

March 22, 1932.

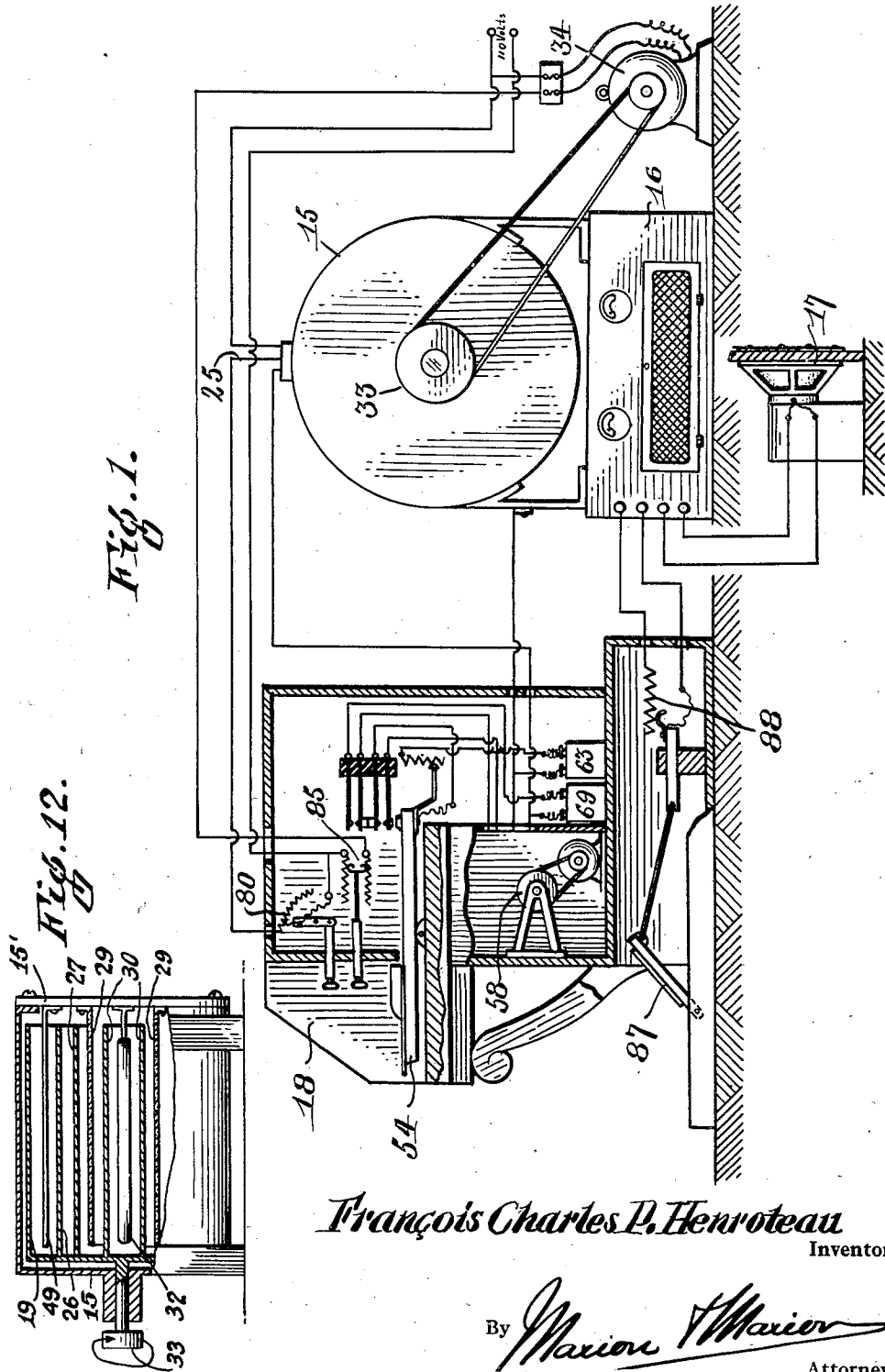
F. C. P. HENROTEAU

1,850,267

PHOTOELECTRIC MUSICAL INSTRUMENT

Filed Feb. 7, 1930

3 Sheets-Sheet 1



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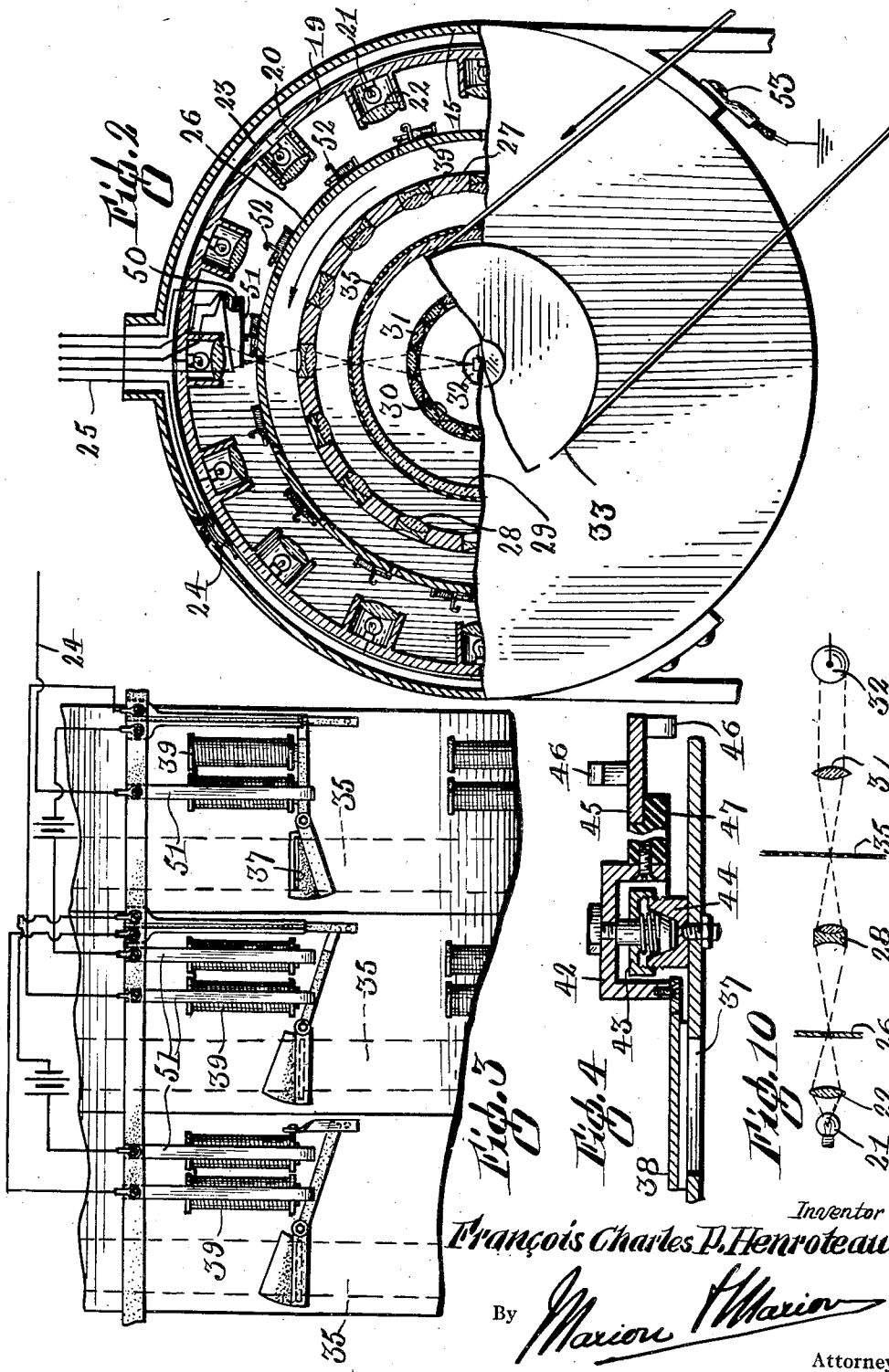
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3 Sheets-Sheet 2



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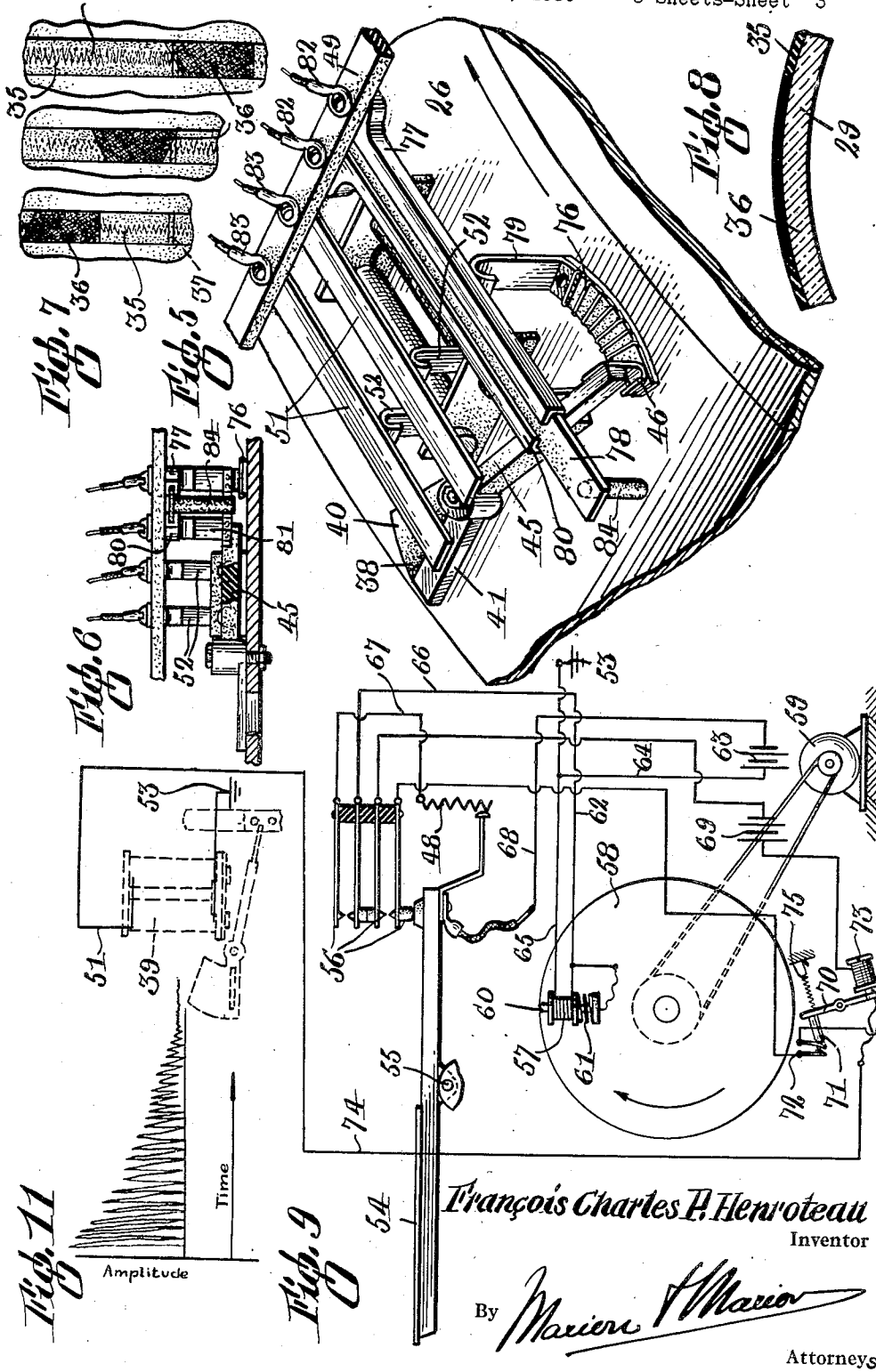
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PHOTOELECTRIC MUSICAL INSTRUMENT

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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PHOTOELECTRIC MUSICAL INSTRUMENT

Application filed February 7, 1930. Serial No. 426,718.

The present invention relates to photoelectric musical instruments and is an improvement over the kind of instruments disclosed in my U. S. Patent No. 1,747,936.

5 The applicant is aware that various instruments have been devised to reproduce electrically musical sounds or in cases human voice; however, in said instruments the sounds produced are more or less oscillations
10 of a pure sine-wave without many of the harmonics so necessary to reproduce faithfully the timber of a musical instrument which it is desired to render. Another disadvantage consists in the fact that in per-
15 cussion instruments the amplitude of a struck note or string was imperfectly rendered so that a selection played lacked the necessary life and individuality provided for by the composer.

20 The present invention eliminates the above disadvantages and provides means whereby absolute synchronism is had between the instant a note is struck and the maximum amplitude of a corresponding note as recorded.

25 Therefore, the main object of the invention is the provision of an apparatus of the photoelectric kind adapted to reproduce electrically the individual note sounds of any musical instrument and more especially that
30 of the percussion type such as the piano, guitar, mandoline, etc.

Another very important object of the invention is the provision of a timing system associated with the instrument whereby any
35 given note can be readily reproduced in rapid succession.

A further object of the invention is the provision of means whereby a given note may
40 be sustained for a considerable period of time.

A still further object of the invention is to provide an apparatus adapted to reproduce electrically the sounds of musical instruments and which can be readily adapted to
45 play any desired music upon changing a single drum.

Another object of the invention resides in the provision of an electrical apparatus adapted to reproduce any given musical instrument and which is comparatively simple,
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efficient and in the case of bulky and expensive musical reproducers much cheaper than the same.

Other objects and advantages of the invention will be in part obvious and in part pointed out throughout the specification.

As an example a preferred embodiment of the invention is illustrated more or less diagrammatically in the attached drawings wherein similar numerals designate corresponding parts throughout the same.

In the drawings:—

Figure 1 represents a diagrammatical arrangement of a device according to the invention and which is intended to play the notes
65 of a piano,

Figure 2 is a fragmentary transverse section through the revolving drum,

Figure 3 is a fractional plan view of the slit covering mechanism,

Figure 4 is a sectional view through the pivot of the slit covering segment,

Figure 5 is a perspective view of the slit controlling mechanism,

Figure 6 is an elevational view thereof,

Figure 7 is a diagrammatic view showing the arrangement of three consecutive strips carrying oscillations of a single continuous note,

Figure 8 is a sectional view through the transparent drum carrying the film record,

Figure 9 is a diagrammatic view of the arrangement permitting the rapid consecutive repetition of the same note,

Figure 10 is a diagrammatic representation of the optical system used for the most efficient utilization of the light produced by the lamps and obtaining the utmost from the photoelectric cell,

Figure 11 represents schematically the oscillogram of a piano note for instance and plotted against time and amplitude of the oscillations, and

Figure 12 is a diagrammatic representation of the relative arrangement of the various drums, but without the apparatus carried thereby.

Referring to the drawings, and more particularly to Figure 1, it will be seen that the apparatus as a whole comprises a closed cas-
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ing 15, a sound amplifier 16 associated with a speaker 17 and a console 18 housing various devices to be described later.

The casing 15 is constructed so that one end wall thereof 15' may be opened, the other end wall comprising a suitable bearing to support a series of revolving cylinders about to be described. First, the outermost cylinder 19 comprises a plurality of cells or chambers 20 wherein is disposed a small electric bulb 21 and which is closed by a lens 22. It will be noted that the said chambers 20 are equally spaced around the inner periphery of the cylinder 19 and that the lamps are illuminated by an electric source supplied to a ring 23 upon which bears a sliding contact 24, said contact 24 being connected to a wire 25 to be identified later.

Concentrically disposed within the cylinder 19 is another smaller one 26 constructed of opaque material and having fixed thereon a plurality of electro magnets such as shown in Figure 5, and which are equal in number to that of the lamps 21.

A third cylinder 27 is provided inside 26 and is fitted with a number of achromatic lenses 28 equalling in number the cells 20 or the lamps 21.

A fixed drum 29 is concentrically disposed within 27, said drum being characterized by walls of transparent material and furthermore fixedly secured to the wall 15' of the casing 15.

Finally, the cylinders and drum assembly is completed by a smaller cylinder 30 which also carries a number of lenses 31 equal to that of the lenses in cylinder 27. As shown to advantage in Fig. 2, the center of the concentric cylinders is occupied by a photoelectric cell 32 of a known construction which is carried by the wall 15'.

All of the various cylinders above described, to the exception of 29, are secured together and are adapted to be rotated; the pulley 33 belt driven by the motor 34 being provided for that purpose as shown in Fig. 12.

An inspection of Figure 2 will disclose the fact that 31, 28 and 22 are exactly aligned so that a light ray coming from the lamp 21 will be impressed on the cell 32 if an aperture in the cylinder 26 happens to be in the path thereof; it being understood that said ray will not be impeded by the drum 29 which is transparent.

If a film having printed thereon a series of parallel lines of varying density and corresponding to the oscillations of a musical note (like that used in synchronized motion pictures) is disposed around 29, it will be obvious that whenever a light beam starting from 21 is allowed to fall on said film, the cell 32 will be more or less affected according to the density of the film portion upon which the light ray happens to strike. Now,

according to the above description, 29 is stationary and the combination of 30, 27, 26 and 19 is adapted to revolve so that a light beam emitted from 21 may be made to fall on the film and follow along the periphery thereof in a complete circle. Of course, during that operation, the cell 32 will be continuously receiving rays of light which are variable according to the printing on the film so that a sound will be produced if the output of the cell is suitably amplified.

From the above, it might be concluded that any given sound may be readily reproduced if the correct oscillations are printed upon the film in a number of successive lines of varying density or in any other suitable manner. This is the principle on which the instrument object of the present invention is based, said principle being also known in the art.

Reference to Figure 11 will show that in percussion instruments such as the piano, the amplitude of the oscillations is greatest at the instant the note is struck. Therefore, it is important that, if an attempt is made to reproduce the notes of this instrument by mechanical means, the maximum of sound issues from the reproducer at the exact instant the corresponding note on the keyboard is struck.

The present invention accordingly has for an object to provide means whereby this synchronization can be had in the most practical manner. In my former application already referred to, a drum carrying printed films was adapted to be revolved intermittently and stopped against an abutment; due to mechanical difficulties and wear of parts, the music reproduced was not exactly synchronized and instead the present system has been adapted wherein the drum 29 carrying a printed film 36 is perfectly stationary and a revolving drum 26 having slits is adapted to project a beam of light unto the film. In order that a light ray will fall on the film at the exact desired moment, an opaque portion 36 is provided which covers the joint of the film and extends a short distance from the end thereof to the other end just before the printing corresponding to the maximum amplitude of the note to be reproduced.

As already stated, the cylinder 26 carries a plurality of magnets and a number of slits 37 (Figs. 3 and 4) which are normally covered by the segment 38 which is secured to an armature adapted to be attracted by the electro magnets 39 as shown to advantage in Figures 3 and 5. The segment 38 is of a material which is graduated from a transparent portion 40 to an opaque portion 41 adapted to completely prevent passage of light through the slits when the armature is in a position away from the electro magnets (Figs. 3 and 5). From the foregoing, it will be apparent that the light travelling through the segment

38 is variable according to the position of the same over the slit.

The shutter carrying the segment 38 comprises a cup-shaped member 42 secured to a shaft 43 which is frictionally retained in a socket 44 secured to the cylinder 26. Fixed to the cup 42 in opposite relation to 38 is an armature bar 45 of magnetic metal and which comprises a pair of sliding contacts 46 insulated from 42 by a non-conducting block 47. The object of the frictional mounting is to prevent as much as possible the armature 45 from swinging the segment 38 too great a distance and to avoid the inertia resulting from said swinging movement; in other words, the slit covering mechanism or shutter is sluggish in action and always remains in any position to which the magnetic force of the magnet 39 has originally attracted the same.

In order that the size of the complete instrument may be comprised within reasonable dimensions, it is necessary that the cylinder 29 should be of a relatively small diameter, and accordingly the film 35 wound thereover may in most cases comprise a length of not over a few feet. Since a piano note can vibrate freely for six or seven seconds or more, the length of the said film is not sufficient to accommodate all the vibrations corresponding to that time. Therefore, two more strips of films are provided to carry the remaining of the oscillations or, in other words, the complete film upon which is printed the vibrations corresponding to a note oscillating for the maximum length of time is divided into three equal portions each of which is disposed around 29 in a side-by-side relation, as shown in Figure 3. Since it is necessary that the sound produced from the light ray modulated by the printing upon the film be continued on to the next film, when the first has been rotated a complete revolution, a series of slit covering and switching mechanism is provided which will be presently described.

Reference to Figures 2, 3 and 5 clearly shows that a plurality of electro-magnets 39 are disposed in a row around the cylinder 26, one row being provided for each film and obviously a row of lamps 21 and lenses 27 and 31 being also necessary for each film. These electro-magnets are directly mounted upon 26 and, as previously stated, are adapted to attract the armature 45 whereby the slit 37 will be uncovered. Reference to Figure 5 will disclose the fact that the amount of light transmitted through 37 is directly dependent upon the distance of 45 from the magnets in view of the fact that the segment 38 secured thereto is graduated from a transparent portion 40 to an opaque portion 41. This arrangement is adapted to simulate as closely as possible the intensity of sound emitted by a piano for instance, according to the strength with which a note is struck. Therefore, the

angle assumed by 45 relative to the magnets is directly dependent upon the electric current flowing therein, which current is constantly variable according to the way a key is struck, by means of a rheostat 48, to be described later on.

Since it is necessary that the slits 37 be uncovered at a given portion of the film 35, a switching mechanism is provided to energize said magnets and cause the opening of the shutter at the same and only point on the film. To achieve this result, a bar 49 of insulating material is provided between the cylinders 26 and 19 at 50 in Figure 2, said bar being secured to wall 15' as depicted in Figure 12. The purpose of this bar is to support a plurality of strips 51 adapted to convey the electric current to the electro-magnets when the same have reached their correct position. Adapted to engage the strips 51, a plurality of brushes 52 are provided adjacent the magnets 59 (as shown in Figures 5 and 6) and being electrically connected thereto. Although the mechanism in Figure 5 shows two strips 51, nevertheless the magnets adapted to control the light affecting the first part of the film corresponding to a given note (see Figure 3) comprise only one strip because one end of this electro-magnet is electrically connected to the cylinder 26 which in turn is grounded at 53 (Figure 2) or common to a battery.

If Figure 2 is closely inspected, it will be found that the length of the strip 51 is only slightly shorter than the distance existing between two adjacent brushes 52. The reasons therefor is that as soon as a brush 52 leaves the left end of 51, the next contact 52 is about ready to engage the right end of 51 so that the interval of time between the successive contacts of 52 against 51 is excessively short. In view of the fact that a great number of lamps and shutters are provided, it is obvious that any given note can be rapidly repeated up to possibly ten or fifteen times a second according to the speed at which 33 rotates.

If it is considered that each time a brush 52 contacts with the strip 51 the corresponding shutter 38 will be opened, it will be apparent that as 26 is rotated each shutter would be in turn opened and a plurality of successive sounds produced. In order that a given note may be sustained without this repetition a mechanism has been devised for this purpose. In Figures 1 and 9 is shown a key-board having keys 54, in simulation of an ordinary organ key-board, and which are pivoted at 55. One end of said key is adapted to close a plurality of contacts 56 which in effect are nothing more than a double-pole single-throw switch. The purpose of these contacts is to energize on one hand the magnets 39 and to actuate on the other hand a solenoid 57 secured to the periphery of a disk 58 which is adapted to be rotated at high speed by a

motor 59. As shown clearly in Figure 9, said solenoid 57 comprises a movable core 60 which is urged inside 57 by a spring 61 and which furthermore is electrically connected to the wire 62 leading to one of the contacts 56. An inspection of the diagram of Figure 9 will disclose the fact that whenever the contacts 56 are closed, 57 will be energized by current from the battery 63 through the conductors 64, 65, 62, 66 and back to the battery through 67, the rheostat 48 and the conductor 68.

A second battery 69 is provided the circuit of which is also opened or closed by the lower pair of contacts 56. When the disk 58 is rotating, if 57 is energized, the core 60 will project outwardly from said disk and is adapted to contact with a pivoted arm 70 which closes by means of an insulated arm 71 a pair of contacts 72 completing the circuit of the battery 69 through the electromagnet 73, whereby one end of the arm 70 will be attracted and retained against the core of 73 as long as the key 54 is depressed. The arm 70 is also electrically connected to a conductor 74 leading to the strip 51 of the first electro magnet; the other end of said magnet being grounded to the drum and said drum in turn connected to the common terminal 53. Reference to Figure 9 will show that the conductor 65 aside from being connected with 64 is also extended to 53 so that one side of the battery 63 is electrically connected to the grounded end of the electro magnet 39.

The arm 70 is urged in a position away from 73 by a spring 75 and when normally at rest is adapted to be engaged by 60 when the same is extended so that an electric contact between 60 and 70 will complete the circuit of the battery 63 to the magnet 39, it being already explained that said magnet is normally connected at 53 which is also one side of said battery.

From the foregoing, it will be readily apparent that whenever a note is to be sustained, the instant the contacts 56 are closed, the core 60 will contact with 70, which is in the path thereof, and while energizing the magnet 39 will, at the same time, push 70 far enough to close the contact 72 and energize 73, whereby 70 is permanently retained in a position away from 60 so that no further contacts are made. Of course, if a note is to be only intermittently sounded, the moment the key is released the arm 70 will be returned to its initial position by the spring 75 and again the cycle of operations repeated.

Again referring to Figure 5, it will be noted that a rheostat 76 is secured to the cylinder 26, one end of which is electrically connected to a channelled bar 77 secured to one side of an insulating strip 78 and in contact thereto by a brush 79. As already disclosed, a sliding contact 46 secured to the shutter is adapted to contact with the rheostat at various points thereon according to the position of said shut-

ter 45. Therefore, the position of 45 and consequently 46 upon 76 is directly dependent upon the magnetizing force of the magnet, which is controlled by the rheostat 48, so it may be stated that the magnetizing strength of the magnets is directly dependent upon the depth to which the key 54 was depressed and accordingly the rheostat 76 is also correspondingly actuated. The object of the rheostat 76 is to control the shutters on the second and third portion of a given film so that the angle of opening thereof is directly dependent upon 48. In view of the fact that the drum 26 is grounded, it is necessary that the return from 46 be insulated from the drum; to this effect, another bar 80 is provided on 78, opposite from 77, and upon which a sliding contact 81 (Fig. 6) is adapted to bear. The connection to 77, 80 and 51 is by means of pairs of lugs 82 and 83, 82 leading to the next set of magnets and 83 coming from the precedent rheostat 76, the arrangement being in series with a separate battery for each set, to insure the independence between the circuits. The circuit of connections is shown in Figure 3.

In order that the shutters be closed at the end of each complete revolution of 26, a stop 84 is provided at the free end of 78 and which is adapted to engage the arm 45 of the shutters so that said arm is returned to its initial position, away from the electro-magnets and the portion 41 directly over the slits 37 to interrupt the light rays falling on the films and to terminate the issue of sound from the loud speakers.

In order that the change from one film to the other may be made less abruptly, the suggestion of Figure 7 may be put in practice whereby the edge of the darkened portions 36 are not directly in line but slanting slightly so that the light falling through one slit may be gradually closed at the same time as the other is gradually opened.

In operation, the lamps 21 are constantly illuminated and electrically connected to a suitable source by means of the sliding contact 24 and the wire 25, which may possibly be connected to any of the batteries provided, to simplify the design.

In practice, if we assume that three films are necessary to accommodate one full note and that say 60 notes are required, a total of 180 films, sets of lamps, lenses and magnets will be required, a similar number of photocells being desirable, although it is possible that by a suitable construction a single photoelectric cell may be employed for the three films of one note.

To complete the apparatus and permit variations in the pitch, volume, etc. of the reproduced music, a rheostat 85 actuated by "stop action" may be provided to alter the speed of the motor 34 and accordingly the pitch of the note. At the same time, it might

be useful to alter the brilliancy of the lamps to indirectly control the output, by means of another rheostat 86, while the entire volume of the device can be controlled by a foot-pedal 87 actuating a volume control 88. In the case of Figure 1, the lamps are illuminated from the electric mains through the rheostat 86 and connected at 25.

It is to be understood that the form of my invention herein shown and described is to be taken as a preferred example of the same, and that various changes as to the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described my invention, I claim:—

1. In a device adapted to reproduce the notes of a musical instrument, a photo-electric cell, an optical system to concentrate upon said cell rays of light traversing an aperture in an opaque cylinder, means to selectively control the amount of light traversing said aperture, a stationary transparent film upon which are printed the oscillations corresponding to the note to be reproduced, means to displace around said film the controlled light rays, and means to always start at the exact predetermined spot on the film the travelling beam of light rays.

2. An instrument adapted to reproduce musical notes, comprising a stationary transparent film carrying printings corresponding to musical vibrations, means to selectively displace over said film a concentrated point of light, a photo-electric cell receiving said point of light, and an electric timing mechanism whereby the point of light is always started at an exact predetermined spot on the film and any given musical note quickly repeated or sustained, at will.

3. An instrument for reproducing musical notes, comprising a printed film, means to selectively control the brilliancy of a light beam falling on said film, a photo-electric cell to receive the beam modulated by the printing on the film, an electric switching mechanism to interrupt or start the flow of light unto the film, and means comprising a rotating disc, a solenoid mounted thereon, a movable core and an associated stationary arm adapted to permit rapid successive actuation of the switching mechanism or selective intermittent actuation thereof.

4. An apparatus adapted to reproduce the individual notes of a musical instrument and played on a key-board, comprising a plurality of transparent members having printed thereon a representation of the oscillations of a musical note, means to displace over said film a beam of light, means to selectively control the brilliancy of said beam according to the strength with which a key is depressed, photo-electric cells receiving the light beam

modulated by the printings on the film, and a timing mechanism whereby a given note may be rapidly repeated or sustained at will.

5. In an apparatus to reproduce the notes of a musical instrument, transparent members having printed thereon the oscillations corresponding to a given note, means to illuminate through said members photo-electric cells by means of a travelling light beam, members of graduated transparency to selectively control the brilliancy of the beam, electro-magnetic means to actuate the graduated members and permit operation thereof at an exact predetermined point of the transparent members, and a timing mechanism whereby any given note may be rapidly repeated or sustained at will.

6. In an instrument adapted to reproduce musical notes in simulation of a piano or other percussion instruments, a transparent drum, transparent films mounted thereon and bearing printings corresponding to the oscillations of a musical note, luminous sources mounted on a cylinder and concentric with the drum, another opaque cylinder having slits opposite the light sources and disposed concentrically between the drum and first cylinder, magnetically operated light graduating members mounted on the second cylinder over the slits, contacting means adapted to actuate the graduated members at always the same exact position, and a timing mechanism comprising a disc having a projecting member adapted to contact with a stationary pivoted arm whereby a given note may be successively sounded or sustained, at will.

7. In an instrument adapted to electrically reproduce the music of any given instrument, and having a keyboard, printed films, photo-electric cells and means to displace and control a light beam over the film, the combination therewith of a timing mechanism comprising a rotating cylinder, a solenoid mounted at the periphery thereof, a core in said solenoid adapted to project outwardly when a key of the keyboard is depressed, a stationary pivoted arm adapted to contact with the core when in an extended position, an electro-magnet adjacent one end of said arm, the arm being adapted to electrically actuate the light controlling means when the core contacts therewith and further adapted to remain against the electro-magnet one engaged by the core while a key is held depressed, whereby further contacts with the core are prevented.

In witness whereof I have hereunto set my hand.

FRANÇOIS CHARLES PIERRE HENROTEAU.