Oct. 21, 1924. 1,512,681

J. ENGL

PRODUCTION OF SOUND RECORD PHOTOGRAPHIC POSITIVES

Filed July 28, 1924

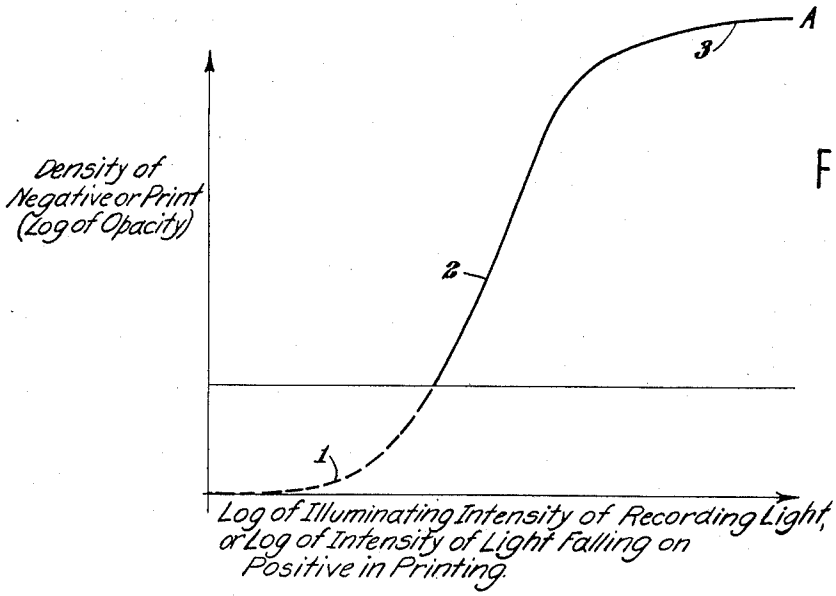


Fig. 1

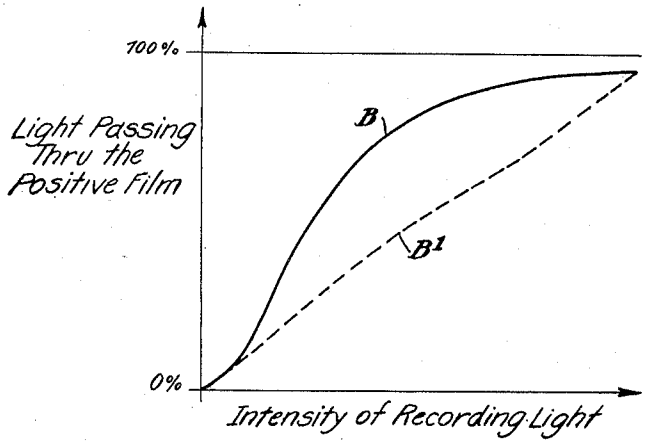


Fig. 2

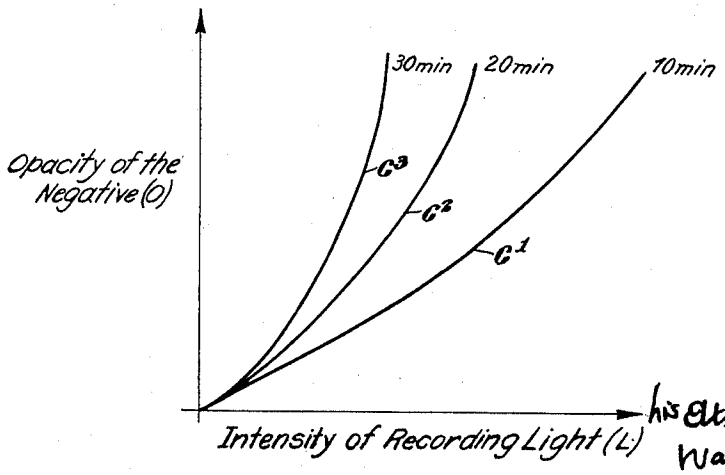


Fig. 3

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UNITED STATES PATENT OFFICE

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PRODUCTION OF SOUND-RECORD PHOTOGRAPHIC POSITIVES.

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To all whom it may concern:

Be it known that I, JOSEF ENGL, a citizen of the German Republic, and resident of Berlin-Grunewald, Germany, have invented certain new and useful Improvements in the Production of Sound-Record Photographic Positives, of which the following is a specification.

The invention relates to the production of sound record photographic positives. More particularly it relates to a process whereby a photographic negative may be made by acoustically-varied light, and a positive print made from such negative bearing a photographic record of varying intensities which may be utilized in the subsequent reproduction of sound therefrom. An object of the invention is the production of a process involving the making of the negative and therefrom the positive photographic record, in such a manner that certain inaccuracies of the photographic steps may be obviated; and that thereby, when sound is reproduced by the utilization of the positive, it will correspond quite accurately to the acoustically-varied light used for producing the negative, without distortions which might arise because of inaccuracies of the photographic process.

It should be understood that the photographic process comprising this invention may comprise part of a complete process or system for recording and subsequently reproducing sound, in which sound vibrations to be reproduced are directed to a form of microphone whereby an electrical current is produced which varies in correspondence with the sound vibrations which produced the same. This current flows in a circuit which includes a recording lamp, the light of which falls upon a suitable sensitized surface, such as a film strip which is moved across the beam of light. This recording light is maintained at constant luminosity when no sound waves are affecting the microphone, and its intensity varies above and below this constant, or average, luminosity when sound vibrations act upon the microphone. Accordingly, when the negative is thus made on the film and developed and a positive print made therefrom, the sound record should appear on the latter in the form of lines of varying density. When the sound is subsequently to be reproduced, the positive film is fed past a constant source of light which passes through the film to greater or less extent in accordance with the varying densities of the sound record lines or images thereon, the light thus passing through the film falling upon a light-sensitive device, such as a photo-electric cell. Electrical currents, which vary in correspondence with the light falling upon the photo-electric cell, will thereby be set up and these electrical currents may be led to some form of loud speaker, or sound reproducing device, whereby sound vibrations may be generated, and these should of course correspond as closely as possible to the original sound vibrations which were received by the microphone in the recording process.

In carrying out such a process, however, problems have arisen in the employment of the properties of the sensitive film as to the reactions of the latter to varying light intensities, in such manner that there shall be no inaccuracies in the photographic recording steps. The varying intensity of the light by which the negatives are made may be made to correspond quite closely to the original sound vibrations, and the final reproduction of sound may be made to correspond quite closely to the variations of current produced by the variations of light passing through the positive film and falling upon the photo-electric cell; but the perfections of process by which these results are attained will be to a considerable extent nullified if substantial inaccuracies are allowed to enter the complete system because of the inaccuracies which appear in the photographic steps as the same are commonly practiced.

In the problem, the solution of which is herein attained, there are two factors which must be considered. First, there should be an approximately constant proportion between the intensity of luminosity of the recording light by which the negative is made and the intensity of the light which passes through the positive film and falls upon the photocell in the sound reproduction process. The second factor to be considered is the desirability of having as great a part as possible of the positive film, or record, comparatively transparent, or as little light-absorptive as possible, because the loudness of the reproduction of sound by the loud speaker will vary in accordance with the

amount of light which passes through the positive film, and acts upon the photo-cell. This can be accomplished when the transparency of the positive record-bearing film, or conversely, its light-absorptive power, has a possible range between zero and 100 per cent. This will be so when portions of the positive film corresponding to average intensity of the recording light have such a density that they will absorb 50 per cent of the light falling upon the same in the subsequent sound-reproducing operation. The average intensity of the recording light, referred to, is that intensity which corresponds to a total absence of sound to be recorded. The intensity of the recording light varies, as stated above, above and below this average value, equally, when sound is being recorded. Accordingly, if the portions of the positive film corresponding to zero sound vibrations absorb 50 per cent of the incident light, the variations in density or light-absorptive power of the print, corresponding to the sound vibrations recorded, can extend equally in both directions, and vary from approximately zero to approximately 100 per cent. With this arrangement the entire range of sounds may be recorded, and also a great part of the film will be of large transparency.

Considering the light which is to act upon the photo-cell, in sound reproduction, as passing through a film of transparent material, celluloid or the like, bearing photographic images of varying darkness, the celluloid or other base is considered as entirely transparent and the light-absorptive properties of the film are considered as depending entirely upon the varying density of the photographic sound record thereon. If this condition is realized, namely that the absorption of the positive film shall be approximately fifty per cent of the light falling thereon when zero sound is to be reproduced, it follows that the light passing through the positive film upon the photo-cell, during reproduction, may vary throughout the entire range of intensity of the acoustically varied recording lamp by which the negatives were made.

These conditions can only be fulfilled by special steps in the photographic process; this because of the fact that the variations of density in the negative, and the positive, are not strictly proportional, with normal development, to variations in the intensity of the recording light. This is particularly so where the illuminating intensity is small, corresponding to a large degree of transparency of the positive. In accordance with this invention these desired conditions are fulfilled by developing the negative in a special way, and making the positive print in a special way, as will be disclosed hereafter. The invention consists in the process, and steps thereof hereinafter more fully set forth and particularly pointed out in the appended claims.

The difficulties to be overcome, and the means by which they are overcome, in accordance with this invention, will be best understood by consideration of the accompanying drawings forming part of this application. In the drawings—

Fig. 1 is a characteristic curve illustrating the manner in which the density of a negative varies for varying intensities of the recording light, with normal development, and also illustrating the manner in which the density of a positive varies for varying intensities of the light passing through a negative and falling upon the positive, in contact printing, with normal development, the general form of the curve being the same in both instances, the ordinate representing logarithms of opacity and the abscissa representing logarithms of intensity, it being the common practice to use logarithmic values in making such curves;

Fig. 2 is a diagram illustrating in full line, the relation between the light passing through the positive film in reproduction and the intensity of the recording light in making the negative, when the density of the print varies as in Fig. 1, and in dash line, the relation when this invention is practiced, and

Fig. 3 is a diagram representing variation in the opacity of the negative as a function of the intensity of the recording light, for varying times of development, by the aid of which the problems referred to may be solved.

One of the difficulties of the problem is made apparent by consideration of Fig. 1. Obviously, if the density, or intensity, of the effect upon the negative or the positive increased proportionately to the increase in the illuminating intensity, the characteristic curve representing this relation would be a straight line, which might, for example, start at the junction of the ordinate and the abscissa of the diagram and form an angle of 45° with each. Such a linear relation to the variations in light intensity and blackening of the film would represent true proportionality between the two. The coatings of photographic light sensitive films, or plates, do not, however, with normal development, vary in this desired manner, and in all photographic emulsions or coatings with which I am familiar the effect of constantly increasing the intensity of light is the production of density or intensity of marking on the film which varies disproportionately to the illuminating intensity, as shown by the curve in Fig. 1, this figure representing in its general form the characteristic of all emulsions under these conditions. It will be noted that the char-

acteristic curve "A" (Fig. 1) has a lower portion 1, illustrated in dash in Fig. 1, which is concave upwards, this corresponding to the lower illuminating intensities. From this point the curve has an approximately straight upwardly inclined portion in which there is an approximately constant relation between the illuminating intensity and the density or intensity produced thereby on the film. This portion of the curve is succeeded by a downwardly concaved portion 3, which is approaching the horizontal.

Referring to Fig. 1 it is evident that when one is working on the lower curved part 1 of the characteristic curve there is a very considerable lack of proportionality between the illuminating intensity and the density or degree of blackening produced on the print. This condition corresponds, of course, to a comparatively small illuminating intensity and also to a rather small degree of blackening of the film which corresponds to less than 50 per cent of absorption when light is subsequently passed through the print in reproducing the sound.

There is a linear proportion between the illuminating intensity and the density or degree of blackening when one operates on the straight line portion 2 of the characteristic curve since this is almost a straight line. It is not possible, however, to work only on the straight line portion 2 of the curve, if the second of the two factors of the problem noted above is to be fulfilled since the lower curved part 1 of the curve corresponds to a large degree of transparency of the print, which as stated above, should be attained.

In Fig. 2 the curve B represents the relation between the light passing through the positive film in reproduction and the intensity of the recording light in making the negative, when the negative has been made by a recording light varying between the same limits as in Fig. 1, and when the development of the negative and positive has been normal, the same as in Fig. 1. In Fig. 2 the abscissa represents the varying intensity of the recording light, and the ordinate represents the proportion of light from zero per cent to 100 per cent passing through the positive film. If there were a proper proportion between the factors represented by the ordinate and the abscissa, the curve B would be a straight line. Curve B, however, departs from the required straight line to a considerable extent, almost the whole of this curve being concave downwards. This curve B is curved in the manner shown because of the curved nature of the characteristic curves A, as shown in Fig. 1, for both positive and negative films. That is to say, the disproportionalities produced in making the negative and in printing the positive, with normal development, are added together, in effect to produce a curve such as B in Fig. 2, the curves shown all being determined experimentally.

The two desirable factors can, however, be fulfilled and an approximately straight line, proportional relation established between the intensity of the recording light and the proportion of light passing through the positive film in reproduction by steps which will now be described, as a result of which the approximately straight line B^1 may be substituted for the concave curve B in Fig. 2. On referring to Fig. 3 it is seen that the opacity of the negative as a function of the intensity of the recording light depends upon the length of time of development of the negative. In this figure the curves C^1, C^2 and C^3 represent the relation between the opacity of the negative and the intensity of the recording light for development times of ten minutes, twenty minutes and thirty minutes respectively. It is evident that with increasing time of development, with the same bath, the curves become increasingly steep in the upper portions of the same. It will be noted that the upper portions of these curves correspond to considerable opacity of the negative; accordingly to considerable transparency of the positive. By suitable choice of an abnormally long time of development the density of the negative film may be so altered that the corresponding curve for the positive film is approximately straight.

The requisite steepness of the curve, such as curve C^3, in Fig. 3, may be expressed mathematically. Calling the opacity of the negative film coating O, the incident light L and the light which passes through the film T, then $O=\frac{L}{T}$. The relation between opacity O and the incident light L is given by the equation $O=L^a$ where a is a constant known as the index of gradation, which depends upon the time taken for development, on the nature of the sensitive film and on the developer used. This relation has been developed by experimental photographic chemistry.

For negative films as commonly made and developed the value of a is not greater than 0.5. In accordance with the present invention the development must be carried so far that a is greater than 1, a value of 1 for the constant a corresponding to a straight line, making an angle of 45° with the abscissa. If a is greater than 1, the curve, such as C^2 or C^3, will depart somewhat from a straight line, and the steepness of such curve, will, of course, be greater than 45°, at all points thereof, and such a condition corresponds to greater opacity of the negative and, therefore, to greater transparency of the positive.

In actual practice the negative is developed for an abnormally long time, which

may, for example, be between twenty and twenty-five minutes with normal intensity of bath. The negative film thus overdeveloped is naturally very dense all over. It is advisable to use a developer which produces as large contrast as possible, i. e., one which acts harshly. It is also advisable to use developers which have but little tendency to fog, and if desired, known means for preventing fogging may be used.

The negative having been developed and fixed and washed in the usual way, the positive is made therefrom preferably by contact printing. Adjustments are made of the various factors concerned in printing such that the portions of the positive print which correspond to the average intensity of the recording light used in making the negative shall be approximately 50 per cent, as has been explained above. This may be accomplished by regulating the intensity of the source of light used for printing, or by adjusting the time of printing, or the time of development of the print, or the intensity of the bath used in developing the print. It is advisable that the development of the print be normal, in order to obtain freedom from fogging, as much as possible. Therefore, the most practical means of adjusting consists in adjusting the intensity of the printing light. The time of printing might, of course, be varied, as stated above, but it is not practical to vary this time to a great extent, particularly since it is, of course, desirable to obtain as great an output in feet of film per day as possible.

It may be advisable to describe the manner in which the printing light is so regulated as to give a transparency of 50 per cent to the positive film at points corresponding to average intensity of the recording light used in making the negative. A transparent strip of film having no photographic record thereon, is interposed between the constant source of light which is used in reproducing, and the photo-electric cell. The current then produced by the photo-electric cell is measured and is considered as 100 per cent. Various strips of film are then taken as samples and on each of the same a negative is made corresponding to average intensity of recording light. That is to say, the recording light is allowed to act upon these strips of negative film when no sound vibrations are affecting the circuit of the recording light, so that this light accordingly is at its constant average value. These sample negative strips are then developed in the ordinary way, and a print is made from one of the same with an intensity of printing light which may be as close to the necessary intensity as can be guessed at. The print thus made is then interposed between the constant reproducing light source and the photo-electric cell, and the current produced by the cell is measured. If the current is less than 50 per cent of that previously obtained, it appears that the intensity of printing light was too great, since the photocell current is in quite exact proportion to the intensity of light passing through the film and falling thereupon. Therefore, in printing from the next sample negative the printing intensity will be reduced somewhat and by this cut and try method a printing light intensity may readily be obtained, after a few tries, in which the photo cell current will be found to be approximately 50 per cent of the current produced when there was no blackening of the film.

Having the intensity of printing light adjusted to the desired point, it is evident that the sound intensities which will be printed will vary equally above and below the average intensity of printing which corresponds to zero sound; therefore, the light absorptive properties of the film will vary through a range extending equally below and above 50 per cent, this range having possible limits of zero and 100 per cent corresponding to total transparency and total opacity.

As stated above, it is, of course, possible to obtain the effect described by varying the development factors or the time of printing. It may, of course, therefore be said that the printing adjustment is made by adjustment of the light intensity used, the time of printing, the time of development and the intensity of the bath. All, or some of the same may be varied, and in case variation is made of the light intensity only, the adjustment of the time of printing, time of development and intensity of bath will be an adjustment at normal figures.

The negative produced by the abnormal time of development, as described, has a density distribution which in fact is a completely distorted record of the real light values. This distortion, however, counteracts the distortion in the positive represented by curve B in Fig. 2. The result, therefore, is the production of a condition represented by the curve or line B^1 in Fig. 2, representing an almost linear relation between the intensity of the recording light and the light passing through the positive film in reproduction. This is, of course, the desired end of the invention, the purpose of which is to produce a succession of images of sound intensities which may subsequently be used in the reproduction of sound as described above, with the result that the light transmitted by the positive will vary quite exactly with the intensity of the recording light used in making the negative. Therefore, the current produced by the photo cell in reproducing will vary in quite exact correspondence with the fluctuating,

acoustically varied, current which fed the recording lamp in making the negatives. There would, of course, be no such correspondence between the recording light and the light passing through the positive if such steps as have been described were not employed. It should also be carefully noted that the process permits the use of intensities of density upon the film ranging from practically zero to 100 per cent, and that the density corresponding to small electrical currents, or low intensities of the recording light, could not be made by the common methods without involving considerable distortions of the light effect produced upon the photo cell.

What I claim is:

1. A process of producing positive photographic sound records, comprising maintaining the intensity of a recording light approximately constant, when the same is not affected by sound, acoustically-varying the light above and below such constant or average intensity, causing such acoustically-varied light to fall upon a sensitized surface, developing the negative thus produced to such a degree of density that the index of gradation is greater than 1, and printing from said negative upon a suitable sensitized surface in such a manner, by adjusting the printing light intensity used, that the print, at points thereof corresponding to the average intensity of the said acoustically-varied recording light, will absorb approximately one-half of the light which subsequently will fall thereupon in the utilization of said print in reproducing sound therefrom.

2. A process of producing positive photographic sound records, comprising maintaining the intensity of a recording light approximately constant, when the same is not affected by sound, acoustically-varying the light above and below such constant or average intensity, causing such acoustically-varied light to fall upon a sensitized surface, developing the negative thus produced to such a degree of density that the index of gradation is greater than 1, and making a print from said negative upon a suitable sensitized surface with adjustment of the printing light intensity used, the time of printing, time of development and intensity of bath, such that the print, at points thereof corresponding to the average intensity of the said acoustically-varied recording light, will absorb approximately one-half of the light which subsequently will fall thereupon in the utilization of said print in reproducing sound therefrom.

3. A process of producing positive photographic sound records, comprising maintaining the intensity of a recording light approximately constant, when the same is not affected by sound, acoustically-varying the light above and below such constant or average intensity, causing such acoustically-varied light to fall upon a sensitized strip with relative movement between the light and strip, to produce a negative which, when developed, will comprise successive images of varying density, overdeveloping the negative to an abnormal extent, and making a print, portions of which are quite transparent, from said negative, upon a sensitized member with transparent base, by adjustment of the printing light intensity used, the time of printing, time of development and intensity of bath, such that the print will have light-absorptive properties upon different parts thereof, when subsequently subjected to light, which will vary upwards from a figure considerably below 50 per cent to a figure above 50 per cent.

In testimony whereof I have signed my name to this specification.

JOSEF ENGL.