

Nov. 12, 1940.

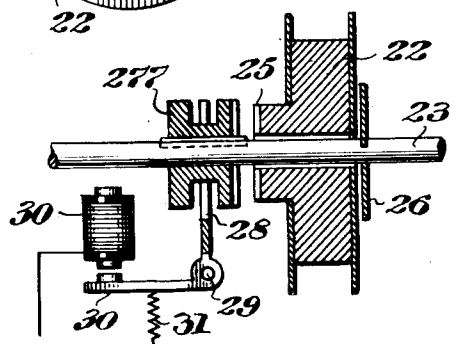
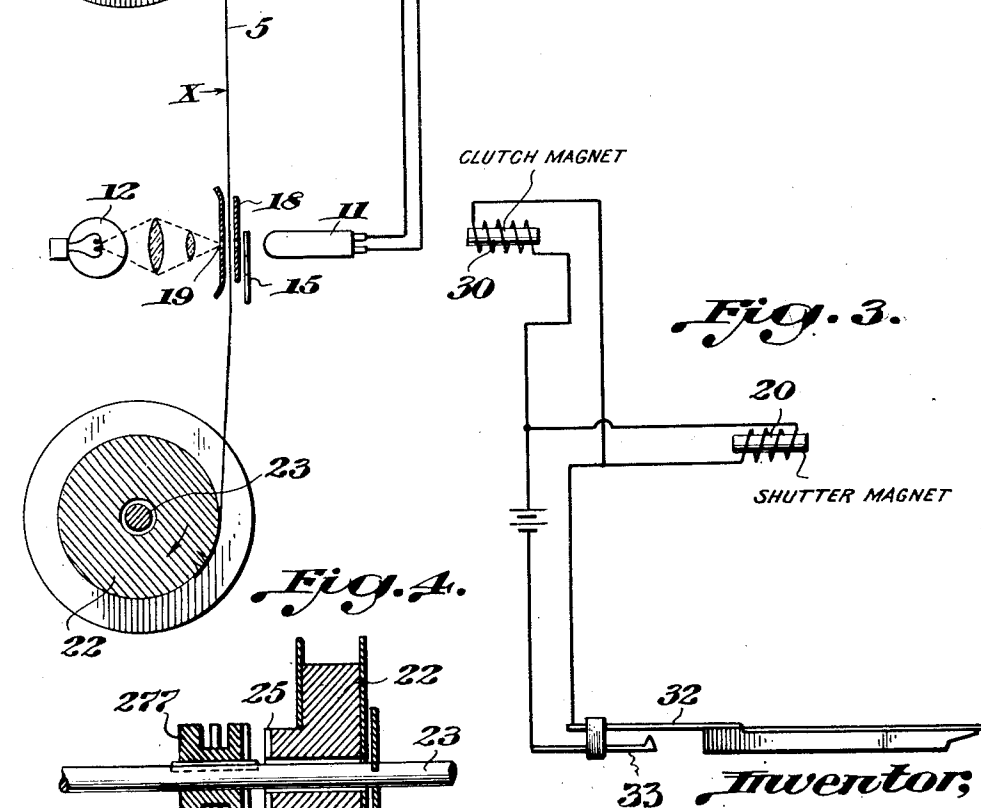
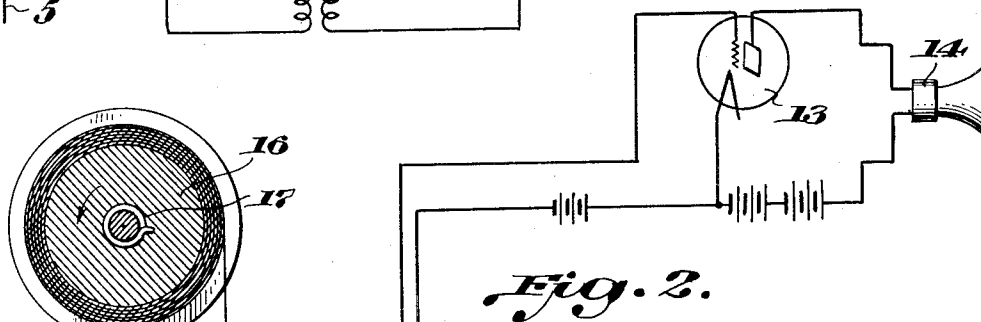
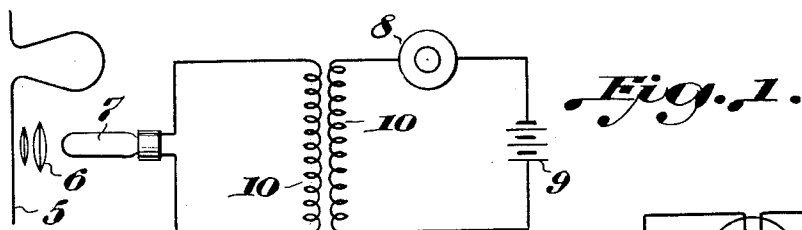
J. A. KOEHL

2,221,097

MUSICAL INSTRUMENT

Filed May 24, 1940

2 Sheets-Sheet 1



Inventor;
James A. Koehl

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Fig. 5.

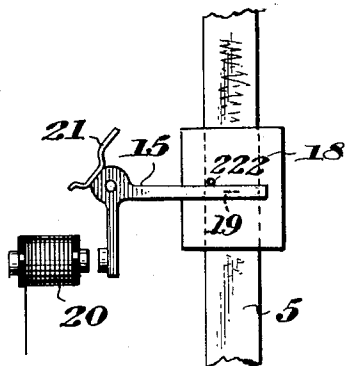


Fig. 6.

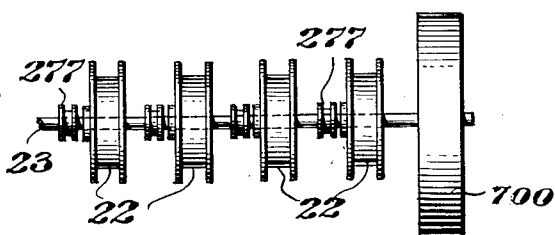


Fig. 7.

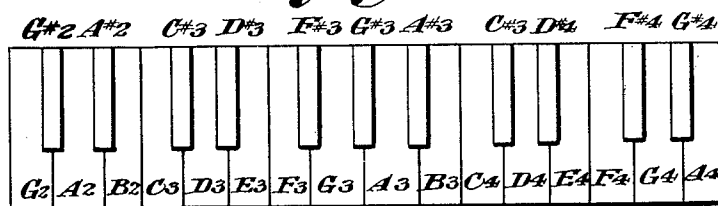
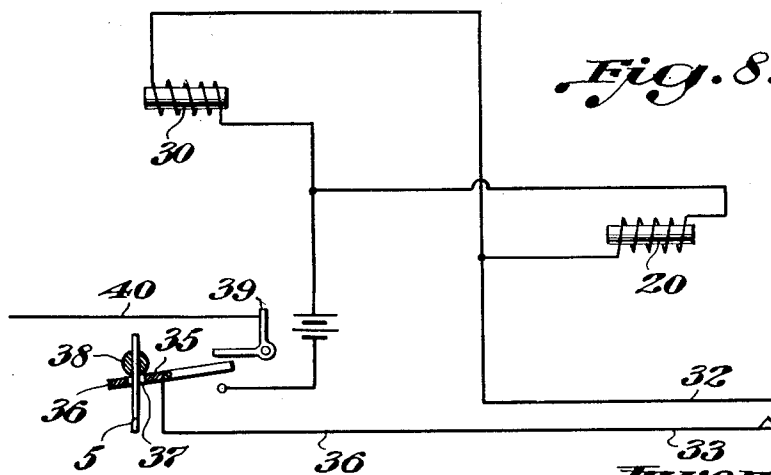


Fig. 8.



Inventor,

James A. Koehl.

UNITED STATES PATENT OFFICE

2,221,097

MUSICAL INSTRUMENT

James A. Koehl, Chicago, Ill., assignor to Central Commercial Company, Chicago, Ill., a corporation of Illinois

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12 Claims. (Cl. 84—1.18)

This invention relates to musical instruments of the type employing playing-keys associated with different notes of a musical scale and has for its general object, the provision of means enabling faithful reproduction of sounds characteristic of various musical instruments and particularly, but not necessarily, sounds characteristic of percussive instruments.

While I have disclosed herein a preferred embodiment of my invention in which photographic sound recordings are converted into undulating potential, thence into sound energy of corresponding waveform, the gist of my invention resides in the provision of a sound record of any well known form, and means including reproducing mechanism for automatically maintaining the front or starting end of a sound track substantially in a starting position relative to an electrical pick-up device when an associated playing-key is elevated and for automatically moving the record in a reproducing direction when the key is depressed and similarly returning the record to said starting position when pressure is removed from the key.

The main objects of my invention are as follows:

(1) To provide an organization of mutually coacting instrumentalities primarily designed, faithfully to simulate the tones of percussive instrument such as chimes, bells or other resonators, vibrating devices, sounders or the like which are attuned to each other in diatonic succession.

(2) To provide key-controlled mechanism for electrically producing percussive sound effects with absolute fidelity, i. e. if the instrument being simulated is a bell or similar vibrating body in which there are no points of absolute rest, the fundamental note of the bell and all harmonic partials periodically generated by the bell's vibrating segments, will be audible and will grow and decay at a rate which is exactly characteristic of a bell when it is struck with a hammer.

(3) To provide key-operated mechanism which electrically controls conduction to an electrical sound producer of undulating potential of any desired pitch and in absolute synchronism with motion in a reproducing direction of a sound record relative to an associated pick-up device and which automatically renders the pick-up device inactive when the record is moving in an opposite direction.

(4) To provide mechanism in which the actions of its parts are timed so that the first end of the

sound track of a sound record which is disposed out of the effective field of a pick-up device when a key is elevated, will be correctly correlated with said pick-up device the moment the record has attained a predetermined reproducing speed, thus insuring that the fundamental tone of the recorded instrument and all the harmonics of said fundamental tone will be sounded in an order exactly characteristic of the recorded instrument and at the pitch of a particular musical note.

(5) To provide record moving mechanism which is common to and by means of which any desired number of sound records can be simultaneously moved at reproducing speeds upon actuation of a like number of playing-keys.

(6) To provide means for moving the records in a reproducing direction, each at a speed which is predetermined relative to the speed at which recordings are made upon the record.

(7) To provide mechanism enabling the same note to be sounded in relatively rapid succession.

(8) To provide an organization of instrumentalities which is compact, simple of construction, inexpensive as compared with the actual cost of an instrument, the tones of which are desired to be simulated, positive in action and capable of being used either as a portable, light weight instrument, complete in itself, or as an accessory to any musical instrument such as a pipe organ, electric organ, piano, or the like.

(9) To provide an organization of the character specified in which a rectilinear record of short length functions in coaction with winding and unwinding mechanism to insure repetitious sounding of the same note substantially with the speed typical of the instrument being simulated.

(10) To provide an instrument enabling faithful reproduction of the tones of a pipe organ both as to the quality of a particular instrument and the rate of growth of the tones.

(11) To provide means for automatically stopping motion of a record in a reproducing direction in the event that a key is held depressed longer than necessary for the full sounding of a note.

(12) To provide means for resetting the motion stopping means from the console of the instrument, the said means being common to all records embodied in the instrument.

My invention will be more clearly understood from the specification hereinafter following and by reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a recording circuit and means therein for making the photo-

graphic sound records employed in my improved instrument;

Figure 2 is a diagrammatic illustration of the reproducing system for converting sound recordings into pulsating potentials and for reconvert-
ing said potentials into sound energy of the same waveform as the recorded sound;

Figure 3 is a diagrammatic illustration of the shutter and motion controlling magnet circuits;

Figure 4 is a view partly in section and partly in elevation of the mechanism for moving a record at a reproducing speed relative to a reproducing system;

Figure 5 is a view in elevation of the shutter control mechanism;

Figure 6 is a detail view in elevation of the continuously operating, constant speed shaft having a common set of loose record winding spools;

Figure 7 is a view in plan of a typical keyboard embodying a key for each record employed in the instrument, and

Figure 8 is a diagrammatic view of a modified form of automatic control circuit for each record and means for resetting same from the console of the instrument.

In order that persons trained in the art to which my invention relates may understand and practice my invention, I have shown in the present embodiment of the invention a short key board consisting of white keys ranging from G₂ to A₄ and black keys, ranging from G#₂ to G#₄, providing a practical range of chime tones. If instruments such as the vibra-harp, glockenspiel, xylophone, piano, string harp, drum, etc. are desired to be simulated, the number of octaves will, of course, be correspondingly increased. As the main invention has broadly to do with means by which any desired percussive tone can be faithfully simulated, the particular type of instrument to be simulated and the number of pitches per manual employed, is of course immaterial, and nothing herein shown or described shall be considered as limiting in this respect.

While I have elected to employ a photo-electric cell or similar light sensitive device as a pick-up in association with a photographic sound record, having recorded thereon a musical note of predetermined pitch to be converted into undulating potential of corresponding wave form by said pick-up device, it shall be understood that any other well known means may be substituted therefor without departing from the spirit and intention of my invention. One such means may consist of a metal tape having magnetically recorded sound thereon which may be magnetically converted into undulating potential when the tape is moved in the pick-up presence of a pick-up magnet.

In Figure 1, a photographic film 5 is continuously moved across the lens 6 at a predetermined recording speed, and the light from a lamp 7 is recorded on the film in the form of a minute ray obtained through a pin point aperture or focused to a point by a lens in a manner well known in the art. The lamp is controlled by and in accordance with sound waves generated in the pick-up transmitter or microphone circuit which includes a transmitter or microphone 8 in a closed circuit with a source of current 9, the lamp circuit and the microphone circuit being inductively coupled to each other through transformer coils 10. If a vibratory body is set in motion in the pick-up vicinity of the microphone 8, sound waves thereby generated will set up pulsating current in the microphone and thereby

operate the closed circuit of the lamp 7, and cause light variations which correspondingly control variation in intensity of light supplied to the sensitized surface of the film which are recorded on the film in the form of varying light exposures.

In Figure 2, reproduction of the recorded sound waves is effected by moving a positive film containing said recordings at the same speed as the recording-speed between a light sensitive electrical device 11 and a source of light 12 of constant intensity. Light passing through the film will vary in accordance with the exposure of the film 5 and pulsating currents produced by said device 11 and varying directly in accordance with the original sound waves will be impressed upon the input circuit of an amplifying system 13 and the amplified currents converted back into sound waves by an electrical sound producer 14 connected in the output circuit of said system.

The light source 12 is cut off from the photo-electric cell 11 by a key-operated shutter 15, the operation of which will be explained presently.

The film 5 shown in Figure 2 is wound upon a rotatable spool 16 and held in a wound condition when an associated playing-key is elevated. For this purpose, a winding spring 17 is employed and has one end fixed to the spool and its other end attached to a suitable fixed point, (not shown). The vertical or rectilinear stretch of the film passes through an aperture gate 18 at the light source 12, and as shown, the small light slit 19 in said gate is closed by the aforementioned shutter 15. A slight movement of the shutter on its pivot, such as will be exacted by a magnet 20 when energized, will move the shutter against the action of a spring 21 and away from a stop 22 to thereby uncover said aperture as long as the key is depressed.

The opposite end of the film is fixed to the large diameter hub of a take-up spool 22, loosely mounted upon a shaft 23 which continuously operates at an assigned reproducing speed. The spool 22 has a clutch face 24 at one side, the opposite side of the spool being in free running engagement with a flat disc 26, fixed to said shaft.

Spined to the shaft 23 to slide thereon relative to the clutch face 24 of the spool 22, is a clutch 27. A fork 28, pivoted at 29 and provided with an armature carrying arm 30 is connected with said clutch, as shown. A magnet 30 is associated with said arm 30 and when energized as when depressing a playing-key, attracts the arm and moves the fork against the action of a clutch releasing spring 31. In this manner, the clutch 27 is engaged with the face 24 of said spool, thereby causing the spool to rotate with the shaft 23 so as to move the film across the light source and against the tension of the spring 17 of the spool 16.

In Figure 2, X denotes the first or starting end of the sound track on the film 5, it being noted, that its position is above the source 12, a distance calculated to enable the film to attain its necessary reproducing motion when the starting end of its sound track shall have arrived at the light source.

The magnets 20 and 30 are connected in the respective parallel circuits shown in Figure 3, and the playing-key which is common to said magnets has a contact device 32 which is close circuited with a contact device 33 which connects to one pole of a source of current for energizing said magnets when the key is depressed. In this manner, the shutter 15 is opened so as to expose the device 11 to the light source 12 simultane-

ously with starting the record in motion in a reproducing direction.

When both magnets are simultaneously deenergized, the shutter returns to its closed position and the film is rapidly rewound upon spool 16.

In order that a small length of film can be used, the record is made upon a film at a slow recording speed which will be the same as the reproducing speed of shaft 23. To make this further possible and thus allow any key to be successively depressed at desired intervals, the diameters of the hubs of both spools 16 and 22 can be large as compared with the overall length of the film.

The shaft 23 is common to any desired number of pairs of spools 16 and 22 and as the operation of each pair of spools is the same and controlled by an associated playing-key, it is thought that the description, detailed as to a single pair of said spools will suffice for the entire set of such pairs of spools. While the shaft 23 is common to said entire set of pairs of said spools, it may also be the source of driving energy for any desired number of said sets as would be desirable when a single instrument is equipped with a plurality of keyboards. The shaft may be driven by means of any well known constant speed motor and is preferably provided with a suitable inertia mass 100.

Any desired number of keyboards can be employed according to the number of different instruments desired to be simulated.

While the invention is particularly useful for the simulation of the qualities of different percussive instruments, it is understood that I am not to be limited in this respect. Pipe tones can be recorded on film in the manner aforementioned and while the tones cannot be sustained indefinitely, desired musical results can never the less be attained in a highly satisfactory manner.

While I show a light source individual to a single light sensitive device, it is understood that in practice, a light source common to any desired number of light sensitive devices can be employed without departing from the spirit and intention of my invention.

In the modified form of my invention shown in Figure 8, a normally close circuited switch 35 is connected in the circuit lead 36 from contact device 33, and has a tail 36 provided with a slot 37 through which an associated record is threaded. The record has a lug 38 which is disposed at the end of its sound track and adapted to engage said tail of the switch and move the latter in a direction to break the circuit and simultaneously cause deenergization of both magnets 20 and 30. This stops further motion of the record and causes the latter to be rewound upon the spool 16. When the switch reaches its opened position, the tip thereof is disposed in close proximity to a resetting lever 39. The lever has a control connection 40 which runs to the console of the instrument and is disposed preferably above an associated key of the instrument. Thus it follows that when a circuit is automatically broken in any instance where the finger of the player is held against a key longer than required for a complete sounding of a note, it can quickly be closed by manipulation of the lever as aforestated.

When the bell sounds its deepest note, the coalescence of its pulses causes it to divide into four vibrating segments, separated from each other by four nodal lines which run up from the sound-bow to the crown of the bell. The place where

the hammer strikes is always the middle of a vibrating segment; the points diametrically opposite are also the middle of such segment. Ninety degrees from these points are also vibrating segments, while at 45 degrees right and left of them are the nodal lines. If a hammer falls on any one of said segments, the sound-bow passes periodically through certain changes, such, that at one moment, it is oval in one plane and at the next moment, it is oval in a plane at right angles to the long axis of the first oval. The changes from one oval to the other, constitute in fact the vibrations of the bell. The four points where the two ovals intersect each other, are the nodes. The number of vibrations executed by a bell in a given time, varies directly as the square of the thickness, and inversely as the bell's diameter. Beginning with the fundamental note, the number of vibrations corresponding to the respective divisions of a bell is as follows:

Number of divisions, 4, 6, 8, 10, 12

Numbers the squares of which

express the rates of vibration, 2, 3, 4, 5, 6

Thus if the vibrations of the fundamental tone be 40, that of the next higher tone will be 90, the next, 160, the next 250, the next 360, and so on.

To the best of my knowledge it has never before been possible faithfully to simulate either the tones of a bell or the tones of other similar vibratile bodies by admixtures of various partials synthetically produced as by means of various well known frequency producing devices. By reason of the fact that my invention employs a sound record of the actual instrument being simulated and that the first or starting end of the record's sound track is always in a starting position when a playing-key is elevated, it follows that not only are the vibrations of the instrument correctly produced, but that, in addition thereto, the rate at which each partial speaks upon and following the blow of the hammer, will be absolutely in accordance with the actual rate of growth and decay of the tones of the bell.

It is of course understood that for each spool 22, there will be one spool 16 which is individual thereto and that the operation of said spool 16 will be wholly independent of any other spool 16 of the set employed.

What I claim as my invention is:

1. The combination with a plurality of idle, movably supported devices respectively controlling production of currents of varying potential, each current of varying potential having the waveform characteristics of a fundamental musical tone and harmonics of said tone; means in co-action with said devices for producing said currents of varying potential during constant motion of said devices; means for urging said devices to idle positions and in starting relation to said current producing means so that when placing said devices in motion the waveforms of currents of varying potential are each thereof sequentially produced in the natural order of the sounding of a fundamental tone and the harmonics of said tone; and means for placing any of said devices in operation to effect production of selected waveforms of current of varying potential and including a selector for each individual one of said devices connected with said means to move said device against the tendency of a respective urging means.

2. In a musical instrument, mechanism and a plurality of idle, movably supported sound rec-

ords adapted to coact therewith and respectively provide waveforms of current of varying potential in the pitch relation of notes of a musical scale; means for operating said records to provide said waveforms of current; a selector for each record; and means for and individual to each selector and coacting with said record operating means to operate a record in a direction to provide current of varying potential, the waveform of which corresponds to the fundamental frequency of the note with which said selector is associated.

3. In a musical instrument, mechanism and a plurality of idle, movably supported sound records adapted to coact therewith and respectively provide waveforms of current of varying potential in the pitch relation of notes of a musical scale; means for operating said records to provide said waveforms of current; a selector for each record; means for and individual to each selector and coacting with said record operating means to operate a record in a direction to provide current of varying potential and then stopping the record; and means for reversing the motion of the record and reestablishing an idle condition thereof.

4. Mechanism of the class described comprising a sound record; means related to and controlled by said record for producing an electric current varying in potential in accordance with said record; means for urging the record to an idle position and in starting relation to said producing means; and selector-controlled means for operating the record against the tendency of said urging means so as to render the record effective upon said producing means and provide said current of varying potential.

5. Mechanism of the class described comprising a sound record; means related to and controlled by the record for producing an electric current varying in potential in accordance with said record; means for coiling the record and disposing the front end of its sound track in starting relation to said producing means; means for uncoiling the record at constant speed to render same effective upon said producing means; a playing-key; and means connecting the key with the uncoiling means to move the record and render same effective upon said producing means when depressing said key and for rendering said uncoiling means inactive upon releasing the key and subjecting the record to the action of said coiling means.

6. The combination with a photographically obtained sound record and means for reproducing the sounds from said record; a playing-key; means tending normally to secure an idle condition of the record and to relate the first end of its sound track with said reproducing means; and means connected with and controlled by depression of said key for moving the record at constant speed against the normal tendency of said urging means so as to render the record effective upon said reproducing means sequentially beginning with the reproduction of sound from said first end of said sound track.

7. The combination with a sound record and means for reproducing sounds from said record; a playing-key; means tending normally to secure an idle condition of the record and to relate the first end of its sound track with said reproducing means; and means connected with and controlled by depression of said key for moving the record at constant speed against the normal tendency of said urging means so as to render the

record effective upon said reproducing means sequentially beginning with the reproduction of sound from said first end of said sound track.

8. A musical instrument for producing chime tones comprising a set of sound records, each record having a rectilinear sound track containing recordings of a complete chime tone of predetermined pitch; sound producing means connected with said records so as to be actuated thereby, a set of record operating devices, there being one such device for each individual record; motion imparting mechanism for said devices by which one or more thereof can be moved and rendered effective upon said sound producing means as desired, and a set of playing keys connected with said motion imparting mechanism for selectively controlling operation of said record operating devices.

9. In mechanism for use in connection with a musical instrument having playing-keys, a sound producer, and a set of flexible sound records for controlling said sound producer; a constant speed motor; a shaft continuously driven by said motor; an idle record-winding spool upon said shaft for each individual sound record; and clutch mechanism for each spool and having connection with an assigned playing-key and a respective spool for effecting rotation of said spool with said shaft upon depressing said key.

10. The combination with a source of constant light, a light sensitive device having an output circuit and a flexible photographically obtained sound record disposed between said source of light and said light sensitive device for controlling the latter in accordance with exposure of said device to said light source and producing current of varying potential in said output circuit; an idler spool to which one end of the record is secured; a coiling spool to which the opposite end of the record is secured; means for tensioning said coiling spool to wind the record on said spool and provide a section of the record between both spools and dispose the starting end of the sound track of the record in starting relation to said light source and said light sensitive device; a continuously operating constant speed motor; and key-controlled means for establishing a driving connection between the idler spool and said motor and to wind the record upon said spool at constant speed when depressing said key.

11. In mechanism of the class described, a light sensitive device, a source of constant light, a film gate disposed between said light source and said light sensitive device, a shutter at said gate normally intercepting a beam of light from and preventing projection thereof upon said light sensitive device, a photographically obtained sound record movable through said gate for controlling said light sensitive device when the shutter is opened, means exerting a pull upon the sound record to position its sound track in starting relation to said light sensitive device, and key-controlled means actuable when depressing said key to open the shutter and place the record in motion at a uniform speed and thereby vary actuation of the light sensitive device and produce current of a potential which varies in accordance with said record and for closing said shutter when the key is released and rendering the record subject to the influence of said pull exerting means and thereby dispose the record in starting relation to said light sensitive device.

12. In mechanism of the class described, a light sensitive device, a source of constant light,

a film gate disposed between said source of light and the light sensitive device and provided with a shutter for intercepting a beam of light from said light source and preventing projection thereof upon said light sensitive device, means for normally closing the shutter, a photographically obtained sound record associated with said gate and adapted when moved at constant speed and the shutter is opened to control actuation of said light sensitive device, means for respectively moving the record in two directions, an electric circuit, a key connected in said circuit for controlling same, and magnetically actuated devices

in said circuit connected respectively with the shutter and said record moving means to open the shutter and move the record in a direction to expose said light sensitive device to said light source and cause actuation of said device in accordance with said record when depressing said key and for enabling closing of the shutter and causing motion of the record in an opposite direction and disposing same in starting relation to said light sensitive device when releasing said key.

JAMES A. KOEHL.