

June 8, 1937.

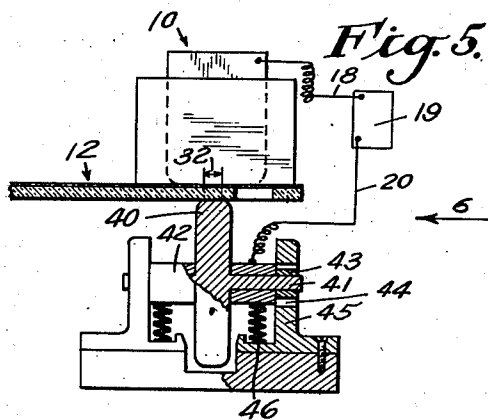
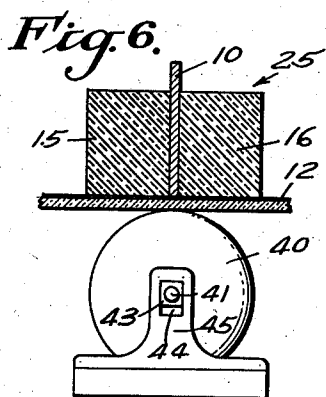
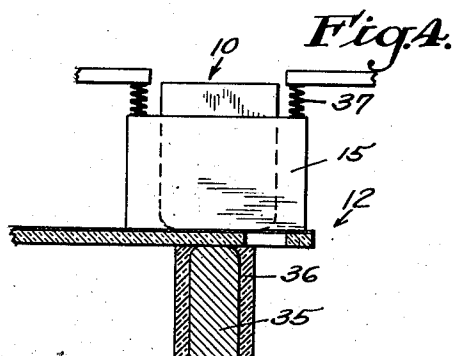
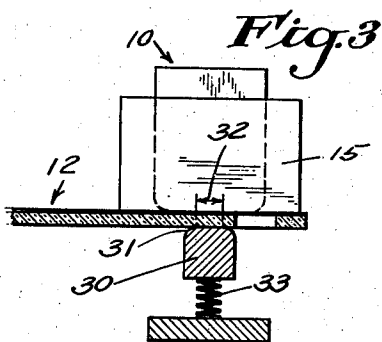
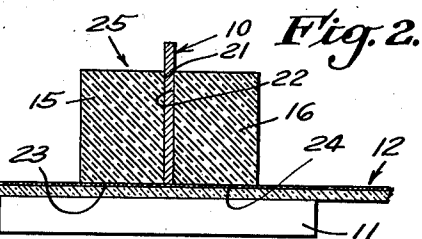
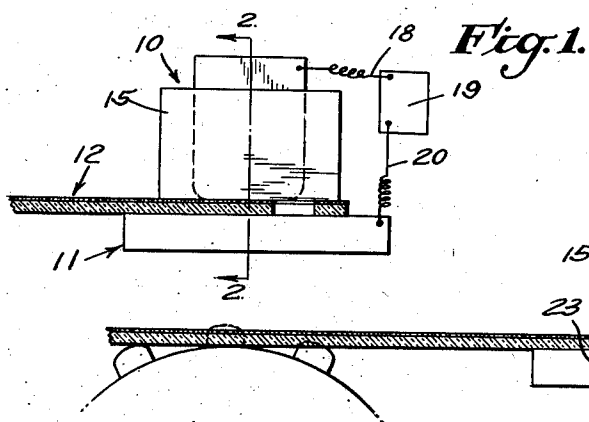
R. M. OTIS

2,082,846

PROCESS OF AND APPARATUS FOR PHOTOGRAPHICALLY RECORDING SOUNDS

Filed July 17, 1929

3 Sheets-Sheet 1



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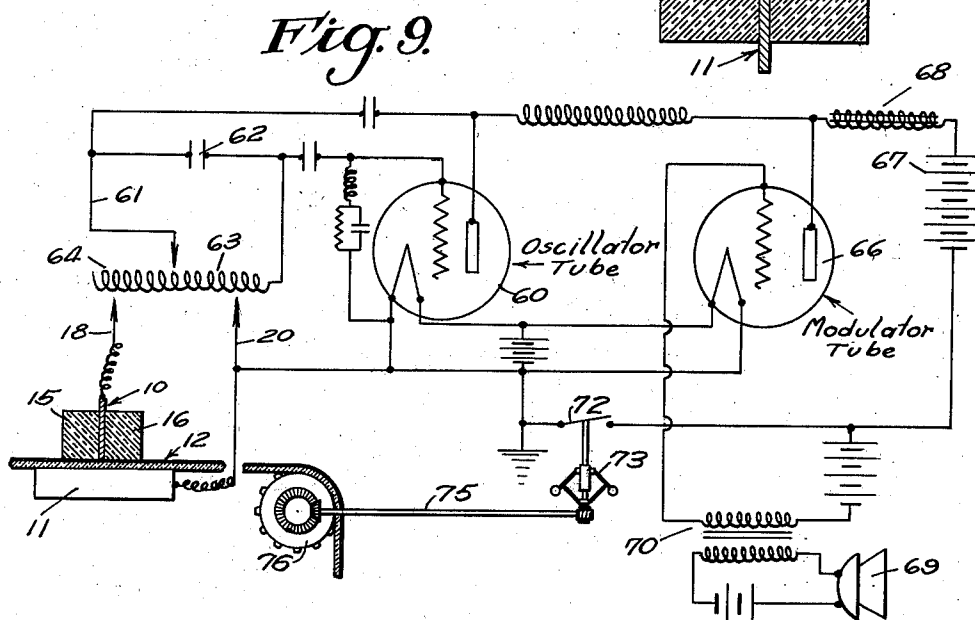
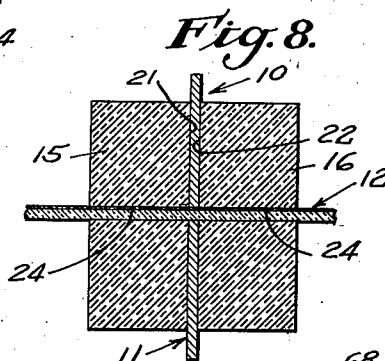
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PROCESS OF AND APPARATUS FOR PHOTOGRAPHICALLY RECORDING SOUNDS

Filed July 17, 1929

3 Sheets-Sheet 2



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June 8, 1937.

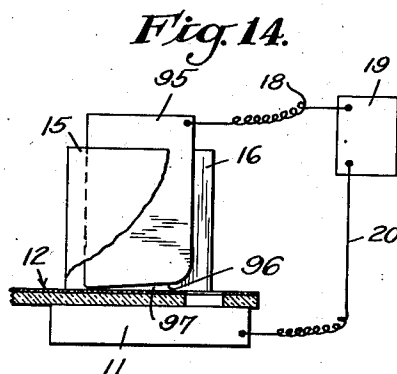
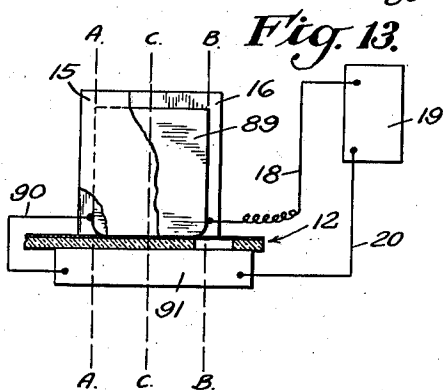
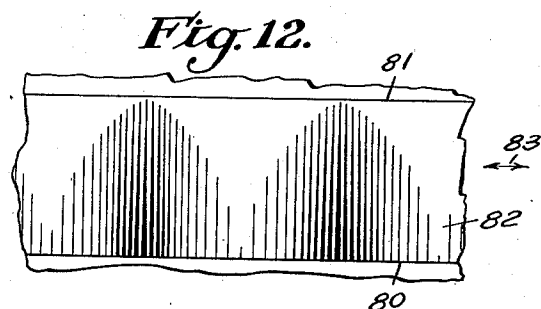
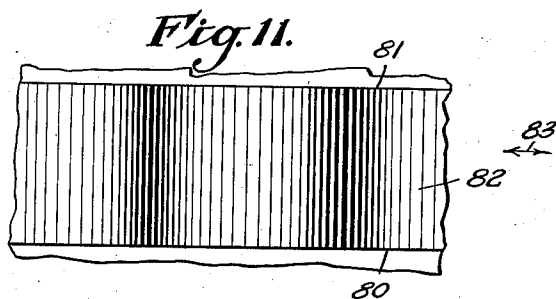
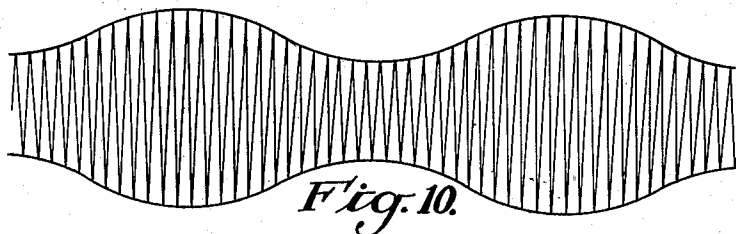
R. M. OTIS

2,082,846

PROCESS OF AND APPARATUS FOR PHOTOGRAPHICALLY RECORDING SOUNDS

Filed July 17, 1929

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,082,846

PROCESS OF AND APPARATUS FOR PHOTO-GRAPHICALLY RECORDING SOUNDS

Russell M. Otis, Alhambra, Calif.

Application July 17, 1929, Serial No. 378,994

22 Claims. (Cl. 179—100.3)

My invention relates to a novel system for indicating or recording various phenomena, and more particularly to a novel method of recording sounds on a motion-picture film or other photo-sensitive element, as well as to novel apparatus for accomplishing this result.

If a pair of electrodes are placed in close contact with opposite sides of a photographic plate, or other photo-sensitive element, and a momentary high potential impressed thereacross, as by the discharging of a Leyden jar therethrough, the photo-sensitive emulsion will be exposed to form a Lichtenberg figure. The shape of this figure is dependent upon the shape of the electrodes. For instance, the use of cylindrical electrodes produces a Lichtenberg figure composed of a large number of lines extending radially outward from the area of contact between the electrode and the photo-sensitive element. Furthermore, my experiments have shown that Lichtenberg figures may be formed in the area of contact between the electrode and the photo-sensitive element if the voltage gradient is sufficiently high.

I have found it possible to confine a Lichtenberg figure to an area of one one-thousandth of an inch or less in width and of a length equal to or somewhat greater than the width of the space on a motion-picture film allotted to a sound track, this being accomplished by suitably designing the electrodes and by utilizing means for preventing uncontrolled fringing of the discharge taking place between the electrodes.

It is an object of this invention to provide a method of and apparatus for utilizing Lichtenberg figures in the production of talking motion-pictures, and in various other recording and indicating arts.

A further object of the invention lies in a novel apparatus and method for confining the discharge forming a Lichtenberg figure to an area of one-thousandth of an inch or less in width, thus making my method applicable to the recording of sound on a motion-picture film travelling at the customary speed.

At present sound records of the variable density or variable area types are formed by complex light valves, vibrating mirrors, or lamps of varying intensity, all of these systems being subject to burn-outs and most systems being affected by vibration to such an extent that portable use of the apparatus is impractical.

It is an object of this invention to provide an apparatus for recording sounds or other phenomena which includes no moving parts, no parts

which will burn out, and which requires no optical system.

A further object of the invention is to provide an extremely simple method of sound-recording which requires no special equipment not readily available to the industry.

Another object of my invention is to provide an apparatus which will form either a sound record of the variable density type, or of a type intermediate between the variable density and variable area types. This new intermediate type of sound record has images thereon which fade or become less dense in a direction transverse to the sound track, as well as in the direction of motion of the film, thus forming a record which is in some instances very desirable.

It is a further object of this invention to provide a motion-picture film having a sound track containing photographic images which fade in a given direction.

These and other objects I accomplish by moving a motion-picture film or other photo-sensitive element between a pair of electrodes suitably designed, and impressing on these electrodes a high potential suitably modulated in accordance with the undulations of the sounds to be recorded or in accordance with the other phenomena to be recorded.

It is an object of this invention to form a sound record on a motion-picture film by the use of a high potential modulated by the undulations of the sound to be recorded.

Still another object of the invention is to use potentials of high frequency in the photographic recording of sounds, thus eliminating the danger of serious shocks and materially decreasing the magnitude of the potentials required.

Another object of the invention is to modulate a high potential, whether or not this potential is of high frequency, with impulses of another frequency to change either the magnitude, wave form, or frequency of the high potential, and to utilize the modulated potential in the formation of Lichtenberg figures.

Yet another object of this invention is to provide a novel knife-edge electrode and mounting structure therefor, as well as a method of making this electrode structure.

Further objects and advantages of my invention will be evident to those skilled in the art.

Referring to the drawings,—

Fig. 1 is a diagrammatic face view of one form of my recording apparatus in combination with a section of motion-picture film.

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1.

Figs. 3 and 4 are alternative forms of the device as illustrated in Fig. 1.

Fig. 5 is still another form of the invention.

Fig. 6 is a view partially in section taken in the direction of the arrow 6 of Fig. 5.

Fig. 7 is a view partially sectioned showing one of the electrodes of my invention in the form of a roller incorporated with a sprocket.

Fig. 8 is a view similar to Fig. 2 illustrating another form of the invention.

Fig. 9 is a wiring diagram illustrating one method of connecting my invention for the purpose of recording sounds.

Fig. 10 is a graph illustrating a modulated high-frequency potential.

Fig. 11 is one type of sound record recorded by my apparatus.

Fig. 12 is another form of sound record which may be recorded.

Fig. 13 is one form of apparatus for recording a sound record such as shown in Fig. 12.

Fig. 14 is another form of apparatus for recording a sound record such as shown in Fig. 12.

Referring particularly to Figs. 1 and 2, my invention in its simplest form utilizes primary and secondary electrodes 10 and 11 spaced a sufficient distance apart to allow a motion-picture film 12 to pass therebetween. The secondary or lower electrode is shown as comprising a metallic plate of a width substantially wider than the sound track of the film 12, and of any suitable length. This secondary electrode may take various different forms as will be hereinafter explained.

The primary electrode shown in Figs. 1 and 2 is made of a very thin piece of metallic foil, the thickness thereof being preferably one one-thousandth of an inch or less, this foil being made of a conducting material having a high melting point such as platinum iridium, as best shown in Fig. 1. This piece of foil is substantially rectangular with its lower corners rounded to prevent a concentration of the discharge thereadjacent. The lower surface of this electrode provides a knife-edge, and it is desirable that the field intensity between this knife-edge and the electrode 11 be substantially constant throughout the length of the knife-edge or throughout that portion of the knife-edge which covers the sound track.

The thinness of this electrode necessitates external support which is furnished by a pair of blocks 15 and 16, these blocks being of a width greater than the width of the electrode 10, and of a height slightly less than that of the electrode to permit easy attachment of a conductor 18 leading to a modulating device 19 of my invention, the other terminal of this device being connected by a conductor 20 to the electrode 11.

Adjacent surfaces 21 and 22 of the blocks 15 and 16 are carefully surfaced so that all portions of each face lie in the same plane. These blocks are preferably formed of opaque glass though other insulating substances may be used, and the surfacing of the adjacent faces 21 and 22 may be accomplished by grinding, being careful to maintain the edges of the blocks intact. Lower faces 23 and 24 of these blocks are also accurately ground so as to lie in a common plane when the adjacent surfaces 21 and 22 are in contact.

The foil forming the electrode 10 is positioned adjacent the surfaces 21 and 22 and clamped or cemented therebetween, the lower edge thereof extending slightly below the lower faces 23 and

24, the electrode 10 and insulating blocks 15 and 16 thus forming an electrode structure 25 which in itself forms a part of my invention.

Subsequently, the protruding portion of the foil is carefully removed by grinding or other means, and the lower faces 23 and 24 repolished to insure a continuous plane surface devoid of depressions, the object being to form a continuous flat surface which may contact the film, this surface including a thin edge of conducting material acting as an electrode. By carefully forming this electrode structure fringing of the Lichtenberg figure can be eliminated to such an extent that it does not noticeably increase the effective thickness of the line formed.

It is also possible to form a thin deposit of metal on one of the adjacent surfaces 21 and 22 by means known in the art, this deposit being used as an electrode.

The electrode structure 25 may be loosely mounted so that the weight thereof is effective in insuring good surface contact with the film 12, or the electrodes may be moved resiliently together by means of suitable springs acting either upon the lower or upper electrode structures as illustrated respectively in Figs. 3 and 4.

In Fig. 3, I have illustrated an alternative form of secondary electrode which is in the form of a bar 30 having rounded upper edges 31 to prevent a brush discharge therefrom, and being adapted to expose a sound track of the film 12, the extent of this sound track being indicated by the double-headed arrow 32, it being noted that the width of this sound track is somewhat less than the length of the lower electrode 30, due to the rounded edges of this electrode. A spring 33 may resiliently move the bar 30 into engagement with the lower surface of the film 12.

Likewise, in Fig. 4, I have shown a bar 35 similar to the bar 30 except that it is rigidly mounted and includes a coating of insulating material 36 which further prevents any extraneous discharge therefrom. In this form springs 37 bear against the electrode structure 25 and resiliently move this structure toward the electrode formed by the bar 35 in a manner to lightly compress the film 12 therebetween.

In some instances it is desirable that the secondary electrode 11 be in the form of a roller so as to provide rolling contact with the film, the line of contact therebetween being directly below the knife-edge formed by the electrode 10. Thus, in Figs. 5 and 6, I have illustrated a roller 40 as serving this function, this roller having a shaft 41 journaled in bearings 42 to which the conductor 20 is connected. Each bearing 42 has a square end portion 43 which is vertically slidable in an elongated opening 44 of a standard 45, the bearings 42 being urged upward relative to the standard by means of springs 46 compressed therebetween. The width of the roller 40 in this instance is slightly greater than the width of the sound track, the width of which is indicated by the arrows 32. This is due to the rounded edges which are usually necessary on the roller 40.

Fig. 7 illustrates a roller 48 serving as a secondary electrode and being mounted in a sprocket 49 formed of insulating material and providing sprocket teeth 50 for driving the film. The roller 48 is also rounded in this form of the invention, and the insulated sprocket 49 is so formed as to correspond to these rounded edges. The sprocket may be formed by a pair of members 51 and 52 clamped on a shaft 53 formed integrally with or

attached to the roller 48, nuts 54 being provided for compressing the members 51 and 52 against the roller 48, but it is preferably formed by molding the roller 48 and shaft 53 into a dielectric such as "bakelite".

Fig. 8 illustrates still another combination of electrodes wherein both the primary and secondary electrodes are of similar construction and being formed in the manner previously described for the electrode structure 25.

I have found it desirable to prevent brush discharge from the electrodes, this being accomplished by rounding the edges thereof as previously described. Rounding the edges of a thin piece of foil is, however, very difficult, so that I have found it best practice to make the foil electrode of greater length than the space allotted to the sound track, and utilize the lower electrode for determining the length of image formed. It is comparatively easy to round the edges of this lower electrode as indicated, for instance, in Figs. 3, 4, 5, 6, and 7 in such a manner as to insure a uniform field and prevent point discharge.

It is thus apparent that the width of the instantaneous image formed at any instant is limited by the blocks 15 and 16, while the length of such an instantaneous image is determined by the shape of the lower electrode. So also the shape of the discharge which takes place from the lower edge of the primary electrode 10 is limited by these blocks and by the shape of the secondary electrode 11.

The modulating device 19 is of such character as to supply to the electrodes 10 and 11 a potential modulated by the undulations of the sounds to be recorded. The amount of exposure of the film may be varied by (1) changing the amplitude or magnitude of the impressed potential (2) changing the wave form of this impressed potential, or (3) changing the frequency thereof. It should thus be clear that I am using the term modulated in a broad sense to include any of these means for varying an exposure, and do not intend this term to be limited to the narrower meanings sometimes allotted thereto wherein only the magnitude of the potential is varied. Thus, in the claims I have used the terms "sound-modulated", "modulated", etc., to include a change in amplitude, wave shape, or frequency of a potential of such magnitude as to be capable of exposing the photographic emulsion on the film 12, or to include a simultaneous change of two or more of these quantities.

The most convenient and simplest system for use in recording sounds is one in which a high frequency potential is modulated by lower frequencies in the audible range. This may most conveniently be accomplished by the system illustrated in Fig. 9 wherein an oscillator tube 60 is connected to a tuned circuit 61 in a manner well-known whereby oscillations are set up therein. The tuned circuit 61 in Fig. 9 includes a condenser 62 and an inductance 63 which also serves as part of a winding of an auto-transformer 64 to which the conductors 18 and 20 connect.

The high frequencies impressed on the tuned circuit 61 by the oscillator tube 60 may be modulated in any well-known manner by impulses of lower frequency corresponding to the undulations of the sounds to be recorded. In Fig. 9 the modulation system includes a modulator tube 66 having a plate supply 67 common to that of the oscillator tube 60, there being an iron core inductance 68 between the supply 67 and the modulator tube whereby changes in plate cur-

rent of the modulator tube change the voltage drop across the inductance 68, thus varying the potential applied to the plate of the oscillator tube 60 and thereby modulating the high frequency currents in the tuned circuit 61 in a manner well-known to the art when voice frequencies are impressed on the grid of the modulator tube 66 by means of a transmitter or microphone 69 connected thereto through the usual transformer 70 or other coupling device. This modulating circuit is well-known, and no claim is made to this circuit per se aside from the particular method of connecting the auto-transformer 64.

Furthermore, while I have shown the coupling device in the form of an auto-transformer this use is not essential for other coupling devices, such, for instance, as an ordinary transformer of suitable design may be used.

The advantages of such a system are manifold. In the first place, the oscillator and modulator tubes may be of types at present in use in radio broadcasting reception, the oscillator tube being either a power tube or, preferably, two power tubes connected in push-pull. The oscillator tube may be operated at a potential of several hundred volts, which potential is further stepped-up by the auto-transformer 64. In the practical operation of my invention as applied to the recording of sounds, I prefer to utilize from one thousand to two thousand volts across the electrodes, and to operate the oscillator tube at a frequency in the neighborhood of six million cycles per second. Lower frequencies may be used so long as they are out of the audible range. Other sources of potential may be utilized, such, for instance, as static machines or high voltage generators or magnetos, but I have found it preferable to use high frequencies, not only from the standpoint of convenience, but primarily because the potential necessary to form Lichtenberg figures is much lower when high frequencies are used than when low frequencies are used, the ratio being in the neighborhood of one to ten. Furthermore, by utilizing high frequencies modulated by audible frequencies all danger of serious injury to an operator is obviated. It is well-known that manual contact with a circuit carrying high voltages of high frequency produces no serious results, though contact with a circuit of equal voltage of low frequency might cause instant death.

It is also much simpler to generate a high frequency current by means such as shown in Fig. 9, for instance, than to produce high direct-current voltages which may be modulated in response to audio frequency impulses. Similarly, systems wherein the oscillation frequency is varied in response to audio frequency impulses ordinarily are more complicated than that shown in Fig. 9, as are also systems wherein the wave form is so varied by audio frequency impulses as to change the exposure of the film in response to such impulses. All of these systems, however, fall within the scope of my invention.

It is sometimes desirable to render the modulating device 19 inoperative in the event that the movement of the film 12 ceases, thus preventing any possibility of burning or puncturing the film. This may be accomplished by a centrifugal switch connected in an appropriate place in the circuit. In Fig. 9, I have shown a switch 72 in the plate circuit of the tubes 60 and 66, this switch being opened by a governor 73 when the film 12 stops. The governor may be suitably connected

by a shaft 75 to a sprocket 76 which drives the film.

My experiments have shown that if the potential of the high frequency current is accidentally increased to such a point that disruptive discharge takes place through the film no harm to the film or apparatus results. While such a disruptive discharge punctures the film the film does not catch fire, and the discharge is quickly stopped.

The type of record produced by the apparatus previously described is diagrammatically illustrated in Fig. 11, and is known as the variable density type due to its having a series of lines extending between boundary lines 80 and 81 of a sound track 82. This type of record is produced by a modulated high frequency wave as shown diagrammatically in Fig. 10, it being understood that the modulation shown is not necessarily one that would be effected by modulation with a complex vocal sound. Degrees of modulation other than that shown in Fig. 10 may also be used.

In Fig. 12, I have illustrated another form of sound track wherein each line varies in intensity between the boundary lines 80 and 81, being of greater intensity adjacent the base line 80. These lines are not of the same length but each one gradually fades out at a point in the sound track depending upon the potential, frequency, and wave form, as well as on other conditions. The result of such a series of lines is diagrammatically shown in Fig. 12 by lines of varying thickness, from which it is apparent that the images not only fade in the direction of the movement of film, indicated by the arrow 83, but also fade in a direction perpendicular thereto, thus forming a sound record which has very desirable characteristics in certain types of recording.

The type of record illustrated diagrammatically in Fig. 12 may be formed by the apparatus illustrated in Figs. 13 or 14. Referring particularly to Fig. 13, I have illustrated the primary electrode as being formed of a coating 89 of high-resistance material. A piece of high-resistance foil may be utilized in some cases in place of this coating 89 or a deposit of a material such as selenium may form this coating. Certain finely ground stones may also be used, usually in combination with a suitable binder which, if desired, may in itself have high-resistance properties. Other substance which may be utilized include finely divided graphite, carbon, etc. usually intermixed with a suitable binder.

A pair of the insulating blocks previously described is used to support the high-resistance electrode and to limit the discharge to a narrow area corresponding in magnitude to the thickness of the electrode 89. In this form of my invention the conductor 18, previously described, is connected to one end of the primary electrode and the other end of this high-resistance electrode is connected by a wire 90 to a secondary electrode 91 which is formed of good conducting material and which is connected by the wire 20 to the modulating device 19. The secondary electrode 91 may be of any one of the forms previously described.

Inasmuch as the upper electrode is made of high-resistance material, it should be apparent that the current passing therethrough causes a voltage drop in this electrode, the difference in potential between the primary and secondary electrodes being thus a function of the distance across the sound track. In other words, the

potential difference between the electrodes at a section A—A would approach zero, due to the fact that the wire 90 short-circuits this end of the primary electrode with the secondary electrode. At a section B—B, however, full potential is established, and the lines formed at this section will be relatively intense, and will form Lichtenberg figures which are dense as indicated at the base line 80 in Fig. 12. At an intermediate section C—C the potential difference between the primary and secondary electrodes is, of course, less than that at section B—B by an amount depending upon the ratio of the horizontal distance between the sections B—B and C—C relative to the distance between the sections A—A and B—B.

Thus, when using a modulated high frequency such as shown in Fig. 10, the lines formed will extend variable distances across the sound track due to the fact that the voltage gradient in the gap between the electrodes varies as previously explained.

Fig. 14 illustrates another pair of electrodes for accomplishing this result. In this figure the primary electrode is formed of a good conducting material, indicated by the numeral 95, and is mounted between insulating blocks as previously described, the only difference between Fig. 14 and Fig. 1, for instance, being that the electrode 95 of Fig. 14 has a lower edge which is not parallel to the surface of the film, this electrode being cut to form an angled surface 96, one end of which lies in the same plane as the surfaces 23 and 24 of the insulating blocks 15 and 16, and the other end lies a distance thereabove so as to form a gap 97 between the knife-edge and the surface of the film, this gap being of variable height throughout the width of the electrode 95.

This gap may be left open to the air, or may be filled with other dielectric. Any difference in potential between the electrodes which is sufficient to produce Lichtenberg figures will register on the sound track at a point adjacent the heel of the electrode 95, and the figure produced will be less dense toward the toe of the electrode due to the varying distances across the gap 97.

It is within the scope of my invention to introduce amplifiers either between the microphone or the modulator or between the oscillator tube and the recording device, or in other places in the event that such amplification is desired.

The time interval required to produce an exposure by my method is very minute, being in the neighborhood of one ten-millionth of a second. This quick action is very desirable in the recording of sounds, inasmuch as my recording system will not vibrate at a natural period in the audible range nor in resonance with sounds in the audible range as do certain other devices at present in use. The extreme sensitivity and speed of the device of my invention is such as to make it desirable in recording high frequency, transient, and other phenomena, my invention being adaptable to these other uses by only slight changes, such, for instance, as the speed of the film and a substitution of the circuit to be tested for the oscillatory circuit to be hereinafter described.

It will be apparent to those skilled in the art that my invention is not limited to the field of sound-recording, but is also applicable to the indication or recordation of various other phenomena. For this reason my invention should not be limited to the use of a motion-picture film,

it being that the Lichtenberg figures may be formed on any suitable photo-sensitive surface such as might be present on a photo-sensitive element such as a photographic plate or on a piece of photographic paper.

It is also possible that it may be subsequently shown that the phenomenon which produces Lichtenberg figures is not an actinic one, but that the exposure of the photo-sensitive emulsion is due to other effects present in the discharge. In such an event my invention would obviously include other substances on which Lichtenberg figures might be formed, the essence of my invention being the subsection of a film or other substance to a variable discharge. In these other arts it is furthermore not necessary that the oscillating frequency be of the magnitude described, nor is it necessary that the modulating frequency be within the audible range. Thus, in certain of the appended claims I have spoken of the primary potential as being modulated by a secondary potential, my invention also finding utility with such a combination whether or not one of the potentials is a unidirectional one.

In the appended claims I have used the term "discharge" not in the sense of a disruptive discharge, but rather such a discharge as is sufficient to produce photographic exposure whether this exposure be due to a bombarding stream of electrons or positive ions or whether due to X-rays or actinic ionization of the air immediately adjacent the surface of the film. Similarly, I have used the term "Lichtenberg figures" and the term "images" to not only designate the figures and images as they appear after development, but also the exposure which may be subsequently developed into a visible Lichtenberg figure or image.

I claim as my invention:

1. A method of producing talking motion-pictures, which method includes the steps of: forming photographic Lichtenberg figures on a motion-picture film varying in density in response to variations of sound to be recorded; and confining said Lichtenberg figures so that they are of substantially constant area and of a width of one-thousandth of an inch or less.

2. A method of recording sound on a photo-sensitive surface, which includes the steps of: providing an electrostatic field of sufficient magnitude to form photographic Lichtenberg figures and influenced in intensity by the audio frequency sounds to be recorded; moving said film through said field; and confining to lineal dimensions the individual Lichtenberg figures formed at any instant of time.

3. In combination: a primary knife-edge electrode positioned on one side of a photo-sensitive element; a secondary electrode on the other side of said photo-sensitive element; means for subjecting the portion of said element lying between said electrodes to an electric stress sufficient to form a photographic Lichtenberg figure on said element; and means for confining said photographic Lichtenberg figure to an area not substantially greater in width than the thickness of said knife-edge electrode at the point of discharge.

4. In an apparatus for recording sounds on a motion-picture film including an unexposed sound track, the combination of: a primary electrode providing a knife-edge of length greater than the width of said sound track; a secondary electrode positioned on the opposite side of said film from said primary electrode; and means for

impressing a sufficient potential across said electrodes to form a photographic Lichtenberg figure on said film, said secondary electrode being so formed as to limit said photographic Lichtenberg figure to a length not materially greater than the width of said sound track.

5. An electrode structure, comprising: a pair of supporting blocks formed of insulating material and having adjacent surfaces; and an extremely thin electrode plate formed of material more conducting than said insulating material and positioned between said adjacent surfaces and terminating in a knife edge bounded on opposite sides by said supporting blocks.

6. An electrode structure, comprising: an electrode providing a knife edge and being so thin as to require external support; and supporting means on opposite sides of said electrode and providing adjacent surfaces engaging faces of said electrode and between which said electrode is supported, said supporting means providing a plane surface lying in the same plane as that end of said electrode forming said knife edge, said surface providing said plane being surfaced to eliminate large pockets adjacent said knife edge.

7. An electrode as defined in claim 5 in which said electrode is formed of an electrically conducting substance and is less than one-thousandth of an inch in thickness.

8. In a recording system, the combination of: a primary electrode in the form of an extremely thin plate providing a knife edge; a secondary electrode spaced from said knife edge, there being a photo-sensitive element therebetween; means for impressing a potential between said electrodes sufficient to form a discharge which is recorded on said photo-sensitive element; and a supporting structure for said primary electrode and terminating in the plane including said knife edge to prevent spreading of said discharge.

9. A combination as defined in claim 8 in which said supporting structure comprises a pair of blocks formed of insulating material and retaining said electrode therebetween, said blocks contacting said photo-sensitive element.

10. In a recording system, the combination of: a primary electrode in the form of an extremely thin plate providing a knife edge; a secondary electrode spaced from said knife edge, there being a photo-sensitive element therebetween; means for impressing a potential between said electrodes sufficient to form an image on said photo-sensitive element immediately beneath said knife edge; and a supporting structure for said secondary electrode, said supporting structure lying adjacent said secondary electrode and engaging said photo-sensitive element.

11. A combination as defined in claim 10 in which said secondary electrode provides rounded edges, and in which said supporting structure conforms to said rounded edges whereby those portions of said secondary electrode and said supporting structure which engage said photo-sensitive element lie in the same plane.

12. In a sound recording system, the combination of: a primary electrode in the form of an extremely thin plate providing a knife edge; a secondary electrode spaced from said knife edge, there being a photo-sensitive element therebetween; means for impressing a potential between said electrodes sufficient to form a discharge which is recorded on said photo-sensitive element at a section immediately beneath said knife edge; means for varying said potential in response to the undulations of the sound to be

recorded; and means for rotatably supporting said secondary electrode.

13. A combination as defined in claim 10 in which said secondary electrode and said supporting structure therefor comprise a sprocket for said photo-sensitive element.

14. In a recording system for recording on a moving photo-sensitive element, the combination of: a primary knife-edge electrode on one side of said photo-sensitive element; a secondary knife-edge electrode on the other side of said photo-sensitive element, the knife edges of said electrodes being parallel and disposed opposite each other; and means for impressing a varying difference in potential between said electrodes sufficient to expose that portion of said photo-sensitive element lying between said electrodes.

15. In a recording system for recording sounds on a motion-picture film having a sound track of a limited width, the combination of: a primary knife-edge electrode extending across said sound track and substantially in contact therewith for a distance greater than the width of said sound track; a secondary electrode on the other side of said film from said primary electrode and substantially engaging said film for a distance substantially equal to said width of said sound track whereby the field set up between said electrodes is of a width substantially equal to the width of said sound track; means for impressing a potential between said electrodes sufficient to expose said film; and means for limiting the area of exposure of said film to substantially that area of said sound track contacted by said primary electrode.

16. In a sound-recording system, the combination of: a primary electrode in the form of a plate and having a thickness less than one one-thousandth of an inch; a pair of supporting blocks, one being positioned on each side of said electrode; a secondary electrode spaced from said primary electrode; means for moving a photo-sensitive element between said electrodes; means for impressing a difference of potential between said electrodes sufficient to expose said photo-sensitive element; and means for varying said difference in potential in response to the sound to be recorded.

17. An electrode structure, comprising: a flat electrode terminating in a knife edge; and means engaging said electrode and confining any electric discharge from said knife edge to an area immediately beneath said knife edge, said means comprising a structure snugly engaging the sides of said electrode adjacent said knife edge to eliminate all air pockets and spaces into which the discharge from said knife edge could spread.

18. A method of recording sounds on a motion-picture film, which includes the steps of: moving said film; forming an electric discharge directed through said moving film and of a shape approaching lineal dimensions, said discharge extending transverse with respect to the direction of movement of said film; varying the intensity of said discharge in response to sound undulations to correspondingly vary the density of the image produced on said film; and limiting the spread of said discharge along the surface of said film to form instantaneous images of substantially constant dimensions and of a width not substantially greater than one-thousandth of an inch.

19. A method of recording sound on a photo-sensitive element, which method includes the steps of: setting up an electrostatic field entirely through said photo-sensitive element and of sufficient intensity to form an image on said photo-sensitive element; varying said electrostatic field in response to the undulations of the sound to be recorded; setting up a relative movement between said photo-sensitive element and said electrostatic field whereby images are formed on successive portions of said photo-sensitive element, said images varying in density with the variations of said electrostatic field; and confining the image formed at any particular instant of time to knife-edge proportions of substantially constant length and width.

20. A method of recording on a moving photo-sensitive element by the use of a pair of electrodes positioned on opposite sides of said photo-sensitive element, which method includes the steps of: establishing a potential difference between said electrodes and of sufficient magnitude to expose said photo-sensitive element to form an image thereon, but of insufficient magnitude to puncture said photo-sensitive element; varying said potential difference in response to the variations in the phenomena to be recorded; confining said image to a substantially constant area of knife-edge dimensions regardless of the potential difference between said electrodes, whereby the variations in said potential produce images correspondingly varying in density but of substantially constant area; and producing relative movement between said electrodes and said photo-sensitive element.

21. A method of recording on a photo-sensitive element by the use of an electrode, which method includes the steps of: bringing said electrode into surface contact with said photo-sensitive element; setting up an electric field adjacent said electrode and through said photo-sensitive element thereby tending to expose said photo-sensitive element to form both a fringing image spreading radially from said electrode in the plane of the surface of said photo-sensitive element and an auxiliary image immediately beneath said electrode and substantially covering the surface of contact between said electrode and said photo-sensitive element; shielding said electrode to eliminate said fringing image allowing only said auxiliary image to be impressed on said photo-sensitive element whereby said auxiliary image is of an area substantially the same as said area of contact; moving said photo-sensitive element through said field; and varying the intensity of said field in response to the phenomena to be recorded whereby the density of said auxiliary image varies correspondingly.

22. A sound recording apparatus consisting of means for converting sound waves into sound modulated electric current, a pair of contact elements connected to said converting means to receive said sound modulated current, one of said contact elements consisting of an electrically conducting film moving element, and a movable photo-sensitive surface placed between and in direct contact with one of said contact elements to be chemically altered thereby to produce a developable latent sound record by the action of said current upon said photo-sensitive surface.