July 25, 1967 R. MANDLER 3,332,775

METHOD FOR THE PHOTOGRAPHIC PRODUCTION OF AN ORIGINAL FOR PRINTING PURPOSES WITH THE AID OF A LINE SCREEN

Filed Oct. 26, 1964 7 Sheets-Sheet 1

Fig. 1

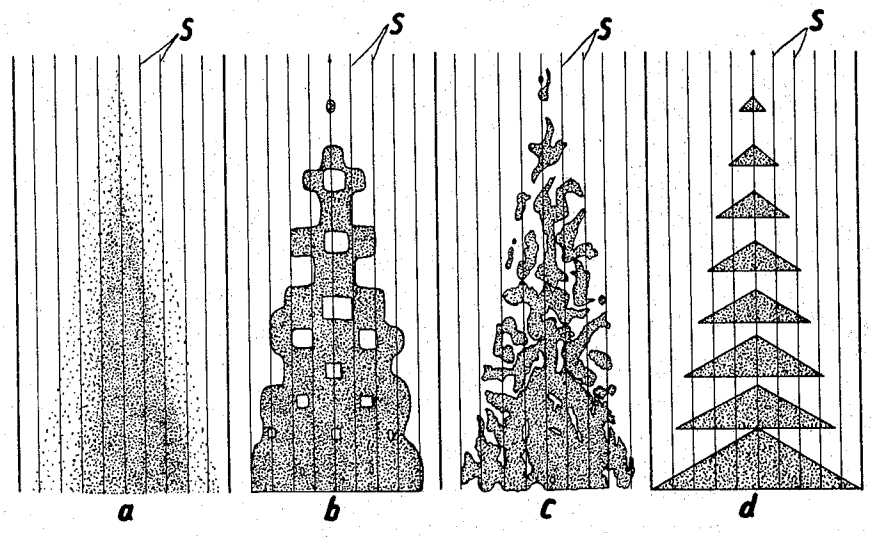

Fig. 2

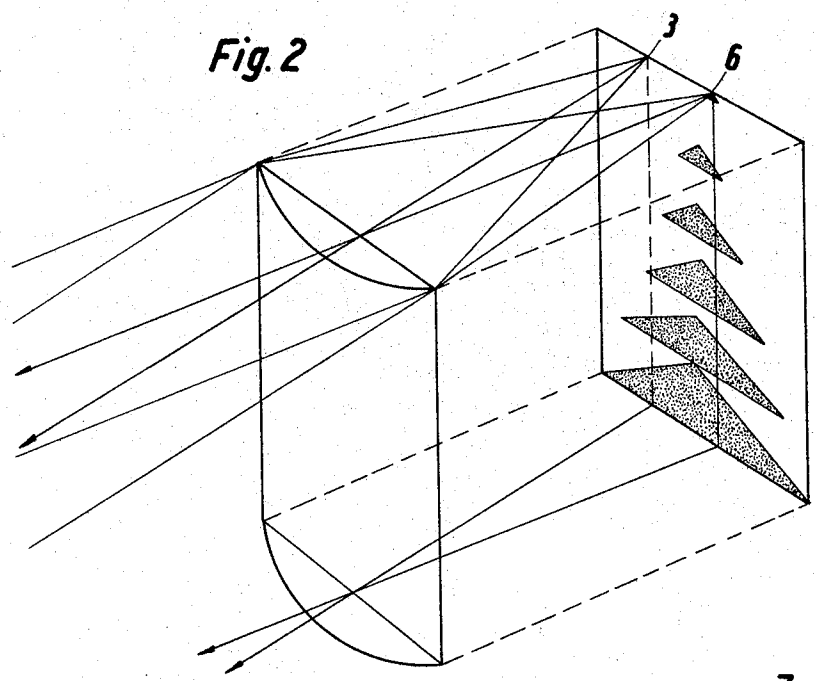

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Fig. 3

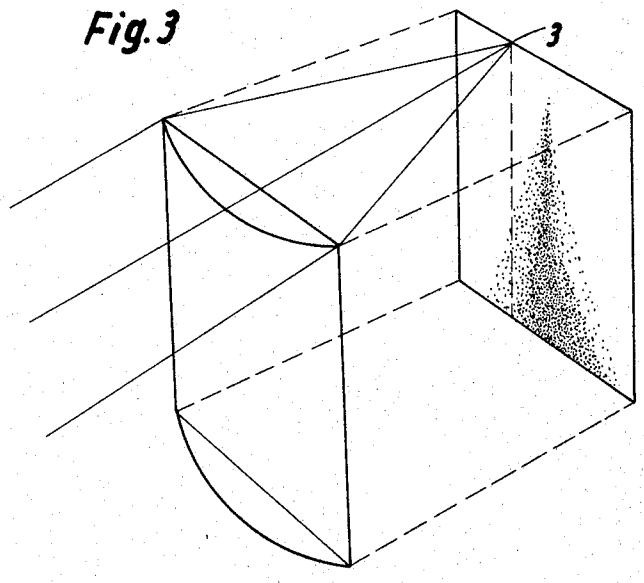

Fig. 4

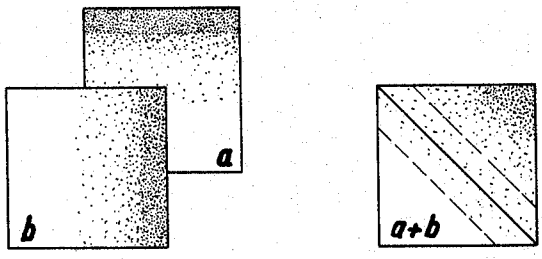

Fig. 5

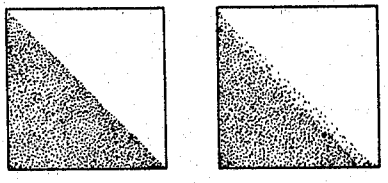

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Fig. 6

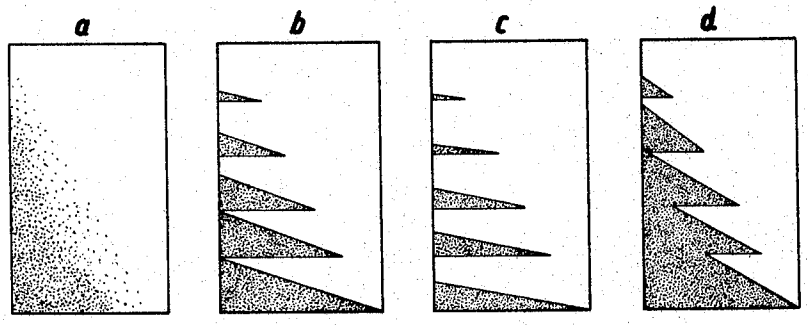
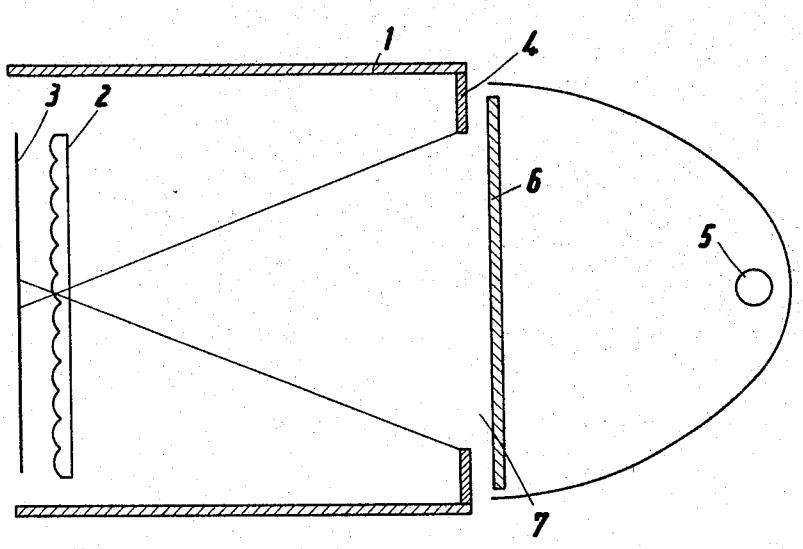


Fig. 7



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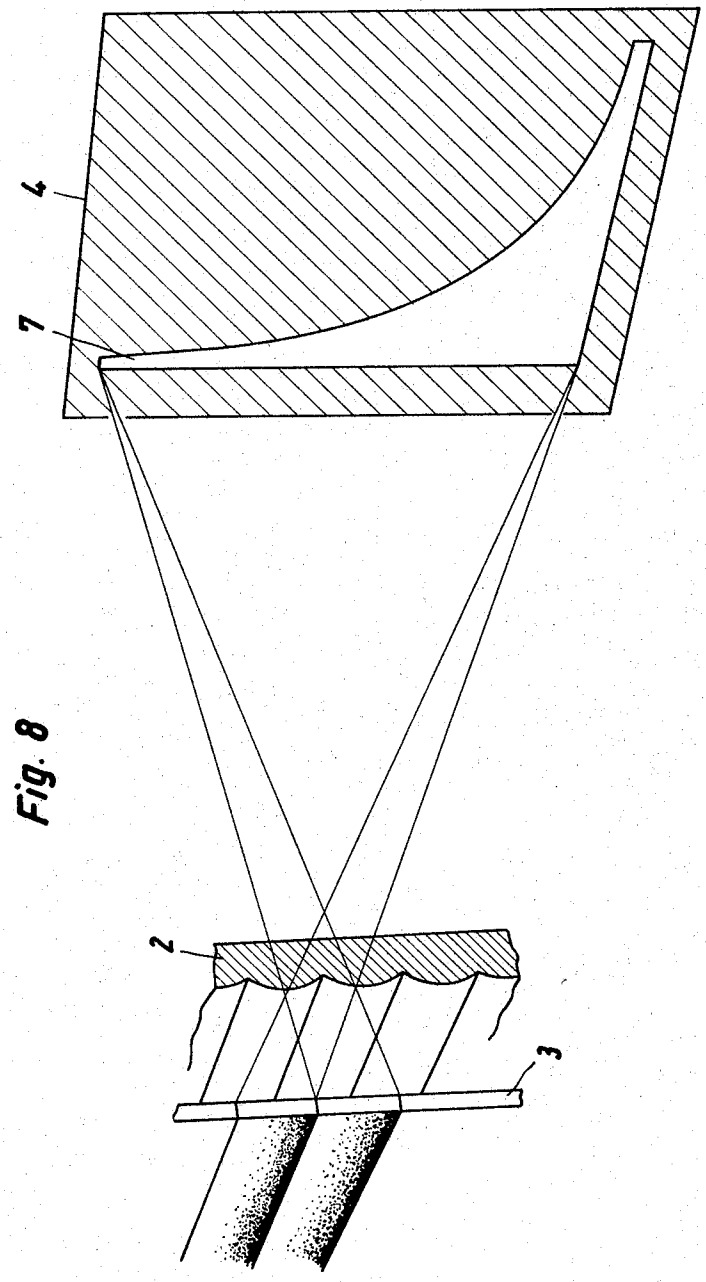

Fig. 8

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METHOD FOR THE PHOTOGRAPHIC PRODUCTION OF AN ORIGINAL FOR PRINTING PURPOSES WITH THE AID OF A LINE SCREEN

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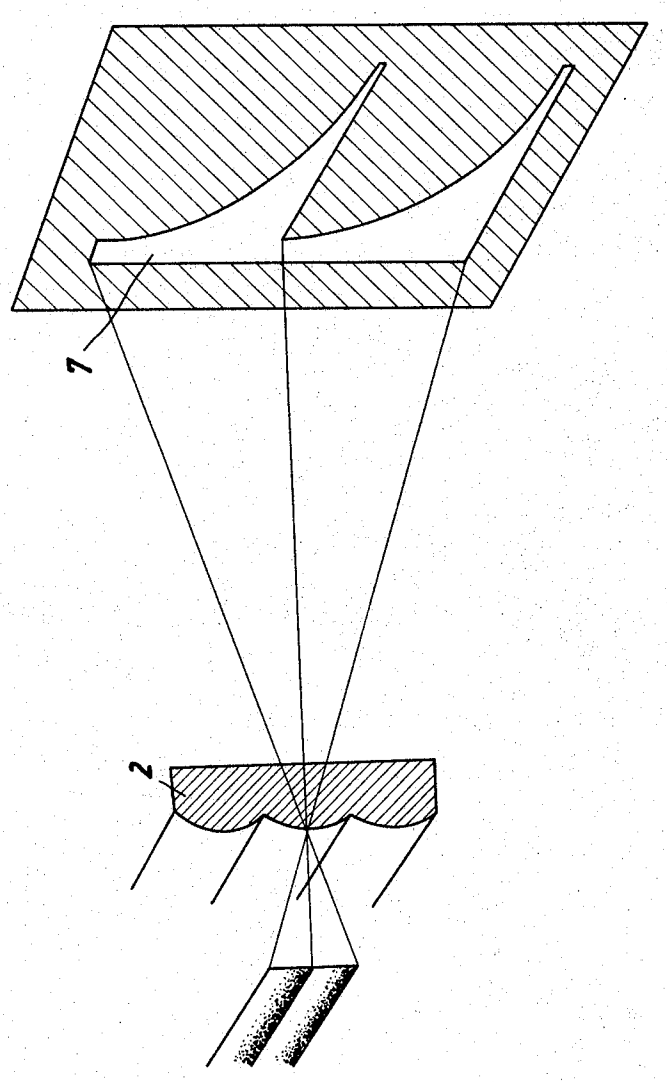

Fig. 9

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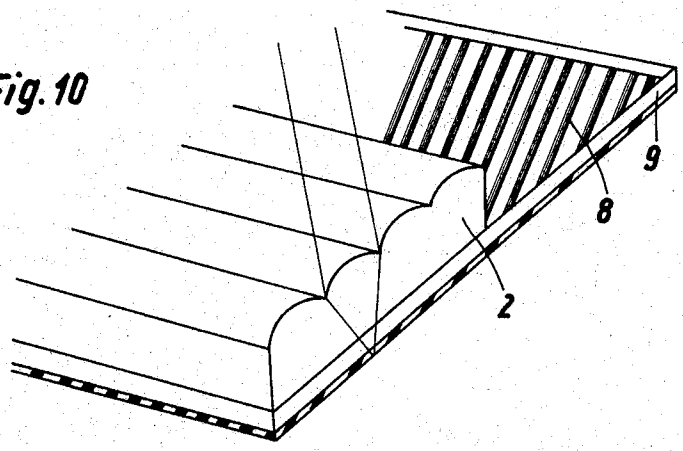
Fig. 10



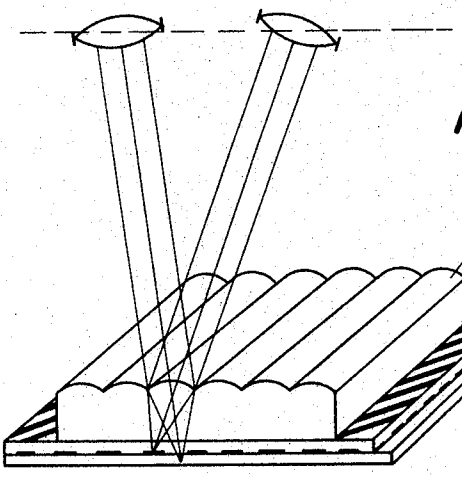
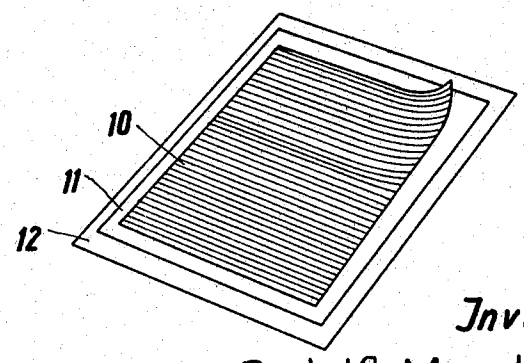


Fig. 11

Fig. 12



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METHOD FOR THE PHOTOGRAPHIC PRODUCTION OF AN ORIGINAL FOR PRINTING PURPOSES WITH THE AID OF A LINE SCREEN

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Fig. 13

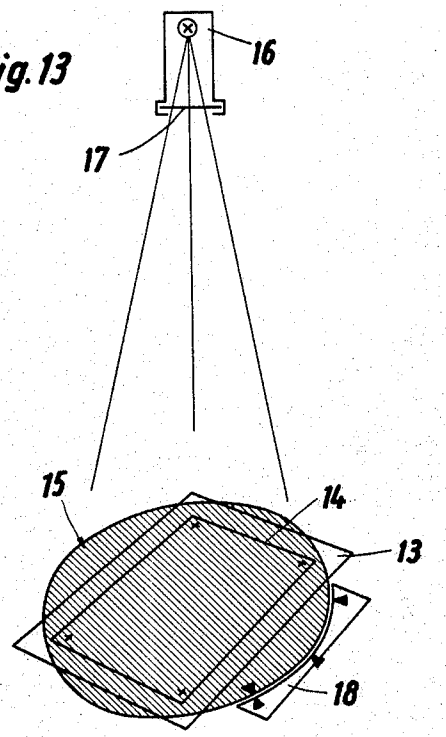
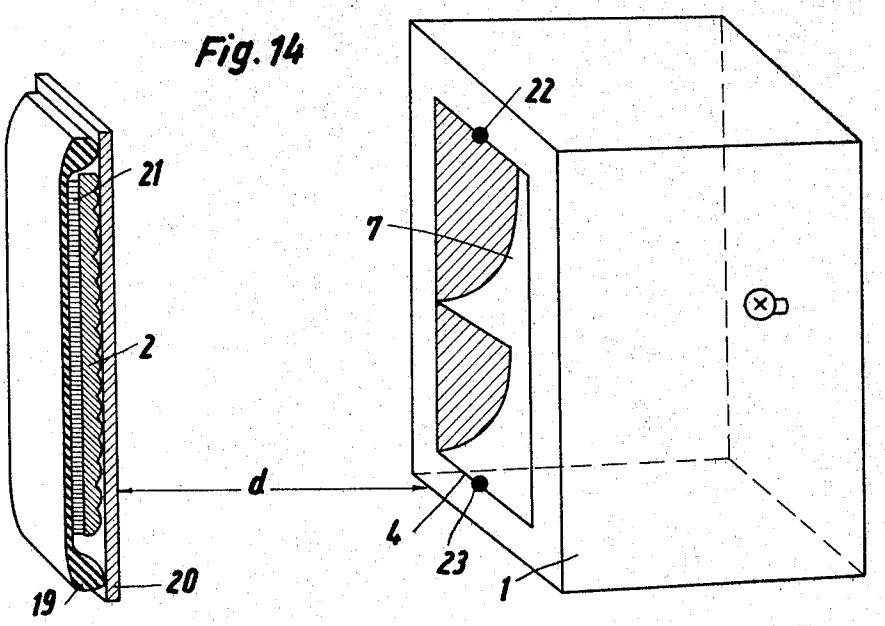


Fig. 14



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United States Patent Office 3,332,775 Patented July 25, 1967

3,332,775

METHOD FOR THE PHOTOGRAPHIC PRODUCTION OF AN ORIGINAL FOR PRINTING PURPOSES WITH THE AID OF A LINE SCREEN

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Filed Oct. 26, 1964, Ser. No. 407,953
Claims priority, application Germany, Nov. 25, 1963, D 43,019
6 Claims. (Cl. 96—45)

The invention deals with a sector of photomechanical printing technique, namely the production of an original, i.e., a printing plate, for printing purposes by photographic means using an area-dividing screen.

Normally, one uses for the screen type division of the printing plate a so-called cross screen, i.e. a combination of two line screens rotated in relation to each other by a preselected angle, each consisting of a sequence of alternating light-permeable and light-impermeable striped zones. If such a cross screen is placed in the photomechanical ray path, there is formed, as is known, by shadow formation a system of dot areas whose light permeability decreases from a center toward the periphery. In connection with light value of the individual appertaining locations of the original there is then formed on the exposed material a system of large or small dots according to the picture content.

Also the production of prints of woodcut character with the aid of a single light-dark stripe or line screen is known, where again by shadow formation of the dark stripes the finished picture is composed of parallel lines of changing width.

The invention proceeds from the experience that such line screens acting by shadow formation result in a brightness distribution, i.e. physical gradation in the individual zone regions, which is fixed by the geometric conditions of the objective, screen, and reproduction plane and is practically not influenceable. For this reason, prints of satisfactory gradation can be produced with a photographic material of given, i.e. normally steepest photographic gradation only with an original of a certain brightness range and/or with known expedients, e.g. diffuse prefogging, postexposure only through the screen, etc.

The present invention provides an improved method for the control of the printing picture gradation.

Accordingly, the invention consists of a method for the photographic production of an original for printing purposes with the aid of a line screen, having one or more screen zones, each characterized by a generally wedge-shaped gradation of light permeability across its width. In other words, the novel line screen thus has the optical effect of a plurality of one-dimensional gray wedge stripes, each of which possesses a wedge length according to the screen constant and which are contiguous without discontinuity with maximum contrast jump. Such a line screen designed with contrast jumps between the individual gray wedge regions has the optical advantage of the maximally possible wedge length. In this alone it differs from the known photographically produced contact screens, which per screen element possess a radial luminosity distribution, i.e. one starting from a central zone. However, the decisive advantage of the novel line screen as compared with all previously known photographic contact screens resides in that one can produce it by projection of a single original with preselectable luminosity gradation by means of a linearly reproducing element of any known design. Owing to this it is possible to use in every case that line screen which produces of an original of given luminosity gradation on a copying material of given photographic gradation an optimal or otherwise desired picture.

The method of the invention for the photographic production of an original with the aid of the line screen according to the invention can be carried into effect in various ways.

In principle, of course, there is required for the execution of the method a light source, the original, the line screen, and the photographic record material. But of these four elements only three need by physical, namely the light source, the record material, and either the original or the line screen, while the other of the two last-named elements may be physical or non-physical, namely produced optically.

Now the optical production of the line screen is effected according to the invention in that, by means of at least one slit covering the width of the picture, an illuminated mask, whose luminosity is graded in wedge form in one coordinate direction, is reproduced multiply in gapless succession in the plane in which the line screen is to be operative, the limiting edges of said slit extending practically crosswise to the graded mask coordinate. Under the concept "graded luminosity" are to be comprised the possibilities that the mask consists either of an equally bright area with wedge-shaped diaphragm boundary or of an area with two mutually parallel limiting lines and transparence extending in wedge form in the direction of these lines, or of a combination of the two variants. In short, the mask original is either a diaphragm of wedge-shaped profile or a gray wedge, both of which are illuminated from behind from a light source. The reproducing slit may be a single slit traveling over the picture area, which in the case of sudden advance may be illuminated over an extended period of time or, in the case of continuous advance, must be flash-illuminated periodically. Alternatively one may use a system of several mutually parallel reproducing slits, and in particularly advantageous manner a cylinder lens screen known in itself. A lens screen, as is known, has the advantage of higher aperture and greater reproduction sharpness over a slit screen. Precisely this last-named property is of advantage for the present case of application, where in the sense of the invention as accurate as possible a geometric design of the mask original in the direction of the graded coordinate is important.

At the site of the multiple reproduction of the mask is located the photographic layer. In it, therefore, is formed the latent picture of the gray wedge zone screen according to the invention, which may be brought about by the usual photochemical means. There is thus formed a physical line screen according to the present invention.

As another alternative, a physical original may be placed on the surface of the photographic layer and one then obtains upon illumination of the multiple reproduction of the mask the final, picture-carrying, screen original.

The picture-carrying screen, original may, as has been indicated, be produced by placing a physical line screen of the above described kind on the photosensitive layer and copying the original optically.

Finally, of course, the physical line screen and the physical original may be copied in one operation in contact, as is customary when using the known cross screens.

To utilize the above stated major advantage of easy adjustability of the picture gradation at given brightness gradation of the original, all that need be done is to adapt the gradation of the mask luminosity and hence of the gray wedge zone screen. Here the rule applies that the brightness range of the gray wedge zone screen should be selected concordantly with the brightness range of the original, so as to reproduce an original of undesired brightness range with normal, that is, graphically desirable brightness gradation in the final picture. This condition is fulfilled, as is known, when at picture points which correspond to the extreme values of the original the printing elements of adjacent zones either just touch (darkest

shade) or are just perceptible (lights). Contrary to the copying rule in half-tone photography, where a "soft" negative is combined with "steep" copying material and vice versa, the rule here is that a "soft" original requires a "flat" screen, i.e. one of small density range, and a "hard" original requires a "steep" screen, i.e. one of great density range.

The method according to the invention is particularly suitable for the production of originals for multiple reproduction by printing of photographically produced screened stereoscopic pictures. Such screened stereoscopic pictures consist of a line cylinder lens screen and a photographic picture located behind this screen, which is produced by special picture-taking devices. This picture consists of very fine filiform sectional pictures of different density and of high reproduction sharpness.

In multiple reproduction all details must be reproduced with greatest accuracy if the stereoscopic impression is to be preserved. With photographic multiple reproduction this condition is easy to fulfill, since with the aid of films and plates of fine grain and suitable gradation a copy true to the original can be made.

In the printing process, however, the half tones must be simulated by screening. A gray area, accordingly, consists of more or less large, regular or irregular dots, depending on their brightness.

These conventional graphic screens, called cross screens or grain screens, are too coarse, however, to obtain the detail sharpness required for the present purpose.

To explain the method according to the invention, reference is made to the figures which show in graphic representation the fundamentals of the method or, respectively, in schematic representation, some devices advantageously applicable for carrying out the method according to the invention.

FIG. 1 shows a picture detail within the recording width of a cylinder lens. Let it be stressed that for sterescopic photography a screen of a lens width of 0.7 mm. is used. Behind each lens are recorded 36 filiform parallactic sectional pictures. Thus each sectional picture has a width of only 0.0195 mm. In a conventional graphic cross screen of 54 lenses/cm. the distance between screen points is already almost ten times as much.

In the picture detail *a* of FIG. 1, the filiform sectional pictures are indicated by vertical lines *s*. For the purpose of easier representation only 10 instead of the mentioned 36 sectional pictures are represented. At *b* is represented the resolution of the sectional picture of *a* with a cross screen, at *c*, with a grain screen. For the present purpose, however, both screen resolutions are insufficient.

According to the invention, a good reproduction of all brightness gradations can, however, be achieved even without the presence of half-tones if a resolution into black-white printing elements is attained as represented at *d* in FIG. 1. In all sectional pictures *b*, *c*, *d* the mentioned filiform sectional pictures are designated by vertical lines *s*.

Since in stereoscopic pictures the cylinder lenses stand vertically, they make a selection of the filform sectional pictures only in horizontal direction, depending on the position of the viewer's eyes. In FIGURE 2, for example, the filiform sectional picture **3** of the right picture **6** is supplied to the left eye and magnified to lens width. In vertical direction no enlargement takes place, and it is therefore sufficient if the distance of the individual printing elements from one another in vertical direction is so small that from the normal viewing distance it is no longer recognized, which means that it is practically smaller than one cylinder lens width. In comparison with the photographic half-tone record shown in FIG. 3, it is seen that the same brightness gradations are supplied to the eye of a viewer within a sectional picture line **3**.

In the photographic original these gradations consist of gray values, and in print, of alternately black and white vertical sections, which, however, due to their small distance are no longer recognized as such. The size of the printing elements is less important than their form.

In the chosen example, therefore, the roof-shaped slant of the triangular printing elements is determining for the correct brightness reproduction. The problem to be solved is to transform the density distribution of the photographic material in horizontal direction into a record of non-transparent picture elements with vertical extension. Thus the relationship between the original and the copy is as between the two forms of variable area sound film-recording.

Now it is necessary and also desirable to effect the formation of the printing elements simultaneously with the formation of the screened stereoscopic picture. Let it be explained once more what is meant by picture gradation. This is not the gradation of the photographic material, which is in any event, as hard as possible, but rather the gradation of the picture broken down into black and white elements as it results at the end of the photographic process. It is to correspond to the originally existing gray values. In this connection let us explain first the sensitometric basis for the genesis of the desired formation of the printing elements.

In FIG. 4 are designated by *a* and *b* two identical photometric wedges, which are so laid one on the other that the direction of increasing density in the one is normal that the in the other. This results in a diagonal density variation, as shown in $a+b$, represented by a diagonal line with two parallels in broken lines.

If the density increase of the two wedges is not the same, there results a more or less inclined density curve deviating from the diagonal. When exposing through such a compound wedge onto a photographic material of very hard gradation, the shown resultant line becomes visible directly. Depending on the exposure time, it lies on the solid line or on a line parallel thereto. It is the sharper, the harder the gradation of the photographic material, the width of the transition zone from black to white being dependent thereon. This is shown in FIG. 5.

Now the represented possibilities of producing from two density variations extending at right angles to each other a resultant black-white boundary can be used to obtain the printing element formation according to the present invention.

In FIG. 6*a* is shown again a picture detail of a screened stereoscopic picture which contains gray values.

FIG. 6*b* shows how the gray values are to be recorded in the reproduction by the method according to the invention.

FIG. 6*c* shows the reproduction with too little contrast and

FIG. 6*d* shows the reproduction with too much contrast.

If one conceives the picture as analyzed into horizontal lines, one may consider the picture content as pieces of a wedge cut into horizontal stripes as per FIG. 6*b*. If each line in itself is given a brightness variation according to the wedge in FIG. 4*a* in vertical direction, there are formed resultant black-white boundaries similar to FIG. $4a+b$. It is now also clear how the correct geometric form of the printing elements and the succession of the lines of high density and hence the gradation of the finished printed picture can be achieved even when photographs of different density range are to be illustrated. The inclination of the resultant black-white boundary can be achieved simply by a change in the density variation of a wedge, that is, to compensate a smaller density range of the photograph also the density range of the wedge must be reduced. This results in a soft screen. To compensate a greater density range of the photograph, also, the density range of the wedge must become greater, resulting in a hard screen.

Now it is necessary to be able to vary at will the density curve within the line screen. An arrangement as shown in principle in FIG. 7 is suitable for this purpose. In a box **1**, a cylindrical lens screen **2** with horizontally

arranged lenses is arranged a little before the filmplane 3. Provision should be made that the focal lines of the cylinder lenses lie in the air space behind the screen and impinge on the plane 3. In the front portion of the box 1 a frame 4 is inserted which is given a specially formed cutout. This cutout is evenly illuminated by means of a lamp 5 through an opal glass disk 6. The ratio of the vertical height of the cutout in frame 4 to its distance from the screen is as the aperture of the cylinder lenses to their focal length. The images of the illuminated cutout produced by the lenses in vertical direction are without discontinuity. As no refraction takes place in horizontal direction through the cylinder lenses, the lateral size of the cutout appears only as a difference in brightness.

In FIG. 8 are shown in perspective view the shape of the cutout 7 in frame 4 and the cylinder lenses 2. On the picture plane 3 are formed, as can be seen, horizontal lines, which are graded in their brightness from the top down. By the cutout 7 the brightness distribution of the lines can now be made to obey any desired law, e.g., a logarithmic law, so that control can be exercised on photographic and printing-technique particularities in any manner. As shown, the height or the vertical width of each screen line conforms to the previously stated requirement that each printing element have a sufficiently small vertical extent so as to be unrecognizable at normal viewing distances, i.e., in practice, having a maximum width approximately equal to the aperture or width of each individual cylindrical lens element. This is assured by proper spacing of the cutout frame 4 and the photosensitive layer 3 relative to the lens screen 2.

It is also possible to double the number of lines, as shown in FIG. 9. Naturally, the cutout 7 can take on also any desired other curve form. This, as has been mentioned, results in any desired brightness distribution.

Now if in the plane 3 in FIGURES 7 and 8 a reproduction film is provided, and in contact therewith a negative, there results a picture analyzed into lines with the printing elements to be obtained according to FIG. 6*b*, if the form of the illuminated cutout is chosen according to the viewpoints set forth. It is possible, therefore, to accommodate the film and the negative as well as the screen in one plane, for only in this way will the tiny picture details be reproduced in full sharpness and in the desired form. With this arrangement there may be used a negative and/or a positive in a three-dimensional photograph. Alternatively it is possible to proceed from a plurality of small-size negatives, which by enlargement with a special apparatus cause enlarged positives to be produced directly under a screen disk. Also, in this case it is possible to bring about the screen-mounting according to the invention directly during the enlarging and without the detour via a large-size film. As the picture and the screen must fall into one plane, but in the present case the picture is formed optically, a real screen is used. The latter is produced as "contact screen" with the device according to FIG. 7, in that instead of placing a negative film between the screen and the reproduction film upon exposure, a half-tone film is used in the place of the hard "repro-film for the line and screen work." With the aid of the curved cutout 7 hard to soft screens in a variety of gradations can be produced. These are used together with the lens screen for the enlarging apparatus.

For this purpose the formed contact screen film is, as shown in FIG. 10, so assembled that its lines 8 intersect with the lenses 2 on the surface of the disc. The focal length of the lenses is so dimensioned that the focal lines of the lenses come to lie approximately in the surface of the contact screen film 9. Thereby the focal lines also come in contact with the copying layer.

In FIG. 11 the arrangement is shown with the use of an enlarging apparatus. Here, of course, a continuous adjustment of the contrast is not possible.

To compensate the different negative character, several screens of different hardness must be used. For monochromatic prints it is advisable to use a right-angle crossing of cylinder lenses and copying screen lines. For multicolor prints the crossing may be under different angles in order to obtain a satisfactory print reproduction without more effect.

In the following, some practical examples of execution according to the method of the present invention are enumerated.

With a black and white streoscopic print a direct stereoscopic photograph, in the present case a portrait, was made on a negative film. The negative was copied in a copying frame in an arrangement according to FIG. 12 on a film, and developed. In the arrangement shown, 10 denotes the stripe copying screen with the layer facing down; 11, the negative with the layer facing up; and 12, the copying material also with the layer facing up.

Since for offset printing the resulting diapositive must be side-reversed, the negative is placed on the other way round and copied through the film. To obtain a good picture sharpness, a punctiform lamp was used, set up at a distance of 2 *m*. As good contact is required between the individual layers, it is advantageous to use a vacuum frame. The position of the stripes of the copying screen was horizontal. The diapositive thus prepared was copied onto a metal plate and printed in known manner.

For the practical execution of a natural-color stereoscopic print, first a direct stereoscopic photograph was made on a negative color film. Of this negative, three separation positives were printed using a contact screen as described above. For this an arrangement as represented in priciple in FIG. 13 was used. At the bottom of a copying frame, not shown, lay a panchromatic repro-film 13. On this lay the color negative 14, and above it, rotatably, a stripe contact screen 15 cut round. At a distance of 2 m. thereabove was a functiform lamp 16 with attachable color filters 17. For the adjustment of the rotation, an index marking 18 is provided at the edge of the screen 15.

The diapositives formed after development in hard repro-developer were copied in known manner on aluminum foils and printed together. For fitting there served some crosses at the edge of the color film. To eliminate exposure defects it may be desirable to photograph also a gray scale at the edge of the picture.

Naturally, it is possible also to let a diapositive take the place of a large-size color negative. But as in this way negatives are first formed, it is necessary to copy twice. For this there are two possibilities. In one instance, the same procedure as described above is followed, resulting in separation negatives. Of these then diapositives are made by simple copying, and with the copying gray value residues in the printing point formation can be eliminated. The second possibility is first to produce unscreened half-tone color separations and then to make the screened positives without filter from the half-tone negatives with insertion of the stripe contrast screen.

By known photomechanical masking methods, the necessity of color correction of individual picture parts—which is actually possible only to a limited extent—can be avoided.

Another possibility of producing printable films from a motion picture film negative such as it results with the process patented to the inventor in German Patent No. 1,139,731 consists in that first a contact copy of the original negative is produced on intermediate positive film. This copy is printed in the usual manner, as mentioned in the above mentioned patent, so that large-size negatives result, which are now treated just as described above. Motion picture photographs on commercial reversal film are treated in the same manner.

Finally, another production possibility for printable films consists in proceeding as stated above in connection with the description of FIGURES 10 and 11. In this manner the intermediate steps are avoided from the start. Of

a conventional color negative motion picture film three copies are made with the arrangement described. Instead of the usual subtractive color filters magenta, yellow, and cyan there are used the color separation filters, red, green, blue. The illumination compensation is effected by gray filter, and as positive material there serves a panchromatic repro-film. The lens screen must, of course, be mounted so that it occupies the same position in all three exposures. Below it may be provided either a circular striped screen or three rectangular screens whose stripe position lies in the desired angle. Lens screens or line screens of small slit width used for the production of such stripe screens must have a width which is at least equal to the diagonal of the picture format. If particularly fine stripe screens are demanded, it is desirable to use the arrangement made in FIG. 9. As this is a one-time operation, a repro-camera is not required. It is advantageous to use for this, a vacuum copying frame. The arrangement adopted is represented in principle in FIG. 14.

Into the vacuum copying frame, of which the rubber cloth is illustrated at **19** and the glass plate at **20**, there are clamped the lens screen **2** and the halftone film **21**. The illuminated curve **7** in the frame **4** of box **1** is set up opposite the copying frame in the darkened room. To determine the correct distance, a red and green bulb **22** and **23** are arranged at box **1**, namely as the upper and lower limits of the frame. Instead of the film, a ground glass plate is applied on the screen, and the red and green separating lines are observed with the magnifying glass. Then the distance *d* is varied until the red and green lines coincide. It is thereby ensured that the lines are contiguous without discontinuity.

I claim:

1. In the method of manufacturing printing plates for reproducing from continuous tone, black and white or colored stereoscopic photographs comprising a series of narrow, juxtaposed stereo separations, half-tone stereoscopic illustrations having a series of similar stereo separations and an attached lenticular viewing screen, the steps of, supporting a photo-sensitive material in the path of a selectively operable light source, projecting onto the photo-sensitive material the image of the continuous-tone photograph and concurrently projecting onto the photo-sensitive material the image of a lineated screen, the lines of which are disposed in non-parallel relationship to the individual stereo separations in the continuous-tone photograph, the individual projected lines of the lineated screen having a maximum width no greater than approximately the width of the individual lenses of the lenticulated viewing screen to be used with the printed stereo illustration, the intensity of each projected screen line continuously varying at least once between a maximum and a minimum across the width thereof.

2. The method as set forth in claim **1** in which the lineated screen comprises a lenticulated screen with cylindrical lenses having substantially the same area as the continuous-tone photograph.

3. The method as set forth in claim **1** in which the image of the lineated screen is formed by projecting light through an opaque screen having a series of slots covering substantially the entire area of the continuous-tone photograph.

4. The method as set forth in claim **1** in which the light intensity in each of the individual screen lines varies twice across its width from a minimum to a maximum.

5. The method as set forth in claim **1** in which the variable light intensity in the individual screen lines is effected by disposing a diaphragm having therein an aperture of predetermined configuration and a lineated screen between the projecting light source and the photosensitive material.

6. In the manufacture of printing plates for reproducing from continuous-tone, black and white or colored stereoscopic photographs, comprising a series of narrow, juxtaposed stereo separations, half-tone stereoscopic illustrations, having a series of similar stereo-separations and an attached lenticular viewing screen, for steps of, supporting a first photosensitive material for impingement of light thereon, projecting the image of a lineated screen onto the first photo-sensitive material, the individual lines of the projected image having a maximum width no greater than approximately the width of the individual lenses of the lenticulated viewing screen to be used with the stereo illustration, the intensity of light in each of the individual lines varying continuously across the width thereof at least once from a minimum to a maximum, developing the latent image of the lineated screen in the first photosensitive material, projecting the developed image onto a second photosensitive material, and concurrently projecting the image of the continuous-tone photograph onto the second photosensitive material.

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