Dec. 13, 1938. J. ENGL ET AL 2,140,003

MEANS AND METHOD OF PHOTOGRAPHICALLY RECORDING SOUND

Filed April 4, 1921

FIG. 1.

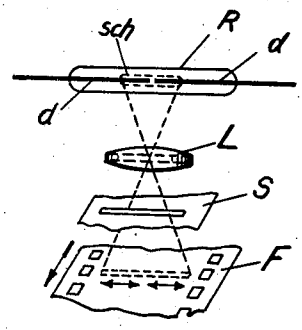
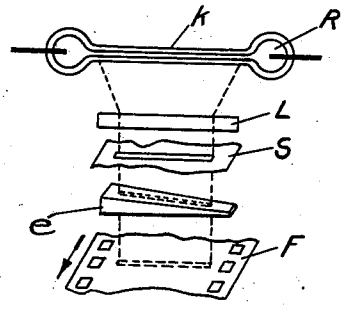


FIG. 2.



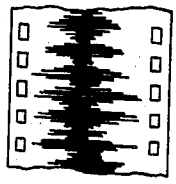


FIG. 3.

FIG. 4.

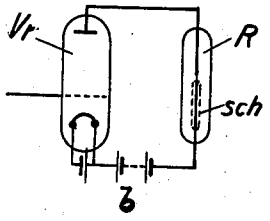


FIG. 5.

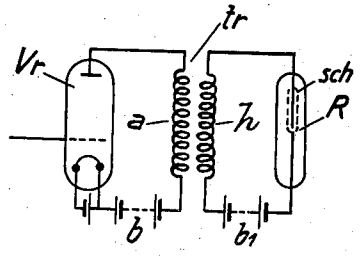


FIG. 6.

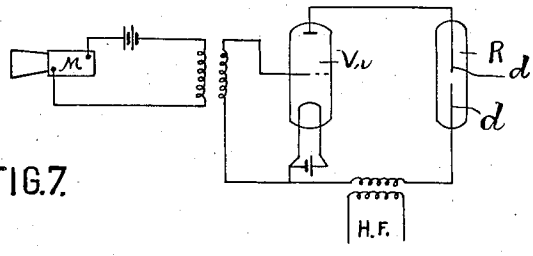


FIG. 7.

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MEANS AND METHOD OF PHOTOGRAPHICALLY RECORDING SOUND

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3 Claims. (Cl. 179—100.3)

It is generally known that sound vibrations can be recorded photographically by influencing in the rhythm of the acoustic frequencies light rays which act upon a suitable light-sensitive medium or phonogram carrier. For the purposes of acoustic kinematography there has chiefly been used hitherto an electric arc as a source of light, which is adapted to be influenced by sound vibrations under certain conditions.

The use of arc discharges for the photographic recording of sound vibrations has however the disadvantages that owing to the inertia of the arc comparatively large variations of resistance are required to secure an influence which is perceptible and sufficient for photographic purposes. The further difficulty, of ensuring the required constancy in the average intensity of the light or its intensity when not modulated by the sound to be recorded, and in particular of preventing the arc from becoming totally extinguished periodically, has hitherto not led to a practically satisfactory method of enabling the optical and particularly the photographical recording of sound waves for the purposes of acoustic kinematography. For the last mentioned field of application irregularities in the source of light are particularly disadvantageous, as it is here important to ensure that the source of light shall be influenced only in accordance with the sound waves which are to be recorded.

This invention provides means for producing photophonograms, particularly for acoustic kinematography, by means of a source of light which ensures solely the influencing thereof by sound waves without itself bringing any source of error into the procedure. With this object in view the glow light discharge, known of itself for other purposes, and which is dependent on the strength of the current in the discharge tube, is used as the source of light. As glow light tubes can be operated by small currents, relatively and absolutely small alterations of resistance suffice, in contradistinction to the hitherto known sources of light, in order to obtain great fluctuations of intensity with a sharper and more rapid control of the intensity of the light. Consequently the most accurate and most delicate photographic recording of the sound vibrations is possible.

The photographic influence upon the moving strip of film, sensitive to light, or other light-sensitive surface, may be effected in such a manner that, by means of an acoustically controlled source of light (glow light), linear transverse blackenings are produced which stand perpendicular to the direction in which the strip of film is fed forward.

According to this invention the acoustic variation of these blackenings is effected either with a constant width of the blackenings, i e., their dimension transverse to the direction of movement, by varying the intensity of the exposure, or with a constant exposure by lateral variations of the width of the blackenings. As, with the variation of intensity the exposure capacity of the bromide of silver coating imposes narrow and not easily controllable limits upon the variation of the source of light, the variation of the width of blackening is, to this extent, preferable, as it permits of an easier adjustment of the maximum elongation and, owing to the possibility of widening the strip of film, of a greater clearness in the recording of the sound marks. The difficulties referred to in connection with the variation of intensity method may, however, be overcome by means not here described.

The invention comprises the means for and method of photographically recording sound, by means of a source of light of the character referred to, maintained quite closely at constant intensity except as it is acoustically-varied, this light source specifically being a glow light discharge, as will be more fully set forth in the following specification, and be particularly pointed out in the appended claims. The invention also consists in the various combinations of elements, steps of process, etc., all as will be more fully set forth hereinafter, and pointed out in the appended claims.

In order that the invention may be clearly understood, we will proceed to describe the same with reference to the different forms of construction shown by way of example in the accompanying drawing, wherein:—

Fig. 1 illustrates diagrammatically a method for the lateral variation of the blackening.

Fig. 2 is a view similar to Fig. 1 showing other means for carrying out the method, with variations of intensity.

Figs. 3 and 4 show parts of a film strip with different forms of laterally varying blackening.

Figs. 5 and 6 are diagrams of connections used in connection with the improved method.

Fig. 7 is a diagram of connections for the glow light tube shown in Fig. 1.

The method can be carried out in such a manner that by varying the resistance of a microphone in use electrical alternating currents are produced the shape of whose curve corresponds with the sound phenomenon. This energy can

for example be supplied to the glow light tubes by means of amplifiers and transformers. Owing to the small amount of electrical power necessary to keep up the glow light discharge only small alternating currents, excited by the sound operation, are required for the control of the glow light discharge, and are sufficient to allow the variation of light to follow the most rapid of acoustic frequencies. The gas used in the light tube is preferably so selected that the wave length of the light emitted has the best possible photographical effect.

The method for the lateral variation of the lines of the blackening can, as shown diagrammatically in Fig. 1, be carried out in a manner that the negative glow light is used which is produced at the cathode of a glow light tube R, when it has the form of a long straight wire *d* or of a narrow strip of sheet metal. The length of this cathode light is fairly in proportion to the discharge current. This phenomenon which accompanies, with sufficient lack of inertia, even high frequency discharge processes, is already utilized with glow light oscillographs for the photographic examination of alternating currents. In connection with the constructional form of glow light tube shown in Fig. 1 acoustically influenced high frequency alternating current is used as glow light current and it produces at both electrodes, which alternately become the cathode, a luminous layer *sch* of varying length. The pencil of rays acting upon the film may be brought to the dimensions required by means of a system of lenses *l* and of a slit in plate S. By means of a reflector, not shown, the intensity of the light acting upon the film may be increased. Preferably the amount of light impinging is selected of such magnitude that the film is overexposed at the points illuminated. The developed film has then the appearance shown in Fig. 3. If, instead of high frequency alternating current, acoustically influenced direct current be used as glow light current, the film will have the appearance shown in Fig. 4.

Conventional circuit connections for the glow light tube R of Fig. 1, as described above, are indicated diagrammatically in Fig. 7, in which the microphone M is shown conventionally as connected in a conventional manner to the input circuit of an amplifier tube Vr. The output circuit of tube Vr is shown as connected to the terminals of the electrodes of the glow light tube R, as shown in Fig. 5. The high frequency alternating current, used as glow light current in this form of construction, as stated, may be introduced into the circuit in any usual manner. The connection from a suitable source of high frequency current is indicated conventionally in Fig. 7 at the coil marked H. F. If direct current is used as glow light current, as in Fig. 2, the high frequency connection is, of course, omitted, and the terminal voltage for the glow light tube supplied, for example, by battery *b* in Fig. 5, or battery b^1 in Fig. 6, hereinafter described.

The method for the alteration of the intensity of the exposure can be carried out, for instance, as shown in Fig. 2. The discharge area of the glow light tube R as there shown may have the form of a capillary *k*, the thin linear light area of which permits of a better concentration of light. The light is thrown, if necessary by means of reflector, upon the film F by a suitable system of lenses Z and by the slit of the plate S. Upon this film, within its areas of exposure, stripes or lines are produced, the darkening or blackening of each of which is uniform in intensity over the whole width of the film, that is throughout the length of each line, the various lines differing, however, from each other in intensity of blackening.

By inserting in the path of the light rays a light diminishing, wedge-shaped body *e* part of the light will be absorbed by the same according to the degree of its transparency. Thus with increasing thickness of the wedge, the film will be gradually less blackened throughout its width. For the complete blackening a greater quantity of light is however necessary, which is determined in the maximum by the maximum thickness of the wedge, whilst the minimum quantity of light determined by the thinnest part of the wedge and still capable of causing exposure, is not materially increased by the wedge. The wedge enables consequently larger variations of light to be obtained between the exposure limits, which are also effective owing to the lateral variation in darkening or blackening. The photographic picture resulting will be similar to that shown by Fig. 4 with the modification that, in the lateral direction there is only present a gradual transition from the lowest to the strongest exposure.

In further pursuance of the invention the novel method is preferably carried out in such wise that, for controlling the strength of the glow current, the electro-acoustic currents are amplified to correspond to the desired current and voltage conditions. For this purpose special amplifying arrangements are required, into the circuit of which the glow light tube R is inserted. Of course, as is well known, a glow light discharge can, owing to its characteristic feature, only be maintained in series with a large resistance. For this purpose use can be made (Fig. 5) of the internal resistance between the cathode and anode of the vacuum tube amplifier Vr, which tube may be the last of a series. A certain amount of inaccuracy may, however, appear with such a connection, because the internal resistance of the amplifier may vary considerably with changes in the acoustically-modulated current in the input circuit thereof. If the discharge of the glow discharge tube be represented by a current-voltage curve the voltage will be seen to drop slightly as the current is increased. The discharge of the glow discharge tube, connected in series with the amplifier, may at any moment be represented by a point on this characteristic curve, and the rapid changes in internal resistance of the amplifier may cause this point to move excessively to and fro over the characteristic. This movement of this point means that the discharge will not be as stable as might be desired, and the movement of this theoretic point should, therefore, for best results be maintained within a somewhat narrow limit. Such connections are indicated in Fig. 5, in which the requisite terminal voltage for the discharge circuit is supplied by the source indicated as battery *b* in the amplifier-glow tube circuit shown in Fig. 5. In this case the difficulty mentioned above may be observed, and the acoustically-modulated discharge phenomenon in glow tube R may not be as stable as is desired. This difficulty may be corrected by inserting the glow light tube R in a second circuit, Fig. 6, inductively coupled to the circuit in which is connected the last vacuum tube, Vr, of the amplifying series. This coupling is shown in Fig. 6 as the transformer *tr*, having primary *a* and secondary *k*. When this is done the movement of the point mentioned, on the

characteristic, becomes less marked, because of the fact that the resistance of the secondary winding of the transformer coupling is constant and the variations in resistance of the amplifier will not have as great an effect upon the glow discharge tube.

A battery *bl* in the circuit *h* supplies the necessary medium or average working voltage, which, through the superimposed induction E. M. F., is magnified or reduced in the acoustic rhythm. By proper selection of the coupling the acoustic modulation of the light of tube R can be altered in the manner desired.

It will be noted that the glow discharge tube or glow light tube herein described is an enclosed luminous gas discharge device which is maintained very closely at constant luminosity, or the luminosity of which is effectively constantly luminous, when the current feeding the same is not acoustically-modulated. This current, as stated, may be high frequency alternating current or direct current. When sound waves are received by the microphone in the system the current reaching the gas discharge device is acoustically-modulated, and the luminosity of the device, or lamp, is accordingly varied by and in accordance with the sound waves, or, phrasing it differently, by and in accordance with telephonic currents. The light thus varied is directed to a sensitized element, the moving film, to make a photographic record thereon as described.

When alternating high-frequency current is used the frequency should be above the audible limits, as is obvious to those skilled in the art, in order that the noises produced by the alternating current should not be reproduced, when reproduction of the recorded sound is effected.

We claim:—

1. In an apparatus for the production of photophonograms, a capillary glow light tube, a microphone circuit by which said tube is controlled, a slotted plate, a lens between the plate and tube, and a wedge-shaped light absorbing body between the plate and film.

2. Means for photographically recording sound waves comprising an enclosed luminous gas discharge device of a type producing a negative glow discharge, means for constantly maintaining said device with the negative glow discharge thereof effectively luminous, and means for varying the luminosity of said negative glow discharge of said device by and in accordance with sound waves, and means for directing the light from the negative glow discharge of said device to a sensitized element.

3. The method of photographically recording sound which comprises varying the luminosity of the negative glow discharge in an effectively constantly luminous enclosed gas discharge device of a type producing a negative glow discharge, such varying of the luminosity of the negative glow discharge being effected by and in accordance with sound waves, and directing light from said varying negative glow discharge onto a moving light sensitive surface.

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