claim 23.

26. A process for the production of colour images on the screen which consists in producing a positive according to claims 24, and projecting the same on the screen by exposing simultaneously two or more adjacent frames substantially as described.

27. A process as in the last preceding claim, such that when two frames are exposed simultaneously which have been taken during the different rest periods of the film such frames are coloured, substantially blue and green respectively, or are projected through filters of such colours.

Dated this 23rd day of August, 1937.

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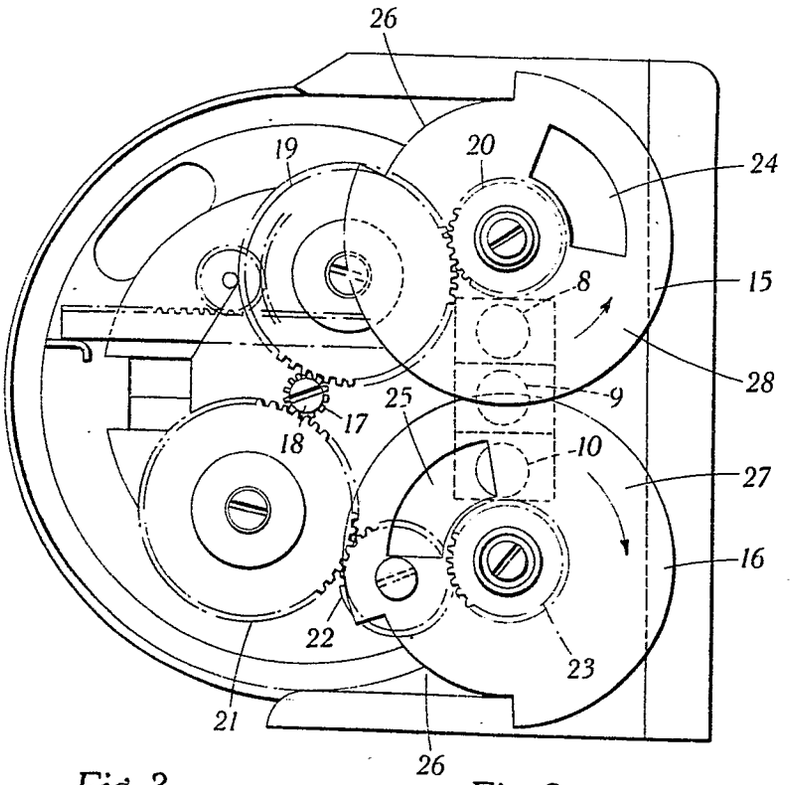
2, Broad Street Buildings,
Liverpool, Street, London, E.C.2,
Patent Agents for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1938.

Fig. 1.



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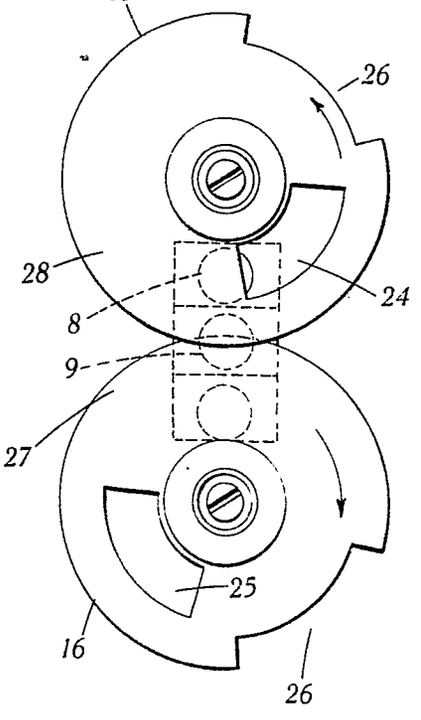

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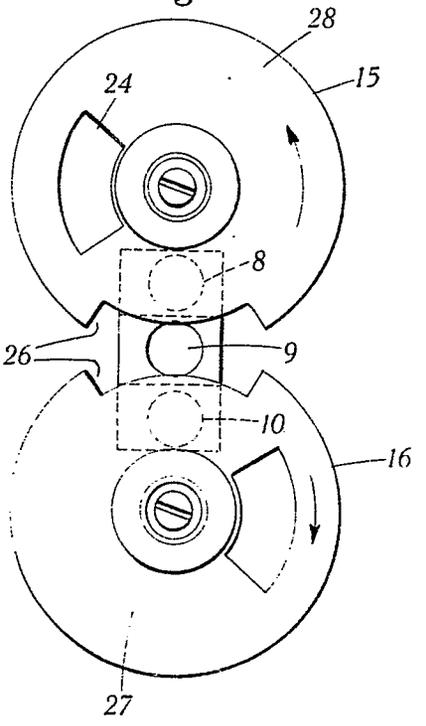

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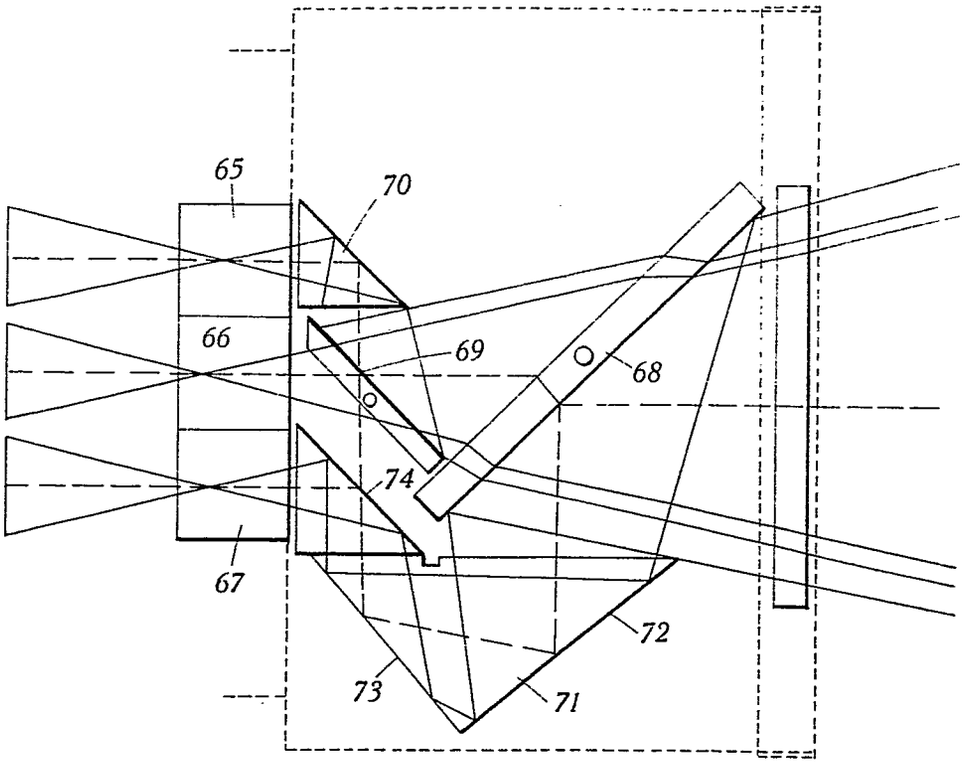
Fig. 4.



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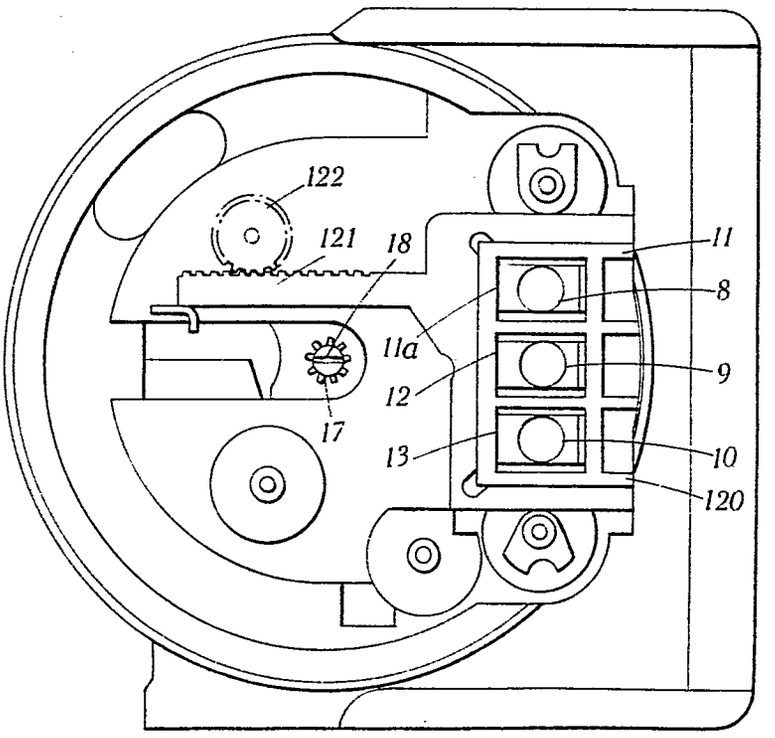

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[This Drawing is a reproduction of the Original on a reduced scale.]

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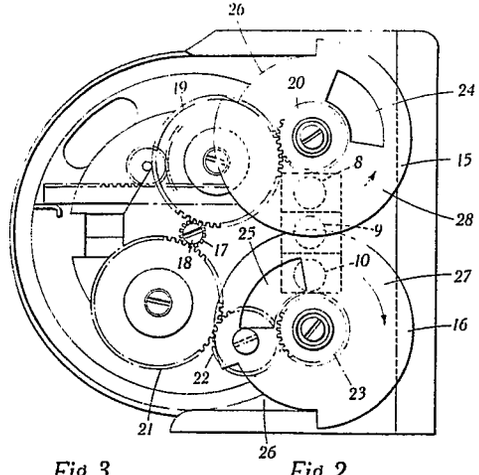

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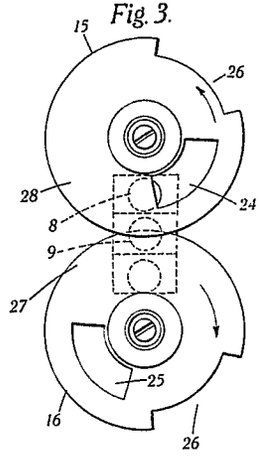

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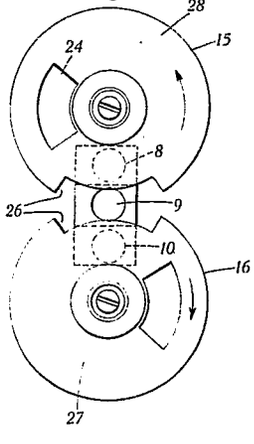

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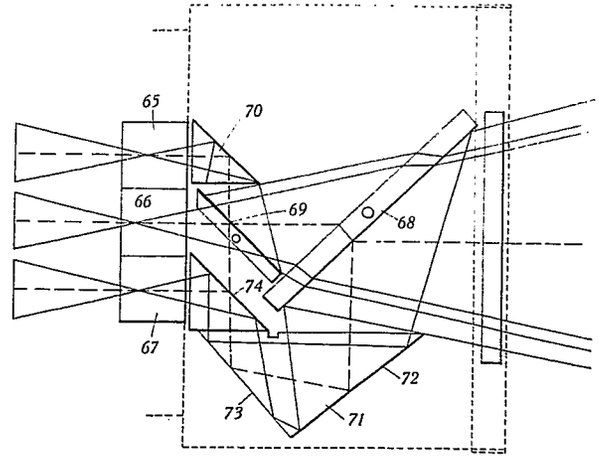

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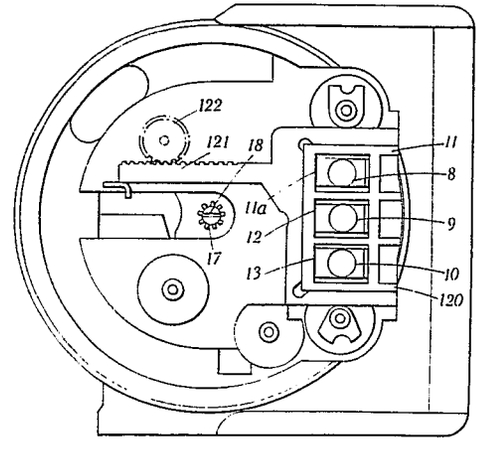

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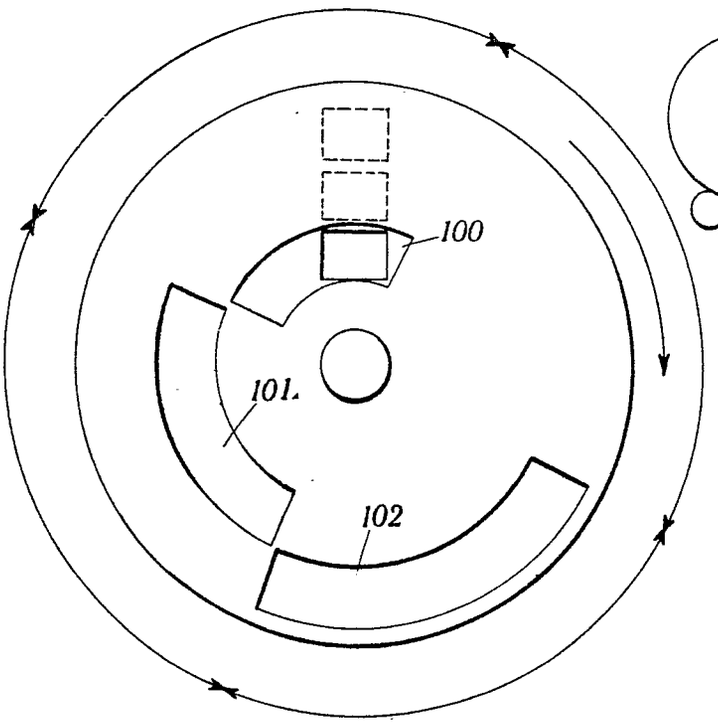

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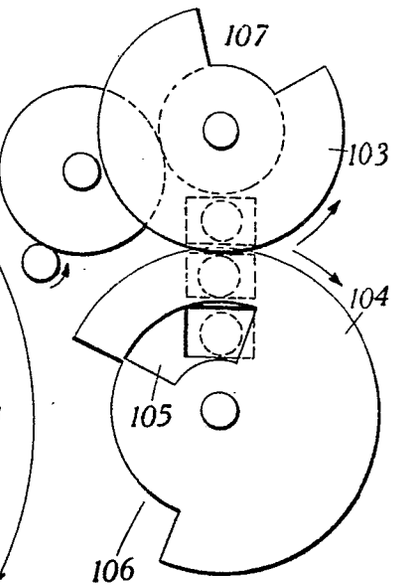

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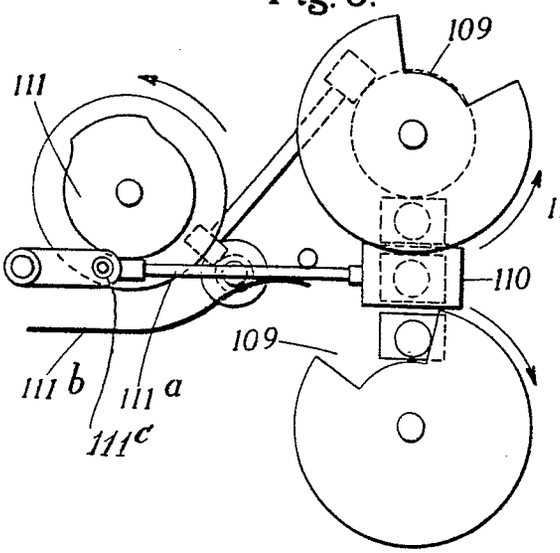

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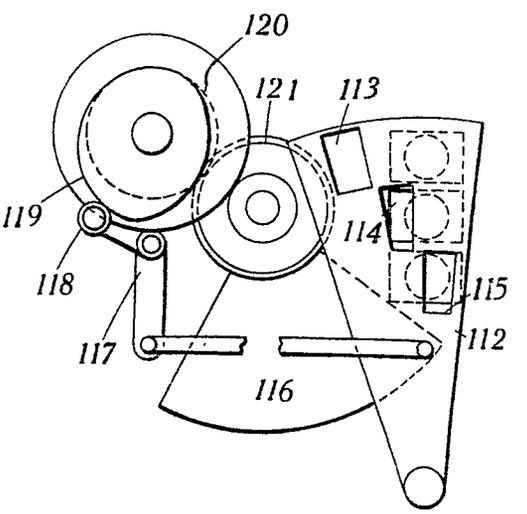

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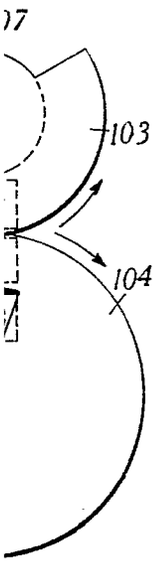

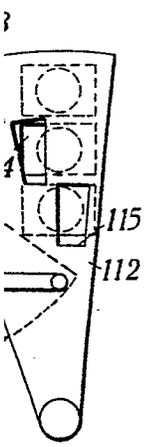

Fig. 10.

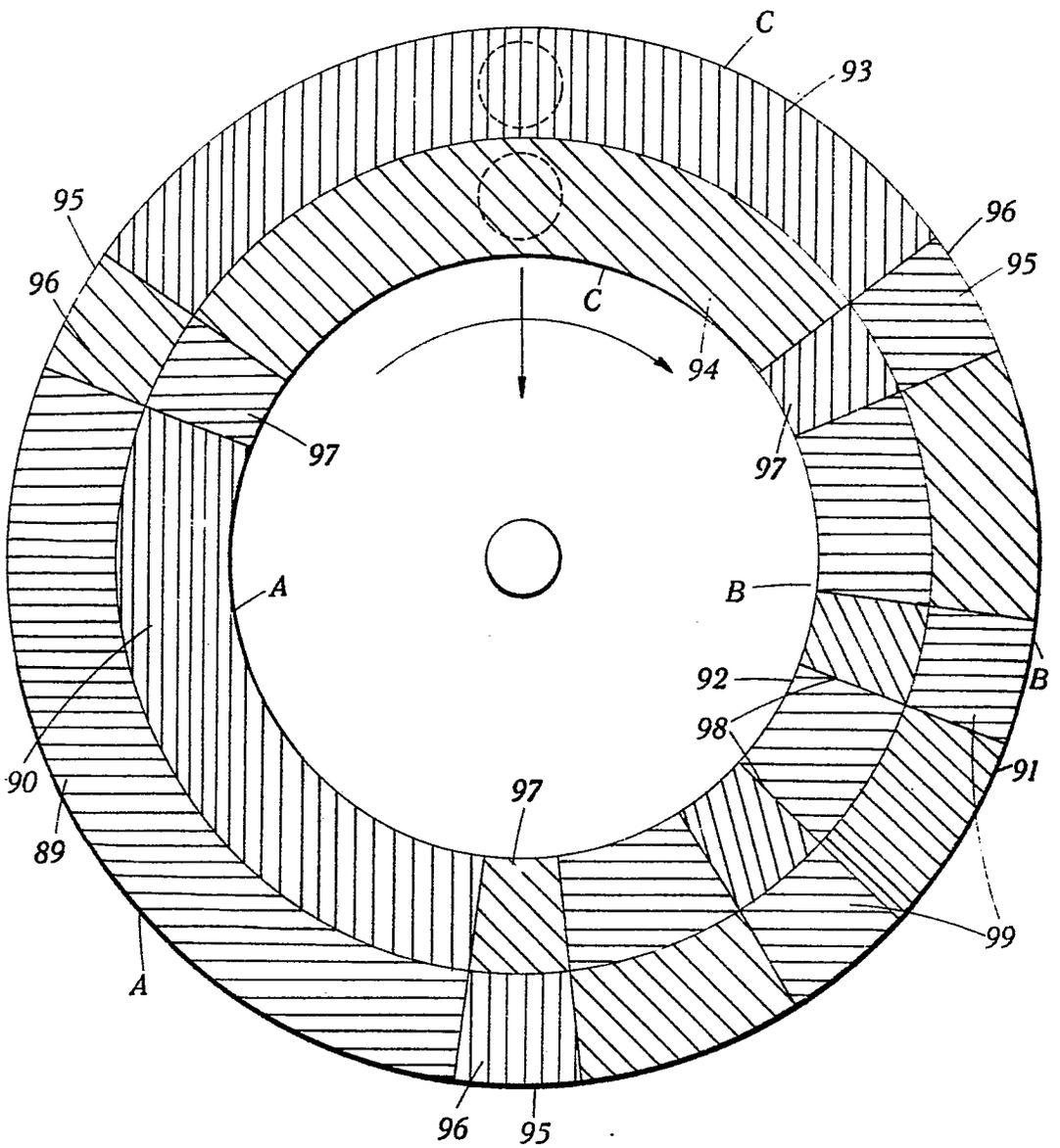

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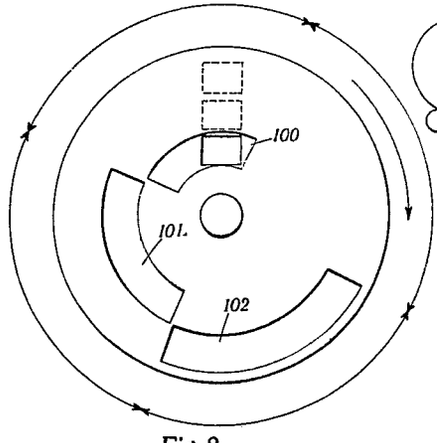
Fig. 6.



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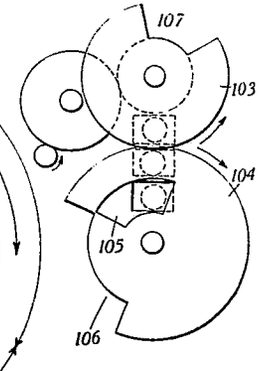

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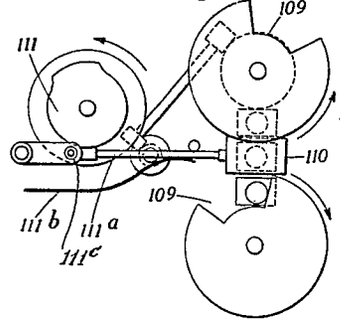

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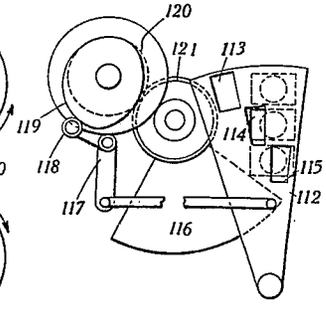

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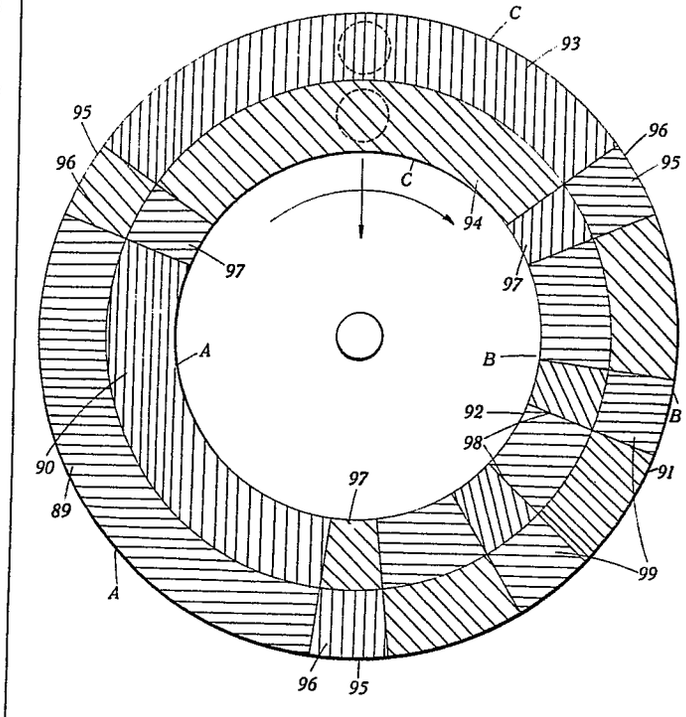

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