PATENT SPECIFICATION

Application Date: Nov. 3, 1934. No. 31624/34.

446,679

Complete Specification Left: Oct. 22, 1935.

Complete Specification Accepted: May 4, 1936.

PROVISIONAL SPECIFICATION

Improvements in or relating to Colour Photography

I, Stanley Dennis Threadgold, a British Subject, of Rodenside Laboratories, 23, Roden Street, Ilford, Essex, do hereby declare the nature of this invention to be as follows:—

This invention consists of improvements in or relating to colour photography and relates particularly to the reproduction of multi-colour photographic records (referred to as the master record) of the type associated with a regular pattern multi-colour screen (referred to as the master screen) by contact printing on to a photographic light sensitive material (referred to as the copy) also associated with a multi-colour screen (referred to as the copy screen) which may or may not be of regular form and may or may not be similar to that associated with the master record.

It is well known that difficulties arise with the reproduction of colour photographs in this manner due to the production of moire patterning on the copy which gives very undesirable effects on the copy picture. This moire patterning would seem to be due to the fact that, as it is impossible in practice to ensure exact registration between the elements of the same colour in the master and copy screens the elements are sometimes in phase in which case light is transmitted by the screens forming a light area, which will affect the emulsion and are sometimes out of phase in which case no light is transmitted forming a dark area which will leave the sensitive copy emulsion unaffected. It is an object of the present invention to reduce or eliminate this effect, which is described in more detail below, without undue loss of definition.

It has been found, that if the light passed by the coloured elements of the master screen is distributed over the copy screen so as to give substantially even illumination of the copy screen then the elements of the two screens cannot, in effect, become out of phase as described above and light and dark areas cannot be formed, except as dictated by the picture itself the effect of which is neglected throughout this specification for simplicity in explanation.

If the two colour screens are arranged in actual contact during printing it would appear impossible to secure this even illumination but in practice, and essentially in carrying out this invention, the screens are separated by a short distance, for example by the thicknesses of both their supports.

One way of securing substantially even illumination of the copy screen has been described in Patent Specification No. 437,888.

In printing multi-colour photographic records of the type associated with a regular pattern multi-colour screen on to copy material also associated with a multi-colour screen there is employed, according to the invention, a station from which light is directed on to the master screen and at which the cross sectional area of the light beam is constrained to dimensions so co-related with the distance between the said station and the master screen, with the size of the screen elements and with the distance between the master and copy screens as to give substantially uniform illumination of the copy screen.

The cross sectional area of the light beam may be constrained by selecting a light source of suitable area or it may be constrained by inserting a mask of suitable area in the path of a beam of light.

The invention and the underlying theory will now be explained, by way of example, with reference to the accompanying diagrammatic drawings in which:—

Figure 1 illustrates the effect produced when two screens composed of lines of two different colours are superposed slightly out of register,

Figure 2 represents a known form of three-colour screen,

Figure 3 shows the arrangement of the several elements during the printing,

Figures 4a, 5a, 6a. and 7a, show the distribution of the light intensities on the copy screen produced by light from a light source of finite dimensions at different distances from the screen and passing through a master screen of equal transparent and opaque portions, Figures 4b, 5b, 6b, and 7b, show the actual light intensities produced on the copy screen with the various arrangements shown in figures 4a to 7a respectively, and

Figures 8a and 8b, show the optimum conditions of distribution and actual intensity respectively for the case where the opaque portions of the master screen are double the width of the transparent portions.

Referring in the first place to Figure 1 which shows two superposed screens of lines of two different colours 1 and 2, say red and blue respectively, and is taken as the simplest case for purposes of explanation, it will be seen that if, as shown, the lines of the two screens are not exactly parallel then at the places where a red line of the upper screen is over a red line of the screen underneath, as at 3, the combined screens will transmit red light. On the other hand, where a red line of the upper screen is over a blue line of the lower screen as at 4 the combined screens will be opaque to lights of all colours. If the lines of the two screens are very nearly parallel the transparent and opaque areas 3 and 4 will be bands of considerable length and it is these light and dark bands which give the moire effect on the copy.

In Figure 3 the light source 5 is constituted by a mask behind which may be placed a diffusing screen, not shown, and the light passes through the master screen 6 on to the copy screen 7 and then on to the copy emulsion.

Turning now to Figures 4 to 7 and still considering the case of the simple two-line screen of red and blue bands of equal width, the master screen may be represented by alternate opaque and clear portions so far as either red or blue light is concerned and is illustrated in this way at 8 where the clear portions are taken as the red bands transmitting red light and the opaque portions as the blue bands transmitting substantially no red light.

If now the screen 8 is illuminated with parallel light perpendicular to its plane and considering only the light transmitted by the red bands this light will produce, on the copy screen 9, red bands of the same width as the master bands and the conditions described in relation to Figure 1 will be produced, giving moire effects.

If, however, a light source of finite dimensions giving diffused light is employed at a suitable distance the red bands formed on the copy screen will be of greater width than the master bands and the effect will be as shown in Figure 4A where the curves 10 represent the intensity of the light on the copy screen and it will be seen that this intensity is a maximum at the centre and diminishes in intensity towards the edges. The width of the bands formed on the copy screen and the intensity across the bands will vary with the angle subtended by the light source at the master screen elements and Figures 4A to 7A represent the effect for different angles which increase from Figure 4A to Figure 7A.

In the cases illustrated in Figures 5A to 7A the bands formed on the copy screen by the light transmitted by adjacent master bands overlap as shown at 11 in Figure 5A and the sum of the intensities of light across the copy screen is shown in Figures 4B to 7B where in each case 9 represents the copy screen and 12 a curve giving the intensity of light at any point across the copy screen.

In the arrangement shown in Figures 6A and 6B the resultant intensity as shown by the curve 12 is constant over the copy screen and thus is the theoretically correct condition for avoiding moire.

Figures 8A and 8B show the theoretically correct conditions when the transparent elements are half the width of the opaque elements.

Although this description has been directed to the light transmitted by the red bands the same conditions will, of course, apply for the light transmitted by the blue elements of the master screen.

It is found in practice that the best conditions are produced when the angle subtended by the light source at the master screen is slightly less than the theoretically ideal arrangement shown in Figures 6A, 6B and 8A and 8B since, for the sake of simplicity, certain factors have been neglected and also the loss of definition will be reduced without appreciably increasing the moire. The best conditions are found by trial and error by making slight experimental variations from the conditions shown in these Figures.

In practice it has been found that using films 1/10 mm. thick arranged back to back, thus making the separation between the master and copy screens 1/5 mm., and having a three-colour screen as shown in Figure 2 and composed of a series of longitudinal red lines 14 of one unit width separated by a space of two units width divided transversely into equal blue and green rectangles 15 and 16 and each $1\frac{1}{2}$ units deep, (a complete pattern unit forming a square 1/20 × 1/20 mm.), a mask having a rectangular aperture 28 mm. × 18 mm. located at a distance of about 10 cms. from the film and with its long side perpendicular to the lines of the screen gives satisfactory results.

The correct orientation of the mask may be found by trial and error by rotating it in its own plane and, as explained above, the best position by moving it to and fro in a direction perpendicular to the plane of the film until the best effect is obtained.

The mask is illuminated uniformly over its area, for example by means of an ordinary diffusing screen uniformly illuminated by any type of light source—filtered with narrow cut filters or otherwise, or for example produced by the method described in specification No. 417,860.

If, as indicated in Figure 6A, the separation between the two screens is "d" and the width of a screen element "u" then the half angle $\frac{\theta}{2}$ subtended by the light source at the master screen for the ideal conditions is easily obtained for any given circumstances from the expression

$$\tan \frac{\theta}{2} = \frac{u}{d}$$

from which

$$\theta = 2 \tan^{-1} \frac{u}{d}.$$

Thus for any given conditions the angle to be subtended at the screen by the light source may easily be calculated and therefore the dimensions of the light source for a given distance or the distance for given dimensions may easily be found. When the screen is unsymmetrical as shown in Figure 2 the dimensions of the light source may be calculated to give the desired result in each direction.

Dated this 3rd day of November, 1934.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in or relating to Colour Photography

I, STANLEY DENNIS THREADGOLD, a British Subject, of Rodenside Laboratories, 23, Roden Street, Ilford, Essex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention consists of improvements in or relating to colour photography and relates particularly to the reproduction of multi-colour photographic records (referred to as the master record) of the type associated with a regular pattern multi-colour screen (referred to as the master screen) by contact printing on to a photographic light sensitive material (referred to as the copy) also associated with a multi-colour screen (referred to as the copy screen) which may or may not be of regular form and may or may not be similar to that associated with the master record.

It is well known that difficulties arise with the reproduction of colour photographs in this manner due to the production of moire patterning on the copy which gives very undesirable effects on the copy picture. This moire patterning would seem to be due to the fact that as it is impossible in practice to ensure exact registration between the elements of the same colour in the master and copy screens, the elements are sometimes in phase in which case light is transmitted by the screens forming a light area, which will affect the emulsion, and are sometimes out of phase in which case no light is transmitted forming a dark area which will leave the sensitive copy emulsion unaffected. It is an object of the present invention to reduce or eliminate this effect, which is described in more detail below, without undue loss of definition.

It has been found that if the light passed by the elements of each of the colours of the master screen is distributed over the copy screen so as to give substantially even illumination of the copy screen with light of each colour, then the elements of the two screens cannot, in effect, become out of phase as described above and light and dark areas cannot be formed, except as dictated by the picture itself, the effect of which is neglected throughout this specification for simplicity in explanation.

If the two colour screens are arranged in actual contact during printing it would appear impossible to secure this even illumination but in practice, and essentially in carrying out this invention, the screens are separated by a short distance, for example by the thickness of one or both their supports.

One way of securing substantially even illumination of the copy screen has been described in Patent Specification No. 437,888.

In printing multi-colour photographic

records of the type associated with a regular pattern multi-colour screen on to copy material also associated with a multi-colour screen there is employed, according to the invention, a beam of diffused printing light (i.e. light whereby there is produced on the copy screen an enlarged image, outwardly decreasing in light intensity at the margins, of each master screen element) directed onto the master screen from a station at which the cross-sectional area of the beam is given dimensions so corelated with the distance between the said station and the master screen, with the size of the screen elements and with the distance between the master and copy screens that the marginal portions of the enlarged images on the copy screen of the master elements of one colour overlap with the marginal portions of adjacent images of similar colour to such extent that the sum of the light intensities at the overlapping portions substantially equals the intensity at the central portions of the images.

The cross sectional area as aforesaid may be given to the light beam by selecting a light source (e.g. an incandescent plate or a filament in the form of a grid) of suitable area or it may be given to the beam by inserting a mask having an aperture of suitable area into the path of a beam of diffused light of larger dimensions.

The invention and the underlying theory will now be explained, by way of example, with reference to the diagrammatic drawings accompanying the provisional specification, in which:—

Figure 1 illustrates the effect produced when two screens composed of lines of two different colours are superposed slightly out of register,

Figure 2 represents a known form of three-colour screen,

Figure 3 shows the arrangement of the several elements during the printing,

Figures 4a, 5a, 6a and 7a show the distribution of the light intensities on the copy screen produced by light from a light source of finite dimensions at different distances from the screen and passing through a master screen of equal transparent and opaque portions,

Figures 4b, 5b, 6b and 7b show the actual light intensities produced on the copy screen with the various arrangements shown in Figures 4a to 7a respectively, and

Figures 8a and 8b show the optimum conditions of distribution and actual intensity respectively for the case where the opaque portions of the master screen are double the width of the transparent portions.

Referring in the first place to Figure 1 which shows two superposed screens of lines of two different colours 1 and 2, say red and blue respectively, and is taken as the simplest case for purposes of explanation, it will be seen that if, as shown, the lines of the two screens are not exactly parallel, then at the places where a red line of the upper screen is over a red line of the screen underneath, as at 3, the combined screens will transmit red light. On the other hand, where a red line of the upper screen is over a blue line of the lower screen as at 4, the combined screens will be opaque to lights of all colours. If the lines of the two screens are very nearly parallel, the transparent and opaque areas 3 and 4 will be bands of considerable length, and it is these light and dark bands which give the moire effect on the copy.

In Figure 3 the light source 5 is constituted by an aperture in a mask behind which is placed an illuminated diffusing screen, not shown, and the light passes through the master screen 6 on to the copy screen 7 and then on to the copy emulsion.

Turning now to Figures 4a to 7a and 4b to 7b, and still considering the case of the simple two-line screen of red and blue bands of equal width, the master screen may be represented by alternate opaque and clear portions so far as either red or blue light is concerned and is illustrated in this way at 8 (Figure 4a) where the clear portions are taken as the red bands transmitting red light and the opaque portions as the blue bands transmitting substantially no red light.

If now the screen 8 is illuminated with parallel light perpendicular to its plane and considering only the light transmitted by the red bands, this light will produce, on the copy screen 9, red bands of the same width as the master bands and the conditions described in relation to Figure 1 will be produced, giving moire effects.

If, however, a light source of finite dimensions giving diffused light is employed at a suitable distance, the red bands formed on the copy screen will be of greater width than the master bands, and the effect will be as shown in Figure 4a where the curves 10 represent the intensity of the light on the copy screen, and it will be seen that this intensity is a maximum at the centre and diminishes in intensity towards the edges. The width of the bands formed on the copy screen and the intensity across the bands will vary with the angle subtended by the light source at the master screen elements, and Figures 4a and 7a represent the effect for different angles which increase from Figure 4a to Figure 7a.

In the cases illustrated in Figures 5a to 7a the bands formed on the copy screen by the light transmitted by adjacent master bands overlap as shown at 11 in Figure 5a, and the sum of the intensities of light across the copy screen is shown in Figures 4b to 7b where in each case 9 represents the copy screen and 12 a curve giving the intensity of light at any point across the copy screen.

In the arrangement shown in Figures 6a and 6b the resultant intensity, as shown by the curve 12, is constant over the copy screen, and this is the theoretically correct condition for avoiding moire.

Figures 8a and 8b show the theoretically correct conditions when the transparent elements are half the width of the opaque elements.

Although this description has been directed to the light transmitted by the red bands, the same conditions will of course apply for the light transmitted by the blue elements of the master screen.

It is found in practice that the best conditions are produced when the angle subtended by the light source at the master screen is slightly less than the theoretically ideal arrangement shown in Figures 6a, 6b and 8a and 8b, since, for the sake of simplicity, certain factors have been neglected and also the loss of definition will be reduced without appreciably increasing the moire. The best conditions are found by trial and error by making slight experimental variations from the conditions shown in these Figures.

In practice it has been found that using films 1/10 mm. thick arranged back to back, thus making the separation between the master and copy screens 1/5 mm., and having a three-colour screen as shown in Figure 2 and composed of a series of longitudinal red lines 14 of one unit width separated by a space of two units width divided transversely into equal blue and green rectangles 15 and 16 and each $1\frac{1}{2}$ units deep, (a complete pattern unit forming a square $1/20 \times 1/20$ mm.), a mash having a rectangular aperture 28 mm. × 18 mm. located at a distance of about 10 cms. from the film and with its long side perpendicular to the lines of the screen, gives satisfactory results.

The correct orientation of the mask may be found by trial and error by rotating it in its own plane, and, as explained above, the best position by moving it to and fro in a direction perpendicular to the plane of the film until the best effect is obtained.

The mask is illuminated uniformly over its area, for example by means of an ordinary diffusing screen uniformly illuminated by any type of light source—filtered with narrow cut filters or otherwise or, for example, produced by the method described in British Specification No. 417,860.

If, as indicated in Figure 6a, the separation between the two screens is "d" and "u" is the distance on either side of the element under consideration over which the light is to be spread, then the half angle $\frac{\theta}{2}$ subtended by the light source at any point on the master screen for the ideal conditions is easily obtained for any given circumstances from the expression

$$\tan \frac{\theta}{2} = \frac{u}{d}$$

from which

$$\theta = 2 \tan^{-1} \frac{u}{d}.$$

The angle subtended by a given light source will not be exactly the same at every point on the master screen but for a picture of normal size the variation will be negligible and will not introduce any noticeable error provided that care is taken to restrict the area of the master screen exposed at any one time in relation to the distance of the screen from the source of light. In practice the light source is arranged centrally over the picture and it is the angle subtended by the light source at the point on the screen perpendicularly opposite the centre of the source which is considered. In the above way for any given conditions the angle to be subtended at a point on the screen by the light source may easily be calculated and therefore the dimensions of the light source for a given distance or the distance for given dimensions may easily be found. When the screen is unsymmetrical, as show in Figure 2, the dimensions of the light source may be calculated to give the desired result in each direction. It will be appreciated that in the case of a screen such as that shown in Figure 2, having a series of elements of different size, there will be a slight unevenness in the illumination from the larger units if the illumination is made even for the smaller units. On a screen having a red line, one unit wide, and a green and blue line two units wide, the size of the aperture necessary to spread the red line evenly over the blue area and the green area, to meet the spread of light from the next adjacent red line, as shown in Figures 6a and 6b, will be larger than that required to spread the light from the blue and green elements to form a uniform illumination over the red line and in the case of the green and blue units this will produce a slight unevenness of illumination in a direction perpendicular to the red lines, similar to that shown in Figures 7a and 7b. In actual practice, however, this unevenness is very slight and is unnoticeable in the final print.

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

1. A method of contact printing multi-colour photographic records of the type associated with a regular pattern multi-colour screen onto copy material also associated with a multi-colour screen which is characterised by the employment of diffused printing light (i.e. light whereby there is produced on the copy screen an enlarged image, outwardly decreasing in light intensity at the margins, of each master screen element) directed onto the master screen from a station at which the cross-sectional area of the beam is given dimensions so co-related with the distance between the said station and the master screen, with the size of the screen elements and with the distance between the master and copy screens that the marginal portions of the enlarged images on the copy screen of the master elements of one colour overlap with the marginal portions of adjacent images of similar colour to such extent that the sum of the light intensities at the overlapping portions substantially equals the intensity at the central portions of the images.

2. A method according to Claim 1 in which the cross-sectional area of the beam of printing light is given dimensions co-related as aforesaid by the insertion of a mask having an aperture of corresponding dimensions in the path of a beam of light.

3. A method according to Claim 1 in which the light source itself (e.g. an incandescent plate or a filament in the form of a grid) has a cross-sectional area of dimensions co-related as aforesaid.

4. A method according to any one of the foregoing Claims in which the dimensions given to the cross-sectional area of the light beam are calculated or approximately estimated from the formula $\theta = 2 \tan^{-1} \frac{u}{d}$ where θ is the angle subtended by the light source at the point on the screen perpendicularly opposite to the centre of the light source, u is the distance on either side of the element under consideration over which the light is to be spread, and d is the separation between the master and copy screens.

5. An optical system for contact printing of multi-colour photographic records associated with a regular pattern multi-colour screen on to photographic material also associated with a multi-colour screen which is characterised by a source of diffused light arranged to produce on the copy screen an enlarged image, outwardly decreasing in intensity at the margins of each master screen element and given at a station in the system finite cross-sectional dimensions so co-related with the distance between the said station and the master screen, with the size of the screen elements and with the distance between the master and copy screens that the marginal portions of the enlarged images on the copy screen of the master elements of one colour overlap with the marginal portions of adjacent images of similar colour to such extent that the screen of the light intensities at the overlapping portions substantially equals the intensity at the central portions of the images.

6. An optical system according to Claim 5 including in conjunction with a light source emitting diffused light, a mask having an aperture arranged to limit the cross-sectional area of the light beam directed towards the master to dimensions co-related as set out in Claim 1.

7. Methods of and apparatus for printing multi-colour photographic records substantially as described herein.

Dated this 22nd day of October, 1935.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden,
London, E.C.1,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1936.

Fig. 1.

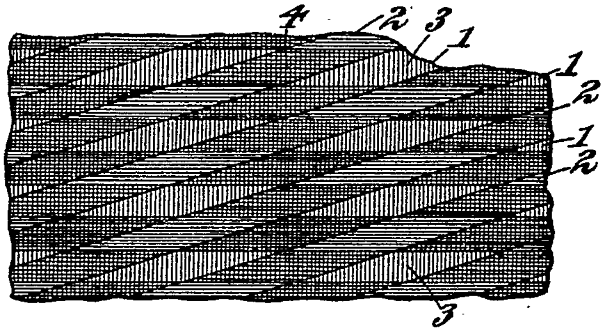


Fig. 2.

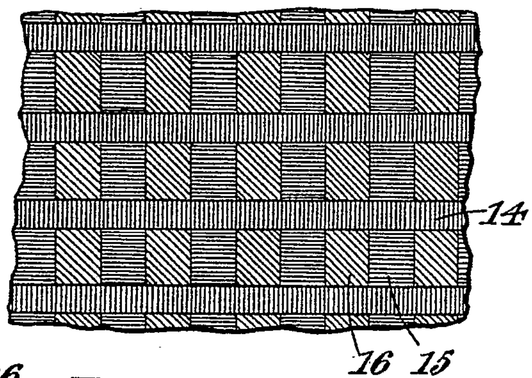


Fig. 3.

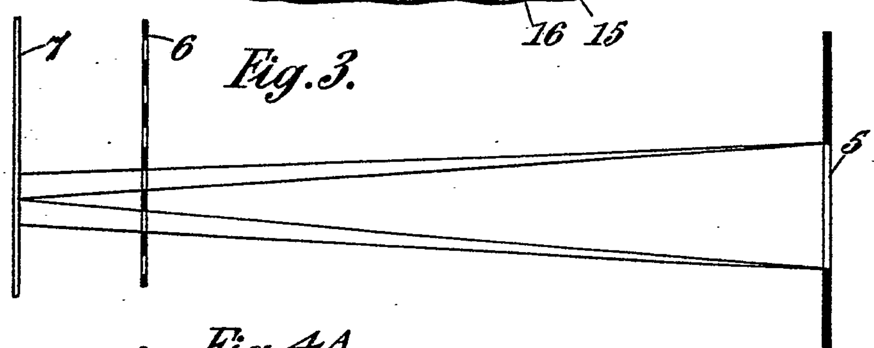


Fig. 4A.

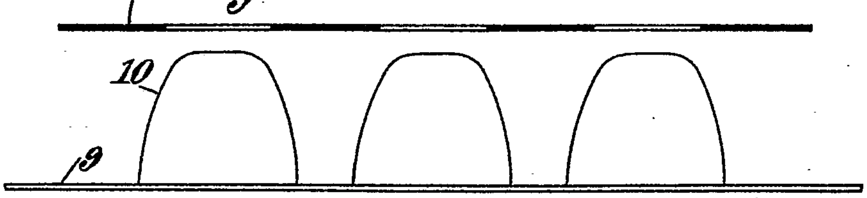
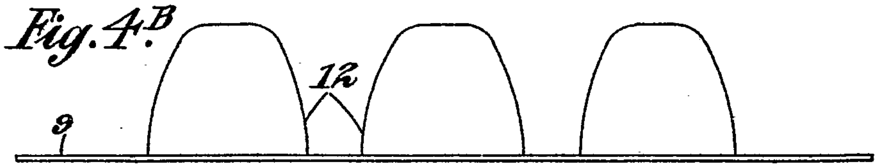


Fig. 4B.



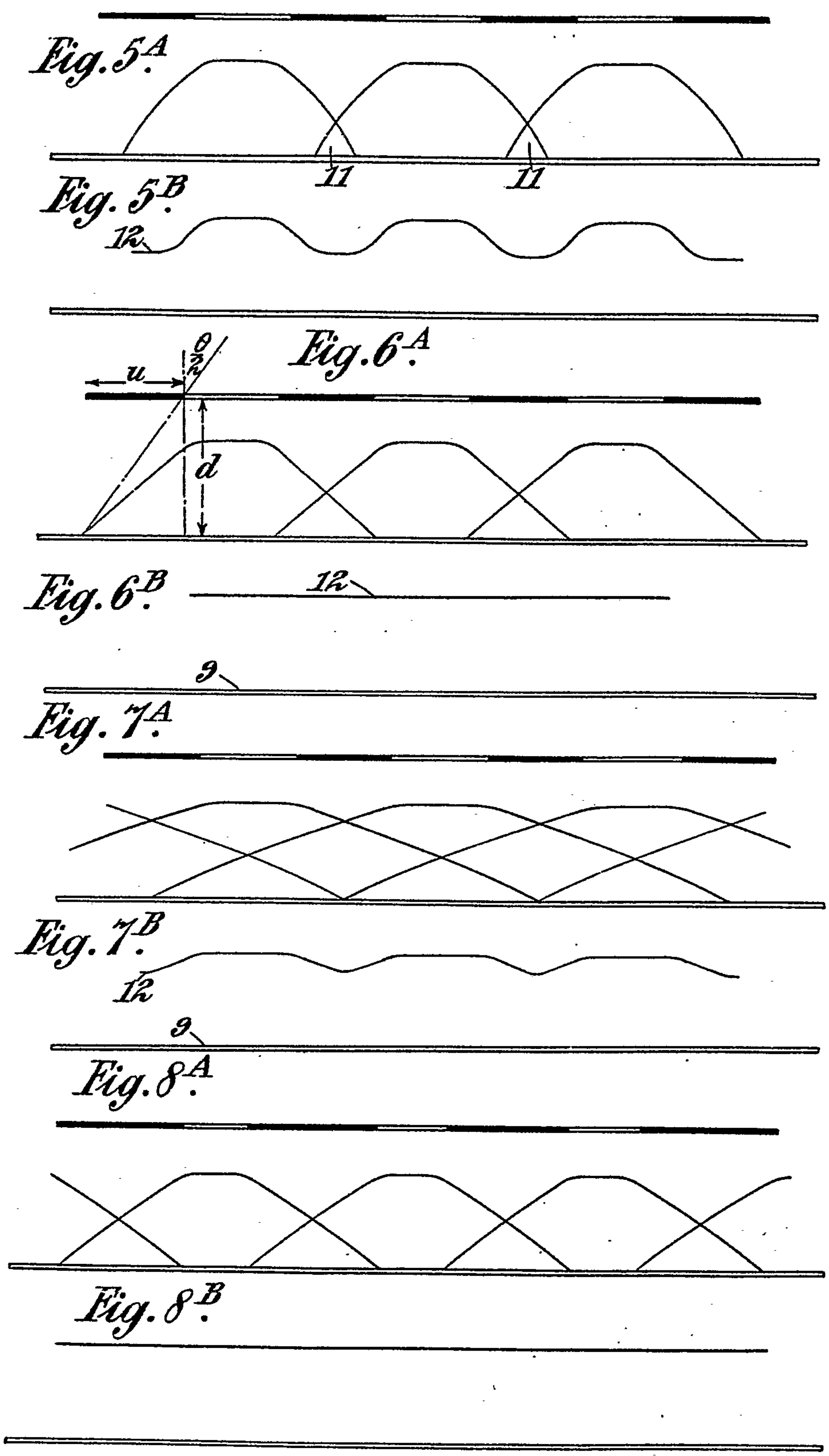


Fig. 5.A
11
11
Fig. 5.B
12
Fig. 6.A
u
θ
h
d
Fig. 6.B
12
9
Fig. 7.A
Fig. 7.B
12
9
Fig. 8.A
Fig. 8.B

SHEET 1

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

Fig. 1.

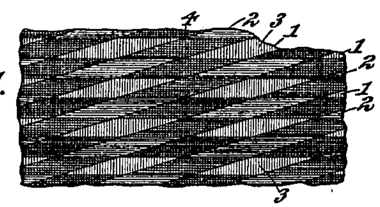


Fig. 2.

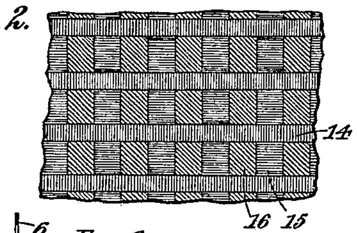


Fig. 3.

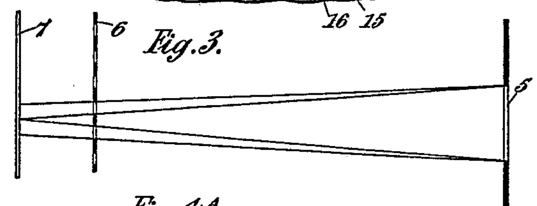


Fig. 4^A.

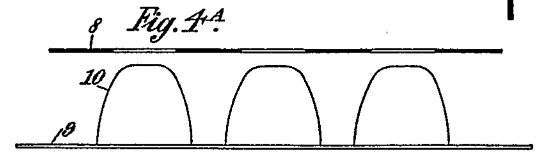


Fig. 4^B.

SHEET 2

Fig. 5^A.

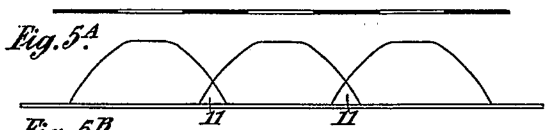


Fig. 5^B.

Fig. 6^A.

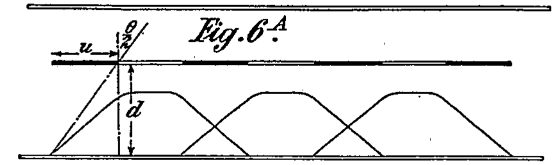


Fig. 6^B.

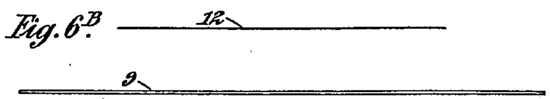


Fig. 7^A.

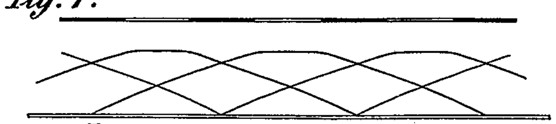


Fig. 7^B.

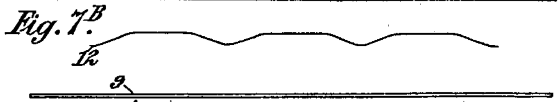


Fig. 8^A.

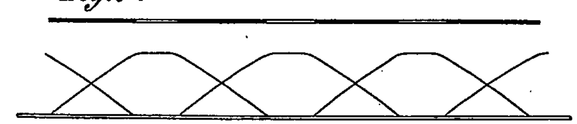


Fig. 8^B.

Malby & Sons, Photo-Lith.