CHAPTER XXIII

# CINEMATOGRAPHY IN COLORS. ADDITIVE PROCESSES

The basis of all cinematographic projection is persistence of vision. A picture formed on the retina persists for a brief period of time, and if a succeeding series of pictures is similarly formed with but small intervals of time between the formation of each picture, the result will be a composite, in which fundamental phases of movement are no longer visible or distinguishable.

This applies equally to color. If red is projected, and immediately afterwards green, and before the red has had time to fade from the retina, the green is virtually superimposed, the resultant color in the brain will be yellow. Nor are we conscious that the latter color is actually composed of red and green. Should blue-violet be added in the same way, the result is white. Obviously this process is an additive one, for we start with a black screen and add light to light.

The only disadvantage of this method is that after some time we become conscious of an irritation, which takes the form with some people of an intense frontal headache and eyestrain. From the practical point of view, it is clear that as there must be approximately the same number of pictures projected as in black and white, the consumption of film is threefold, in order to show the same total amount of subject. Further than that, as a rule a special form of projector is required and this obviously limits the use of this process.

Attempts have been made to produce each projected picture complete in itself in colors on the screen, and while this method produces less eyestrain, the apparatus necessary for projection is more complicated, and consequently more costly. There is the further disadvantage of having to keep the pictures in register all the time, which entails the watching of the screen by a competent operator, which again increases the cost beyond commercial limits.

Were it possible to obtain each picture in colors on the film itself, one would have the same amount of film used as in black and white, the eyestrain, or color bombardment, as it is called, would be eliminated. Numerous processes have been attempted or patented to this end, mostly by means of a two-color method.

We may, therefore, divide the subject into two main divisions: the additive and subtractive. The former is again divisible into projection by persistence of vision, and simultaneous projection. The former being defined as that in which each picture is projected in a single color. The

sectors, and proposed to equalize exposures by variable speed of the shutter or darkening the green and blue sectors.

H. L. Huet and A. Daubresse[6] employed a series of lenses mounted on a drum at axial distances equal to the interaxial separation of the successive pictures. There was also a film-carrying drum with a series of reflectors. This arrangement of lenses, and Wenham prisms were used, antedates some later patents. M. C. Hopkins[7] proposed an improvement on this by using two oppositely moving drums with reflectors and color filters.

C. M. Higgins[8] would use a series of fourteen lenses mounted on a sprocket chain, each lens being fitted with a colored diaphragm at the rear. The interesting point about this patent is that the inventor used a central aperture to admit white light: "the central apertures are of such size that the unobstructed light passing through the rest of the diaphragm will produce the desired actinic effect upon the sensitive surface of the film. The colored light alone is not sufficiently active chemically to produce the effect with sufficient speed for kinetographic work, and consequently the central aperture is provided to give the additional light necessary." This idea of adding white light was first suggested by J. W. Gifford (see p. 61), and has been used for cinematography by Raleigh and others. B. A. Brigden[9] also used the idea of multiple lenses.

J. Berthon and J. Gambs[10] used revolving sectors and[11] would also use mirrors, glasses or prisms interposed between the lens and film. The projecting filters were differentiated in color from the taking filters. Berthon, Gambs & Theurier[12] would project a successively taken positive simultaneously with two of the images through concentric shutters. H. Joly[13] when dealing with the positives for projection would do away with rotary shutters and color each positive itself, a device patented by many others. W. N. L. Davidson[14] proposed to use an endless band of celluloid, bearing the filters, thus doing away with the sector shutter. W. Friese-Greene[15] also proposed to use the endless band, in this case with three colors, whereas Davidson used two only. W. F. Vaughan[16] used an opaque band with the rotary color shutter.

O. Pfenninger[17] would do away with the opaque sectors and arrange the shutter in front of the film so that the color sectors overlapped one another at a particular period of their revolution, thus making a temporary safe-light when the film was moved. H. W. H. Palmer[18] proposed to use the sector shutter for the negative, but stain up the positive like Joly. E. Maurich[19] arranged the sector shutter for projection so that the colors followed one another in the order blue, yellow and red, with a longer dark break between the colors as a whole than between the individual colors, claiming better fusion. Viscount Tiverton and E. A. Merckel[20] proposed to use the dark interval both in taking and projection to obtain and show a second picture by another camera or projector. In taking this was said to give great increase in speed.

L. C. Van Riper[21] on the assumption that the red sensation lasts longer than the others, would project in the order red, green, red, blue for tri-color pictures and red, red, green for two-color. J. S. Higham[22] utilized the same idea. J. Campbell[23] patented the affixing of the appropriate color filter to each positive, or the color might be sprayed on or imbibed.[24] In conjunction with Thompson[25] stencils were to be used to protect one picture; or a quick-drying liquid,[26] such as collodion might be used. The same inventors[27] would apply colored celluloid or gelatin in the same way. A. J. Waggett[28] also used colored strips of celluloid. This idea was followed by C. J. Coleman.[29] Campbell & Thompson[30] suggested the application of colored gelatin or celluloid to panchromatic negative stock, and stripping after development, the exposure being through the base. L. Herzberg[31] patented the local coloring of the positive, also F. Royston.[32] W. B. Featherstone[33] would make the celluloid colored in the first instance and then coat with emulsion. J. Shaw and J. W. Berwick[34] proposed to use a resist of rubber to protect alternate pictures, or a continuous cloth with openings. L. F. Douglass[35] would also locally apply the colors or tone each image.

Campbell & Thompson[36] patented a shutter with a blue sector of 36 degrees with red and green sectors of 72 degrees. In a later patent[37] the angles were made variable. The same thing was patented by E. Zollinger and S. Mischonsiky.[38] F. W. Hochstetter[39] would provide a frame for the filters with reciprocating motion. In a modification[40] the filters were arranged on a swinging arm, and a box-like arrangement[41] was used. In another form[42] a drum with radial tubes. Another form[43] was a disk with spaced rectangular areas concentrically disposed, each carrying a plurality of color divisions. J. Shaw[44] would do away with color bombardment by alternating the colors, thus red, green, red, yellow, red, blue for taking the negatives; but the positives were projected through red and green only. Later[45] the colors were altered.

P. Richy[46] proposed what he called a three-color system in which two vertically juxtaposed lenses were used with violet and green sector shutters. Positives were printed in orange and black for one film and in black and orange for the other film and these two films were projected through the taking filters, and the result was said to be all colors. Boudreaux & Semat[47] would make a negative on panchromatic film, and color the positive by hand, then make negatives through filters from this and project positives through the same filters. A. Miethe[48] used a colored sector shutter and projected in the same way. He contended that the trouble of flicker would be overcome by using a triple-width film. Zoechrome and T. P. Middleton[49] patented a film that could be used for color or black and white. Exposures were made at the rate of 32 per second with a red, green and blue sector shutter alternating with yellow or white ones. The inventors seem to have had some peculiar notions, as the alternation of

the black and white with the color pictures was said to reduce fringing, and this was further reduced by throwing the color pictures slightly out of focus while printing. Various methods were suggested for printing.

The Silent Drama Syndicate[50] would use standard size film but reduce the pictures to half the usual width and take them alternately staggered, so that the center of one picture was level with the dividing line of two pictures of the next row. H. Dony[51] proposed to obtain the negatives in the usual way, then color the images in accordance with the filters or use a sector shutter and three or four images might be used in blue, yellow, red and yellow. The same inventor[52] would use a rotary shutter with red, yellow, green and yellow sectors, claiming better exposures. The same shutter could be used for projection.

H. May[53] proposed to take the negatives with equal color sectors, but project with sectors variable so as to agree with the sensibility of the eye to colors. C. Friese-Greene[54] described his process of two-color cinematography by the persistence method. A color sector filter was rotated behind the camera shutter, and the former had a white light aperture, thus utilizing the ideas of Raleigh, Kelley and others. Ordinary positives were produced and the colors applied to each positive, thus copying Joly, Campbell and others. A. Hnatek[55] used the persistence method with two objectives and projected each image twice, like Lee & Turner. R. B. Barcala[56] patented the usual tri-color sectors for taking and projecting. Pathé[57] patented a projector with the usual sectors and an additional shutter behind the gate. H. Blanc[58] proposed the normal sector for taking and projecting through red, yellow and blue, or the whole seven spectral colors might be used. The Lesjakplattenpackfabrik[59] patented color sectors before the gate.

**Additive Simultaneous Projection.**—F. M. Lee and E. R. Turner[60] although not claiming simultaneous projection, yet in their specification stated that "the positives of the various color sensations may be exhibited singly in rapid succession, or two or more of them may be superposed." And in projecting there was some sort of simultaneous superposition, which must, however, never have been actually sharp. Because the three negatives were taken in succession and not simultaneously, therefore, in any movement there must have been different phases recorded in successive pictures, so that actual superposition could not have been obtained. The familiar color sector shutter was used with opaque sectors in between. In projection although the same colors were used in the sectors, they were placed in different order in the three divisions. Three projecting objectives were used vertically superposed and three pictures simultaneously shown, each component being shown first through the top lens, then by the middle and lastly by the bottom lens. The shutter had colored concentric sectors, with narrow, opaque, radial sectors between each triad of filters. In the first triad the order of the colors from the periphery to the center

was red, blue-violet, green; in the second green, red and blue-violet and in the third blue-violet, green and red, therefore, it is clear that each constituent record passed behind each lens accompanied with its own filter.

B. Jumeaux and W. N. L. Davidson[61] proposed to use prisms in front of a single lens, in which case they were separated with their bases towards one another, or with three lenses, in which case the prisms were placed in front of the outer lenses; in the former case the separation of the prisms allowed the red rays to have direct access to the film. Davidson[62] pro-

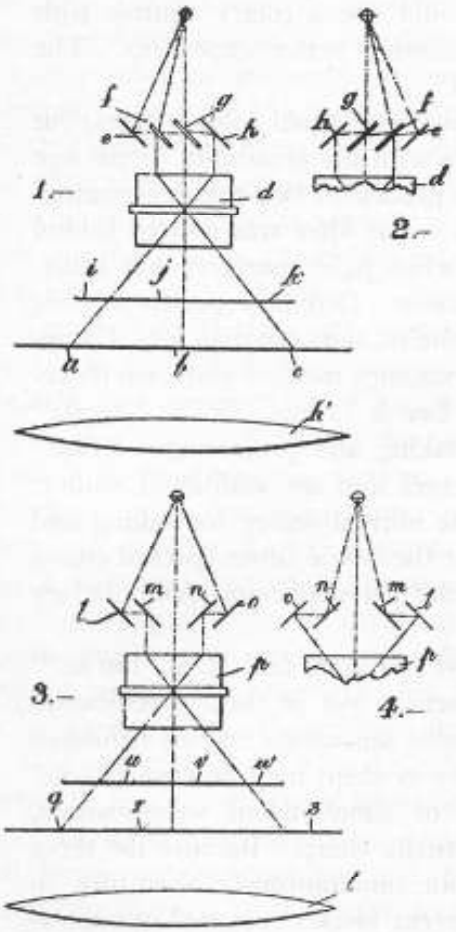

FIG. 158. Davidson's E.P. 7,179, 1904.

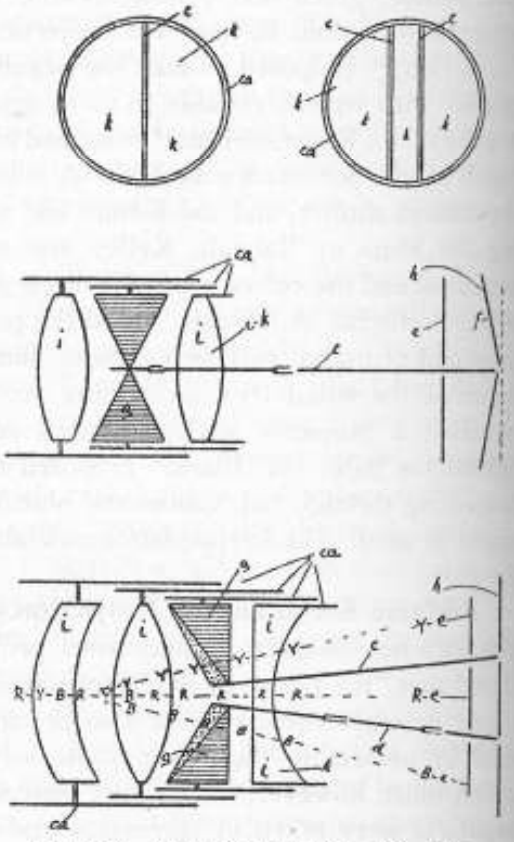

FIG. 159. Pfenninger's E.P. 332, 1905.

posed an arrangement of mirrors, mainly for projection, though it was said that under favorable conditions the same might be used for the negatives. Fig. 158 requires little explanation, except that of *4*, and it was said that: "this arrangement gives color records from almost the same point of view unless very near objects are photographed." The same inventor[63] would use two prisms point to point behind the lens, thus avoiding the formation of double pictures. O. Pfenninger[64] would use non-achromatic

or achromatic prisms between the combinations of the lens, as shown in Fig. 159; the middle diagram showing the arrangement for two-color and the lower for three-color work; the planes of the images is shown by *h*. W. Friese-Greene[65] proposed to place a prism covering half the lens at the back, as shown in Fig. 160, in which the rays are coming from the left to the lens *c*; *d* being the prism, *e* a yellow-orange filter and *f* a blue-red one and *g* the focal plane of the lens. The picture taken direct would be sharp, but the other one would lie in a different plane and would be less sharp than with other prism forms, because of the greater dispersive power of the prism.

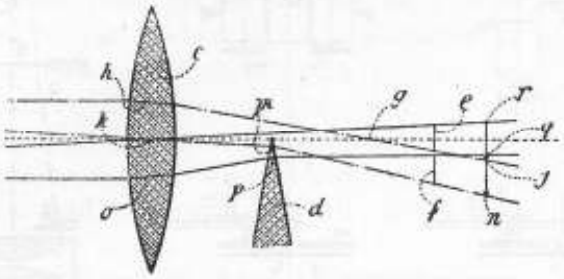

FIG. 160. Friese-Greene's E.P. 9,465, 1905.

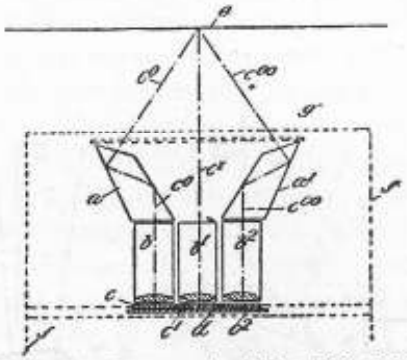

FIG. 161. Jumeaux's E.P. 3,766, 1906.

R. Berthon and J. Gambs[66] proposed an arrangement of the sectors like Lee & Turner, with three vertically disposed lenses. B. Jumeaux[67] proposed to use two modified Wenham prisms, as shown in Fig. 161, in front of two side lenses *b* and $b,^2$ and these were adjustable so as to register on the screen. The filters were behind the lenses at $c,^1$ *d* and $c,^2$ the film passing at *f*. The disadvantage of this was that the angles between the two side lenses, and the optical paths of the rays were not equal, the images thus not being of the same size.

O. Pfenninger[68] utilized a mirror box in front of the lens (see p. 169). In a later patent[69] "prismoids" were used, which were modified Wenham prisms, with three vertically superposed lenses cut down as to

their diameters, as shown in Fig. 162. This system might be used for two or three-color and the prisms placed in front of or behind the lenses. R. Bjerregard and the Continental Films Co.[70] proposed to use mirrors or prisms to obtain the three images side by side, as shown in Fig. 163, and this system could be used for projection as well, when a concave lens was placed between the main condenser and the prism or lenses. Later[71]

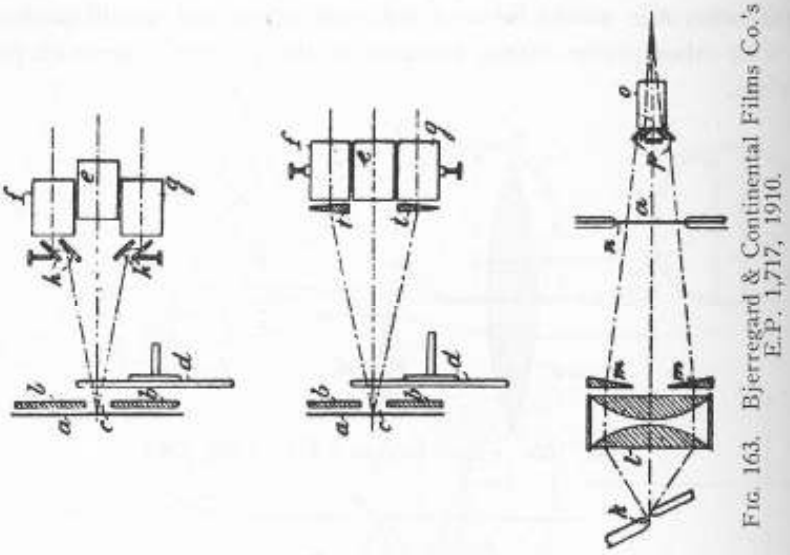

FIG. 163. Bjerregard & Continental Films Co.'s E.P. 1,717, 1910.

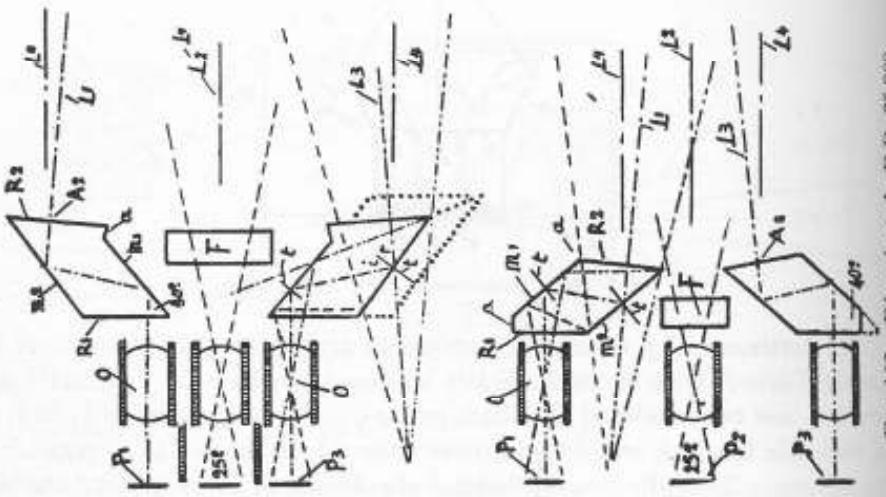

FIG. 162. Pfenninger's E.P. 25,908.

apochromatic prisms are claimed between the lenses and the screen and the use of a non-transparent black frame for each picture on the film, to obviate any color fringes on the screen. Zeiss[72] also patented a method of simultaneous projection in which each picture was surrounded by a black mask, photographically produced.

The Natural Color Moving Picture Co.[73] patented three lenses side by side; the side ones being fitted with adjustable total reflecting prisms, so that the reflected rays might be directed into line with the optical axis. The central lens might be placed at a slightly greater distance from the film than the side ones, thus equalizing the optical paths. T. D. Kelly[74] would use three projectors, the side ones being angled.

P. Ulysee[75] proposed to obtain on normal width film multiple images of small size and the scheme was further elaborated,[76] as shown in Fig. 164, in which *1* shows the normal film and *2* to *10* the modifications proposed; while *12* to *14* show the projection system and *15* to *19* the particular arrangement of the lenses. Later[77] a multiple lens or film was moved and four small images obtained on a standard area, the images being formed in space and projected by a single lens. A plurality of light-sources[78] such as a multi-carbon arc, or a single arc with multi-focal condensers consisting of decentered dioptric rings was used in conjunction with rotating color sectors. A modification[79] of this was one light-source with triple condensers with mirrors and prisms, or prisms only or parabolic reflectors with and without condensers. Continuous projection[80] was also patented.

O. Pfenninger and W. Agate[81] patented a two or three lens camera, with sawn-off lenses, with a bi-prism in front of the lenses; a rotary shutter with excentrically cut opaque sector in front. Filters might be inserted in the path of the beams and might be achromatic. F. E. Ives[82] also proposed to take two pictures in one picture space, either side by side or over one another, or to turn the pictures through an angle of 90 degrees, or turn each image through 90 degrees in opposite directions. Various prism systems are described for this purpose. Two colors were to be used, red and green, and the apparatus might be used for taking and projecting with simultaneous addition. R. M. Craig[83] used some very complicated prismatic devices and looping of the film, so that some pictures were taken on the front and some on the back.

L. Mauclaire, A. Garbarini and G. Gautier[84] proposed to take four negatives through filters and occupy the space of two normal pictures. Two of the colors were to be 120 degrees apart on the chromatic circle, while the third one, that should occupy the third 120 degree point, was split into two colors, which were complementaries to the first pair. Two superposed lenses were used with annular sector shutters, and the same system was used for projection. P. Ulysee[85] would use two groups of three lenses, one with fixed focus for distant objects and another with variable focus for near ones. A projector was disclosed with arrangement for showing both black and white and colored pictures.

J. Szczepanik[86] patented a complicated camera and projector for continuously moving film, which passed round a drum. W. Späth[87] would do away with filters altogether for projection by utilizing either two Nicol

prisms, or a Duboscq calcite prism and a Nicol, or two polarizing bundles of glass, with a double-refracting plate between. C. Zeiss[88] patented two projection machines coupled together with synchronously moving film, and the light was reflected from a moving octagonal drum with mirror and a collective system. A. Köhler[89] patented a projection system, in which two apertures were placed close to the condenser, in front of which was placed a collective system of lenses, composed of one large and two small ones; the image of the light-source being projected into the entrance pupil

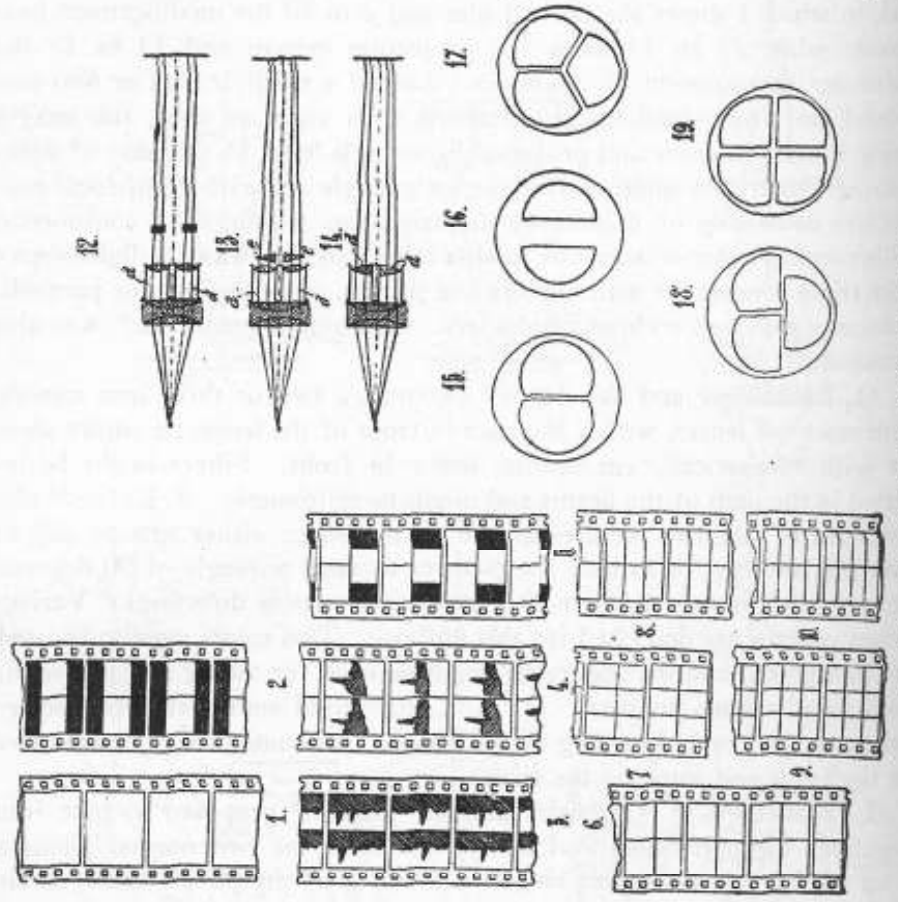

FIG. 164. Ulysse's F.P. 398,220 (Page 591).

of the small lenses. F. Bollmann[90] patented the use of three superposed projectors with rotary shutters.

W. Thorner[91] would use the filters on the lenses, mirrors or prisms in a projector with continuously moving film. B. A. Johnson[92] patented three lenses mounted side by side on the arc of a circle, so that their axes converged to a common focus. Filters were placed in front of or behind the lenses and changed synchronously with the film. The pictures were taken alternately right and left, for instance red and green, then green and

red. A. P. Plahn[93] used the old idea of Wenham prisms for the side pictures and a glass block to equalize the path of the central ray. F. Lenhold-Wyld[94] would obtain stereo color effects by simultaneous projection of two images on to a spherical mirror. It being claimed that the aberrations and distortions introduced by the mirror produced stereoscopic effects.

Boudreaux and Semat[95] projected films taken simultaneously or successively through filters, while a luminous beam of the complementary color was thrown on the screen. They also[96] treated positives so that the silver image became reflective, and transmitted and reflected light was used. They also[97] would take a negative on a panchromatic film and color the positive by hand and make the record negatives from this. Castel and Mazo[98] used a single light-source with triple condensers and lenses. Chaupe[99] patented tri-color pictures taken successively and projected through filters. Stefanik[100] used a reflecting telescope to form a parallel beam on three filters and three lenses; the size of the latter being adjusted to the chemical action of the rays. J. Sacré[101] used a series of six mirrors or prisms, inclined at angles to one another and placed in front of three lenses, superposed for taking and projecting.

P. Mortier[102] used simultaneous monochromes with centers on an oblique line, not contiguous, obtained with three lenses and dioptric blocks in front to obtain identical images. Projection was effected through a common condenser with trapezoidal facets and prisms of weak deviation. Later[103] the image was resolved into four monchromatic images, the effective rays recording each image passing through filters before reaching the film. The filters were arranged in pairs, the individual colors of each being complementary and equidistant on the chromatic circle. By this method four impressions, forming a tetrachromatic set, could be obtained on one film, either side by side or in vertical alinement, with or without stereoscopic relief. Gebay[104] used a single lens and three standard films, one arranged at right angles to the optic axis, the other two at each side parallel to the axis. Two rotary mirrors at right angles to one another, but at an angle of 45° to the optic axis projected the images in succession to the side films and allowed it to pass to the central film. The same arrangement could be used for projection with three arc lamps.

E. Sommavilla[105] patented a process in which yellow, green and blue filters were used to obtain the negatives. The yellow filter passed red and green, and the red record was made by printing through the yellow record positive and the green record negative. Additive projection was used. G. Casieri[106] would use two reflectors, the front one being transparent. The images being thus obtained from the same standpoint and through a complementary sector shutter. B. D. Underhill[107] would use a two-lens system, mounted side by side with prisms for throwing the images at an angle, so that the lenses were close together. A revolvable disk carried auxiliary lenses, which might be used to alter the focus of the principal

lens. L. Mauclaire and A. Breon[108] used the ordinary width film, but the color records were split into two series, though occupying the same picture space as the ordinary film. The red record occupied half one picture space and the blue-green the other half, while in the succeeding space the green occupied one-half and the violet-red the other.

L. Gaumont[109] patented two coupled projectors for showing black and white and color pictures, one common motor driving the two. Later[110] an operator was placed close to the screen and manipulated an electric drum, connected with the lenses to ensure accurate superposition. A solenoid[111] was also used. Later[112] a band of paper was perforated during the first run, thus serving to automatically adjust registration in subsequent shows. L. Mauclaire[113] would use vertically or horizontally juxtaposed lenses, the pictures being half the usual size. Projection was to be effected through an annular sector shutter, two of the elementary colors being used, while the third was split into two; the color sectors might be graded. T. A. Mills[114] also patented the taking of the negative through lenses of different foci, so that one large negative corresponded with two or three small ones, as in the Ulysee and Mauclaire patents. O. Fielitz[115] proposed to take blue and red pictures and blue and green simultaneously and project to form one image.

J. Shaw[116] patented a method in which the negative was taken through red, yellow, red, blue, red, green filters and printed two positives of each color record in sequence, in which the blue and green pairs were dyed green and the red pairs red. It was claimed that color fringing and color bombardment were much reduced. Later[117] the same sequence of filters was to be used for the negative and all the red records were to be printed on one side of double-coated stock, but doubled images for each picture, that is two positives from each of the same negative. S. Maximowitsch[118] proposed to reduce the too frequent rosy tinge of additive projection pictures by reducing the color depth of the filters to one-half, so that they formed white on the screen. T. A. Killman[10] used two truncated prisms with their apices in contact, placed in front between the gate and lens. A rotary annular sector shutter being used between the condensers and gates. M. Héraut[120] also used simultaneous projection, but the result was not very satisfactory, there being some fringing.

The Chromo-Filmgesellschaft[121] proposed to project two vertically juxtaposed pictures by means of mirrors or Wenham prisms placed behind the lenses, the two pictures being at a double-depth gate. Cinechrome Instruments, Ltd.,[122] patented projectors for simultaneous projection. A. Wilson[123] would obtain stereo effects in color by passing one film past two gates and taking negative pairs through red and green sector shutters. They were to be shown in the same way. F. B. Prinsen[124] arranged three lenses in trefoil pattern and projected with a similar arrangement. The images might be reflected by a 45° mirror, at right angles to the first, and

taken up by a second set of lenses. Or an aerial image might be formed and taken up by a second set of lenses.

A. Sauvé[125] patented a complicated projection system for still additive methods in which four reflectors and four lenses were used. B. Weinberg[126] patented twin positives synchronously projected by complementary lights and viewing through similar spectacles, which system was said to be useful for color work. H. A. Rogers[127] patented a form of mutoscope that could be used for viewing either black and white or natural color films. J. Henley[128] patented a stereoscopic system with occulting shutter, said to be applicable to color work. H. Shorrocks[129] used a shutter with masking strips, which might also comprise color screens, that could be turned into operative position, while the shutter was in motion, and when desired to change from black and white to color.

H. R. Evans[130] patented the staining of positives so that the colors were not in accord with the color sensations, but in any desired manner so as to obtain pleasing results. L. Horst[131] patented a three-apertured gate for showing three pictures simultaneously. F. W. Kent[132] patented the use of two shutters with sectors that could be regulated as to size and which were run at different speeds so as to give different exposures for different colors. C. Zeiss[133] patented a continuously moving film with a cube of glass interposed between the film and a ring of moving lenses. The light being split up into a spectrum, T. P. Middleton[134] used a projector in which two side by side lenses were used with one light source, the two beams being obtained from mirrors or split condensers. The K. & S. Syndicate[135] patented a color sector shutter for projectors.

**Two-Color Processes.**—Elsewhere have been recorded the facts as to the use of two-color processes for still work, and these methods have been applied to color cinematography It may seem somewhat curious to attempt to restrict the colors to only two, but as a matter of fact, the addition of the blue-violet records in ordinary color projection has mostly the effect of brightening up the colors and forming actual white, the true violets and deep blues. In all two-color processes, with normal filters at least, there are no true whites formed; but white is but a relative term, and the pale yellowish whites formed by the usual red and green filters appear white to the normal eye by contrast against the other colors.

Assuming that red and green are the colors used, the main difficulty is in the rendering of the violets and blues, if the filters are too deep in color, that is with restricted spectral transmission. On the other hand, if the transmission band of the green filter be widened too much all the colors will be paled by the addition of white.[136]

Another trouble with these processes is the preponderance of one of the constituent hues in the shadows, which is chiefly due to the emulsion, which gives a different characteristic curve for the red and green filters; the former having, as a rule, a much longer period of under exposure than

the green, therefore, giving a little more detail in the positive green.[137] The question as to the best filters for two-color work is dealt with under subtractive processes.

G. A. Smith[138] patented a two-color process with rotary shutters of red and green sectors, with opaque sectors between, relying on the persistence of vision. This was known as Kinemacolor and had for a short time quite a rage. But like most of the persistence methods the eye-strain was very marked. Actually the first two-color process was exhibited by B. Jumeaux and W. N. L. Davidson[139] in Paris in 1904, and at the Photographic Convention at Southampton, England, in 1906.

C. N. Bennett[140] proposed to use two vertically superposed lenses with rotary shutters, and although the inventor admitted the occurrence of parallax, he claimed an improvement because there would be precisely the same movement in the two successive pictures. J. Campbell and T. Thompson[141] used a rotary shutter in which opaque sectors of 90° each, and transparent filters ranging from green to violet-blue of 60° aperture, and from yellow to red of 120°. The particular virtue in grading the filters is not apparent, and precisely the same effect would be obtained if the whole of the sector were made of that color, which is the sum of the graded one. This matter is referred to later. The same inventors[142] would use separate cameras or projectors and angle them horizontally. Later[143] a shutter with variable sectors was patented. Still later[144] the transmissions of the filters were exactly defined, thus the blue included from 4200 to 5200, and the orange from 5400 to the red end, and these were separated by opaque sectors respectively of 90° and 135°. The positives were to be projected through screens of from 4000 to 5500 for the blue, and from 5800 to the red for the orange.

J. Campbell[145] patented the use of two vertically superposed lenses and annular sector shutters, with the red the outer annulus in one and the green the outer in the other, so that the red was exposed through the two lenses, and as the outer annulus was longer more exposure was given. Another variation by the same inventor[146] was to use a plurality of films with several lenses with annular shutters for each color. Projection was to be effected in the same way. Later[147] rotary shutters were used.

W. B. Featherstone[148] would use this principle of double exposure for each picture through two lenses and annular shutters. P. Ulysee[149] proposed to give four partial exposures to the same film area, at slightly different times. The same inventor[150] to save film, would cut down the size of the pictures, thus crowding two into the area of one normal. C. Raleigh[151] patented the marking of the negative film with a readily distinguishable mark, such as one perforation in each picture space, with a circular hole, so as to be able to differentiate the color record. C. Urban[152] and T. Royston[153] patented the same idea.

W. F. Fox, W. H. Hickey and Kinemacolor of America[154] patented a

two-color process in which a red sector was used, the other being white, so that one had the whole of the blue, violet and ultra-violet impressed. Projection was to be effected in the same way and it was stated that the colorless pictures appeared green, due to the fatigue of the eye!

H. R. Evans[155] patented a printer in which the light was automatically varied for the two colors. T. H. Blair[156] used a projector in which rotary shutters could be moved out of the axis to show black and white pictures. H. W. Joy[157] split the blue-green sector into two by an opaque sector, claiming better fusion of the colors. M. J. Wohl and R. Mayer[158] would use four colors for the negatives, but only two for projection. Red, orange-yellow, blue-green and blue-violet being the taking colors and for projection a combination of the first two and last two being used. In a later patent[159] four colors were claimed for projection. L. F. Douglass[160] would alter the angles of the sectors for those subjects, which had a predominance of green, and also for distance.

C. Raleigh and W. V. D. Kelley[161] had a somewhat confused color theory, according to which, each picture was to be recorded by two colors, that is to say for instance, by red and blue, and by green and red. The same method was to be used for projection and the inventors stated that purple and yellow light gave red, as the former cancelled the latter. In the same way blue-green and yellow gave green, because the blue cancelled the yellow. As a matter of fact mere tints would thus be formed, as a large amount of white light would be the result in each case. The same inventors[162] patented shutters that admitted white light, and claimed that this intensified the colors and leveled them up. Obviously the same result would be obtained by using very pale filters, the sum of the white light and the colors.

G. Remy[163] proposed a system in which the negatives were taken through red, peacock-blue, orange and blue-violet and in this order, while the positives were to be projected through red and blue-violet; these colors being said to be complementary. C. J. Coleman[164] patented a film with transverse stripes more sensitive for red than green. Various non-commercial methods were disclosed for making this film. E. H. Lysle[165] patented a combined camera and projector also applicable to color, with continuously moving film and an endless chain of twenty-two mirrors. V. L. Duhem[166] patented two spaced lenses and filters with gearing so that the pictures were taken in succession but with ten picture spaces between pairs.

L. A. Pineschi and S. V. Santon[167] also used a two-color method. R. Bjerregard and Continental Films Co.[168] used two or more lenses with prisms in the camera so that the negatives were taken simultaneously. The positives were also projected simultaneously, the central beam being lengthened by a negative lens, and prisms being used for the side pictures. F. W. Donisthorpe[169] patented a device for effecting optical rotation

through an angle of 90° of a pair of images, placed side by side with the horizontal lines of the objects parallel to the length of the film. In projection the images were also thus turned. A single erecting prism or a combination of three right-angled prisms or mirrors might be used. F. Weinstock[170] used two lenses side by side at stereoscopic separation, with mirrors and prisms to reflect the images simultaneously one above the other. Semat[171] would take stereo negatives side by side on single-width film, using filters for taking and projection.

F. Leiber[172] patented a system which was designed to obviate the defect of Kinemacolor in giving yellowish whites, and the procedure was apparently doubled with the shutters giving a tendency to blue in the resultant pictures. Four filters were used in pairs. The Continental Films Co. and R. Bjerregard[173] used a sector shutter with inserted white sector. C. Raleigh[174] used a rotating shutter with overlapping sectors. C. Schlochauer and E. Albert[175] patented a film in which one or more colored pictures were followed by one or more black and white ones.

W. B. Wescott[176] patented a camera with two gates spaced two picture areas apart, with automatic pressure frames and parallel guides for the film during exposure. A projector on the same lines[177] and for use with positives obtained from the negatives was also patented, and a printing machine was also[178] devised. J. Hunt[179] patented a projector for two-color films in which two gates spaced apart were used. A. Alessandri[180] proposed to obtain two images side by side in one normal picture area by horizontally juxtaposed lenses. A red filter was used for the one lens and blue and green filters for the other, and these were changed during the exposure. The two images were projected simultaneously after reflection in a system of prisms. N. H. Losey[181] used two stereoscopic films with red and green pictures side by side, the observers being provided with similar spectacles. The Ica Gesellschaft[182] patented a rotary shutter, which could be revolved on the shaft.

J. W. Berwick[183] proposed to use a rotating shutter with three or four apertures, two of which were filled with selective filters and the others merely fitted with iris diaphragms, which could be closed down. This was used in the camera, and the non-filter apertures gave a black and white picture, which was said to enhance the shadows. Either the additive or subtractive process might be used for the positives. L. Brown[184] would make pictures of the usual size but in staggered formation, so that the dividing line of one series came opposite the center of the others, the film being moved zig-zag fashion, thus all the series of one color would fall on one side of the film and the other color on the other.

**Bi-Packs and Tri-Packs.**—M. F. de Colombier[185] appears to have been the first to suggest the application of this system to cinematography, and like so many French patents it is a little indefinite in phraseology. Three films were employed representing the same view and perfectly

superposable. The positives were wholely colored, each having one of the fundamental colors or the complementaries, generally three, blue, red and yellow. The combination of the tints, more or less neutralized by the blacks and whites of the film, would give animated projections possessing their true colors. The three pictures were exactly superposed, either by apparatus having synchronous movement and automatic focusing, and superposed or separate projectors were used. And it was stated that it was possible to employ superposable films without preliminary coloring; it being sufficient to provide each projector with a different filter, yellow, blue and red. Another arrangement consisted in making reels of three or more films rolled up together, the impression of the image would then be simultaneous, the small thickness of the film base and its opacity being without action. It would be sufficient to color the films separately and place them in their first order so as to have a single trichromatic film; in this case an ordinary projector might be used. From this it is clear that the inventor had the idea of using a tri-pack for exposure; also he would use the additive as well as the subtractive processes.

G. Battistini[186] suggested two methods, the one shown in the upper diagram of Fig. 165, in which three films, *4*, *5* and *6* were rolled up on a spool *3* and passed to spool *2*. Translucent or transparent emulsion might be used for the film nearest the lens in order to facilitate the transmission of the light. But the inventor stated that he had found this condition was not indispensable. For the selection of the colors, filters might be dispensed with by sensitizing each film for a given color, for instance, the front film for violet, the second for green and the third for orange. The arrangement of the films might be with the red-sensitive one in the middle. For two-colors, red and blue should be chosen, and in this case the front film was to be stained orange to act as a filter for the rear one. If a filter was required for the front film, it could be arranged near the lens. If two films were to be used it was preferable to arrange them emulsion to emulsion, they would thus be in the same focal plane. Positives from each negative were to be stained with the complementary color of the filter, and the three positives might be placed one behind the other in an ordinary projector, and in this case gelatin should be against gelatin. The above is taken from the amended specification, but in the original, the arrangement, shown in the lower diagram is given, and is thus described: in the case of three superposed films the celluloid constitutes a thickness sufficient to prevent accurate exposure of all three sensitive surfaces at the same time, and it is preferable to form two bands, one constituted by the superposition of two films, and the other by the third film, and to expose these two bands simultaneously in two machines as shown in *2*, where *7* and *8* represent two cameras of ordinary type, mounted on a base *13*, and operated simultaneously synchronously by a crank and the rod *10*, and universal joints *11*, *11*. In one machine the band is made up of two

superposed films, the third being in the other machine, and a transparent mirror *9* arranged in front of the two machines so as to deflect some of the rays and thus form two identical images.

A somewhat similar arrangement was proposed by W. Buchanan-Taylor and others[187] and the camera contained a semi-transparent mirror to transmit and reflect the light to one film and also to the other two in contact. Suitable gearing at right angles synchronously actuated the films. The single film might be exposed through a red filter, and the other two through a blue filter, and a thin film of yellow gelatin might be interposed between them to make the green filter, or the yellow tint of the two films might be sufficient.

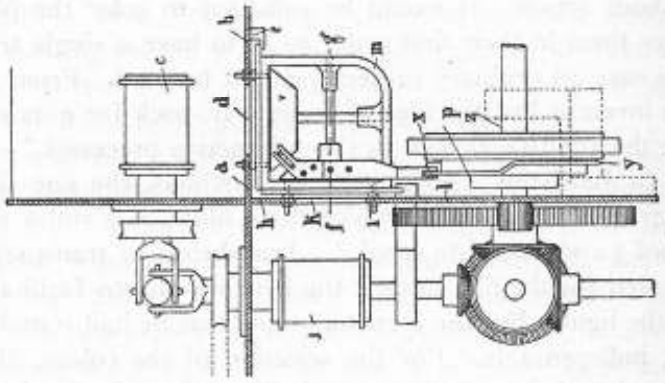

FIG. 166.
Battistini's E.P. 873, 1915 (Page 599). Hamburger & Day's E.P. 136,595.

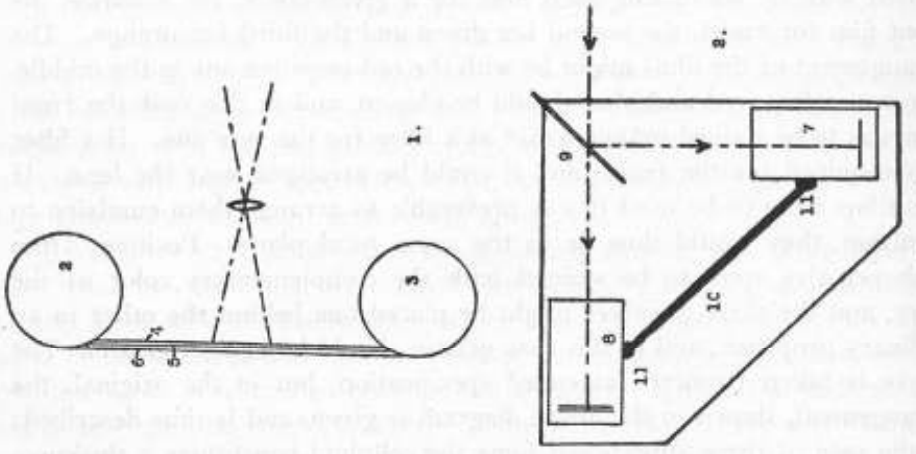

FIG. 165.

F. E. Ives[188] patented a bi-pack, using red and green positive colors. The front film was to be specially translucent and sensitized for green by an extremely dilute solution of erythrosin and ammonia. The rear film might be body-dyed, or a superficial red filter placed on the front film face; a yellow filter might be used over the lens. The films were to be kept in contact at the moment of exposure by pressure of a resilient pad against a block of glass. The inventor stated that he believed that the

front specially translucent film was new, but it will be seen that it was suggested by his anticipators above. The positives might be stained up in various ways. The inventor also stated that he considered that the use of the two films wound on one reel face to face to be novel, and that it was an important feature of his system, whereas this was previously employed by Buchanan-Taylor and Battistini. He claimed: "producing local intimate contact of the sensitized surfaces of the two strips by a resilient squeezing pressure at the rear thereof against a rigid transparent plate located behind the lens." But the resilient pressure dates back to 1856, for in Thornthwaite's "Guide to Photography," published by S. D. Humphrey, New York, 1856, page 20, it says: "but the double back (Fig. 27) is employed exclusively for sensitive paper; it consists of two frames hinged together at the bottom, and each having a mounted glass plate (g), inside and a moveable shutter outside. By this arrangement two pieces of prepared paper can be retained in a frame of no larger size than the ordinary single back, fitting the same size groove at the back of the camera. When used the glass plates should be nicely cleaned, and one piece of paper laid face downwards, upon one of the plates of glass; a piece of bibulous paper, the size of the sensitive paper, is then laid upon it, and the other sheet of sensitive paper placed, face upwards, upon the bibulous paper; that portion of the frame and glass which is not occupied by the papers is now turned upon them, and secured in its position by two or more fastenings at the sides. By this arrangement the papers are pressed perfectly flat against the two inner surfaces of the glass plates, etc." R. Krügener[188] had used a front plate of glass to keep films flat during exposure, in 1892. Le Prince also, in 1888,[190] also Marey.[191] Friese-Greene[192] stated: "to keep the film fast and steady whilst opposite the aperture it is passed between cushions or glass plates *15*, the back one of which is mounted on a spring arm."

A. Hamburger and W. E. L. Day[193] also patented a semi-dialyte method, and a plan view of the suggested camera is shown in Fig. 166, in which *c* and *j* are the driving sprockets for the films. Two films, sensitive respectively to blue and green, were to be arranged face to face to pass over *c* and the aperture plate *de*, and they received the image reflected from a refraction-reflection element or glass, interposed on the optical axis *fg*. The other film, which was to be red-sensitive, passed over the sprocket *j* past the aperture *k* in the gate *l*, in front of which was the red filter. The other details are merely for the operating mechanism. The patent is for the film-feeding mechanism, and no details are given as to the positives.

A. Gleichmar[194] patented a light-splitting mirror with the use of three films. The transmitted light affected the red-sensitive element, and the reflected light traversed a green filter and acted on the green and blue-sensitive films at the same exposure field. J. de Frenes[195] assumed that

the film was faster to green than red and proposed to cut down the exposure for the former and increase it for the latter, by giving a longer pause to the film in the latter area. F. Pramor[196] proposed to use three thin films rolled up on one spool, which were passed behind three slits, placed one above the other, containing the filters; each film being rolled up on a separate spool, as soon as it had passed a slit.

R. O. Humphrey and C. H. Friese-Greene[197] patented a method of obtaining negatives for two-color additive projection, in which a two-aperture shutter was used. One aperture being so arranged that white light with blue-green was passed and the other passing from yellow to red. The colors might be graded and it was claimed that there was less color fringing, and fuller exposure obtained. Obviously the reasoning here is weak and the admission of white light and the grading of the colors had been patented by Wohl & Mayer, Raleigh & Kelley.

W. Friese-Greene and Color Photography, Ltd.[198] would make negatives on a single sensitive surface by alternate exposures to white light and through a filter. This idea had already been patented by W. Friese-Greene,[199] who also patented[200] the idea of interposing a black section or picture space at intervals in the recurrent color pictures, for relieving eye-strain.

**Screen-Plate Processes.**—Were it possible to carry out this process practically, it would undoubtedly be the ideal, for each individual picture would be the carrier of its own appropriate colors, complete in every detail. The film could be run through any projector and one would have, possibly, nothing but the straight processes of black and white work, assuming that manufacturers could produce commercially the necessary negative and positive film stock. But there are one or two grave hindrances to its general adoption. In the first place, if we assume that the negative is to be obtained in the complementary colors, we shall have to print on to positive screen-film, and the difficulties have been pointed out in the section dealing with screen-plates generally. But there is the initial difficulty as to whether the negative film could be made sufficiently rapid for ordinary work. True, if we did not want to reverse the negative, this might be accomplished, and one can assume that the exposure would be no longer through the screen elements than through the normal filters. The practical application of extremely fine elements to long lengths of celluloid, however, is no mean task.

If we consider the size of the units, we must argue back from the enlarged screen-image, and in some theaters this is 20 ft. across, but if we accept a 15 ft. screen as the mean, we shall find that our screen elements must be quite small. As the actual projected picture is approximately 1 inch, the magnification becomes 180 times. W. Scheffer has shown (see p. 461), that the resolving power of the eye is of such an

order that it will see lines separate, if their period (twice their separating distance for lines of equal width to the spaces) is one-thousandth of their distance from the eye. Thus the screen unit must not be more than 2.54 mm. on the projection screen, and if the magnification is as stated above, we find that the actual size of the unit must be 0.015 mm.

Some inventors have been rash enough to put on paper at least, what they consider possible methods of using the screen-plate process. L. Vidal[201] suggested the use of the Joly screen for Edison's Kinetoscope. F. W. May and E. Judson[202] would utilize a transfer process, and paper was coated with dichromated gelatin, exposed to light and then after washing and calendering, the gelatin was rubbed over with wax in benzol and a second coat of plain gelatin and sugar applied, which was termed the "transfer." The colored elements might be applied in the form of lines or dots in a resist, and the dyes might be mordanted by ferric chloride. F. W. May[203] patented the production of a screen-plate or film, in which a resist of gelatin in lines was applied to a gelatin-coated support. The film was to be hardened and the color applied in the free spaces, then the surface treated with formaldehyde, ferric chloride or aluminum acetate. The resist was washed off and the process repeated for the other colors.

H. A. Dorten[204] would make his negative by the screen-plate process, make a positive from the same, project the picture and make three constituent negatives with successive pictures, or by separating each color record, then the positives could be made as usual and projected with a rotary shutter. In a later patent[205] the same inventor would make a color positive film by a screen process and then enlarge this about five diameters, copy through the usual filters on to three films three times the normal width, each picture being exposed by itself. Then from the negative thus obtained positives could be made as usual.

H. Workman[206] proposed to apply the screen elements to the positive film made from a screen negative, by mechanical means. Fig. 167 represents one of the various patterns that might be employed: *1* shows the arrangement of the camera with the lens *a*, *b* the film was fed in the usual way, and *c* is the gate, *d* the sectional color screen, "disposed therein so as to be in contact or nearly so with the front of the film." The positive was to be made from the negative thus obtained, and it is clear from the wording that the negative was merely a black and white one with the image broken up into the screen pattern. To the positive the color elements were now to be applied by mechanical impression, dyeing or a combination of both. It may as well be pointed out that in "nearly so" contact with a screen-plate is useless, as there can be no possible accurate pattern thus obtained. The negative taking screen is shown in *2*, *R*, *G*, *B* standing for the colors red, green and blue. The three printing surfaces are shown in *3*, *4* and *5*. H. Tress[207] patented an aperture plate with

guides to keep a film in contact with a screen-plate fixed in the gate of the camera.

R. G. Bradshaw and J. C. Lyell[208] proposed to color both sides of the celluloid, then scrape away the colored surfaces so as to leave juxtaposed but not superposed points, lines or other areas. Green and red might be used, or green, red and violet and the substance of the celluloid itself might be colored. Then the lines or figures might be obtained by the aid of planes, scrapers or revolving circular cutters. As an alternative the

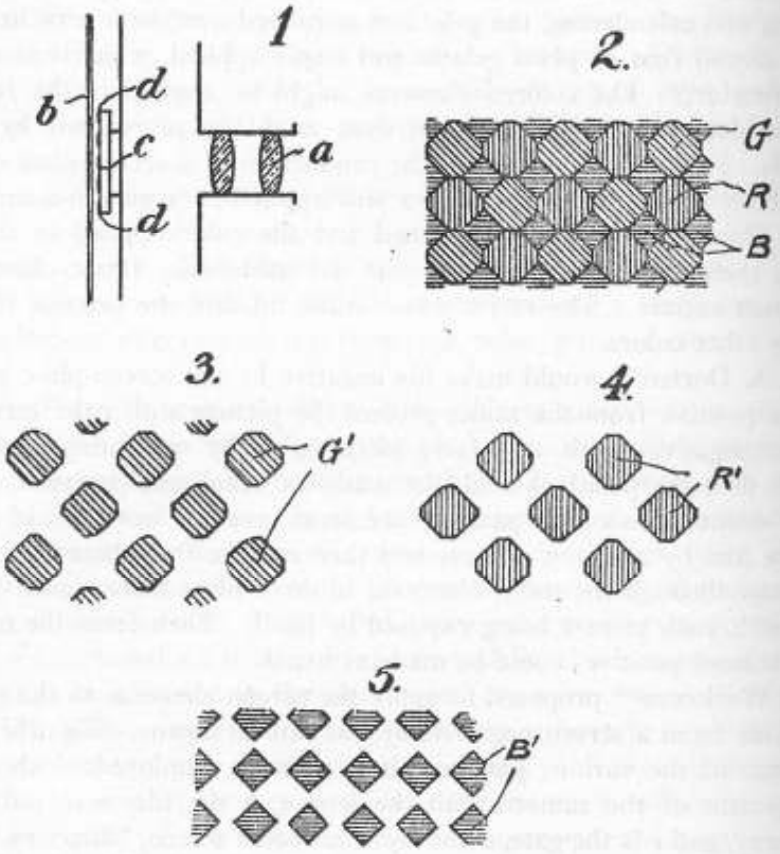


FIG. 167. Workman's E.P. 9,610, 1913 (Page 603).

base, after being colored or not, might be manufactured with raised figures, the raised parts being planed or scraped off to produce the same effect. Fig. 168 shows one form of the invention, *1* and *2* are perspective views of the film in section, showing a two-color film, *3* shows a three-color film; *a* is the film ready for scraping, and *b* one color and *c* the other. In *3* the stripes of red overlap the green *c* at the dotted lines *x* and *y* forming violet. It is presumably unnecessary to point out that this would form an additive film.

W. V. D. Kelley[209] patented a process, which, it was claimed, gave better and more uniform definition and which was applicable to two-, three- or more-color systems. Approximately half the area of the film subject was recorded without color filters, by the interposition between the film and lens of a black and white screen. The clear and opaque areas being approximately equal. The remainder of the exposure might be made through the usual filters over the entire area of the picture or only on the previously unexposed parts. It was claimed that this impression would be, for instance, of the red in the subject, and the color records

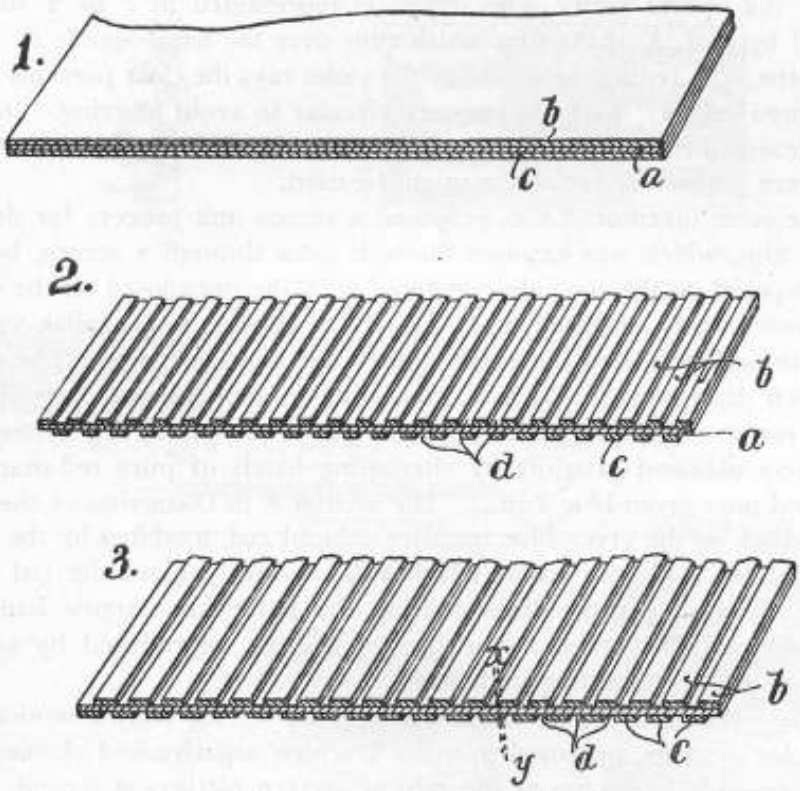


FIG. 168. Bradshaw & Lyell's E.P. 6,894, 1913.

would be fully recorded in the unexposed areas, and also there would be a further impression of color on the already exposed parts. There is a weak point in this argument, for if we assume that the primary exposure gave a latent density of 2, and this was further impressed by red light, sufficient to produce a latent density of 0.5, then the final density would be at this point 2.5, so that the positive would have less density there and the color would be diluted with white. One method of making the exposures was to use three shutters on the camera; the regular cut-off one, covering the change of film, and change of screen-film; a second shutter

carrying the line screen and a third the filter. The line screen frame would come into position at the film change and move intermittently, while the filter frame, in a two-color scheme, would move one-half revolution for each picture and might move continuously. In projection the ordinary shutter was used. Fig. 169 *1* represents a perspective view of one form of shutter, filter and screen arrangement; *A* is a rotary frame carrying the cut-off shutter *B; C* is a rotary filter frame carrying the filters *D* and *E* and the former was provided with a clear space *F* for each filter. The spaces *G* between the sections *D* and *E* and the clear section *F* constitute shutters, which permit the line screen to be shifted out of the optical path. The screen is represented in *2* by a slide *H* worked by *I; J, K* is the film which runs over the usual spools *L, L; M* is the lens. To reduce the action of the violet rays the clear portions might be colored yellow. In *3* the lines are circular to avoid blurring. In *4, 5, 6* other modifications are shown. Screens with 200 to 400 lines to the inch were suggested, but others might be used.

The same inventor[210] also proposed a screen unit process for double-coated film, which was exposed on both sides through a screen, but the lines exposed on the one side registered with the unexposed on the other, as shown greatly enlarged in *1*, Fig. 170. And *2* is a similar view, *9* being the celluloid and the small figures the exposed parts. The object is shown diagrammatically in *5*, consisting of two white sectors *W, W*, a red sector *R* and a green sector *G*. In *4* section *C*, the sectors are additively obtained in white by alternating bands of pure red-orange, *5* in *2*, and pure green-blue *8* in *2*. The section *R* in *C* consists of the print on the back of the green-blue negative colored red, modified by the green colored lines *8* on the front, which still additively gives the red print, even although the green lines overlap the red print, narrow bands of black occur. The green sector *G* was likewise reproduced by narrow bands of green alternating with black.

J. E. Thornton[211] after summarizing some of the known motion picture color systems, proposed to make a screen negative and claimed that it was possible to expose at the rate of sixteen pictures a second. Any pattern elements could be used, and from this negative the individual records were to be prepared. The patterns being obliterated as was done in Dorten's patent and screen-plate work generally. This was to be done by using black and white screens, like Brasseur and others, or by angling the light as in the Powrie, Smith and other methods.

F. Habere[212] would get over the graininess by enlarging the horizontal elements. S. Kolowrat and A. Nekut[213] pointed out that the grain of existing screen-plates was too coarse for cine work and proposed to centrifugally separate silver iodide from an emulsion, stain up in the three colors and re-emulsify in gelatin. The dyes were to be fixed with tannin and the silver salt dissolved. As it would not be possible to coat these grains

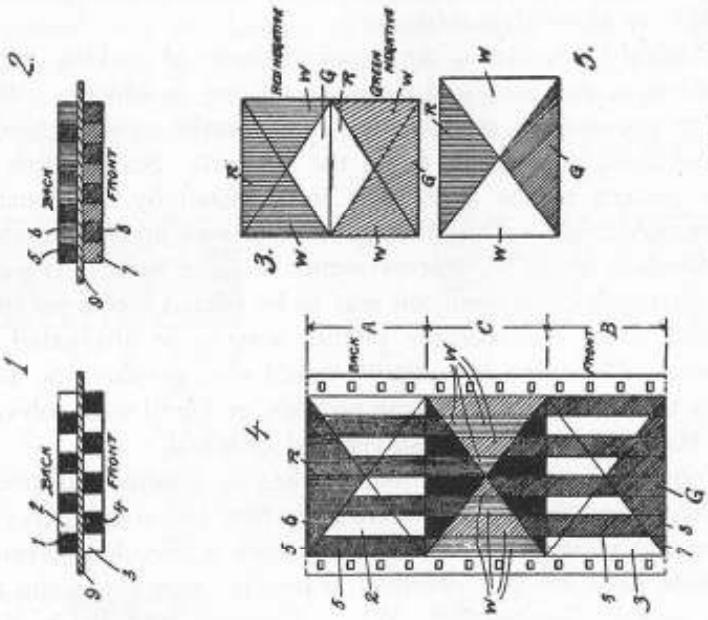


Fig. 170. Kelley's U.S.P. 1,337,775.

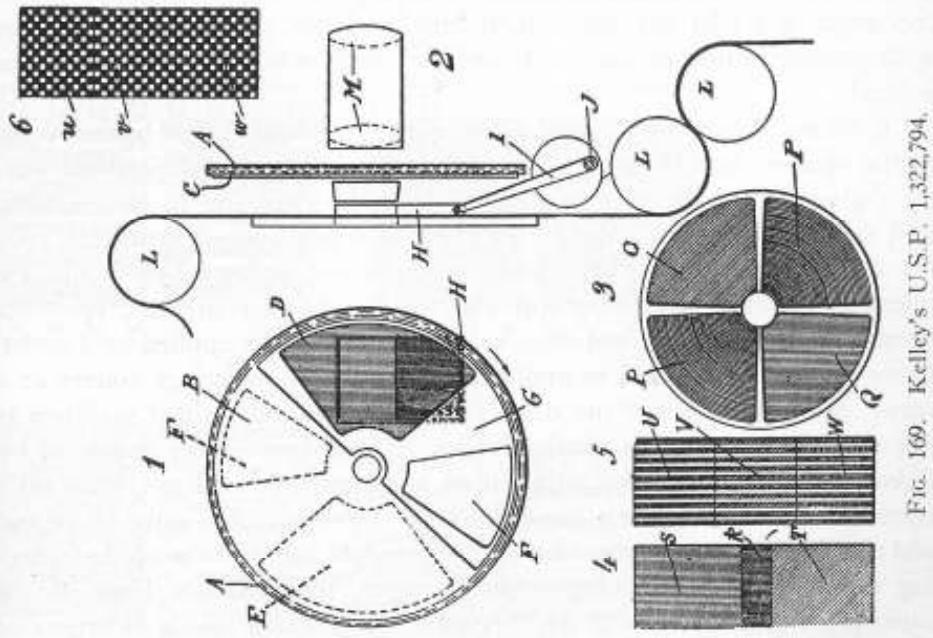


Fig. 169. Kelley's U.S.P. 1,322,794.

in a single layer, they were to be stained yellow, blue-green and crimson, so that by superposition the subtractive colors would be formed; although all screen-plates are of the additive class. The Deutsche Rastergesellschaft[214] proposed to obtain stereoscopic effects by using two-color screens and providing the spectators with suitable spectacles. The method of

making the screen was with a greasy resist, and the process was said to be applicable to cinematography.

J. T. Smith[215] considered the usual methods of making the patterns were all defective and proposed a compound one, in which a colloid resist was used to prevent the etching action of certain etching-coloring solutions on celluloid, which was to be the support. Stained fish-glue was applied in pattern to the base, then insolublized by dichromating and light or formaldehyde. The etching solution was preferably anilin with dyes dissolved in it. The process seems to have been a two-color one and after varnishing the emulsion was to be coated direct on the screen. A black and white monochrome picture was to be alternated with the colored ones. The same inventor[216] would also prepare the surface of celluloid by treatment with abrading powder, or liquid with solvent action, and apply the dye in solution of solvents of celluloid.

The Compagnie Générale Phonographes et Cinématographes[217] proposed to take a negative on a panchromatic film and color each picture on its positive and photograph the same through a tri-color screen. From the composite negative thus obtained, a positive was made and projected through a reduced line screen. W. G. Finnigan and R. A. Rodgers[218] proposed to expose a film in contact with a piece of ground glass. From the negative a film covered with minute particles in any pattern, coated with positive emulsion was used, and the result was said to be in natural colors!

I. Kitsee[219] proposed to make a template with transparent spaces equal to the opaque, and from this to make a master key of longitudinal lines the full width of the emulsion-coated base, by exposing to an arc lamp and then developing. From this a print was made on dichromated gelatin, containing a dye. The exposed parts would be hardened, whilst the unexposed would swell in water and the dye be discharged. The lines would also be raised up and the second color was to be applied by a roller. Later Kitsee[220] proposed to apply the elements by means of rollers or a spray, using Canada balsam, dissolved in alcohol and stained up, then to dye the interspaces with another color. The inventor lays stress on his discovery that an aqueous solution of a second dye will not stain up a resinous resist, and claims the use of one color miscible only in alcohol and the other only in water. Later[221] a template was to be made by reducing down by photographing squared paper, the alternate lines of the squares being filled up with ink. Apparently this was also a dichromated gelatin process. Another modification[222] was a resinous resist and the celluloid itself dyed up. While a modification of the formation of the elements was patented.[223]

R. Wellesley and T. M. Saunders[224] patented a method of transferring a color screen to a positive picture from a temporary celluloid support. The positive was to be passed through an adhesive-applying ap-

paratus, then pressed on the screen-film by rollers. The combined film was then passed over an illuminated inspection plate, on which the relative positions of the positive film and screen were adjusted by hand. The film was then treated with warm water plus acetic acid, so that the temporary support might be stripped off. B. Bock[225] proposed a screen-

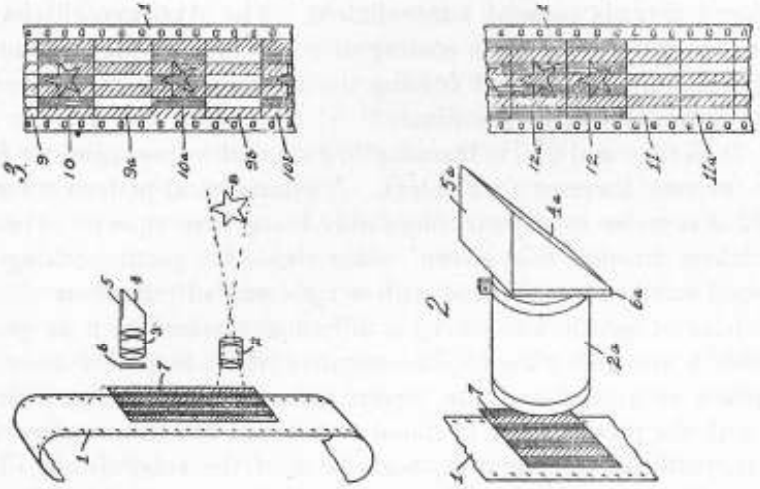

FIG. 172
Kelley & Dunning's U.S.P. 1,431,309
(Page 610).

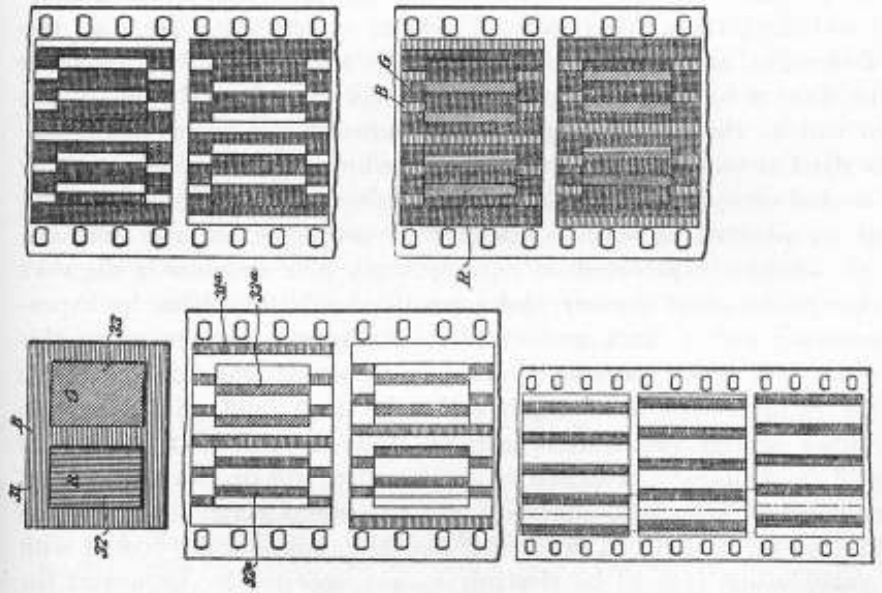

FIG. 171.
O'Grady's U.S.P. 1,402,371 (Page 610).

film in which the elements of only two colors should occur in each picture, and these colors should change in successive pictures, so that in three succeeding pictures each color should occur twice.

F. T. O'Grady[226] would apply the filters to the surface of panchro negative stock in lines longitudinally of the base in the usual triad, of

from 1/1000 to 1/2000ths of an inch, and stagger the lines, as shown in Fig. 171, in which *R, G, B* represent the colors. The filter lines were to be removed by washing; the result being merely a linear negative in black and white, from which a positive was made as usual. This positive was then ruled with the necessary lines and it was claimed that marked sterescopic effect as well as colors was obtained. L. Herzberg[227] proposed to use colored threads pressed into celluloid. The Aktiengesellschaft f. Anilinfabrikation[228] patented the coating of celluloid with the elements by passing it through a liquid and forcing the elements into the latter and allowing them to deposit on the film.

W. V. D. Kelley and C. H. Dunning[229] proposed to use a line or regular screen for two, three or four colors. A symmetrical pattern screen, *7* in Fig. 172 was to be used, two colors only being here shown. The picture was taken through this screen, while above the picture-taking lens was arranged another one *3* fitted with a right-angled mirror or prism *4* above the base of which was placed a diffusing surface, such as ground glass; a filter *6* also being used. The negative film was pulled down two picture spaces at a time and the screen pattern impressed in alternate sequence with the pictures. It is stated that where the color-values were recorded correctly in the negative, regardless of the subdivisions of the spectrum used, that it was possible to reproduce them satisfactorily with but two projection colors. The positive film was preferably double-coated and the picture areas were all printed in successive areas on one side of the film, and the design or pattern on the other. And assuming that the filter *6* be greenish-blue, it is obvious that the red lines of the pattern will be clear in the negative and dense in the positive, and can then be dyed or toned red, while the alternate lines, which are dense in the negative and clear in the positive will be stained green. Thus would be formed an additive screen-film, capable of projection in any machine.

J. W. Flender[230] patented an extraordinary idea in which a negative was taken in the usual manner, and a positive made therefrom by exposing in contact with a black and white matrix screen and projecting this positive on to a screen, bearing a mosaic pattern. It was said that: "the resulting pictures will have depth and color tone, and will accurately show, either in black and white or in colors, the color values of the original settings." C. Dupuis[231] proposed to obtain either still or cinematographic pictures by a screen-plate, either on one or several plates or films, and then to print on to polished silver that had been superficially coated with silver subchloride, formed by electrolysis, as suggested by Becquerel for the Seebeck process. It was stated that the picture could be projected 175 times without alteration of the colors.

W. V. D. Kelley[232] would imprint the sensitive surface with lines by the action of light and then to issue the same so that the user might print his picture on the same mordant the lines after development, with suitable

colors. This was also claimed for double-coated film. F. T. O'Grady[233] would apply the filters to the emulsion as in his previous patent. In a subsequent patent[234] the negative was taken through a two-color rotating sector shutter and the positives printed through a line screen, all the one color records being printed first and the other record printed in accurate juxtaposition.

C. J. Coleman[235] would overcome the difficulty of ruling very fine lines by placing in front of the camera lens at a distance equal to about one-twentieth or more of the distance between the lens and the subject, a line screen. It was stated that by thus placing the screen "the resistance to and choking or decreasing of the volume of light passing through the lens is decreased very materially." The same arrangement was to be practically used in projection. L. Dufay[236] would dye one side of the celluloid blue and print resist lines thereon. An alcoholic red dye was then applied, which destroyed the blue exposed spaces. The resist was removed and a yellow dye applied which produced green and orange. A fresh series of resist lines were then printed at an angle to the first and a blue-violet dye applied, which destroyed the yellow in the unprotected parts. A four-color screen was thus produced.

L. F. Douglass[237] proposed to copy a series of black dots or figures on a positive film and dye-tone them red. Then sensitize the clear gelatin with a ferric salt, expose and develope with ferricyanide, forming a blue ground. The whole film was then stained yellow, so that the red became an orange-red and blue a blue-green. M. C. Hopkins[238] would obtain the constituent negatives in the ordinary way, make therefrom positives with linear screen of monochrome colors, thus following the patents of Bradshaw & Lyell and Kelley, that is with the color lines displaced as regards one another. S. Schapovaloff[239] patented a process applicable to a screen-film or one with superposed images, in which successive coatings were sensitized, and which might contain a white diffusive material.

The Aktiengesellschaft f. Anilinfabrikation[240] proposed to reproduce on a mosaic screen through the taking filters, three record positives, or the image additively projected in colors might be printed by the same method.

1. Les Mondes, Feb. 25, 1869. Subsequently published as a separate pamphlet, entitled: "Solution générale du Problème de la Photographie des Couleurs," Paris, 1869.

2. D.R.P. 98,799, 1897; Silbermann, **2**, 343; Brit. J. Phot. 1916, **63**, Col. Phot. Supp. **9**, 19; Jahrbuch, 1900, **14**, 561; Phot. Rund. 1899, **13**, 29.

C. F. Jenkins, Brit. J. Phot. 1900, **47**, Supp. 4, also suggested color cinematography with red, yellow and blue filters. T. C. Porter, E.P. 12,921, 1897 patented alternate projection of the pictures with occulting shutter for the observers, for stereoscopy; the process might be used for color work.

3. E.P. 21,649, 1898; abst. Brit. J. Phot. 1899, **46**, 729; 1907, **54**, Col. Phot. Supp. **1**, 47; Photogram, 1900, **7**, 109.

For a lantern on similar lines see E.P. 13,883, 1900.

4. E.P. 10,611, 1907; Brit. J. Phot. 1908, **55**, 598, 607; F.P. 377,374; Can.P. 108,152; Belg.P. 199,772; Phot. Coul. 1908, **3**, 216.

R. Krayn, E.P. 10,000, 1900, void; Brit. J. Phot. 1900, **47**, Supp. 96 also pro-

posed to mount the three positives with filters and pass them successively in front of an opening in a wheel. Cf. W. Bishop, Brit. J. Phot. 1892, **39**, 362.

5. E.P. 23,863, 1898; abst. Brit. J. Phot. 1900, **47**, Supp. 94; 1907, **54**, Col. Phot. Supp. **1**, 64; U.S.P. 676,532; D.R.P. 128,907; Silbermann, **2**, 343.
6. E.P. 7,035, 1900; abst. Brit. J. Phot. 1907, **54**, Col. Phot. Supp. **1**, 64.
7. U.S.P. 1,204,771; E.P. 16,201, 1913; F.P. 459,960.
8. U.S.P. 727,948, 1903.
9. U.S.P. 1,143,608; F.P. 472,002, 1914.
10. F.P. 364,369, 1906.
11. Addit. to above 6,193, 1906.
12. F.P. 375,110, 1907.
13. F.P. 381,494, 1906.
14. E.P. 453, 1908; Brit. J. Phot. 1909, **56**, 126.

Patented also by H. R. Evans, F.P. 478,847, 1915, and R. Nuber, D.R.P. 338,182, 1920.

15. E.P. 11,791, 1908; Brit. J. Phot. 1909, **56**, 202; U.S.P. 937,367; Austr.P. 41,127; Phot. Ind. 1910, 561; Jahrbuch, 1911, **25**, 337.
16. E.P. 249, 1902.
17. E.P. 5,945, 1909; Brit. J. Phot. 1910, **57**, 407.
18. E.P. 9,912, 1909; Brit. J. Phot. 1910, **57**, 407.
19. D.R.P. 239,382, 1910; Phot. Ind. 1911, 1727; Jahrbuch, 1912, **26**, 241; F.P. 421,053; Austr.P. 53,257.
20. E.P. 24,161, 1912; Brit. J. Phot. 1914, **61**, 182. In E.P. 28,365, 1912, stereoscopic pictures were to be shown.
21. F.P. 456,344; Belg.P. 255,340; E.P. 8,063, 1913; Brit. J. Phot. 1914, **61**, 502; D.R.P. 281,362; U.S.P. 1,130,221.

In D.R.P. 285,558, 1913 the inventor proposed to equalize exposures by partly employing the color values of one picture in the next. In F.P. 456,343; E.P. 8,062, 1913 he used oscillating color reflectors for successive pictures.

22. E.P. 26,292, 1912; Brit. J. Phot. 1913, **60**, 730.
23. E.P. 21,261, 1911; Brit. J. Phot. 1912, **59**, 541; F.P. 448,488; U.S.P. 1,184,226; Jahrbuch, 1915, **29**, 158.
24. E.P. 2,704, 1914; Brit. J. Phot. 1915, **62**, 155.
25. E.P. 19,098, 1912.
26. E.P. 23,386, 1911; Brit. J. Phot. 1912, **59**, 202; abst. J. S. C. I. 1912, **31**, 258; U.S.P. 1,184,226; D.R.P. 270,551; Phot. Ind. 1914, 280; Jahrbuch, 1912, **26**, 240.
27. E.P. 23,499, 1911; abst. Brit. J. Phot. 1912, **59**, 885. In E.P. 7,477, 1912; Brit. J. Phot. 1913, **60**, 29 a machine was patented for applying the color film to the positives.
28. E.P. 23,221, 1911; abst. Brit. J. Phot. 1912, **59**, 835.
29. U.S.P. 1,293,040, 1919.
30. E.P. 23,499, 1911; Brit. J. Phot. 1912, **59**, 885.
31. E.P. 14,133, 1912; Brit. J. Phot. 1913, **60**, 558; D.G.M. 504,520.
32. F.P. 445,601, 1911.
33. U.S.P. 1,145,410, 1915. Cf. Pathé, F.P. 437,445, 1920.
34. U.S.P. 1,287,594, 1918; E.P. 131,478; Brit. J. Phot. 1920, **67**, 288; Col. Phot. Supp. **13**, 18; Jahrbuch, 1915, **29**, 159.
35. E.P. 117,864, 1918; Brit. J. Phot. 1919, **66**, 16; Col. Phot. Supp. **13**, 3; abst. J. S. C. I. 1918, **37**, 607a; U.S.P. 1,325,279; F.P. 487,306; Jahrbuch, 1915, **29**, 155.
36. E.P. 23,497, 1911; abst. Brit. J. Phot. 1912, **58**, 1000. Cf. W. H. Kunz, U.S.P. 1,175,961, 1916 for the same idea. Also A. Markus, D.G.M. 545,977.
37. E.P. 1,489, 1912; Brit. J. Phot. 1913, **60**, 500.
38. E.P. 26,976, 1912; Brit. J. Phot. 1913, **60**, 500; D.R.P. 274,710; U.S.P. 1,203,681.
39. U.S.P. 1,094,147; F.P. 471,082; E.P. 9,229, 1914. In U.S.P. 1,243,273 an endless linked chain carrying the filters is patented. Cf. A. G. Donnelly, U.S.P. 1,098,370.
40. U.S.P. 1,094,148; E.P. 9,230, 1914.
41. U.S.P. 1,115,538; E.P. 9,765, 1914; F.P. 471,290. Cf. Hochstetter and Pryce, U.S.P. 1,255,421.
42. U.S.P. 1,137,320; E.P. 9,764, 1914; Brit. J. Phot. 1915, **60**, 243; F.P. 471,289; 471,083 granted to P. M. Pierson and Hochstetter.
43. U.S.P. 1,301,265, 1919.

44. U.S.P. 1,289,940; E.P. 126,220, 1918; Brit. J. Phot. 1919, **66**, 386; Col. Phot. Supp. **12**, 26; F.P. 385,249; 513,802; abst. Sci. Tech. Ind. Phot. 1921, **1**, 53.

45. U.S.P. 1,300,887, 1919.

46. Photo-Rev. 1920, **32**, 11, 49.

I. Kitsee, U.S.P. 1,070,699 proposed to use incandescent lamps, with colored bulbs, and alternately light these.

47. F.P. 470,244, 1913. Cf. F.P. 467,609; 435,745.

C. A. Coppier, F.P. 527,145; addit. 24,045; 24,985, proposed to take objects in front of a black or white background, enlarge and paint the prints and then reduce down again to normal size.

48. Phot. Chron. 1904, **11**, 571.

49. E.P. 154,150, 1920; Brit. J. Phot. 1921, **68**, Col. Phot. Supp. **14**, 10; D.R.P. 352,649. Cf. T. H. Blair, U.S.P. 1,186,612, 1916.

50. F.P. 513,885, 1920.

51. F.P. 561,711; Sci. Ind. Phot. 1924, **4**, 83.

52. E.P. 202,271, 1922; Brit. J. Phot. 1924, **71**, 344.

53. F.P. 569,954, 1922; E.P. 200,292; abst. Sci. Ind. Phot. 1924, **4**, 153, 185. In D.R.P. 371,323, 1919 May patented an adjustable stand for the projector shutter.

54. Phot. J. 1924, **64**, 397.

C. Paraloni and G. Perron, F.P. 569,407; E.P. 219,957; abst. Sci. Ind. Phot. 1924, **4**, 184, patented the use of negatives of half the usual height, thus saving film. The positives were to be projected through a rotary sector shutter or with a two-color filter in the lens and prisms. Cf. Brit. J. Phot. 1921, **68**, Col. Phot. Supp. **15**, 4. L. Brown, U.S.P. 1,514,501, 1924, in this the images might be staggered.

55. Der Phot. 1923, **33**, 93.

56. E.P. 212,875; F.P. 571,003, 1923; abst. C. A. 1924, **18**, 2294; Sci. Ind. Phot. 1924, **4**, 198.

57. F.P. 537,445; E.P. 171,975.

58. F.P. 552,781.

59. D.R.P. 371,117; addit. to 328,192.

W. F. Fox, U.S.P. 1,166,120 also patented a projector for persistence of vision, which could be used for black and white. Cf. W. C. Vinten, E.P. 546, 1914.

For notes on Miethe's projector see: Brit. J. Phot. 1902, **49**, 281, 581; 1903, **50**, 102, 121, 828; Photo-Era, 1903, **10**, 138; Phot. Chron. 1903, **10**, 442, 445; 1904, **11**, 571; 1905, **12**, 9; Phot. Korr. 1904, **41**, 286; 1905, **42**, 21; Zeits. wiss. Phot. 1905, **3**, 40.

60. E.P. 6,202, 1899; abst. Brit. J. Phot. 1907, **54**, Col. Phot. Supp. **1**, 48; U.S.P. 645,477, 1900. Cf. C. Forch, "Der Kinematograph," 1913, 129. Hopwood and Foster, "Living Pictures," 1915, 262.

61. E.P. 3,729, 1903; Brit. J. Phot. 1907, **54**, Col. Phot. Supp. **1**, 88; F.P. 342,445.

62. E.P. 7,179, 1904; Brit. J. Phot. 1905, **52**, 254. No patent granted on this application. D.R.P. 162,049, 1903; Silbermann, **2**, 338.

63. E.P. 27,419, 1904.

64. E.P. 322, 1905; Brit. J. Phot. 1905, **52**, 1012.

65. E.P. 9,465, 1905; Brit. J. Phot. 1905, **52**, 213.

66. F.P. 369,092; addit. 7,480, 1907, this last deals with a positive from a successively taken negative projected through three lenses vertically juxtaposed, in conjunction with a rotating sector shutter, on to a positive from a negative taken without filters, this latter being run synchronously.

67. E.P. 3,766, 1906; Brit. J. Phot. 1907, **54**, 294; D.R.P. 198,196; Phot. Chron. 1908, **15**, 590; Jahrbuch, 1909, **23**, 235; U.S.P. 944,787. The same device was suggested in Brit. J. Phot. 1909, **56**, Col. Phot. Supp. **3**, 72; Jahrbuch, 1910, **24**, 340.

68. E.P. 25,908, 1906; Brit. J. Phot. 1907, **54**, 582.

69. E.P. 15,726, 1907; Brit. J. Phot. 1908, **55**, 590. In E.P. 2,538, 1913; Brit. J. Phot. 1914, **60**, 32; Jahrbuch, 1914, **28**, 521, three lenses vertically juxtaposed were used. Cf. F. Fissi, Penrose's Annual, 1912, **18**, 235.

70. E.P. 1,717, 1910; Brit. J. Phot. 1911, **58**, 145; F.P. 411,557; addit. 13,521; D.R.P. 231,526; 242,101. The concave lens is claimed in the additional F.P. and in E.P. 25,869, 1910; Brit. J. Phot. 1911, **58**, 920; D.R.P. 237,423; 234,775; Phot. Ind. 1911, 28, 2122; Jahrbuch, 1911, **25**, 326; 1912, **26**, 242.

71. U.S.P. 1,130,702, 1915.

72. D.R.P. 276,870, 1913.

Cf. G. Griffith, U.S.P. 1,513,984, 1924; abst. Amer. Phot. 1925, **19**, 520.

73. E.P. 18,340, 1909; Brit. J. Phot. 1910, **57**, 518; U.S.P. 973,961; 963,962 granted to W. E. Oliver; Motography, 1911, **5**, 20. In a later patent E.P. 24,779, 1910; Brit. J. Phot. 1911, **58**, 899; Jahrbuch, 1912, **26**, 240, granted to Oliver, mirrors were used instead of prisms.

74. E.P. 29,596, 1912; Brit. J. Phot. 1913, **60**, 979.

75. F.P. 398,220, 1908; addit. 12,942; E.P. 17,872, 1910; Brit. J. Phot. 1911, **58**, 615; E.P. 672, 1914; Brit. J. Phot. 1915, **62**, 138; Belg.P. 252,280; 256,695.

76. E.P. 18,431, 1912; Brit. J. Phot. 1912, **59**, 330; F.P. 433,162.

77. E.P. 30,108, 1912; Brit. J. Phot. 1914, **61**, 143; F.P. 449,962.

78. E.P. 12,577, 1913; Brit. J. Phot. 1914, **61**, 616; F.P. 455,693.

79. F.P. 464,905, 1913.

80. F.P. 502,078, 1920.

81. E.P. 166,344, 1920; Brit. J. Phot. 1921, **68**, 539; abst. Sci. Tech. Ind. Phot. 1922, **2**, 39; F.P. 534,011. Cf. O. Pfenninger, Gaumont, Ulysee, Gergacsevics, Bjerregard, etc.

82. U.S.P. 1,262,954, 1918.

83. U.S.P. 1,247,646, 1917.

84. F.P. 487,501; E.P. 112,940, 1917; Can.P. 204,789.

85. F.P. 523,552, 1920; abst. Sci. Tech. Ind. Phot. 1922, **2**, 11.

86. E.P. 148,254; 155,764; U.S.P. 1,423,697, 1922. Cf. Kinotechnik, 1924, **6**, 293, 322; Sci. Ind. Phot. 1925, **5**, A, 19.

87. U.S.P. 1,430,765, 1922; Amer. Phot. 1923, **17**, 184; E.P. 196,778; Brit. J. Phot. 1923, **70**, Col. Phot. Supp. **17**, 32; F.P. 554,755; Sci. Ind. Phot. 1924, **4**, 72; D.R.P. 371,201. Cf. D.R.P. 395,001.

88. D.G.M. 817,507; Phot. Ind. 1922, 702.

89. U.S.P. 1,428,103, 1922; Swiss P. 87,589. Cf. C. Zeiss, D.G.M. 558,541.

90. D.R.P. 187,199, 1905.

91. D.R.P. 267,500, 1912; E.P. 134,926.

In E.P. 216,518; Brit. J. Phot. 1924, **71**, Col. Phot. Supp. **18**, 42 Thorner proposed to use four colors projected by split condensers; F.P. 581,921.

92. F.P. 505,901; E.P. 134,926, 1918; Brit. J. Phot. 1920, **67**, 143; D.R.P. 352,631; U.S.P. 1,425,775.

93. F.P. 506,441; E.P. 134,842, 1918; Brit. J. Phot. 1920, **67**, Col. Phot. Supp. **13**, 46; U.S.P. 1,355,498; D.R.P. 340,569.

94. F.P. 506,097, 1920; U.S.P. 1,419,901.

95. F.P. 465,786, 1913.

96. F.P. 467,609, 1913.

97. F.P. 470,244, 1913.

98. F.P. 397,934, 1908.

99. F.P. 453,059, 1912.

100. F.P. 422,526, 1910.

101. F.P. 460,310, 1913.

102. F.P. 456,203; E.P. 8,035, 1914.

103. E.P. 6,565, 1913; Brit. J. Phot. 1914, **61**, 633.

104. F.P. 464,637, 1913.

105. D.R.P. 313,561; Phot. Ind. 1920, 139; Phot. Korr. 1920, **57**, 277; Jahrbuch, 1915, **29**, 164; F.P. 519,442; abst. Sci. Tech. Ind. Phot. 1921, **1**, 93.

106. E.P. 147,767, 1920; Brit. J. Phot. 1921, **68**, 718; Col. Phot. Supp. **15**, 46; abst. Sci. Tech. Ind. Phot. 1921, **1**, 8; F.P. 517,523.

107. U.S.P. 1,340,923, 1920.

108. E.P. 18,646, 1914; Brit. J. Phot. 1915, **62**, 690; F.P. 472,710; Belg.P. 253,190, 1913. In addit. 19,319 to above F.P. four colors were used, complementary to one another.

109. U.S.P. 1,385,912; Bull. Soc. franç. Phot. 1912, **54**, 370; abst. Sci. Tech. Ind. Phot. 1922, **2**, 52. Cf. U.S.P. 1,223,881.

110. F.P. 525,883, 527,132; abst. Sci. Tech Ind. Phot. 1922, **2**, 24.

111. Addit. 23,941, 1920 to above F.P. 525,883.

112. F.P. 533,812; abst. Sci. Tech. Ind. Phot. 1922, **2**, 77; U.S.P. 1,490,979 granted to G. Mareschal and H. Aschel.

113. U.S.P. 1,421,279; Belg.P. 259,342, 1913. Cf. Mauclaire, A. Breon and P. Randebel, F.P. 464,345; addit. 18,403; 465,496; 465,543; 466,827, 1913.

114. U.S.P. 1,407,875; E.P. 172,714, 1920; Brit. J. Phot. 1922, **69**, Col. Phot. Supp. **16**, 6; D.R.P. 350,188; Phot. Ind. 1922, 506; Sci. Tech. Ind. Phot. 1922, **2**, 79; F.P. 542,337.

115. D.R.P. 317,787, 1917.
116. U.S.P. 1,402,668; abst. Sci. Tech. Ind. Phot. 1923, **3**, 19.
117. U.S.P. 1,402,669, 1922.
118. D.R.P. 310,349, 1913; Phot. Ind. 1919, 140.
119. U.S.P. 1,413,591, 1922. Cf. U.S.P. 1,458,210.
120. Brit. J. Phot. 1921, **68**, 279; Sci. Tech. Ind. Phot. 1923, **3**, 76. Probably produced under the following F.P. A. H. Héraut, 526,602; 526,603; abst. Sci. Tech. Ind. Phot. 1922, **2**, 24; F.P. 528,889; abst. ibid. 1922, **2**, 38; Chim. Ind. 1922, **7**, 1170.
121. D.R.P. 375,513, 1922; F.P. 554,947; E.P. 195,630; Sci. Ind. Phot. 1924, **4**, 103. In a later patent D.R.P. 392,849, 1922; Phot. Ind. 1924, 612 the Wenham prisms were split into two right-angled prisms. Cf. D.R.P. 393,969; 393,970.
122. E.P. 206,003; 206,682, 1922; F.P. 572,020; abst. Sci. Ind. Phot. 1924, **4**, 187.
123. E.P. 197,409, 1922.
124. F.P. 561,175; E.P. 192,078, 1923; abst. Sci. Ind. Phot. 1924, **4**, 83.
125. E.P. 10,923, 1900.
126. F.P. 386,264, 1908.
127. E.P. 14,583; 14,584, 1914; U.S.P. 1,294,172.
128. E.P. 106,373, 1916; U.S.P. 1,284,673.
129. E.P. 121,751.
130. E.P. 11,514, 1914.
131. U.S.P. 1,437,895, 1922.
132. E.P. 17,483, 1912.
133. F.P. 559,431, 1922.
134. E.P. 27,675, 1909.
135. E.P. 204,378; F.P. 567,419; Brit. J. Phot. 1923, **70**, 692; abst. Sci. Ind. Phot. 1924, **4**, 148, 171.
136. See L. A. Jones, "Color Analyses of two component mixtures," Brit. J. Phot. 1915, **62**, Col. Phot. Supp. **9**, 11, 13.
137. It should be noted that the Kodak panchromatic negative stock (1921) is apparently coated first with a green-sensitive emulsion, and then with the red-sensitive. Obviously in the case of a very weak light, as in the shadows of a subject, the light might not have sufficient penetrative power to reach the underlying green-sensitive layer.
138. E.P. 26,671, 1906; J. Soc. Arts, 1908, **57**, 70; Brit. J. Phot. 1907, **54**, 642; 1908, **55**, 960; Photography, 1911, 377; Nature, 1909, **79**, 314; D.R.P. 200,128; F.P. 376,837; Jahrbuch, 1910, **24**, 337; Photo-Rev. 1909, **21**, 189; Phot. Rund. 1912, **26**, 159; Phot. Mitt. 1909, **46**, 120; Wien. Mitt. 1909, 322; U.S.P. 941,960; Penrose's Annual, 1909, **15**, 129; 1911, **17**, 161; 1912, **18**, 217; La Nature, 1912, 214. In 1915 this patent was annulled on the grounds that its claims were too broad, as all colors were said to be reproduced, and also on the ground of ambiguity; Brit. J. Phot. 1915, **62**, Col. Phot. Supp. **8**, 16; Jahrbuch, 1910, **24**, 31, 337. Cf. O. Pfenninger, Jahrbuch, 1910, **24**, 29.
139. E.P. 3,729, 1903. An opaque light screen was placed between and projecting from the faces of the prisms, and to guard against ghosts and double reflections the objects had to be posed against a black background, and the angle of the prisms had to be calculated for a given distance both for the camera and projector.
140. E.P. 1,642, 1911; Brit. J. Phot. 1911, **58**, 419; Bioscope, 1911, 860; Belg.P. 246,294; U.S.P. 1,217,391; Can.P. 147,445. In E.P. 1,900, 1912; Brit. J. Phot. 1912, **59**, 941; Jahrbuch, 1913, **27**, 145, the multiple shift principle was applied in projection. In E.P. 10,639, 1912; ibid. 1913, **60**, 426; Can.P. 150,316 spacing apart of the pictures by one or more spaces was proposed. In E.P. 26,173, 1912 Bennett patented a printer in which the negative and positive films were pulled down two or more picture spaces. And for color work when desired to differentiate between the pictures, the light might be cut down for one by the interposition of a grey glass, etc.
141. E.P. 24,645, 1911; Brit. J. Phot. 1912, **58**, 659; U.S.P. 1,278,302. Cf. E.P. 23,829, 1912; Brit. J. Phot. 1912, **59**, 862; Jahrbuch, 1914, **28**, 522.
142. E.P. 24,646, 1911; Brit. J. Phot. 1912, **59**, 925.
143. E.P. 89, 1912; ibid. 866.
144. E.P. 15,478, 1912; ibid. 1913, **60**, 166.

145. E.P. 2,786, 1913; ibid. 1914, **61,** 387. Another variation was patented in E.P. 2,787, 1913; ibid. 425.
146. E.P. 5,440, 1913; ibid. 1914, **61,** 142.
147. E.P. 8,144, 1913; ibid. 1914, **62,** 462.
148. U.S.P. 1,209,420, 1916; M. P. News, 1918, 2234.
149. E.P. 100,021, 1914; Brit. J. Phot. 1921, **68,** 600; Col. Phot. Supp. **15,** 40.
150. E.P. 18,451, 1912; Brit. J. Phot. 1913, **60,** 330; D.R.P. 259,136; abst. Phot. Ind. 1913, 806; Jahrbuch, 1914, **28,** 524; F.P. 433,162.
151. E.P. 21,271, 1912; Brit. J. Phot. 1913, **60,** 92; F.P. 448,546.
152. D.R.P. 263,817; Phot. Ind. 1913, 1499; E.P. 24,948, 1912; Brit. J. Phot. 1913, **60,** 997.
153. D.R.P. 244,943, 1911.
154. E.P. 636, 1914; Brit. J. Phot. 1914, **61,** 669; F.P. 470,834.
155. E.P. 14,270, 1914; Brit. J. Phot. 1915, **62,** 531; D.R.P. 321,550; U.S.P. 1,425,461; Can.P. 173,257.
156. U.S.P. 1,186,612, 1916.
157. U.S.P. 1,202,724; F.P. 480,530; E.P. 22,595, 1914; Brit. J. Phot. 1916, **63,** 87; F.P. 482,783; D.R.P. 380,361; Phot. Ind. 1924, 137. In E.P. 101,814, 1916 Joy patented a combination camera which could be used for black and white and colors by alteration of the path of the film. In U.S.P. 1,250,186 a combined projector for black and white and color was patented.
158. U.S.P. 1,211,904, 1917; Can.P. 161,771.
159. U.S.P. 1,279,065, 1918. Cf. U.S.P. 1,122,455; Can.P. 161,771 for the same thing granted to Kelley and Raleigh.
160. U.S.P. 1,325,280, 1919.
161. U.S.P. 1,133,730; Can.P. 185,187; E.P. 22,921, 1914; Brit. J. Phot. 1916, **63,** 319; 1917, **64,** Col. Phot. Supp. **11,** 14; ibid. **12,** 8; F.P. 477,728; Phot. Korr. 1918, **55,** 156; Phot. Ind. 1917, 617. Cf. U.S.P. 1,122,455, 1914 granted to Wohl and Mayer.
162. U.S.P. 1,216,493; 1,217,425; 1,278,211; 1,325,204; E.P. 14,225, 1915; Brit. J. Phot. 1915, **63,** 652; F.P. 479,921; D.R.P. 331,746; Phot. Ind. 1921, 373; Sci. Tech. Ind. Phot. 1921, **1,** 72; Can.P. 185,159.
163. Photo-Rev. 1919, **31,** 36.
164. U.S.P. 1,276,330, 1918. In U.S.P. 1,271,668 Coleman used alternate red and green-violet rotating sectors with the red sector larger than the other and the mechanism governing the movement of the film caused a longer dwell when the red was used. Cf. U.S.P. 1,271,667.

The use of transverse stripes of emulsion with different color-sensitiveness was also patented by E. Wolff, D.R.P. 371,449; Phot. Ind. 1924, 543, but the filter dyes were incorporated in the emulsion. In D.R.P. 390,232 the Radebeuler Maschinen-Fabrik A. Koebig patented a machine for coating film with transverse strips; a carriage with three tanks being moved across the film; Phot. Ind. 1924, 543.

165. U.S.P. 1,375,922, 1921.
166. U.S.P. 1,108,838, 1911.
167. Ital.P. 458,218, 1916.
168. E.P. 1,717, 1910; F.P. 411,557; addit. 13,521.
169. E.P. 102,280, 1916; Brit. J. Phot. 1917, **64,** 251; F.P. 484,116; U.S.P. 1,350,143. In a subsequent E.P. 210,823, 1922; F.P. 571,648; abst. Sci. Ind. Phot. 1925, **5,** 26 three mirrors were used for combining the images, one of them being split and capable of being tilted through small angles in two planes. Cf. D. C. L. Syndicate, D.R.P. 397,654.
170. F.P. 470,138, 1914.
171. F.P. 444,866, 1912.
172. D.R.P. 263,038, 1911; F.P. 448,557.
173. D.R.P. 242,101; Jahrbuch, 1911, **26,** 242; Phot. Ind. 1912, 122.
174. F.P. 443,315, 1912.
175. D.R.P. 225,438; Jahrbuch, 1911, **25,** 338; Phot. Ind. 1910, 1307.
176. U.S.P. 1,383,357, 1921; abst. Sci. Tech. Ind. Phot. 1922, **2,** 28. In U.S.P. 1,502,077; 1,502,078, 1924 lens fronts are patented, revolving so as to bring the lens opposite the finder.
177. U.S.P. 1,391,029, 1921.
178. U.S.P. 1,409,628; 1,417,005, 1922; abst. Sci. Tech. Ind. Phot. 1923, **3,** 84.
179. U.S.P. 1,404,773, 1922.
180. F.P. 526,870, 1920; abst. Sci. Tech. Ind. Phot. 1922, **2,** 25.

181. U.S.P. 1,291,954, 1919.
182. D.R.P. 259,931, 1912.
183. U.S.P. 1,321,705, 1919.
184. U.S.P. 1,344,616, 1920.
185. F.P. 395,981, 1908.
186. E.P. 873, 1915; Brit. J. Phot. 1915, **62**, 611; Ital.P. 456,137; F.P. 477,378; Jahrbuch, 1915, **29**, 157.
187. E.P. 12,469, 1914; Brit. J. Phot. 1915, **62**, 612.
188. U.S.P. 1,320,760, 1919.
189. E.P. 18,899, 1892.
190. Hopwood and Foster, "Living Pictures," 1915, 57.
191. Loc. cit. 77.
192. E.P. 22,928, 1896.
193. E.P. 136,595, 1918; U.S.P. 1,332,828; F.P. 506,418 is for a similar mechanism granted to Holam Ltd.; Chim. Ind. 1921, **5**, 564. Cf. C. Raleigh, F.P. 396,103.
194. D.R.P. 326,369; Austr.P. 5,859; Jahrbuch, 1915, **29**, 147; F.P. 509,333; Phot. Ind. 1920, 848.
195. E.P. 1,607, 1913; Brit. J. Phot. 1914, **61**, 308.
196. D.R.P. 229,136, 1907; Jahrbuch, 1911, **25**, 378; Chem. Ztg. Rep. 1907, 88; F.P. 415,276; Austr.P. 46,899.
197. E.P. 183,150, 1921; Brit. J. Phot. 1922, **69**, 607; Col. Phot. Supp. **16**, 39; ibid. **18**, 1, 16; Amer. Phot. 1923, **17**, 185; J. S. C. I. 1922, **41**, 729A; F.P. 558,139; Austral.P. 9,844; abst. Brit. J. Almanac, 1925, 323; U.S.P. 1,513,322; D.R.P. 388,751; 388,700; Can.P. 239,131.
198. E.P. 165,826, 1919; Brit. J. Phot. 1921, **68**, 525; Col. Phot. Supp. **14**, 39; U.S.P. 1,383,460; F.P. 531,987; abst. Sci. Tech. Ind. Phot. 1922, **2**, 27; Brit. J. Almanac, 1924, 387.
199. E.P. 4,774, 1912; Brit. J. Phot. 1913, **60**, 255; Austr.P. 1,257, 1912; U.S.P. 1,155,056; Jahrbuch, 1913, **27**, 140.
200. E.P. 26,927, 1910; Brit. J. Phot. 1912, **59**, 220; F.P. 436,540; D.R.P. 365,707; Jahrbuch, 1912, **26**, 244.

E. Suess and F. Lejeune, D.R.P. 403,591 patented the obtaining of record negatives through filters absorbing about one-third of the spectrum, blueish-red, yellow and greenish-blue. Positives were to be projected so that the high lights were white and the shadows of that color complementary to the taking filter. Or black and white positives might be used and the screen illuminated with the complementary colors. Finzi, D.R.P. 395,001, 1922 would use polarized light for taking the negatives, obtained with quartz plates in the sectors of a rotary shutter.

201. Jahrbuch, 1895, **9**, 269.
202. E.P. 23,645, 1911; Brit. J. Phot. 1913, **60**, 443.
203. D.R.P. 351,763, 1921; abst. J. S. C. I. 1922, **41**, 729A; Amer. Phot. 1923, **17**, 185.
204. D.R.P. 271,882; 278,168; E.P. 15,098. 1913; Brit. J. Phot. 1914, **61**, 88; Austr.P. A, 5,570; F.P. 459,727; Belg.P. 257,987.
205. D.R.P. 278,168, 1913.
206. E.P. 9,610, 1913; Brit. J. Phot. 1914, **61**, 579. This patent carried two provisional specifications 9,610; 9,680.
207. E.P. 11,496, 1913; Brit. J. Phot. 1914, **61**, 482.
208. E.P. 6,894, 1913; Brit. J. Phot. 1913, **60**, 997; abst. C. A. 1915, **9**, 1723; D.R.P. 329,272; Phot. Ind. 1921, 190; Austr.P. 2,625; Jahrbuch, 1915, **29**, 143; U.S.P. 1,139,633; F.P. 459,612; Belg.P. 265,825. In E.P. 19,175, 1913; Brit. J. Phot. 1914, **61**, 699 a machine for making the film is described.
209. U.S.P. 1,322,794, 1919.
210. U.S.P. 1,337,775; F.P. 504,589; E.P. 129,638, 1918; Brit. J. Phot. 1920, **67**, Col. Phot. Supp. **13**, 47; Jahrbuch, 1915, **29**, 158; D.R.P. 345,784.
211. E.P. 14,145, 1914; Brit. J. Phot. 1915, **62**, 517. Cf. E.P. 100,629; Brit. J. Phot. 1916, **63**, 587; U.S.P. 1,281,714; abst. C. A. 1919, **13**, 99; U.S.P. 1,360,156; 1,361,783; 1,435,759; 1,435,760. In U.S.P. 1,408,312; 1,408,313; 1,408,314; 1,408,315 various modifications of the methods of applying the colors by photomechanical processes are given. Cf. E.P. 5,100, 1915; 16,899, 1914; F.P. 481,357; E.P. 8,300, 1915; U.S.P. 1,288,753; Sci. Ind. Phot. 1924, **4**, 104; E.P. 213,647; 213,866; 214,934; 224,569; 224,570; 224,571; 224,572; 224,573; Brit. J. Phot. 1925, **72**, 7, 143; Col. Phot. Supp. **19**, 4, 10.
212. Austr.P. 140, 1914; Phot. Ind. 1914, 970.

213. Austr.P. 79,955, 1917; Jahrbuch, 1915, **29**, 144.
214. E.P. 12,891, 1911; Brit. J. Phot. 1912, **59**, 162.
215. E.P. 129,717; Brit. J. Phot. 1919, **66**, 712; Col. Phot. Supp. **12**, 46; F.P. 500,963; U.S.P. 1,390,252; D.R.P. 347,437; Jahrbuch, 1915, **29**, 143; Dan.P. 29,486.
216. E.P. 161,995, 1920; abst. Sci. Tech. Ind. Phot. 1922, **2**, 14.
217. F.P. 368,565, 1906; Phot. Coul. 1907, **2**, Supp. 20.
Cf. L. Sabourin, F.P. 582,252.
218. E.P. 138,396; Brit. J. Phot. 1920, **67**, 174; Jahrbuch, 1915, **29**, 150.
219. U.S.P. 1,383,819; abst. Sci. Tech. Ind. Phot. 1922, **2**, 28.
Cf. W. B. Bolton, Brit. J. Phot. 1891, **38**, 116.
220. U.S.P. 1,426,995; abst. J. S. C. I. 1922, **41**, 788A; Can.P. 219,898.
221. U.S.P. 1,426,996, 1922.
222. U.S.P. 1,446,049; 1,446,050, 1923; abst. C. A. 1923, **17**, 1388; J. S. C. I. 1923, **42**, 378A.
223. U.S.P. 1,449,417, 1923. In U.S.P. 1,477,880; E.P. 225,659; Brit. J. Phot. 1925, **72**, 125, Kitsee proposed to dye the celluloid and cut away the dyed surface mechanically in lines and redye the exposed parts. In U.S.P. 1,477,881; 1,477,882 the production of regular mosaics was claimed. U.S.P. 1,477,883; F.P. 572,827; abst. Sci. Ind. Phot. 1924, **4**, 16 is for machines for making the patterns.
224. E.P. 140,560; F.P. 522,418, 1920; abst. Sci. Tech. Ind. Phot. 1921, **1**, 103; D.R.P. 341,736; U.S.P. 1,441,615; Amer. Phot. 1923, **17**, 493; Can.P. 216,860.
225. D.R.P. 332,313; Phot. Ind. 1921, 373; abst. Sci. Tech. Ind. Phot. 1921, **1**, 80
226. U.S.P. 1,402,371; abst. Sci. Tech. Ind. Phot. 1922, **2**, 127.
227. D.R.P. 259,471, 1911.
228. D.R.P. 261,341, 1911.
229. U.S.P. 1,431,309, 1922; E.P. 205,941; Brit. J. Phot. 1923, **70**, Col. Phot. Supp. **17**, 3; ibid. **18**, 3; abst. Sci. Ind. Phot. 1924, **4**, 70, 186; Brit. J. Almanac, 1925, 320.
230. U.S.P. 1,458,410, 1923; abst. Sci. Ind. Phot. 1925, **5**, 28.
231. F.P. 395,506, 1908.
232. U.S.P. 1,465,643.
233. U.S.P. 1,465,053; abst. Sci. Ind. Phot. 1925, **5**, 52.
234. U.S.P. 1,465,054; abst. Sci. Ind. Phot. 1925, **5**, 52.
235. U.S.P. 1,271,667, 1918.
236. E.P. 217,557, 1923; Brit. J. Phot. 1924, **71**, Col. Phot. Supp. **18**, 40; 1925, **72**, **203**, Col. Phot. Supp. **19**, 16; Phot. Ind. 1924, 971; F.P. 579,300; abst. C. A. 1925, **19**, 218; D.R.P. 411, 612.
237. U.S.P. 1,504,465, 1924; abst. C. A. 1924, **18**, 3327.
238. U.S.P. 1,460,673, 1923; abst. Sci. Ind. Phot. 1925, **5**, 28.
239. E.P. 217,234, 1923; abst. C. A. 1925, **19**, 219; J. S. C. I. 1925, **44**, B28; F.P. 582,330; Sci. Ind. Phot. 1925, **5**, 67; D.R.P. 403,592.
M. J. Vinik, U.S.P. 1,218,342, 1917 patented a camera with revolving half sector shutter, which was stated to be adaptable for three-color cine films, and which could be used for the additive process.
240. F.P. 573,180, 1923; abst. Sci. Ind. Phot. 1925, **5**, 23.