Nov. 28, 1933. J. H. HAMMOND, JR 1,937,021

SYSTEM FOR REPRODUCING SOUND

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Fig. 1

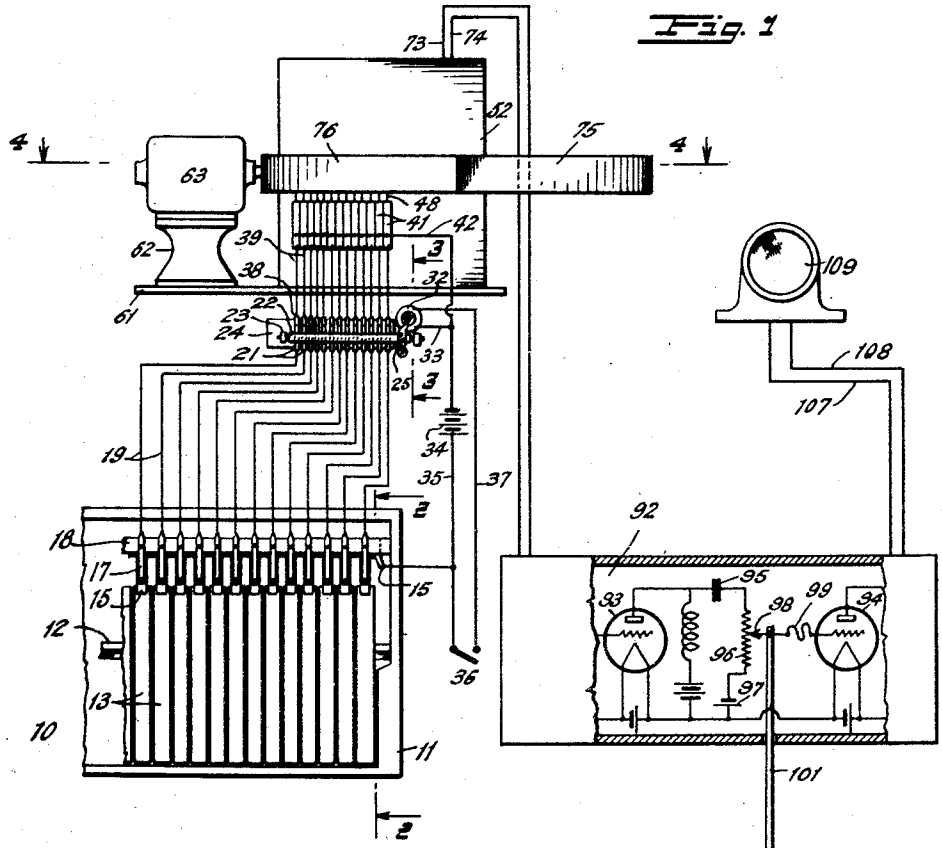


Fig. 2

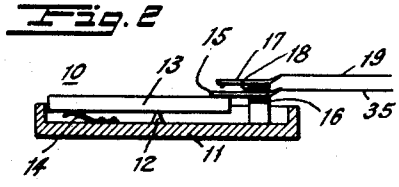
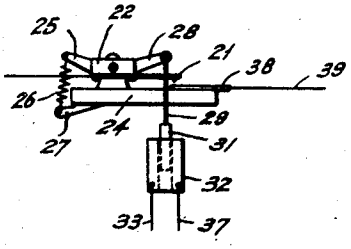
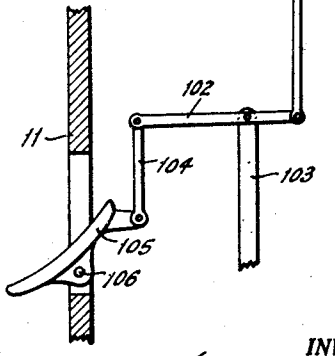


Fig. 3





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Fig. 4

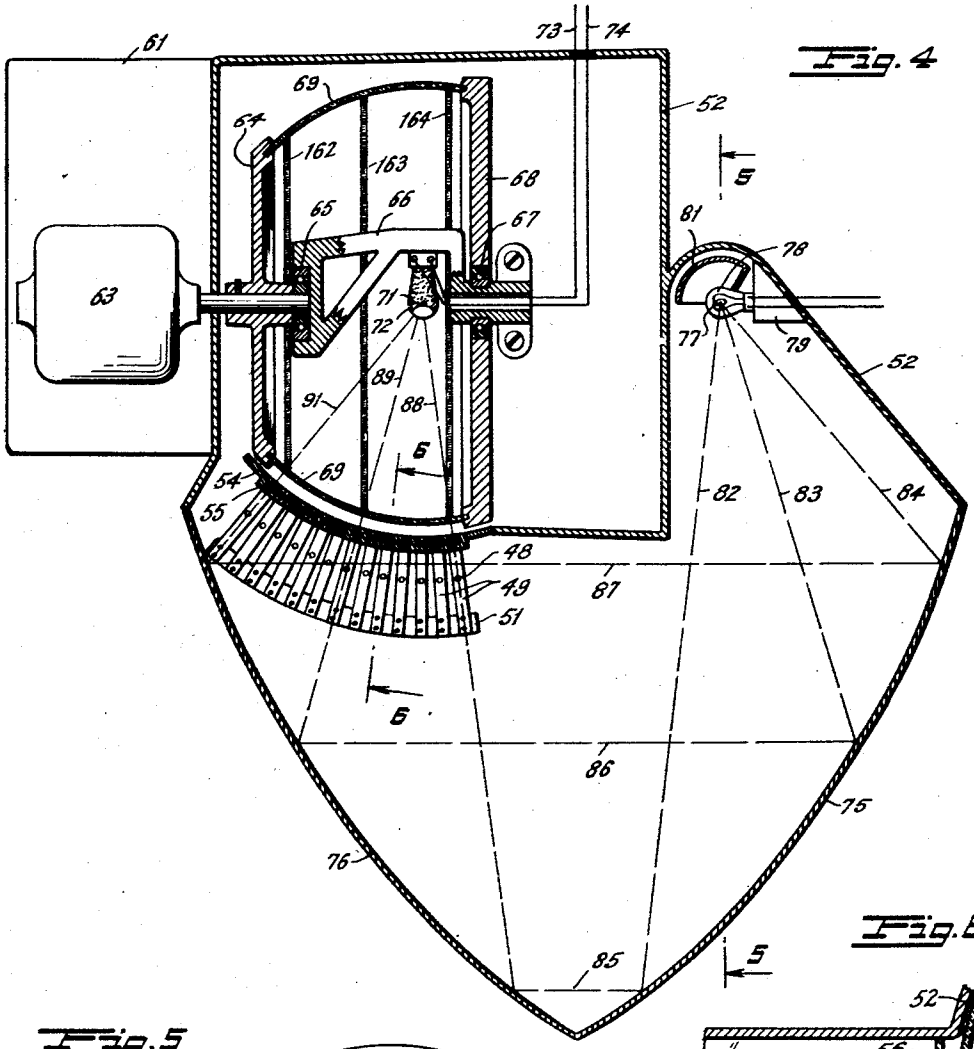


Fig. 5

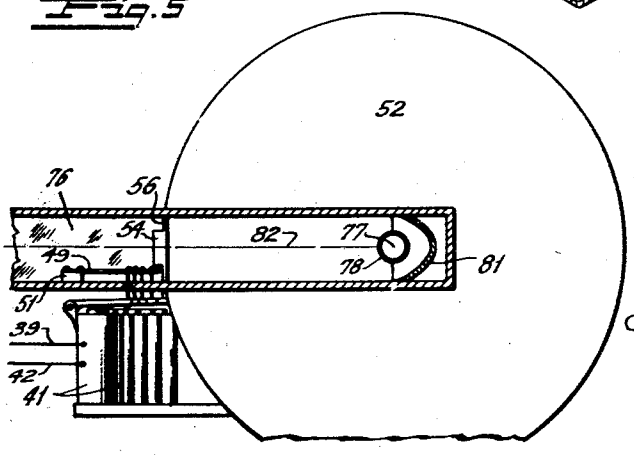
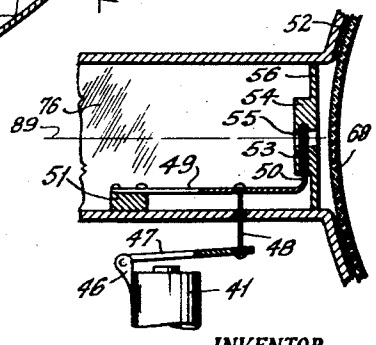


Fig. 6



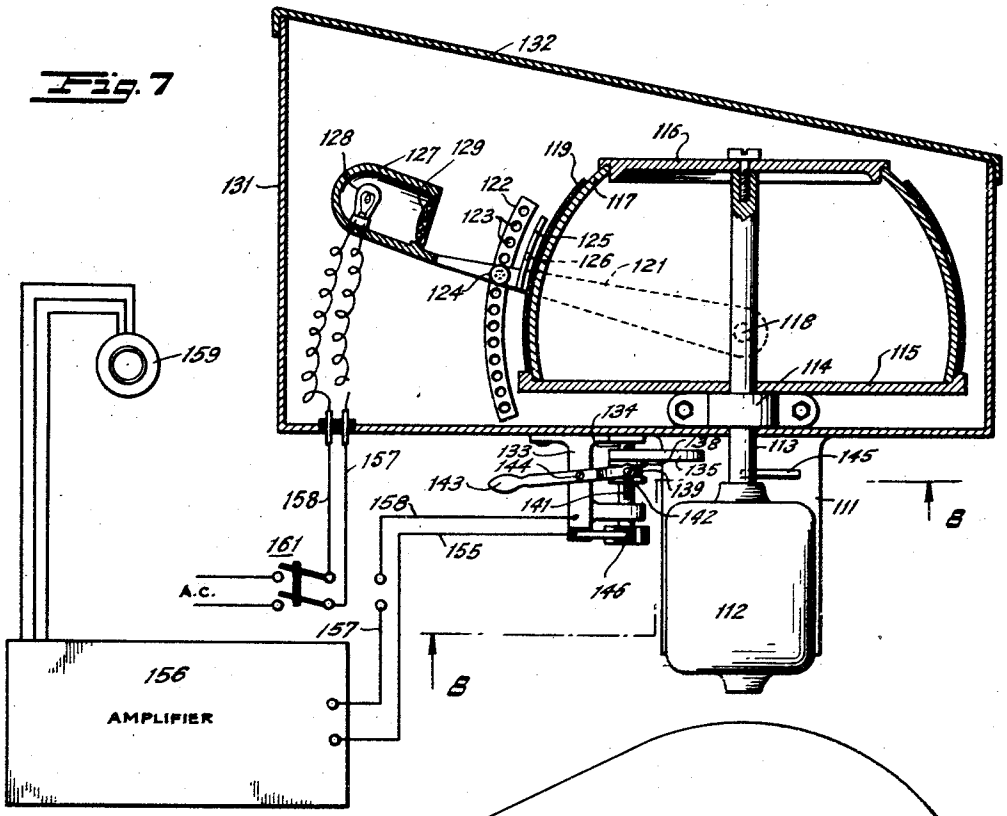
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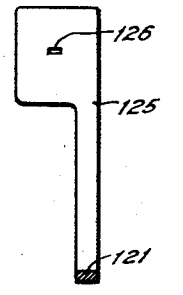
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Fig. 7





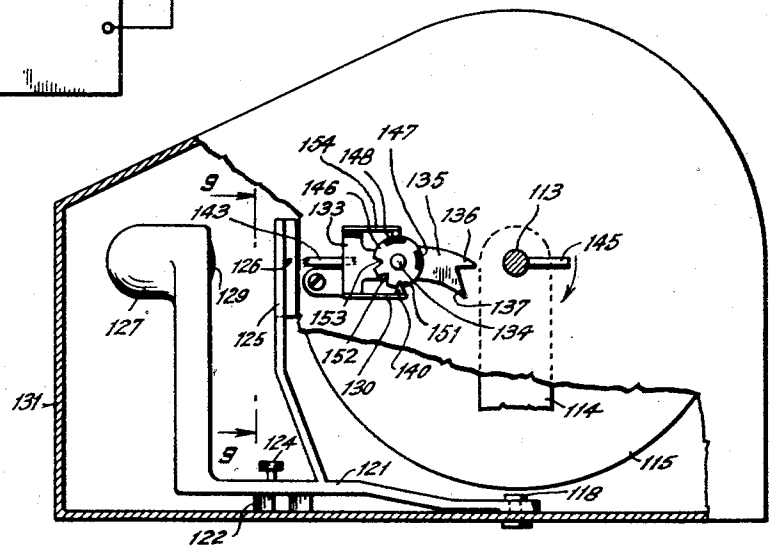


Fig. 9

Fig. 8

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UNITED STATES PATENT OFFICE

1,937,021

SYSTEM FOR REPRODUCING SOUND

John Hays Hammond, Jr., Gloucester, Mass.

Application October 29, 1929. Serial No. 403,207

5 Claims. (Cl. 84—1)

This invention relates to acoustic systems and more particularly to a system for imprinting a plurality of sonorous effects upon a recording element and then selectively reproducing said effects from said recording element.

According to a preferred form of the invention means are provided whereby the tones of a musical instrument are photographically recorded, and then selectively reproduced either singularly or in combination from the record obtained thereby, so as to effect any desirable musical score whose tonal characteristics will have a timbre corresponding to that of the musical instrument.

In an embodiment of the invention means are provided for translating the compressional waves emanating from a musical instrument into corresponding current pulsations. These pulsations are then translated into correspondingly characterized light rays which are projected successively on separate portions of a sensitized recording element. A permanent photographic record is then obtained from said element.

In reproducing the tones of said musical instrument in any selective combination, a key board is provided with keys mounted thereon corresponding to the successive notes imprinted on said photographic record. Means are also provided responsive to the actuation of the said keys for permitting light rays of constant luminosity to be projected upon those parts of the photographic record corresponding to the actuated key. In its passage through the selected portion of said photographic record the constant light ray is altered in characteristics in accordance to the opacity of that portion of the record. The altered ray is impressed upon a photoelectric cell which translates these rays into corresponding current pulsations. A sound propagating device is then actuated in response to said current pulsations.

The invention also provides means for sustaining the reproduction of a sound effect to any desired extent irrespective of the degree of sustentation of the original sound effect during the recording operations. This is accomplished by registering the sound effect along an endless path on the recording element. According to one embodiment of the inventior the recording element may have a continuous bounding surface so that an endless sound record can be registered thereon.

The invention also consists in certain new and original features of construction and combinations of parts hereinafter set forth and claimed.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation and the manner of its organization may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Fig. 1 is a diagrammatic elevation of the entire apparatus;

Fig. 2 is a section taken on line 2—2 of Fig. 1;

Fig. 3 is a section taken on line 3—3 of Fig. 1;

Fig. 4 is a plan view taken on line 4—4 of Fig. 1;

Fig. 5 is a sectional elevation taken on line 5—5 of Fig. 4;

Fig. 6 is a fragmentary sectional elevation taken on line 6—6 of Fig. 4;

Fig. 7 is a sectional plan view of the recording apparatus used in this system;

Fig. 8 is an end elevation partly in section of this recording apparatus; and

Fig. 9 is a view of a detail of the mechanism shown in Figs. 7 and 8.

Like reference characters denote like parts in the several figures of the drawings.

In the following description and in the claims parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

In the form of the invention shown in Fig. 1, a key-board 10 is mounted in any suitable location. This key-board consists of a frame 11 which is provided with the longitudinal pivot bar 12. Transversely mounted on this bar are a plurality of keys 13 with springs 14 disposed on the underside of said keys. Abutting the ends of the keys 13, are contact springs 15, which are mounted on a bar of insulation 16. Mounted above the springs 15 are secondary springs 17 which are mounted on the strip of insulation 18. The contacts 17 are connected by a plurality of conductors 19 to an equal number of contacts 21, mounted on the under surface of a rotatable switch 22, which is pivoted for rotation in bracket 23 carried by a base plate 24 made of insulating material. An arm 25 is secured to the switch 22, and is connected by a spring 26 to a small bracket 27 secured to the base 24. An arm 28 is also secured to the switch 22, and is connected by means of a flexible wire 29 to the core 31 of a solenoid 32. One side of the winding of this solenoid is connected by a conductor 33 to a battery 34, the other side of which is connected by a conductor 35 to all the contacts 15, and to a switch 36, and then

by a conductor 37 to the solenoid 32. Any number of switches similar to 22 may be employed, the contacts of which are connected in parallel to those of 21.

The contacts 21 of the switch 22 at suitable times engage contacts 38, which are mounted on the base plate 24. These contacts are connected by conductors 39 to one side of the windings of a plurality of solenoids 41. The other sides of the windings of these solenoids are connected by a conductor 42 to the battery 34. The solenoids 41 are provided with brackets 46, to which are pivoted armatures 47. These are connected by means of flexible wires 48 to a plurality of shutters 49 which are made of spring material and are mounted on a block 51 carried by a casing 52 of the reproducing apparatus. The shutters 49 have offset ends 50 which slide in grooves 53 provided in a member 54. This member is provided with small rectangular openings 55, which are normally closed by the shutters 50. The member 54 is mounted in a partition 56, which is secured to the casing 52.

The casing 52 is supported on a base 61 to which is secured a pedestal 62 surmounted by a motor 63. This motor may be run from any suitable source of supply and its speed is kept constant at any desired point by means of any well known speed regulating system which need not be more fully described herein. Secured to the shaft of the motor 63 is a plate 64. The end of the shaft of the motor 63 is mounted in a ball bearing 65, which is carried in a bracket 66. This bracket also carries a ball bearing 67 to which is secured a second disk 68. Between disks 64 and 68 is mounted a drum 69 having a continuous bounding surface of transparent material. The surface of the drum shown is of a spherical shape, the center of the sphere being located at the point 71. At this point there is mounted on the bracket 66, a photoelectric cell 72 which is connected to the two conductors 73 and 74.

Mounted in the casing 52 are two curved mirrors 75 and 76. The curvature of these mirrors in the plane of Fig. 4 are sections of a parabola, and are so located that the focal point of the parabola 76 is at the point 71 and the focus of the parabola 75 is at the point 77. At this point there is mounted a source of illumination 78, such as the usual incandescent lamp used in projector work, this lamp being supplied by any suitable source of current not shown. This lamp is mounted on a base 79 secured to the casing 52. Mounted back of the lamp 78 is a reflector 81, the curvature of which in the plane of Fig. 4 is a section of a circle with its center at the point 77. A section of this reflector perpendicular to this plane is a parabola with its focus slightly above the point 77 as seen in Fig. 5. The light from the reflector 81 is reflected in the direction of the dotted lines 82, 83, 84 etc., to the mirror 75 from which the light is reflected in a substantially parallel beam along the lines 85, 86 and 87 to the mirror 76, from which the light is reflected along the dotted lines 88, 89 and 91 to the member 54 where it is projected in the form of a flat beam on the openings 55. The sharpness of focus of this flat beam on these openings is dependent upon the proper construction and adjustment of the reflector 81. When the shutters 50 are open, the beams of light 88, 89, 91 etc., strike the photoelectric cell 72. Opposite the openings 55, and in line with the beams of light passing through these openings, there are endless photographic records on the surface of the drum 69, corresponding to the notes of a given instrument, such for example as the oboe and clarinet. Each one of these records on the drum 69 corresponds to the individual note of the particular instrument being reproduced. The method by which these records are made will be described hereafter.

The conductors 73 and 74 are connected to the input circuit of any suitable amplifier 92. Two of the vacum tubes of this amplifier are shown at 93 and 94, the plate of the tube 93 being connected through a condenser 95 to a resistance 96 the other side of which is connected through a battery 97 to the filaments of the two tubes. The sliding contact 98 is connected by a flexible conductor 99 to the grid of the tube 94. The adjustable contact 98 which slides over the resistance 96 is mounted on the end of a rod 101, which is pivoted at its lower end to an arm 102, pivoted to a bracket 103. The other end of the arm 102 is pivoted to one end of a link 104, the other end of which is pivoted to a swell pedal 105. This pedal is pivoted at 106 to the frame 11 of the keyboard 10, and is located beneath this keyboard so that the person playing the instrument can operate the pedal 105 with his foot. The output of the amplifier 92, is connected by two conductors 107 and 108 to any suitable sound producer such as a loud speaker 109.

The mechanism for producing the records on the drum 69 is shown in Figs. 7, 8 and 9. This mechanism consists of a base plate 111 on which is mounted a motor 112. The shaft 113 of this motor passes through a bearing 114, and has secured thereto a plate 115. Screwed to the end of the shaft 113 is a second plate 116 between which and the plate 115 is mounted a drum 117 which is spherically shaped, the center of the sphere being at the point 118. A sensitized celluloid film 119 is slipped over this drum. This film may be made by any well known photographic process. Pivoted to the base 111 directly below the point 118 is an arm 121 which slides over a curved block 122 provided with a plurality of holes 123. Slidably mounted in arm 121 is a pin 124 which selectively engages in any one of the holes 123. Mounted on the arm 121 is a plate 125 provided with a small rectangular opening 126. (See Fig. 9.) Mounted on the extension of the arm 121 is a casing 127 in which is mounted a variable source of light 128, such as a neon tube, and also a lens 129 which focuses the light from the tube 128 upon the film 119. Surrounding this apparatus is a casing 131 provided with a removable cover 132. Secured to the casing 131 is a bracket 133 in which is rotatably mounted a shaft 134. Slidably mounted on this shaft is a member 135, provided with two teeth 136 and 137. This member is provided with the sleeve 138 which has a groove 139. This member is keyed to the shaft 134 which is provided with a keyway 141. Sliding in groove 139 are two pins 142 which are carried by the end of a Y shaped arm 143, which is pivoted to the bracket 133 at the point 144. A finger 145 is carried by the shaft 113, and at suitable times engages the teeth 136, 137.

Secured to the end of the shaft 134 is a commutator 146 which is provided with two sections of insulation 147 and 148 and with three notches 151 and 152 and 153. Mounted on the bracket 133 is an arm 130 constructed of spring material, and provided on the free end thereof with a wedge shaped lug 140 which is adapted to engage in the notches 151, 152 and 153. Mounted on but insulated from the bracket 133 is a contact 154 which engages the commutator 146 and

is connected by a conductor 155 to the output circuit of an amplifier 156. The other side of the output circuit of this amplifier is connected by a conductor 157 to one side of the variable light source 128 the other side of which is connected by conductor 158 to the bracket 133. The input of the amplifier 156 is connected to a microphone 159.

For producing the record of the various tones the sensitized film 119 is placed on the drum 117 (see Figs. 7 and 8). The handle 143 and the member 135 are placed in the position shown in these figures and the pin 124 is placed in the first hole of the bar 122. The motor 112 is then started and brought up to the desired speed which is kept constant by any suitable speed regulating devices. The microphone 159 is then placed near the source of sound to be recorded, such for example as an organ pipe. This pipe is then sounded by the usual means and the arm 143 is rotated in a clockwise direction. This brings the tooth 136 into the path of the moving finger 145, which strikes this tooth, thus rotating the member 135 through about 30° in a counter clockwise direction as seen in Fig. 8. This will cause a corresponding rotation of the commutator 146 so as to bring the contact 154 in engagement with the metal part of this commutator, thus closing the circuit between the conductors 155 and 158. As the commutator 146 is rotated from the position shown in Fig. 8 the lug 140 will be sprung out of engagement from the notch 151 and will move into engagement with the successive notch 152. The engagement of said lug with said notch 152 will obviate the overrunning of the commutator 146 beyond the desired rotational movement.

The tone of the pipe which is picked up by the microphone 159 is amplified by means of the amplifier 156 and is thence carried by the conductors 157 and 158 to the variable light source 128. The light from this is focused by the lens 129 on to the film 119 after passing through the small rectangular opening 126 in the plate 125. The variable intensity of the light produced from the source of illumination 128 causes a corresponding variation in the photographic action on the film 119 as this is rapidly rotated back of the opening 126. This action continues until the shaft 113, and therefore the drum 117 has made one complete revolution at the end of which the finger 145 will strike the tooth 137. This will cause the member 135 and the commutator 146 to rotate through about 30° more thus bringing the contact 154 on to the insulation 147, thereby breaking the circuit to the lamp 128. In this way an endless record of the sound picked up by the microphone 159 is made upon the film 119 this record being in the form of a circle. Due to the action of the commutator 146 as above described this record is made exactly for one revolution of the film 119 so that there is neither an open place in the record or any over lapping of it.

The pin 124 is then moved to the next hole in the bar 122 and the next pipe of the organ is sounded so that a second circular record is made on the film 119. In a similar manner a record is made for each one of the organ pipes so that a complete record is made for every note of the organ, these records being made in circular form one below the other on the film 119. The whole apparatus is located in a dark room so that the cover 132 may be removed, and the film 119 taken from the drum 117 and developed by ordinary photographic processes, thus forming a negative of the records produced. The drum 117 is then replaced by the drum 69 which is made of any suitable transparent material, and which is provided with a surface sensitized with positive photographic emulsion. The negative film 119 is then placed over this drum and the variable light source 128 is replaced by any suitable source of illumination, such as an incandescent lamp, and the conductors 157 and 158 are disconnected from the amplifier 156 by means of a switch 161. The pin 124 is then placed in the first hole of the bar 122 and the motor 112 is started and brought up to the desired speed. The switch 161 is then thrown to the left connecting the conductors 157 and 158 with any suitable source of supply to light the lamp in the casing 127, which by means of the lens 129 focuses its light upon the film 119 through the opening 126 as the film 119 is rotated. This light will act through the film on to the positive emulsion on the drum 69 thus making a photographic record on this drum from the negative record on the film 119. This process is repeated for each one of the notes recorded on the film 119, thus producing the positive record of these notes on the transparent drum 69. This record is then fixed by any suitable photographic process upon this drum which is then permanently placed in the reproducing mechanism shown in Figs. 4, 5 and 6. The record of three of the notes on this drum are shown by the shaded lines 162, 163 and 164. Any desired number of these transparent drums may be made from the negative 119 and also any number of these drums may be made for different instruments so that by using a plurality of reproducing devices all the stops of an organ can be obtained.

The drums 69 are placed in the various reproducers, and the motors 63 of these reproducers are all started and brought up to the desired speed which is maintained by any suitable speed regulating device. When it is desired to use a certain stop or instrument the corresponding switch 36 (see Fig. 1) is closed thus energizing the corresponding solenoid 32. This will rotate the corresponding switch 22 by means of the flexible connection 29, so as to cause all the contacts 21 of this switch to engage the corresponding contact plates 38 located on the base 24. If it is then desired to sound a given note of this stop, the proper key 13 is depressed, thereby causing the corresponding contact 15 to engage the contact 17 which causes the circuit to be closed from the battery 34 through the conductor 35, contacts 15 and 17, conductor 19, contacts 21 and 38, conductor 39, magnet 41, and conductor 42, back to the battery 34. This will energize the corresponding magnet 41 which by means of the flexible connection 48 will open the shutter 50 thereby allowing light from the lamp 78 to pass through the opening 55, after being reflected from the mirrors 81, 75 and 76. The light ray then passes through the corresponding photographic record on the drum 69 and projected upon the photoelectric cell 72. The fluctuation in current produced in this cell is communicated to the conductors 73 and 74 and then to the amplifier 92 where it is amplified and impressed upon the loud speaker 109 over the conductors 107 and 108. This actuates the loud speaker thereby reproducing the exact tone of that note of the organ which was picked up by the microphone 159 when this note was recorded. The intensity of this note may be varied by manipulating the pedal 105, which when rotated in a clockwise direction will cause the rod 101 to be moved upwardly increasing thereby the intensity of the tone, and when ro-

tated in the opposite direction will cause this rod to move downwardly with a corresponding decrease in the intensity of the tone.

It is thus seen that by closing any desired stop switch 36 and depressing any desired key 13 any desired note of any particular instrument may be produced by the loud speaker 109 and the intensity of this note may be controlled by means of the pedal 105.

The sound record on the drum 119 has herein been described as being effected in accordance with the variable intensity system but it is obvious that a variable area system can also be used without departing from the spirit of the invention. It is also obvious that the various sound tracks may be so located on the spherical record that a whole number of cycles is included in each track and that there is no phase shift when the record is continuously reproduced. The location of the sound tracks on the surface of the drum may be determined by calculations based upon the speed of rotaton of the drum and the frequency of the tone to be photographed so that an exact integral number of sound vibrations will be photographed in one revolution of the drum. This is a simple matter of mathematics and geometry.

Referring, for instance, to the shaded line 163 in Fig. 4, this line will contain a number of complete cycles of alternate, relatively transparent and relatively opaque portions, corresponding to the frequency of the note it is desired to produce at the given speed of the motor 63. It is obvious that the total number of complete cycles of line 163 passing member 54 in a second, determines the pitch of the particular note. Furthermore, the number of compete cycles per second is independent of the diameter of the sphere 69 at this point since the lineal size of each cycle will be predetermined to give the desired number per second. It is clear that the line 163 may be shifted slightly so as to contain an exact integral number of complete cycles in one revolution of the drum. Thus, the pitch of the note is determined by the number of complete cycles in the path 163 and not by the physical length of the path 163.

By means of the present invention all the essence and qualities of a cumbersome musical instrument such as an organ can be embodied in a simple portable record which can be transported very easily to any desired place for reproducing purposes.

It should be noted that any orchestral combination can be effected by a number of such records having impressed thereon different instrumental characteristics and mounted upon a corresponding number of reproducing devices.

It should also be noted that the invention has been described with particular reference to its adaptation to the recording and reproduction of the notes of a musical instrument. But it is obvious that it can be advantageously applied to the reproduction of any acoustic effect. It may for instance be adapted to produce any audible stage effect such as thunder, roar of a lion, etc. All of these varied effects may be distinctly impressed upon one record and then selectively reproduced as the occasion demands. These reproduced effects can be sustained to any desired extent merely by maintaining the depression or actuation of corresponding key.

While certain novel features of the invention have been shown and described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes in the forms and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. In a device for reproducing sonorous action previously recorded, the combination comprising a first and second parabolic reflector disposed with their axes in parallel relationship, a light source disposed at the focal point of said first reflector, a photoelectric cell at the focal point of said second parabolic reflector, and a photographic record upon which the sonorous action has been previously recorded, said record being interposed between said second parabolic reflector and the photoelectric cell.

2. In a device for reproducing sonorous action previously recorded, the combination comprising a first and second parabolic reflector disposed with their axes in parallel relationship, a light source disposed at the focal point of said first reflector, a photoelectric cell at the focal point of said second parabolic reflector, a photographic record upon which the sonorous action has been previously recorded, said record being interposed between said second parabolic reflector and the photoelectric cell, shutter device interposed between said second parabolic reflector and said photographic record, and means for selectively actuating the shutter elements of said shutter device whereby the corresponding portion of said photographic record is subjected to the action of the rays reflected from said second reflector.

3. A system for reproducing sound on a sound record which comprises a photographic sound record having a plurality of endless sound tracks thereon spaced transversely and representing various tones, a single concentrated light source, means including a set of parabolic reflectors for expanding the rays from said source and causing said rays to pass normally through each of said tracks after reflection from said reflectors, a photoelectric cell, means for causing said rays after passing through said tracks to be applied to said cell and means for selectively admitting said rays to a predetermined track whereby the various tones may be reproduced at will.

4. In combination with a photographic sound record comprising a plurality of sound tracks formed in parallel circles on a spherical surface, a light propagating element and a light sensitive element, one of said elements being mounted at the center of said spherical surface, the other of said elements being mounted externally thereof and means including a set of reflectors whereby the light rays are passed between said elements and through said spherical surface in a direction normal to said surface after reflection from said reflectors.

5. A system for reproducing sound comprising a photographic sound record formed on a recording element having a spherical bounding surface, a photoelectric cell mounted at the center of said spherical surface and adapted to receive light rays which have passed through said record, a light source mounted externally of said spherical surface, and reflecting means for expanding rays from said source and for causing the same to pass through said record normal to said spherical surface after reflection from said reflecting means.

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