

March 26, 1929.

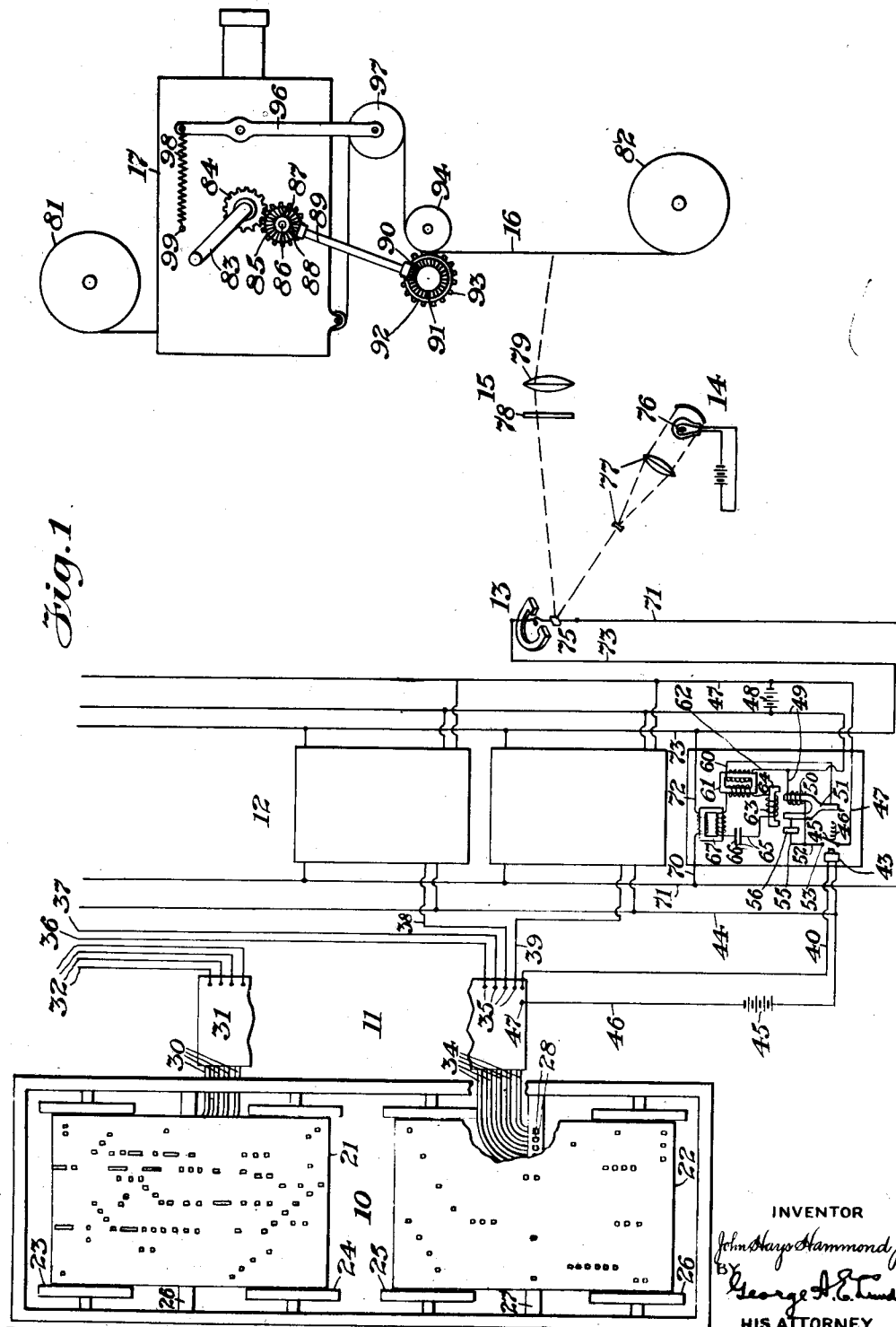
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1,706,731

PHOTO ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS

Filed April 14, 1924

6 Sheets-Sheet 1



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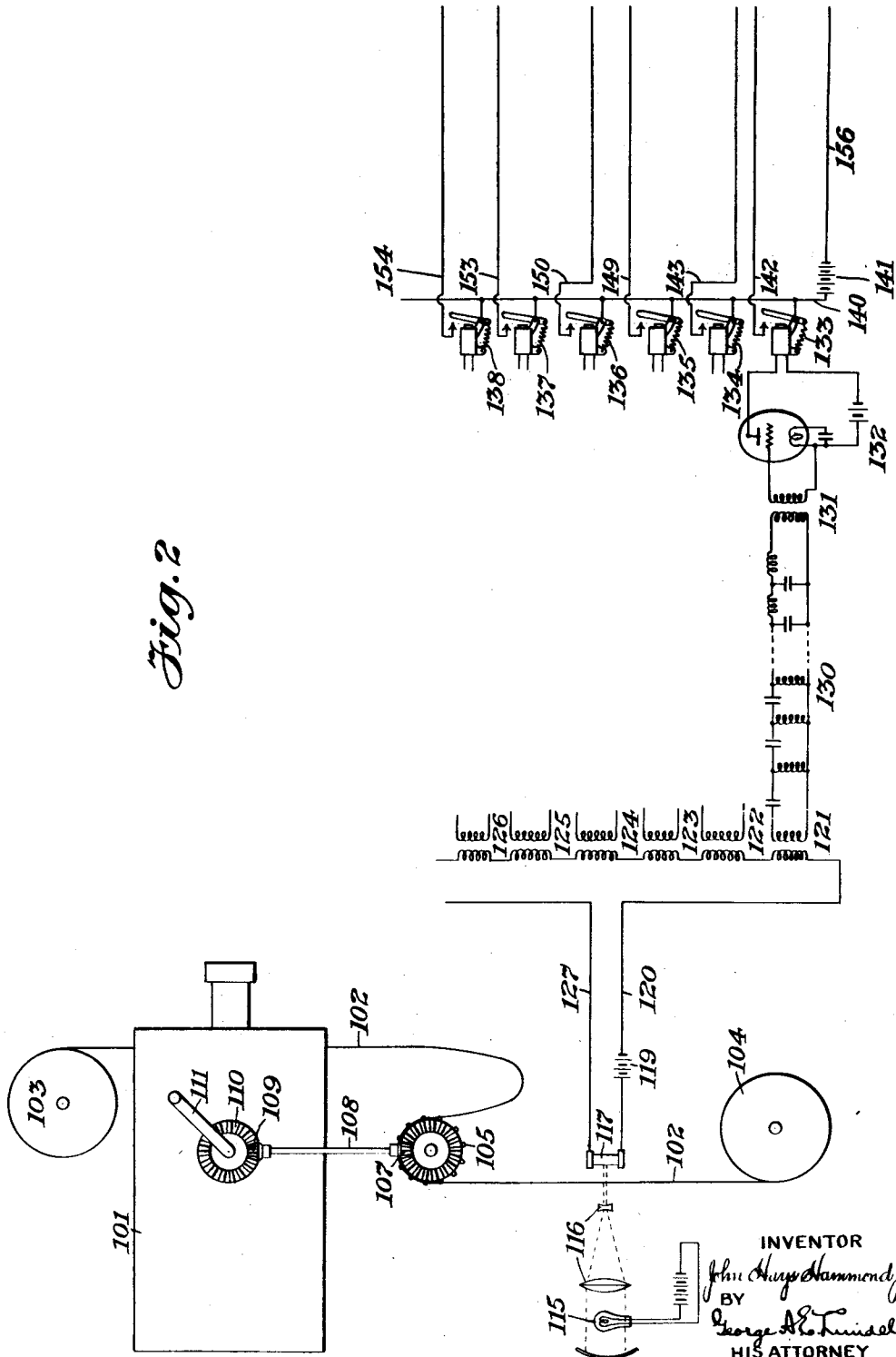
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PHOTO ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS

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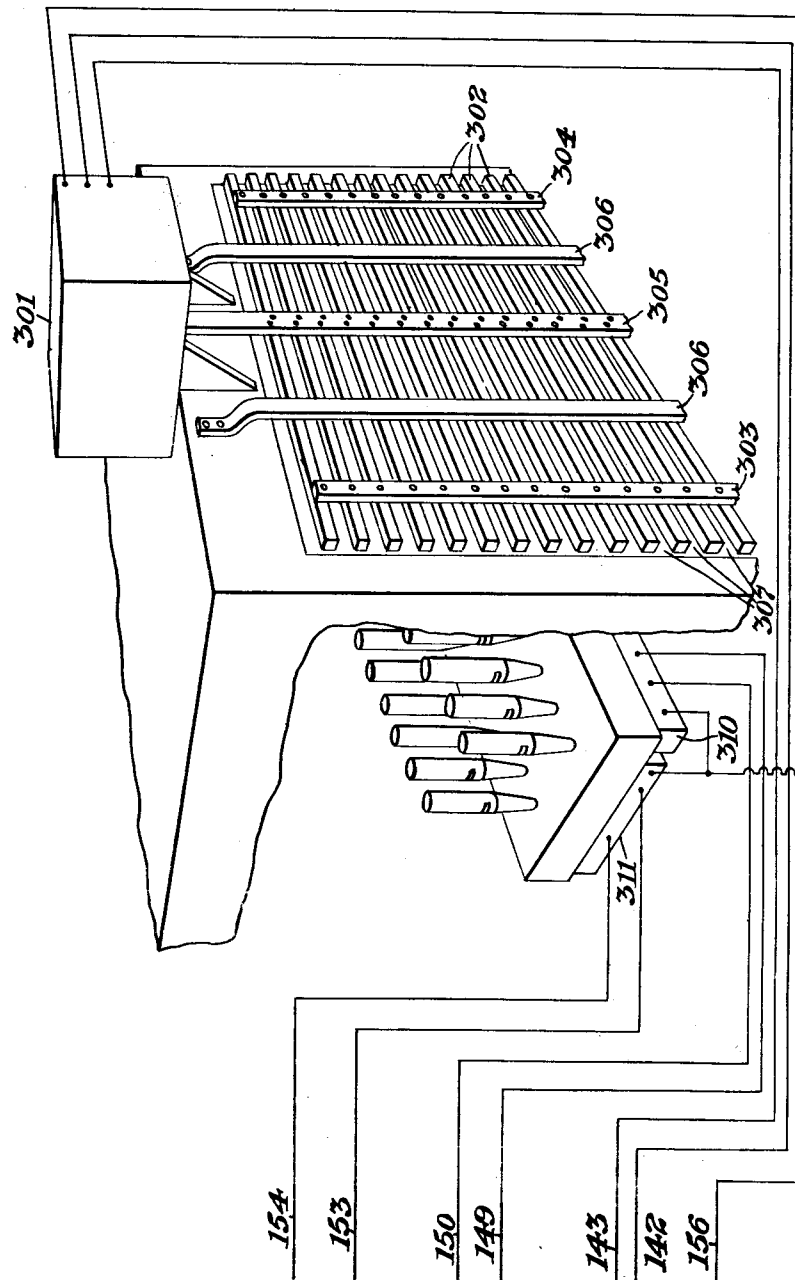
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PHOTO ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS

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6 Sheets-Sheet 3

Fig. 3



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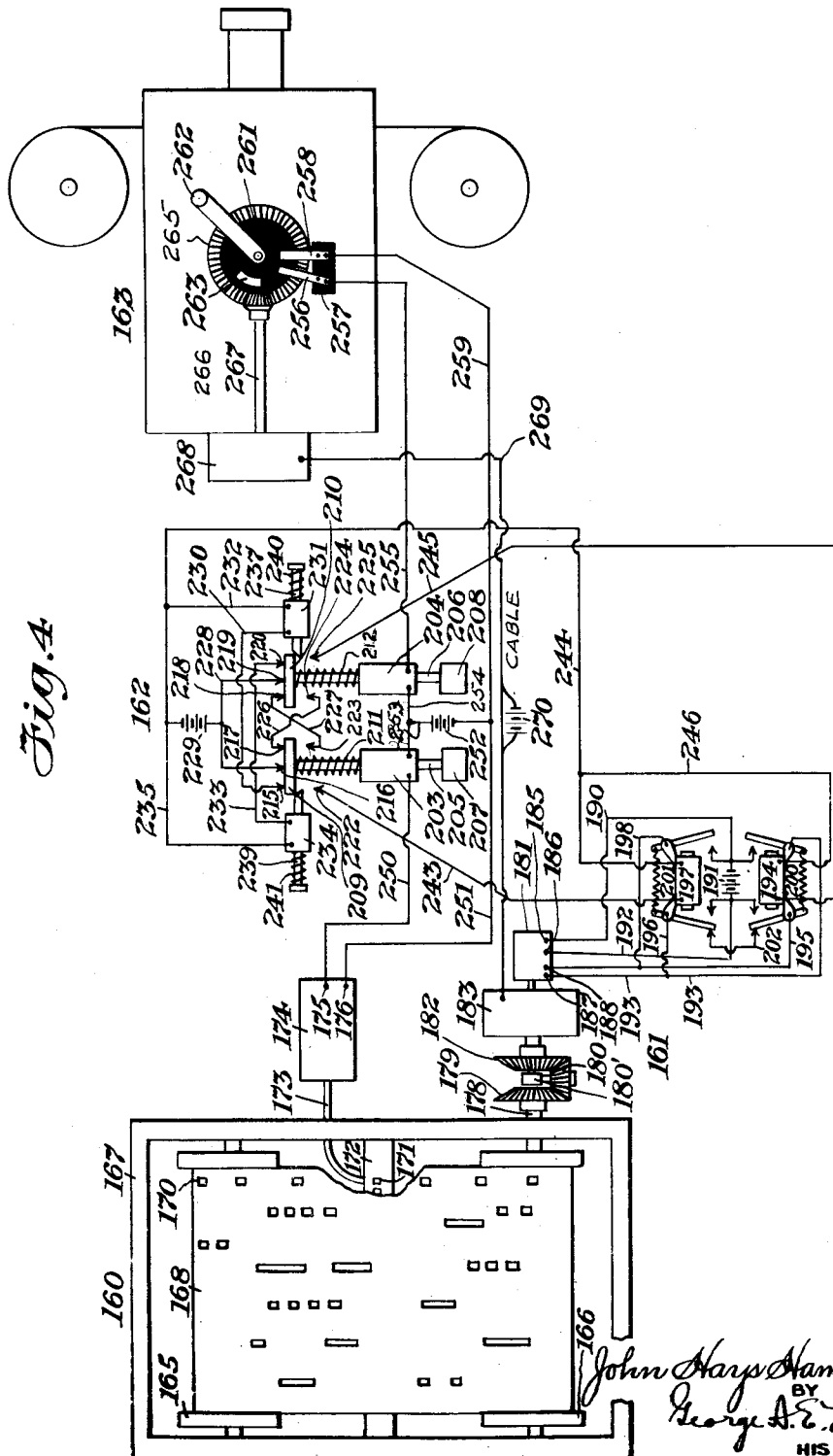
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PHOTO ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS

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6 Sheets-Sheet 4



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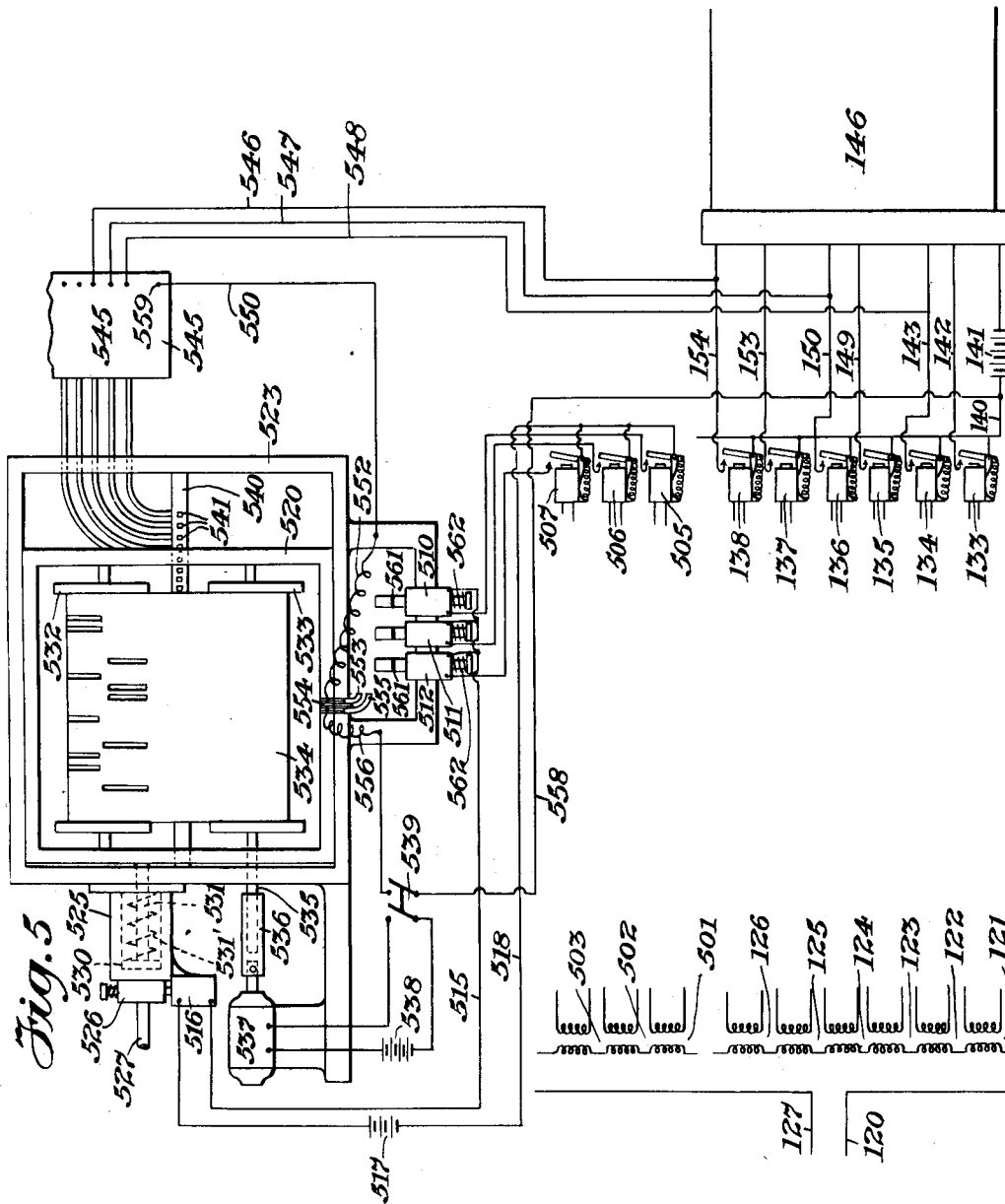
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PHOTO ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS

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6 Sheets-Sheet 5



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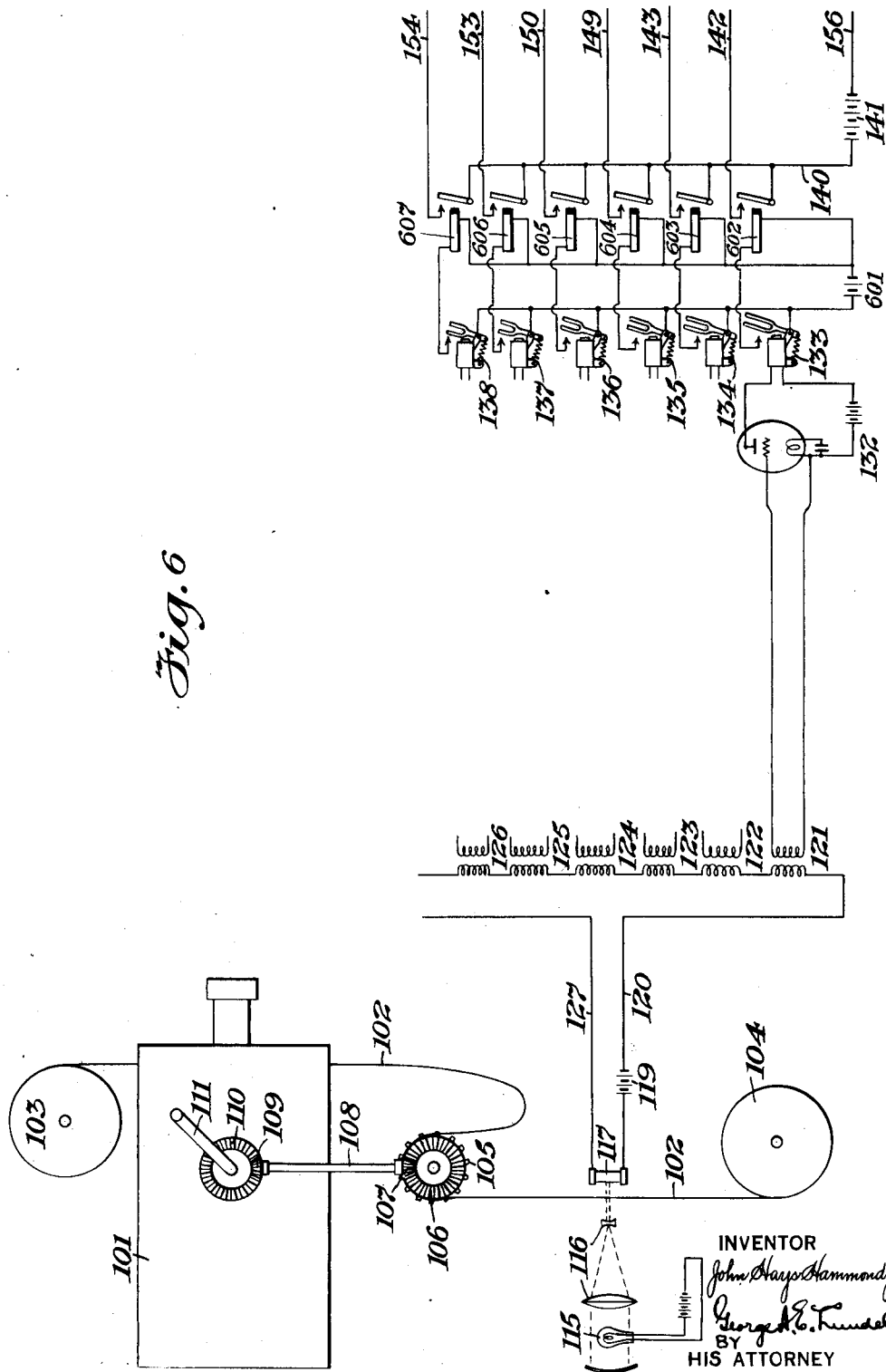
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PHOTO ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS

Filed April 14, 1924

6 Sheets-Sheet 6



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PHOTO-ELECTRIC CONTROL SYSTEM FOR PIPE ORGANS.

Application filed April 14, 1924. Serial No. 706,245.

Some of the objects of this invention are to provide means for playing an organ in synchronism with a moving picture film and to provide means for automatically impressing on a circuit a plurality of frequencies, the resultant of which causes a variation in the intensity of a beam of light which affects a photographic film, and to provide means for causing that portion of the photographic film which has been affected by the beam of light to reproduce the original frequencies which in turn operate a plurality of circuits; to provide means for causing a predetermined sequence of chords to be played on the organ when the moving picture film is accidentally broken; to provide means for automatically causing these chords to be played in the same key as the music was being played in, at the time that the film broke.

Other objects will appear from the following description taken in connection with the accompanying drawings in which

Figure 1 is a diagrammatic view of a system constructed so as to automatically produce a plurality of frequencies, the resultant of which affects the intensity of a beam of light which strikes a photographic film; Fig. 2 is a diagrammatic view of a system constructed so as to cause that portion of the photographic film which was affected by the beam of light to reproduce the original frequencies which operate a number of tuned circuits; Fig. 3 shows diagrammatically a tone chamber and a swell shutter; Fig. 4 is a diagrammatic view of a system constructed so as to produce the synchronous operation of a motion picture film and a roll of perforated paper for playing a pipe organ or other musical instrument; Fig. 5 is a modified form of the system of Fig. 2, arranged for playing chords should the film be broken, and for automatically selecting the same key as that of the music; and Figure 6 is a modified form of the structure of Figure 2.

Referring to the accompanying drawings, and principally to Figure 1, one embodiment of this invention comprises a control system 10, a relay mechanism 11, a plurality of vibrating systems 12, which are controlled by the relay system 11 and which operate a sensitive galvanometer 13 which controls a beam of light from a source of illumination 14 and projects it through a light varying means 15 onto a film 16 which is fed from a motion picture camera 17.

The control system 10 consists of two strips of perforated paper 21 and 22 which are wound upon rolls 23 and 24, 25 and 26 respectively. These strips of paper pass over tracker bars 26 and 27 which are provided with a plurality of holes 28. The rolls 24 and 26 are driven by any suitable means, not shown, such as that employed in standard player mechanisms for pianos, etc., thus causing the strips of paper 21 and 22 to be moved over the tracker bars 27 and 26 at a uniform rate. Any suitable system for synchronizing the motion of these paper strips may be used, for example, as that shown in my copending application, Serial No. 707,551, filed April 19, 1924.

The holes in the tracker bar 26 are connected by tubes 30 to the pneumatic relay mechanism 11 which may be of any well-known standard construction. When air is admitted to any one of the tubes 30 it will cause a circuit to be closed through the corresponding terminal 31, and thus current passes over conductors 32. The holes in the tracker bar 27 are connected by pipes 34 to the relay mechanism 11 and control the circuit from the terminals 35 through conductors 36, 37, 38, 39 and 40 respectively to the vibrating mechanisms 12. Each of these mechanisms consists of a magnet 43, one end of the windings of which is connected respectively to the conductors 40, 39, 38, 37, 36 and 32. The other ends of the windings are connected by a conductor 44 which is connected to one pole of the battery 45, the other pole of which is connected by a conductor 46 to the terminal 47 which in turn is connected to the common return of the relay mechanism 11. Each magnet 43 is provided with an armature 45' which is held in its retracted position, as shown by means of a spring 46', and a front contact with which the respective armature makes contact when in its operated position. The armature 45 is connected by a conductor 47 to one pole of a battery 48, the other pole of which is connected by a conductor 49 to one terminal of a coil 50, wound upon one leg of a tuning fork 51. The other terminal of the coil 50 is connected by a conductor 52 to a contact 53 which is engaged by the armature 45 when the magnet 43 is energized. The conductor 52 is connected by a branch conductor 55 to a microphone button 56 which in turn is connected to the other leg of the tuning fork. The base of the tuning fork 51 is connected by a conductor 60

to one end of a primary winding of the transformer 61, the other end of this winding being connected by a conductor 62 to the conductor 49. One end of the primary winding of the transformer 61 is connected to one end of a winding 63 wound around an armature 64. The other end of the winding 63 is connected by a conductor 65 to one terminal of a condenser 66, the other terminal of which is connected to one terminal of a primary winding of a transformer 67, the other terminal of the winding of which is connected to the primary winding of the transformer 61. One terminal of the secondary winding of the transformer 67 is connected by a conductor 70 to a conductor 71, and the other terminal of the secondary of the transformer 67 is connected by a conductor 72 to a conductor 73. The conductors 71 and 73 are connected to the coil of the sensitive galvanometer 13 which carries a small mirror 75. This mirror reflects the light from the light producing source 14, which consists of any suitable lamp 76, the rays of which pass through a lens system 77, to a screen 78 which is made of suitable transparent material and is constructed so that the amount of light which it allows to pass through it varies as the beam is shifted from one end to the other of the screen. The beam of light after leaving the screen 78 is focused by a lens 79 upon the moving picture film 16. As the mirror 75 is rotated from one extreme position to the other it will cause a variation in the intensity of the beam of light striking the photographic film from a maximum to a minimum depending upon the strength of current in the coil of the galvanometer 13. The film 16 is wound upon two rolls 81 and 82 and passes through the standard motion picture camera 17. To the crank 83 of the camera is secured a gear 84 which meshes with a second gear 85 which rotates about the axis 86. Secured to the gear 85 is a bevelled gear 87 which meshes with a bevelled pinion 88 rigidly secured to one end of the shaft 89. The other end of the shaft 89 carries a similar bevelled pinion 90 which meshes with a beveled gear 91 secured to a drum 92 provided with teeth 93 which engage suitable depressions in a second drum 94 between which passes the film 16.

Pivoted to the camera 17 is an arm 96 which carries at its lower end a drum 97 over which passes the film 16, and at its upper end is connected a spring 98, the other end of which is secured to a pin 99 fastened to the side of the camera 17.

The system shown in Fig. 2 consists of a standard type of motion picture projector 101 provided with a film 102 which is rolled upon spools 103 and 104 and passes over a toothed drum 105. This drum is provided with a beveled gear 106 which meshes with

a beveled pinion 107 secured to a shaft 108, the other end of which carries a similar beveled pinion 109, meshing with a beveled gear 110 rigidly secured to the crank 111 which operates the projector 101.

Located adjacent to the film 102 is a suitable source of illumination 115, the light from which is focused by means of a lens system 116 on to the film 102 on the other side of which is located a photo electric cell 117, one terminal of which is connected to a battery 119, the other terminal of which is connected by a conductor 120 to the primary windings of a plurality of transformers 121 to 126, etc. connected in series. The return circuit from these transformers includes a conductor 127 to the photo electric cell 117. The secondary windings of the transformers 121 to 126 are connected to suitable wave filters 130 which are inductively connected by transformers 131 to the input circuit of an amplifying system 132, the output circuits of which control relays 133 to 138, etc. The armatures of these relays are connected by conductors 140 to a battery 141. The relays 133 and 134 control circuits through conductors 142 and 143 extending to the terminals of a swell shutter motor 301, which controls the actions of the swell shutters of the organ. The swell shutters comprise a series of narrow strips 302 rigidly connected together in spaced parallel relation by strips 303, 304, 305. The strip 305 extends upwardly and is operatively connected with the swell shutter motor 301. A pair of spaced guides 306, 306, is provided for maintaining the strips 302 against the face of the chest. The strips 302 normally cover a corresponding plurality of slots such as 307. It will be seen that upon the actuation of the swell shutter motor 301, the slots 307 are uncovered. The shutter strips 302 are preferably faced with a layer of felt for deadening the sound. The relays 135 and 136 control circuits through conductors 149 and 150 extending to the primary note action 310 of the organ, and the notes are thus sounded when the respective circuits are closed. Similarly, relays 137 and 138 control circuits through conductors 153 and 154 which are connected to the primary stop action 311 of the organ, to control the operation of the various stops of the organ. The return current from all these circuits includes a common conductor 156 to the battery 141.

It will be understood that in practice a sufficient number of sets of band filters, amplifying circuits relays, etc. each duplicates of those shown by way of illustration, will be provided to control all the circuits of the swell pedal, keys and stop action of the organ.

In the operation of the form of the invention shown in Figures 1, 2 and 3 the paper strips 21 and 22 are first cut, or perforated.

so as to produce the desired music, the notes, for example, being cut on the strip 22 and the control of the stop action, swell shutters, etc. cut on the roll 21 (as shown in my co-pending application hereinbefore referred to). As these paper strips pass over the tracker bars 26 and 27 they will allow air to enter the pipes 30 and 34 whenever a perforation in the paper comes opposite a hole in the tracker bar. This will operate the relay mechanism 11 to close the corresponding circuit through the conductors 32, 36, 37, 38, 39 and 40 as the case may be. Suppose, for example, that the circuit is closed through the conductor 40, thus energizing the magnet 43 which places the field magnetizing coil 50 across the battery 48 which is also thrown across the primary of the input transformer 61 and in series with the microphone buttons 56. This causes the tuning fork 51 to vibrate at its natural frequency which sets up oscillations in the resonant circuit composed of the coil 63, condenser 66 and the primary of the transformer 67, and the secondary of the transformer 61. This causes current of the frequency of the tuning fork 51 to be supplied to the conductors 71 and 73 from the secondary of the transformer 67. This current, passing through the coil of the sensitive galvanometer 13 causes the mirror 75 to vibrate at the same frequency as the tuning fork 51. If a circuit is closed through the conductor 39 a similar action will take place in the next audio oscillator, producing a current of a slightly different frequency from that produced by the tuning fork 51, as the tuning forks of the various vibrating systems 12 are tuned to slightly different frequencies so that each hole of the tracker bars 36 and 37 when exposed by the perforation in the paper will produce a frequency of a predetermined pitch in the circuit 71, 73 thus causing the mirror 75 of the sensitive galvanometer to vibrate at a frequency which is the resultant of all of the combined frequencies of the circuits which may be closed at any given instant. This resultant frequency causes the beam of light from the light source 76 to vibrate back and forth across the screen 78 thence through the lens 79 to a point on the film 16, the intensity of this light depending upon the place on the screen 78 through which the beam of light passes at that instant. The beam of light which strikes the film 16 will therefore be varied in intensity an amount proportional to the vibrations of the mirror 75, and therefore to the resultant frequency produced in the circuit 71, 73 so that there will be produced on the film a narrow strip, the transparency of which varies according to this resultant frequency.

The film 16 is moved past the point where the beam of light strikes it at a uniform

rate by rotation of the drum 92 which is driven by the gear train 84, 85, 87, 88, 90, 91 from the crank handle 83 of the motion picture camera 17. The film 16 will therefore move in synchronism with this handle, which is turned manually at a uniform rate by the operator, taking the picture. As the film 16 is fed out of the camera 17 intermittently the drum 70 is provided for taking up this slack so that the film will be fed continually between the rolls 92 and 94.

In this manner a picture and the record from the beam of light are impressed on the film synchronously, the operator controlling the motion of the paper strips 21 and 22 being able to control the motion of these music rolls 21 and 22 so that they will be in exact synchronism with the taking of the moving picture, this being necessary so as to produce the desired effect when the picture is to be shown at any theatre at any future time.

When the film is put into the projector 101 it is fed from the roll 103 in an intermittent manner by the operation of the crank 111. This crank by means of the gear train 110, 109, 107 and 106 causes the uniform rotation of the drum 105. This feeds the film 102 at a uniform rate in front of the beam of light produced by the light source 115, this beam of light being focused upon the narrow strip on the film containing the record produced by the beam of light reflected from the mirror 75. The amount of light which is allowed to pass through the film 102 will be proportional to the light passed through the screen 78, and therefore proportional to the position of the mirror 75. This light falling upon the photo electric cell 117 will produce a variation in current passing through this cell which will be similar to the current passing in the coil of the galvanometer 13 and therefore the resultant current produced by the vibrating systems 12. This modulating current is then fed through the primary windings of the transformers 122 to 126 and acts upon the wave filters 130. These filters operate so as to select out definite frequencies, for example, the filter shown at 130 could be tuned to the frequency of the tuning fork 51 and the successive wave filters tuned to the frequencies of the successive tuning forks. In this way if a certain perforation in the paper strip passes over a hole in the tracker bar it will have impressed upon the sensitive film a variation in light intensity proportional to the frequency of the corresponding tuning fork, and when this film passes in front of the photo electric cell it will set up corresponding vibrations which will be selected out by the proper wave filter and will operate the corresponding relay, for each hole in the tracker bar will correspond to one of the relays 133, 134 etc. which control the swell shutters, notes and stop action of

the pipe organ. In this way when the film is passed through the motion picture projector it will cause certain of the relays to be operated so as to reproduce the music cut on the paper strips 21 and 22 and will thus keep the playing of the organ in synchronism with the showing of the film.

The modified form of this invention shown in Fig. 4 of the drawings, comprises a player mechanism 160, a driving means 161 for operating the player mechanism, a control means 162 for controlling the operation of the driving means 161 and a moving picture projector 163 for projecting the pictures, and also for co-operating with the control mechanism 162 for controlling the driving means 161.

The player mechanism 160 consists of two rolls 165 and 166 mounted for rotation in a frame work 167. Wound upon the rolls 165 and 166 is a strip of perforated paper 168, the perforations of which control the playing of a pipe organ in a well-known manner. At the right hand edge of the paper strip 168 is a row of perforations 170 which at suitable times pass in front of a hole 171 located in a tracker bar 172. The hole 171 is connected by a pipe 173 to a primary pneumatic 174, which when the hole is open to the atmosphere, closes a circuit between two terminals 175 and 176.

The roll 166 is provided with a shaft 178 to the end of which is secured a bevelled gear 179 meshing with a bevelled pinion 180 which is loosely mounted on an arm 180' which is carried by the shaft of a motor 181. The bevelled pinion 180 in turn meshes with a bevelled gear 182 which is carried by the shaft of an electrical repeater 183 which may be of any well-known and standard construction. The shaft of the repeater 183 is hollow so that the shaft of the motor 181 may freely pass through it. The ends of field windings of the motor 181 are connected to terminals 185 and 186, and the armature brushes are connected to terminals 187 and 188. The terminal 185 is connected by a conductor 190 to one pole of a battery 191, the other pole of which is connected by a conductor 192 to the terminal 186. The terminal 187 is connected by a conductor 193 to the righthand armature of a relay 194. The left hand armature of the relay 194 is connected by a conductor 195 to the terminal 188. The conductor 193 is connected by a conductor 196 to one armature of a double relay 197, the other armature of which is connected by a conductor 198 to the conductor 195. The armatures of the relays 194 and 197 are held in the position shown when the relays are de-energized by means of springs 200 and 201, respectively. A conductor 202 interconnects the back contacts of the left hand armatures of the relays 194 and 197.

The control mechanism 162 consists of two solenoids 203 and 204 which are provided with cores 205 and 206, the lower ends of which are connected to plungers in suitable dash pots 207 and 208 which are of such construction that they allow the plungers to move downward rapidly and upward slowly. Secured to the upper ends of the cores 205 and 206 are cross arms 209 and 210. These cross arms are held in their retracted positions as shown by means of springs 211 and 212. Engaging the arm 209 are three contacts 215, 216 and 217, and engaging the arm 210 are three contacts 218, 219 and 220. When the arm 209 is moved to its lowest position it engages two contacts 222 and 223 and when the arm 210 is in its lowest position it engages two contacts 224 and 225. The contacts 217 and 224 are connected together by the conductor 226, and the contacts 218 and 223 are connected together by a conductor 227. The contacts 216 and 219 are connected together by a conductor 228 and to one pole of a battery 229. The contact 215 is connected by a conductor 230 to one end of a winding of the solenoid 231, the other end of said winding being connected by a conductor 232 to the battery 229. The contact 220 is connected by a conductor 233 to one terminal of a winding of the solenoid 234, the other end of the winding of which is connected by a conductor 235 to the battery 229. The solenoids 231 and 234 are provided with movable cores 237 and 239 arranged so that when the respective solenoid is energized each catches the respective arm 210 or 209. The cores 237 and 239 are provided with springs 240 and 241 respectively which move them out of engagement with the arms when the solenoids are de-energized. The contact 222 is connected by a conductor 243 to one end of the winding of the relay 197, the other end of the winding of which is connected by a conductor 244 to the conductor 232. The contact 225 is connected by a conductor 245 to one end of the winding of the relay 194, the other end of which is connected by a conductor 246 to the conductor 244.

One end of the winding of the solenoid 203 is connected by a conductor 250 to the terminal 175. The terminal 176 is connected by a conductor 251 to one pole of a battery 252, the other pole of which is connected by the conductor 253 to the other end of the winding of the solenoid 203. One end of the winding of the solenoid 204 is connected by a conductor 254 to the conductor 253. The other end of the winding of this solenoid is connected by a conductor 255 to a brush 256 located on a strip of insulation 257 secured to the side of the moving picture projector 163.

Secured to the strip of insulation 257 is a second brush 258 which is connected by a

conductor 259 to the conductor 251. The brushes 256 and 258 press against a disc of insulating material 261 secured to the handle 262 of the moving picture machine. Inlaid in the insulation 261 is a segment of conducting material 263 which intermittently closes the circuit between the brushes 256 and 258. Rigidly secured to the outside of the disc of insulation 261 is a bevelled gear 265 which meshes with a bevelled pinion 266 secured to the shaft 267 of an electric motion transmitter 268. The transmitter 268 is connected by a four-wire cable 269, shown schematically, to the repeater 283. Inserted in one of the wires of this cable is a battery 270.

In the operation of the form of the invention shown in Fig. 4, the paper strip 168 is set in an initial point at the time the film in the motion picture projector 163 is at its starting place. As the handle 262 is turned by the operator to cause the motion picture to be projected upon the screen it will rotate the shaft 267 of the transmitter 268 which will transmit this motion to the repeater 183, thus driving the bevelled gear 182 and by means of the bevelled pinion 180 the bevelled gear 179. This causes the shaft 178 to be rotated, thus winding up the strip of perforated paper 169 on the roll 166. The speed at which the roll 166 is turned will therefore be proportional to the speed with which the handle 262 is rotated so that the film in the motion picture camera and the paper strip 268 will be moving in synchronism. Due, however, to the stretching of the paper and other inequalities in the mechanism it is probable that the paper strip 168 will start to run slightly faster or slightly slower than the proper rate to keep in synchronism with the motion picture film. If the paper strip 168 is moving at its proper rate a perforation 170 will come opposite the hole 171 at the same time that the contact segment 263 closes the circuit between the brushes 256 and 258. This will close the circuit from the battery 252 through the conductor 259, brush 258, segment 263, brush 256, along conductor 255 through solenoid 204 back to the battery 252 at the same time that the circuit is closed from this battery through the conductor 251, primary pneumatic 174, conductor 250, solenoid 203, back to the battery 252. These two solenoids will then be energized simultaneously thus pulling down the two arms 209 and 210 at the same instant, and since contacts 216 and 219 are opened the circuits of the relays 194 and 197 are opened, and these relays cannot be energized to cause the speed of the driving mechanism to be modified. As soon as these arms move down from the position shown they will break the circuits through the two solenoids 234 and 231, thus allowing the springs 241 and 240 to move the cores outwardly so that when the solenoids 203 and 204 are de-energized by the paper strip 168 moving over the hole 171 and the segment 263 moving out of engagement with a brush 258, the arms 209 and 210 will be allowed to move upwardly under the action of the springs 211 and 212, retarded by the dash pots 207 and 208 until they will have assumed their initial positions as shown in Fig. 4 at which time the solenoids 234 and 231 will be again energized, moving their cores into the position shown in Fig. 4.

If the paper strip 168 should be moving slightly faster than its proper rate one of the perforations 170 will come opposite the hole 171 before the segment 163 closes the circuit between the brushes 258 and 256. This will cause the solenoid 203 to be energized while 204 remains de-energized, thus pulling down the arm 209 which snaps by the score 239 of the solenoid 234 and is held in its lower-most position, closing the circuit between contacts 223 and 222, thus allowing current to pass from the battery 229 through conductor 228, arm 210, conductor 227, arm 209, conductor 243, relay 197, conductor 244, back to the battery 229, thus energizing the relay 197 which attracts its armatures. This closes the circuit from the battery 191 to the armature terminals 187 and 188, thus causing the motor 181 to be rotated in such a manner as to cause the pinion 180 to be revolved about the axis of the motor 181 in the same direction as the bevelled gear 182 which will slow down the motion of the bevelled gear 179 and therefore slow down the motion of the roll 166. This will continue until the segment 263 has engaged the brushes 258 and 256 which will energize the solenoid 204, pulling down its arm 210. This will break the circuit through the magnet 197 and also through the solenoid 234, whose core will be moved to the left, thus releasing the arm 209 which will move upward under the action of the spring 211, this motion being retarded by the dash pot 207 until it reaches its uppermost position. Before the arm 209 reaches its uppermost position the segment 263 will have moved out of engagement with the contacts 256 and 258, thus deenergizing the solenoid 204 which will allow the arm 210 to move upward under the action of the spring 212, this motion being slowed down by the dash pot 208. The core 237 of the solenoid 231 will not have engaged the arm 210, as the circuit through this solenoid will be open due to the arm 209 being out of engagement with the contact 215. The arm 210 will continue upward until it reaches the position shown in Fig. 3, at which time the mechanism is again set in its initial position, and should the paper strip 168 be again slightly in advance of its proper position this action will be repeated.

If the paper strip 168 should be moving

slightly slower than its proper rate the contact 263 will close the circuit through the solenoid 204 before the perforation 170 closes the circuit through the solenoid 203. This will cause the arm 210 to be moved downward until it engages the contacts 224 and 225. It will be held in this position by the core 237 of the solenoid 231 and will cause the relay 194 to be energized, thus closing the circuits from the battery 191 to the armature terminals 188 and 187 which will reverse the direction of current in the armature, and causing the motor 181 to be rotated in the opposite direction so as to tend to increase the speed of the bevelled gear 179, thus increasing the speed of the paper strip 168 so as to bring it up to its proper position. This continues until the perforation 170 has caused the solenoid 203 to be energized which pulls down the arm 209, thus breaking the circuit through the relay 194, thus stopping the motor 181. The two arms 210 and 209 then return to their initial positions as previously described.

When the two relays 194 and 197 are de-energized their left-hand armatures are connected together by means of the conductor 202, thus short circuiting the armature of the motor 181 which will tend to hold the arm 180' in a fixed position so as not to affect the differential gears 182 and 179, thus allowing the repeater 183 to transmit its motion without change of speed to the shaft 178.

It will be seen from the foregoing description that if the paper strip 168 is running at its proper speed both solenoids 203 and 204 will be energized simultaneously and no modification will be effected by the differential 182, 180, and 179. If, however, the paper strip is running faster than its proper speed this differential will tend to slow down its motion and the time during which the differential is made effective will be determined by the interval of time between the moment that the circuit is closed by the primary action 174 due to a perforation 170 passing in front of hole 171, and the moment at which the segment 263 closes the circuit between the contacts 256 and 258.

The time which the differential acts is therefore proportional to the amount that the paper strip 168 is either ahead or behind its proper position which will thus tend to bring it rapidly into synchronism with the film of the moving picture projector 163.

Figure 5 shows the same mechanism as that depicted in Fig. 2 with the addition of the necessary apparatus for producing a series of musical chords or other tones in the same key as the music, if the film is inadvertently broken. This additional apparatus consists of a plurality of transformers 501, 502, 503, etc., the primary windings of which are in series with the primary wind-

ings of the transformers 121, 122, etc. The secondary windings of the transformers 501, 502, 503, etc., are connected to suitable wave filters which control relays 505, 506, 507, etc. in a manner similar to that described in connection with the circuit 130, 131 and 132. The relays 505, 506, 507, etc., control the operation of the solenoids 510, 511, 512, etc. The return circuit from these solenoids includes a conductor 515 which is connected to one end of the winding of a solenoid 516 the other end of the winding of which is connected to one pole of a battery 517, the other pole of which is connected by a conductor 518 to the armatures of the relays 505, 506, 507, etc.

Located adjacent to the solenoids 510, 511, 512, etc. is a slidable frame 520 which may move freely in a transverse direction on a stationary frame work 523. Mounted on the stationary frame work 523 is a pneumatic cylinder 525, the supply of air to which is controlled by a valve 526 operated by the solenoid 516. The valve 526 is connected by a pipe 527 to a supply of air under pressure (not shown). Slidably mounted in the cylinder 525 is a piston 530 which is connected to one end of a piston rod 531 the other end of which is secured to the sliding frame 520. Located in the cylinder 525 is a coiled spring 531 which tends to move the piston 530 and the frame 520 to the left. Mounted upon the sliding frame 520 are two spools 532 and 533 over which passes a strip of perforated paper 534. The shaft which carries the lower spool 533 is provided with an extension 535, the left-hand end of which is squared and fits snugly but slidably in a collar 536 which is carried by the shaft of a motor 537 which is mounted on the frame work 523 and which is driven by a battery 538, the circuit of which is controlled by one side of a double pole switch 539. Rigidly mounted in the fixed frame work 523 is a tracker bar 540 provided with a plurality of holes 541 which are connected by tubes 542 to a relay mechanism 545 which controls the flow of current to a plurality of conductors 546, 547, 548, etc., which are connected to the conductors 154, 150 and 143, respectively. The return current from the relay mechanism 545 passes along a conductor 550 and by a flexible conductor 552 to a contact 553 mounted on a block of insulation 554. A contact 555 is also mounted on the insulation 554 and is connected by a flexible conductor 556 to one pole of the double pole switch 539 the other side of which is connected by a conductor 558 to the conductor 140.

The cores of the solenoids 510, 511, 512, etc., are provided at their upper ends with a segment of conducting material 560 which is insulated from the core by a strip of insulation 561. When the solenoids are energized the segments 560 are moved up into the

path of the contacts 553 and 555. The cores are normally held in the position shown by springs 562.

In the transmitting apparatus shown in Fig. 1 a certain group of holes on the tracker bar 27 are used for denoting the key in which the music is being played, so that when the music is being played in a given key, for example, that of G, the group of perforations in the paper strip 22 will continuously uncover the hole in the tracker bar 27 which will operate the relay, mechanism 11 to cause a given vibrating system 12, to be set in action, thus producing a given frequency of vibration which as previously described is combined with the other vibrations produced to form the curve on the film 16. For each key in which the music may be played there will be a given frequency which will be produced when the music is played in that key.

When the film is run through the motion picture projector 101, the curve will cause the proper circuit to be energized which in turn will close the proper relay of which, for example, is 505. This will close the circuit through the solenoid 510, thus causing its core to be lifted and at the same time current will pass through the conductor 515 and energize the solenoid 516, thus allowing air to enter the cylinder 525 which will cause the piston 530 to be moved to the right, thus shifting the sliding frame work 520 to the right until the contacts 553 and 555 engage the segment 560 of the solenoid 510, thus stopping the motion of the sliding frame 520. In this position, the sliding frame will be so located that the music which is cut in the paper strip 534 will be played in the key G. As long as the switch 539 is open, however, this music can not be played as the relay mechanism 545 will be inoperative. If the moving picture film 102 should break, the operator will immediately close the switch 539 which will thus throw in the relay mechanism 545 and the organ will be played from the paper strip 534 in a similar manner as that described in Fig. 2.

When the film has been repaired, and the machine started in operation again, the operator will open the switch 539, thus disconnecting the relay mechanism 545 which will stop the playing of the organ from the paper strip 534 and will allow it to be played again from the film 102 as already described.

If the key in which the music is being played is changed the relay 505 will be de-energized thus breaking the circuit through the solenoids 510 and 516. This will shut off the supply of air to the cylinder 525 and will allow it to exhaust to the atmosphere. The spring 531 will then return the sliding frame 520 to its initial position at the left. As soon as another relay, such for example, 507 is energized, denoting that the music is

played in another key, say for example the key of C, the solenoids 512 and 516 will be energized and the frame work 520 will be moved, as previously described, into a position which will cause the music to be played in the key of C.

In the construction of the form of the invention shown in Figure 5 the paper strip 534 is made of sufficient width so that when it is in any of the playing positions its edges will entirely cover the row of holes 541 so that these holes will only be exposed when perforations in the paper 534 come in front of them.

It is evident that this modified form of the invention may be so constructed that the frame 520 is stationary, and that the tracker bar 540 may be made movable by connecting it to the piston rod 531 and by locating the contacts 551 and 555 upon the tracker bar, and placing the solenoids 510, 511 and 512 etc. in a suitable position. If this were done it would be necessary to make the tubes 542 of some flexible material such as rubber tubing.

The system shown in Figure 6 is a modified form of the system of Figure 2 and comprises a standard type of motion picture projector 101 provided with a film 102 which is rolled upon spools 103 and 104 and passes over a toothed drum 105. This drum is provided with a bevelled gear 106 which meshes with a bevelled pinion 107 secured to a shaft 108, the other end of which carries a similar bevelled pinion 109, meshing with a bevelled gear 110 rigidly secured to the crank 111 which operates the projector 101.

Located adjacent to the film 102 is a suitable source of illumination 115, the light from which is focused by means of a lens system 116 on the film 102 on the other side of which is located a photo electric cell 117, one terminal of which is connected to a battery 119, the other terminal of which is connected by a conductor 120 to the primary windings of a plurality of transformers 121 to 126, etc. connected in series. The return circuit from these transformers includes a conductor 127 to the photo electric cell 117. The secondary windings of the transformers 121 to 126 are connected to the input circuits of an amplifying system 132, the output circuits of which control relays 133 to 138, etc. The armatures of these relays are connected together and to one pole of a battery 601, the opposite pole of which is connected to the windings of a plurality of relays 602 to 607, etc., the same in number as the relays 133 to 138. Each of the windings of the relays 602 to 607, etc., is connected by means of an individual conductor to a front contact of a relay on the train of relays 133 to 138, etc., and thus the relay 602 is controlled by the relay 133, relay 603 by relay 134, relay 604 by relay 135, relay 605 by relay 136, relay

606 by relay 137, and relay 607 by relay 138, respectively. The relays 133 to 138, etc. are of the so-called harmonic type relay, and are provided with weighted or mechanically
 5 tuned armatures each tuned to a different period of vibration. The armature operated only when the respective relay winding is energized by a current having substantially the same periodicity.

10 Each of the relays 602 to 607, etc. is provided upon its core with a copper slug whereby the said relays are caused to be slow releasing. Consequently, when any of the said relays is operated due to the energiza-
 15 tion of its respective tuned relay of the train 133 to 138, etc., it will not respond to momentary interruptions of its circuit caused by vibrations of the tuned relay armature, but will maintain its own armature in the
 20 operated position independent of such vibrations or fluctuations. The relays 602 and 603 control circuits through conductors 142 and 143 extending to the terminals of a swell shutter motor 301 which controls the
 25 actions of the swell shutters of the organ in a manner hereinbefore described. The swell shutters are controlled by relays 604, 605 in a manner already described, and similarly the primary stop action 11 is controlled
 30 by relays 606 and 607 over conductors 153 and 154 as has been described.

It will be understood that in practice a sufficient number of sets of band filters, amplifying circuits, relays, etc. each duplicates
 35 of those shown by way of illustration, will be provided to control all the circuits of the swell pedals, keys and stop action of the organ.

The structure of Figure 6 may be employed in connection with that of Figure 3
 40 in the same manner as was Figure 2 previously described, the figures being arranged with Figure 6 immediately to the left of Figure 3. In the operation of a system including Figures 6 and 3, the film having
 45 been prepared by means of the apparatus of Figure 1 as has been described, the film is put into the projector 101 and it is fed from the roll 103 in an intermittent manner by
 50 the operation of the crank 111. This crank by means of the gear train 110, 109, 107 and 106 causes the uniform rotation of the drum 105. This feeds the film 102 at a uniform
 55 rate in front of the beam of light produced by the light source 115, this beam of light being focused upon the narrow strip on the film containing the record produced by the beam of light reflected from the mirror 75. The amount of light which is allowed to pass
 60 through the film 102 will be proportional to the light passed through the screens 78, and therefore proportional to the position of the mirror 75. This light falling upon the photo electric cell 117 will produce a variation in
 65 current passing through this cell which will

be similar to the current passing in the coil of the galvanometer 13 and therefore the resultant current produced by the vibrating
 systems 12. This modulating current is then fed through the primary windings of the
 70 transformers 122 to 126 and acts upon the respective tuned relay of the relay train 133 to 138, etc., through the associated amplifier such as 132. These tuned relays respond
 75 only to predetermined frequencies in each case and in the present instance are each tuned to one of the frequencies of the tuning forks employed in the vibrating systems 12 of Figure 1. For example, the relay 133 is
 80 preferably tuned to the frequency of the tuning fork 51 of Figure 1 and the successive relays of the group of tuned relays tuned to the frequencies of the successive tuning forks. In this way if a certain perforation in the paper strip passes over a
 85 hole in the tracker bar it will have impressed upon the sensitive film a variation in light intensity proportional to the frequency of the corresponding tuning fork, and when this film passes in front of the photo electric
 90 cell it will set up corresponding vibrations which will be selected out by the proper wave filter and will operate the corresponding relay, for each hole in the tracker bar will
 95 correspond to one of the relays 133, 134, etc. which by means of the associated slowly releasing relays 602, 603, etc., control the swell shutters, notes and stop action of the pipe organ. In this way when the film is passed
 100 through the motion picture projector it will cause certain of the relays to be operated so as to reproduce the music cut on the paper strips 21 and 22 and will thus keep the playing of the organ in synchronism with the
 105 showing of the film.

While I have shown and described and have pointed out in the annexed claims certain novel features of my invention, 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 my invention.

Having thus described my invention, what I claim is:—

1. The method of producing music which consists in registering photographically on a film a series of light waves of varying intensity according to the music to be played,
 126 transmitting through such film a beam of light so as to effect a photosensitive cell, producing thereby a series of electrical oscillations of predetermined frequency, producing independently thereof a musical tone,
 125 and controlling the emission of the musical tone by said electrical oscillations.

2. The method of producing music which consists in registering photographically on
 130 a film a series of light waves of varying in-

tensity according to the music to be played, transmitting through such film a beam of light so as to effect a photosensitive cell, producing thereby a series of electrical oscillations of predetermined frequency, producing independently thereof a musical tone of a relatively different frequency, and controlling the emission of the musical tone by said electrical oscillations.

3. In a musical instrument, the combination of means for registering on a sensitive photographic film a series of light waves of varying intensity according to the music to be played, means for transmitting through said film a beam of light, a photo-sensitive cell responsive to variations in intensity of said transmitted beam of light, means for producing a plurality of sounds selectively, a circuit controlled by said photo-sensitive cell, said circuit including a plurality of electrical filtering devices arranged to actuate said sound producing means respectively for controlling the production of sound, said electrical filtering devices being selectively responsive to electrical energy of predetermined frequency.

4. The method of producing sound which consists in registering photographically on a film a series of light waves of varying intensity according to the sound to be played, transmitting through such film a beam of light so as to effect a photosensitive cell, producing thereby a series of electrical oscillations of predetermined frequency, producing independently thereof a series of sounds, and controlling the emission of the sound by said electrical oscillations.

5. The method of producing sound which consists in registering photographically on a film a series of light waves of varying intensity according to the sound to be played, transmitting through such film a beam of light so as to effect a photosensitive cell, producing thereby a series of electrical oscillations of predetermined frequency, producing independently thereof a series of sounds of a relatively different frequency, and controlling the emission of the sound by said electrical oscillations.

6. A system of producing sound comprising means for producing light waves of varying intensity, a photo sensitive cell controlled by said waves, a circuit including said cell and controlled thereby to produce a series of electrical oscillations, and means including a source of sound having a pitch independent of the frequency of the variations in intensity of the light, said means being controlled by the electrical oscillations of predetermined frequency.

7. In an instrument for producing sound, the combination of an automatic music roll having perforations, pneumatic relay mechanism selectively controlled thereby, a plurality of sources of electrical oscillations of

relatively different frequency respectively controlled by said pneumatic relay mechanism, a mirror galvanometer actuated by said oscillations to control a beam of light, a light sensitive element in the path of said light beam, and means controlled by said light sensitive element to produce music in accordance with the perforations in said roll.

8. In an instrument for producing sound, the combination of an automatic music roll having perforations, pneumatic relay mechanism selectively controlled thereby, a plurality of sources of electrical oscillations of relatively different frequency respectively controlled by said pneumatic relay mechanism, a mirror galvanometer actuated by said oscillations to control a beam of light, a light sensitive element in the path of said light beam, an organ, and means controlled by said light sensitive element to actuate said organ in accordance with the perforations in said roll.

9. In a sound recording system, the combination of an automatic music roll having perforations, a plurality of pneumatic relays selectively controlled thereby, a corresponding plurality of sources of electrical oscillations of relatively different frequency controlled by said pneumatic relays respectively, a mirror galvanometer actuated by said oscillations to control a beam of light, a light sensitive element in the path of said light beam, a musical instrument, and means controlled by said light sensitive element to actuate the musical instrument in accordance with the perforations in said roll.

10. In an instrument for producing sound, the combination of an automatic music roll having perforations, pneumatic relay mechanism selectively controlled thereby, a plurality of sources of electrical oscillations of relatively different frequency respectively controlled by said pneumatic relay mechanism, a mirror galvanometer actuated by said oscillations to control a beam of light, a light sensitive element in the path of said light beam, and means controlled by said light sensitive element to produce music in accordance with the perforations in said roll.

11. In a sound recording system, the combination with sound recording means including an automatic music roll having perforations, a plurality of pneumatic relays selectively controlled thereby, a corresponding plurality of sources of electrical oscillations of relatively different frequency controlled by said pneumatic relays respectively, a mirror to control a beam of light, a magnet actuated by said oscillations to operate the mirror, and a light sensitive element in the path of said light beam, of reproducing mechanism controlled by said light sensitive element including a plurality of electrical

filters each tuned to the frequency of one of said electrical oscillations respectively, an amplifier in the output of each of said filters, an electromagnetic device controlled by each of said amplifiers, and a plurality of organ actions controlled by said relays respectively.

12. In a sound recording and reproducing system, the combination with means for recording a musical composition on a photographic film, of reproducing mechanism including a source of musical sound of predetermined pitch and light sensitive means controlled by said film arranged to control the operation of the sound source to reproduce the musical composition.

13. In a sound recording and reproducing system, the combination with means for recording a musical composition on a light sensitive recording film, of reproducing mechanism including an organ, means for transmitting a beam of light through the film on which the record is made, and means responsive to variations in intensity of said transmitted light beam to control the operation of said organ to reproduce the musical composition.

14. In a sound recording and reproducing system the combination with means for recording a musical composition written in a predetermined key of the musical scale, including means for modifying a photographic film to make the record, of producing mechanism including a source of musical sound, light sensitive means controlled by said film, and means actuated by said light sensitive means for causing the sound source to reproduce the musical composition in a relatively different key of the musical scale.

15. In a sound recording and reproducing system the combination with means for recording a musical composition written in a predetermined key of the musical scale, including means for modifying a photographic film to make the record, of producing mechanism including an organ, light sensitive means controlled by said film, and means actuated by said light sensitive means for causing the organ to reproduce the musical composition in a relatively different key of the musical scale.

16. Apparatus for recording music comprising a light sensitive element, a source of light, a mirror galvanometer arranged to control a beam of light emanating from said source so as to impinge upon said light sensitive element, a plurality of sources of oscillatory current for actuating said galvanometer, and means including a perforated music sheet for selectively controlling said sources of current.

17. Apparatus for recording music comprising a light sensitive element, a source of light, a mirror galvanometer arranged to control a beam of light from said source so as to impinge upon said light sensitive ele-

ment, a plurality of sources of oscillatory current for actuating said galvanometer, and means including a perforated music sheet for selectively rendering said sources of current effective.

18. Apparatus for recording music comprising a light sensitive element, a source of light, an electromagnet, light reflecting means controlled by said electromagnet and arranged to control a beam of light emanating from said source so as to impinge upon said light sensitive element, a plurality of sources of oscillatory current for actuating said electro-magnet, and means including a perforated music sheet for selectively controlling said source of current.

19. Apparatus for recording music comprising a light sensitive element, a source of light, an electromagnet, light reflecting means controlled by said electromagnet and arranged to control a beam of light emanating from said source so as to impinge upon said light sensitive element, a plurality of sources of oscillatory current for actuating said electromagnet, and means including a perforated music sheet for selectively rendering said sources of current effective.

20. Apparatus for recording music comprising in combination, a light sensitive element, a source of light, and means for variably impressing light emanating from said source upon the light sensitive element including a perforated music sheet, a plurality of pneumatic relays selectively controlled by said sheet and a corresponding plurality of sources of oscillatory current, each of said sources including a tuning fork, for actuating said impressing means.

21. Apparatus for recording music including a sensitized film, a source of light and means for variably impressing light emanating from said source upon the light sensitive element including a perforated music sheet, a plurality of pneumatic relays selectively controlled by said sheet, a corresponding plurality of sources of oscillatory current for actuating said impressing means, and a plurality of tuning forks for controlling the frequency of current produced by said sources respectively.

22. Apparatus for recording a musical composition including a paper roll having perforations corresponding to musical sounds required in the production of the composition, a plurality of sources of oscillatory currents of different frequencies respectively rendered effective by perforations in the note sheet respectively, means actuated by waves produced by said current for variably controlling light, and a light sensitive element arranged in the path of the controlled light for recording the light variations, the frequencies of said currents being independent of the wave frequency of the musical sounds recorded thereby.

23. Apparatus for the production of a musical composition including a light sensitive element having an image thereon, a source of light positioned to one side of said element, a photo electric cell on the opposite side of said element and responsive to variations in said image, a musical instrument, a player action for operating said instrument to produce musical sound in a desired key, and means selectively controlled by the photo electric cell for actuating said player action to select the key in which the music is to be played.

24. Apparatus for the production of a musical composition including a film having an image thereon, a source of light positioned to one side of said film, a photo electric cell on the opposite side of said film and responsive to variations in said image, a musical instrument, a player action for operating said instrument to produce music, and means controlled by the photo electric cell for moving said action into a desired active position.

25. In a sound reproducing system, a musical instrument, a source of varying light rays and means operable in response to variations in said light rays for controlling said instrument.

26. In a sound reproducing system, a musical instrument, a source of light rays, means for varying said light rays at different frequencies and means dependent upon the frequency of said variations for controlling the emission of said sound waves from said instrument.

27. In combination with a musical instrument a photographic film, means for control-

ling said instrument by the image on said film and means controlled by an interruption of said film for causing said musical instrument to produce a predetermined group of notes.

28. In combination with a musical instrument a remote control therefor comprising a photographic film and means responsive to a discontinuance of said film for causing a predetermined group of notes to be played by said instrument and means whereby said notes are selected in the same key as that of the music being played prior to such interruption.

29. In combination with a musical instrument a remote control therefor, means responsive to said remote control whereby said musical instrument is caused to play music in a predetermined key and means operable upon failure of said remote control for causing said musical instrument to play a sequence of notes in said key.

30. In combination with a musical instrument a remote control therefor, and means operable in response to abnormalities in said remote control for causing said instrument to continue playing preselected notes.

31. In combination with a musical instrument a remote control therefor, and means operable in response to abnormalities in said remote control for causing said instrument to continue playing preselected notes, said notes being in the same key as that played prior to such abnormality.

In testimony whereof I hereunto affix my signature.

JOHN HAYS HAMMOND, JR.