

Feb. 20, 1923.

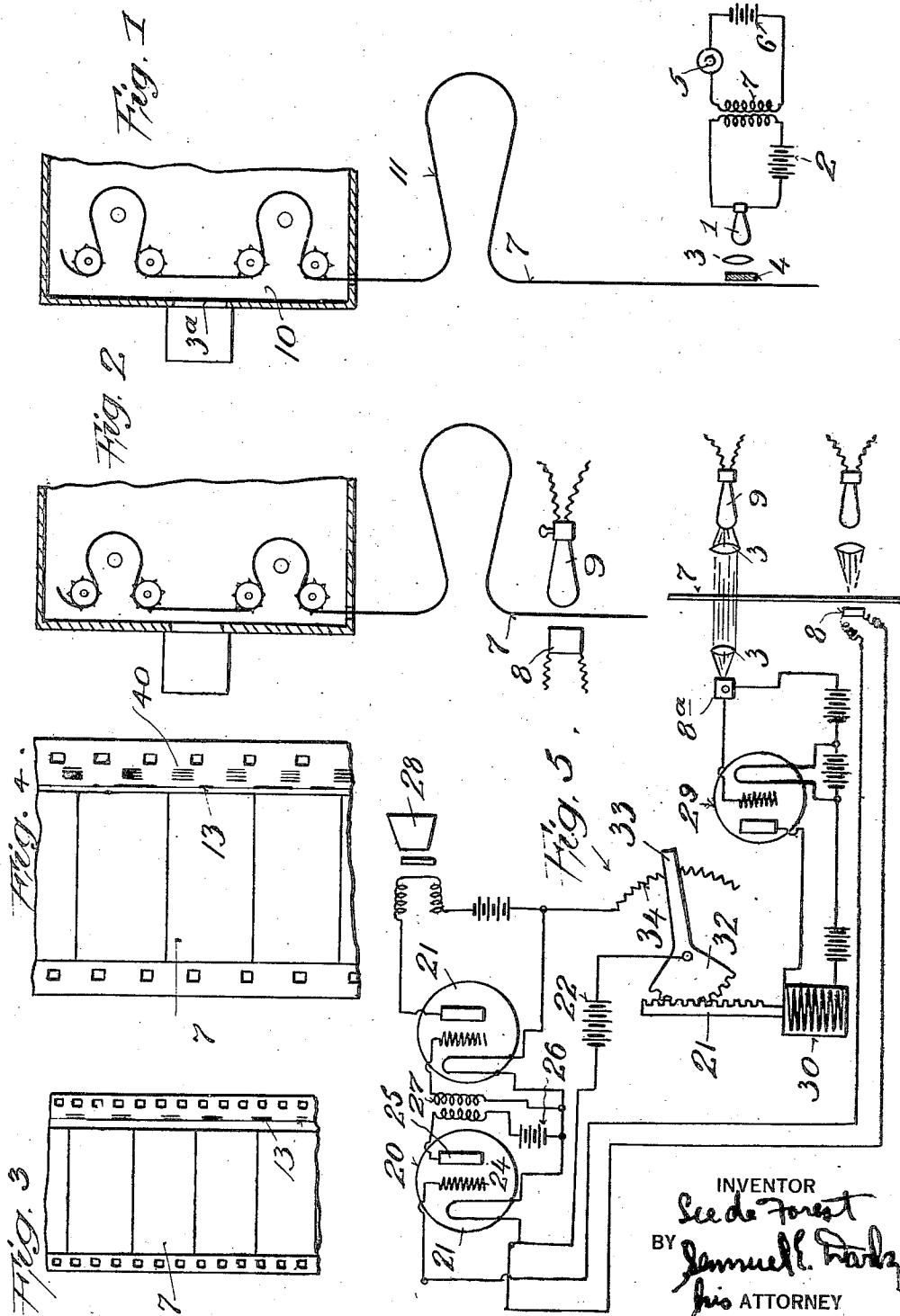
L. DE FOREST.

1,446,246.

MEANS FOR RECORDING AND REPRODUCING SOUND.

FILED SEPT 18, 1919.

2 SHEETS—SHEET 1.



INVENTOR
Lee de Forest
BY Samuel L. Park
his ATTORNEY

Feb. 20, 1923.

1,446,246.

L. DE FOREST.

MEANS FOR RECORDING AND REPRODUCING SOUND.

FILED SEPT 18, 1919.

2 SHEETS—SHEET 2.

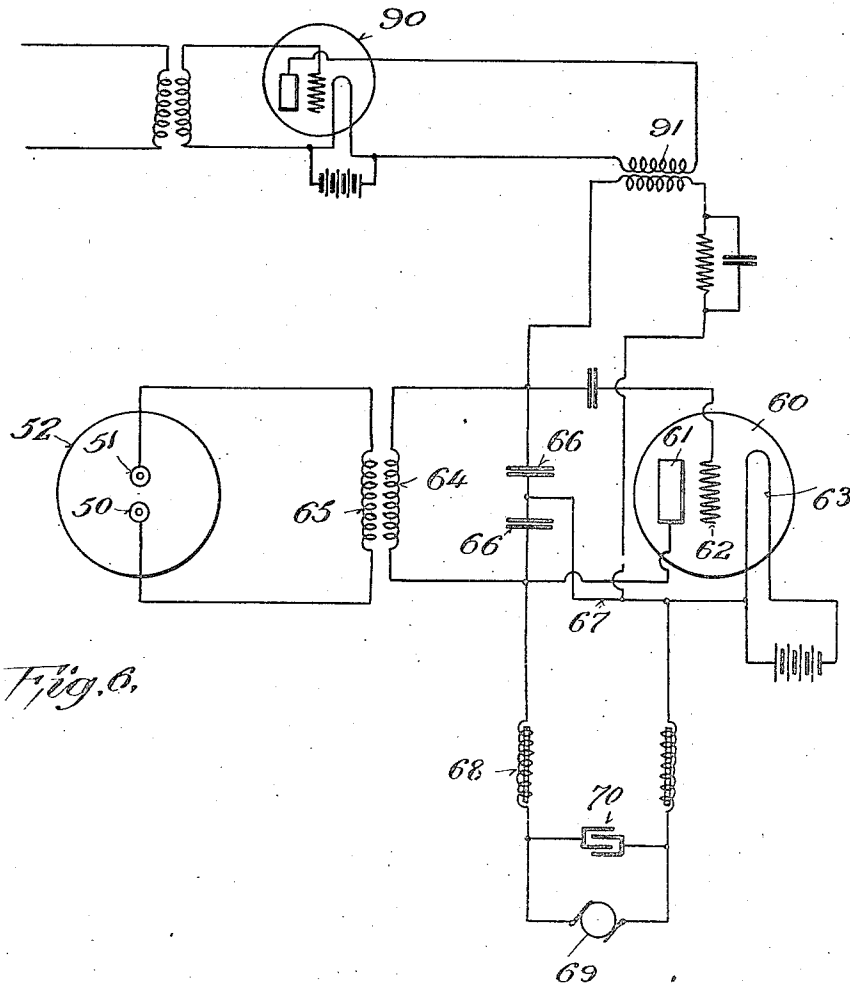


Fig. 6.

INVENTOR
Lee de Forest
BY Samuel I. Darby
his ATTORNEY

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

MEANS FOR RECORDING AND REPRODUCING SOUND.

Application filed September 18, 1919. Serial No. 324,683.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, county and State of New York, have made a certain new and useful Invention in Means for Recording and Reproducing Sound, of which the following is a specification.

This invention relates to making a record of sound waves and to reproducing the same from the record so made.

The object of the invention is to provide an electrically operated means for recording and reproducing recorded sound.

A further object of the invention is to provide a novel form of sound record.

A further object of the invention is to provide a simultaneous recording of sound waves and light waves and the simultaneous reproduction thereof.

A further object of the invention is to provide a photographic film having recorded thereon photographs and sound record.

A further object of the invention is to simultaneously reproduce from such photographic film the sound record and the pictures or negative developed thereon, or, in other words, to reproduce talking moving pictures from a single roll of film.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location, and relative arrangement of parts, all as will be more fully hereinafter set forth, as shown by the accompanying drawing and finally pointed out in the appended claims.

Referring to the drawings,—

Fig. 1 is a diagrammatic illustration of a sound recording arrangement embodying my invention.

Fig. 2 is a similar view showing a sound reproducing arrangement embodying my invention.

Figs. 3 and 4 illustrate modified forms of sound records obtained in accordance with my invention.

Fig. 5 is a diagrammatic view showing an automatic means for reproducing the sound from its record and for simultaneously controlling the intensity of volume or pitch thereof.

Fig. 6 is a similar view showing a modified light source.

The same part is designated by the same reference character wherever it appears throughout the several views.

It is among the special purposes of my present invention to record sound waves upon a photographic film such as an ordinary film employed in motion picture photography. This can be accomplished in many ways. I have discovered, however, that a source of light may be directly controlled by the intensity, pitch and volume of sound in such a manner that the fluctuations caused by sound waves in the intensity of light emitted from the source may be photographed upon the film. My investigations have revealed that certain light cells are more sensitive to the ultra violet rays of the spectrum than others.

I have shown and described in detail in a companion application Serial No. 324,685 filed on even date herewith a number of efficient means for controlling electric currents by means of light variations for any purpose, and in accordance with this invention I provide a source of light, for example, a lamp 1, the filament or incandescent electrode of which may be lighted to its sensitive or critical point of incandescence by means of any suitable source of current, for example, battery 2. The light rays pass through a lens in the usual well known manner 3, and, if desired, a color filter 4, which color filter is preferably of a dark blue, as I have found that the best results when using a photoelectric cell of the Kuntz variety are obtained by using a filter of this color. A photographic film is passed by the lens and filters 3 and 4 in the usual well known manner, and the light emanating from the lamp 1 is recorded on the film, preferably in the nature of a minute ray obtained through a pin point aperture or focused to a point by a lens. The lamp 1 is controlled directly by and in accordance with sound waves, and while this may be effected in many different ways I have illustrated for the purposes of this application a simple microphone circuit comprising a transmitter or microphone 5, included in a closed circuit with a source of current 6, the lamp circuit and the microphone circuit being inductively associated with each other through transformer coils 7. With this arrangement sound waves in

the microphone set up weak pulsating currents which effect the closed circuit of the lamp 1 and thereby cause light variations which effects variation in intensity of light supplied to the sensitized surface of the film and thereby recorded on the film in the form of varying light exposures. In Fig. 2 I have shown a simple arrangement for reproducing the sound waves from the recorded waves on the film wherein the film 7 passes between a light sensitive electrical device diagrammatically illustrated at 8 and a source of light 9 which is constant in intensity. The light sensitive electrical device 8 may be any device of this nature, for example, it may be a selenium cell or a photo electrical cell, both of which I have found to be suitable for this purpose. It will be apparent that the light that passes through the film 7 to affect the electrical devices 8 will vary in accordance with the exposure on the film 7 and the fluctuating currents thereby set up in the circuit including the electrical device 8 will consequently vary directly in accordance with the original sound waves from which the sound record was produced. It will be obvious that the pulsating currents thus produced in the electrical devices 8 may be converted in any well known manner back into sound waves either with or without previous amplification, and in my copending application above mentioned I show various means for reproducing with and without amplification the pulsating currents set up in the electrical devices 8 in the form of the original sound waves. The applications of the foregoing principles are many, and while I have shown and will now describe its application to motion picture photography to thereby obtain "talking moving pictures" I wish it to be understood that I do not desire to be limited or restricted in this respect as this particular application has been selected for the purposes of illustration of the utility of the invention involved.

It is recognized that the great difficulty heretofore encountered in the production of talking moving pictures has been the impossibility of obtaining perfect synchronism between the sound record and the picture in reproduction or projection. At a glance it will be apparent that I am enabled to simultaneously record or expose the film to the scene to be photographed and to the sound waves produced by the talking, singing, or otherwise sound producing parts of the scene being photographed. By recording the sound waves and the light waves simultaneously on the same film the problem of synchronism is obviously solved, for the sound waves, that is, their record, will be reproduced with the record of the light waves at its proper place in the projection or re-

production of the same. It will thus be apparent that I have provided means which will enable making a permanent record not only of plays but of all talking, singing, or other sound wave producing parts of the plays and enable the reproduction of the same with perfect synchronism inasmuch as they are on the same record or film in proper relation relative to each other. In Fig. 1 I show diagrammatically at 10 a motion picture camera through which the motion picture film 7 passes intermittently in the usual well known manner. I provide a suitable loop 11 in the passage of the film and on one side of the loop I subject the film to the sound controlled light rays, the sound for controlling which is produced by the actors, musicians, or the like, which are being photographed. The loop which is provided between the sound recording devices and the camera or light recording devices is to enable the film 7 to pass continuously by the lens 3 as distinguished from the intermittent feed of the film past the camera aperture 3^a for the obvious reason of maintaining the sound record as a continuous record. The relative speed of travel of the film 7 past the sound lens 3 and past the camera aperture 3^a can easily be regulated in any well known manner, such as at present employed in the motion picture photography art for making and maintaining speed loops. The sound record may be made on the film in any suitable manner, for example, the present form of film employed in the motion picture art, and illustrated in Fig. 3, may be widened a sufficient distance to permit the sound record illustrated at 13 to be made on or near one margin thereof, or the size of the exposure itself may be diminished in width to permit a narrow band along one edge to be concealed when the scene exposure is made and exposed only when it reaches the sound controlled recorder. The film 7 passing by the reproducing mechanism, for example, as shown in Fig. 5, sets up currents in the electrical devices 8 in the manner hereinbefore described, whereby these currents are capable of conversion back into sound waves. I have shown one arrangement for accomplishing this wherein I employ the audion of my invention indicated at 20, which audion is used extensively in the wire and radio communication art and wherein the filament electrode 21 heated in the usual well known manner by means of current source 22 is connected to one terminal of the electrical devices 8, the other terminal of which is connected with the grid electrode 24. The plate electrode 25 of the audion 20 is connected through current source 26 to the filament in the usual manner. In the arrangement shown I employ a cascade amplifier or a combination detector and amplifier whereby

the currents of the current variations in the input or grid filament circuit of the audion 20 are amplified and conducted through the transformer 27 into the input circuit of the amplifier audion 21, the output or plate filament circuit of which includes a loud speaking horn 28, or other suitable device, for converting electrical currents into sound waves. It will be apparent that the intensity of the sound waves produced will depend upon, to a great extent, the intensity of the sound waves producing the original record. It may be desirable, however, to afford additional means for controlling the intensity of the sound waves, and this may readily be accomplished by controlling any of the variable elements in the audion circuits, for example, the current source 22 for supplying the current to the filaments of the respective audions can effectively control the intensity of the output circuit of the last audion of the series, and I therefore provide means whereby the film 7 on which the sound waves have been recorded in the form of light exposures passes by two reproducing devices adjacent to each other, the one device 8 feeding into the input circuit of the audion amplifier system and the other device 8^a controlling the filament current of the amplifier system to make louder or softer or otherwise vary the intensity and pitch of the reproduced sound waves by and in accordance with the original sound record. This is accomplished for example by including the auxiliary electrical devices 8^a in the grid filament circuit of audion 29, the output or plate filament circuit of which includes a solenoid coil 30, the plunger of which is in the form of a rack 31 which meshes with a segment 32 which forms the control arm 33 of a rheostat resistance 34 for controlling the filament current source 22. The foregoing arrangement is preferable to the modification shown in Fig. 4, and which I will hereinafter describe in that the entire operation of the reproduction of the sound is automatic in operation and relies solely upon the original sound waves and the record thereof for controlling the intensity and pitch of the sound waves reproduced therefrom. It is possible, however, to artificially effect the volume or pitch or intensity control on the film by means of an auxiliary or tone record 40 in a parallel line on the film adjacent the sound record 13 as illustrated in Fig. 4, the said artificial record 40 being made by the director or operator after the simultaneous light and sound records have been made, in which case the auxiliary electrical devices 8^a would obviously be placed out of alignment with the electrical devices 8 so that they would both simultaneously be affected.

With reference to the lamp 1 I will now describe a little more in detail several forms

of lamp which I have found to be efficient for the purpose of supplying a source of sound controlled light. I find that a suitable source of light, the intensity of which is voice controlled, consists of a small incandescent filament lamp, preferably of .25 to .50 amperes filament current. This filament should be very short, preferably from one-eighth to one-sixteenth of an inch long, and should be mounted across two leading wires of relatively large cross section, and as short as possible inside the lamp, but leading out through the glass seal to afford the maximum possible cooling or heat conducting facilities. It is highly important that the filament should be as small as possible and that every possible facility for conducting the heat away from the filament should be provided. I prefer therefore to use a nitrogen, or other gas filled lamp, to a high vacuum lamp. With such a lamp as described I find the degree of light variation by and in accordance with the sound to be from four to five times that of a similar low voltage small filament lamp but having the usual small lead in wires and evacuation. Moreover, the light from a nitrogen filled lamp is much richer in violet and ultra violet rays, which most actively affect both the photographic film and the photo-electric cell. I find that to get the most sensitive voice control of the light from such a lamp it is important to have the filament normally lighted from a local source (which may be a battery as above described), and regulating the normal light thus obtained by means of a rheostat in the usual manner in series with the said source and the secondary of the transformer, in the primary circuit of which is the microphone or voice controlled currents, as above explained. I therefore always use such a source of current in series with the secondary of a transformer and the lamp filament, and normally burn the filament at the brilliancy found by trial to give the most sensitive response to the superimposed voice currents.

In place of the above described incandescent lamp method of controlling by sound waves the light intensity I may use a small arc lamp as shown in Fig. 6. Such lamp preferably consists of two heavy tungsten ball electrodes 50 and 51, separated by a small gap, for example, 0.5 millimeters, mounted in a small glass vessel 52, either evacuated or filled with some gas, such as nitrogen, mercury vapor, etc., to make the light from such arc as rich as possible in ultra violet rays. I energize such arc from a source of high frequency current, the frequency of which must be well above the audible limits, and modulate the high frequency currents supplied the arc lamp with alternating or pulsating currents set up by and in accordance with the sound waves.

For example, the high frequency currents may be supplied the arc lamp by the oscillion illustrated at 60 and comprising the usual plate electrode 61 and grid electrode 5 62 interposed between the plate and filament electrode 63. The grid and plate electrodes are connected by an oscillating current comprising transformer coil 64, which is inductively associated with the transformer 10 coil 65, connected at its terminals to the respective balls 50 and 51. The condensers 66 are shunted around inductance 64 and a tap connection 67 is provided between this oscillating circuit and the filament electrode 15 63. The common oscillating circuit is provided with a connection to the filament electrode 63 including impedance coil 68 and a source of current 69 shunted by a condenser 70. The foregoing is briefly a well established and now well known form of high 20 frequency generation circuit forming the subject matter of separate patents and applications. The alternating or pulsating currents produced by the microphone as hereinbefore described are led to the input 25 electrode of the audion amplifier 90, the output electrode of which leads into the filament and oscillating circuit tap 67 through the transformer 91, as will be readily understood, thereby effecting a modulation of the 30 high frequency oscillations generated by the balance of the oscillion system, and the modulated high frequency oscillations vary the degree of brilliancy of light emitted 35 from the arc lamp by the unmodulated high frequency currents, which variations are proportional in every respect to the original modulating audible frequency alternating or pulsating currents in the microphone circuit. 40 Many modifications and changes in details will readily occur to those skilled in the art

without departing from the spirit and scope of my invention as defined in the claims, therefore what I claim as new and useful and of my own invention and desire to secure 45 by Letters Patents is,—

1. The combination with a photographically obtained sound record, of means controlled by said record for producing an electric current varying in potential in accordance with said record, an audion amplifier for amplifying said current, and a sound 50 producer controlled by the output circuit of said audion, and means controlled by the record for controlling the current supplied 55 the filament of said audion to thereby control the volume of the sound produced by said producer.

2. The combination with a photographically obtained sound record, of means for 60 reproducing the sounds from the photographic record, and means controlled by the record independently of the reproduction thereof for controlling the volume of sounds 65 reproduced therefrom.

3. The combination with a photographically obtained sound record, of means controlled by said record for producing an electric current varying in potential in accordance with said record, an audion amplifier 70 system for amplifying said current, a sound producer controlled by said audion amplifier system, and means controlled by the record for controlling a variable element 75 included in said audion amplifier system to thereby control the volume of the sound produced by said producer.

In testimony whereof I have hereunto set my hand on this 12th day of September, A. D, 1919.

LEE DE FOREST.