July 31, 1928. 1,678,872

R. K. POTTER

METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS

Filed Jan. 2, 1926 6 Sheets-Sheet 1

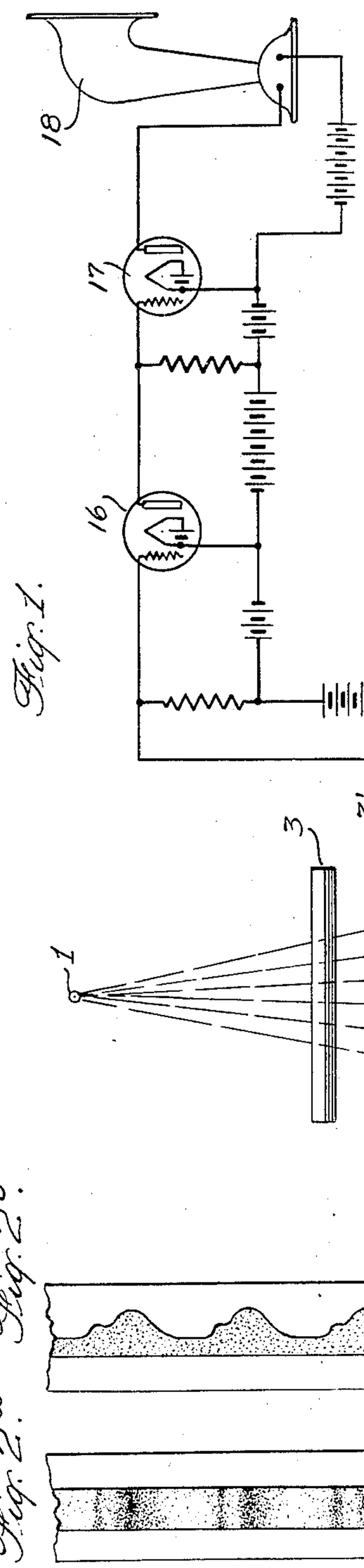

Fig. 1.

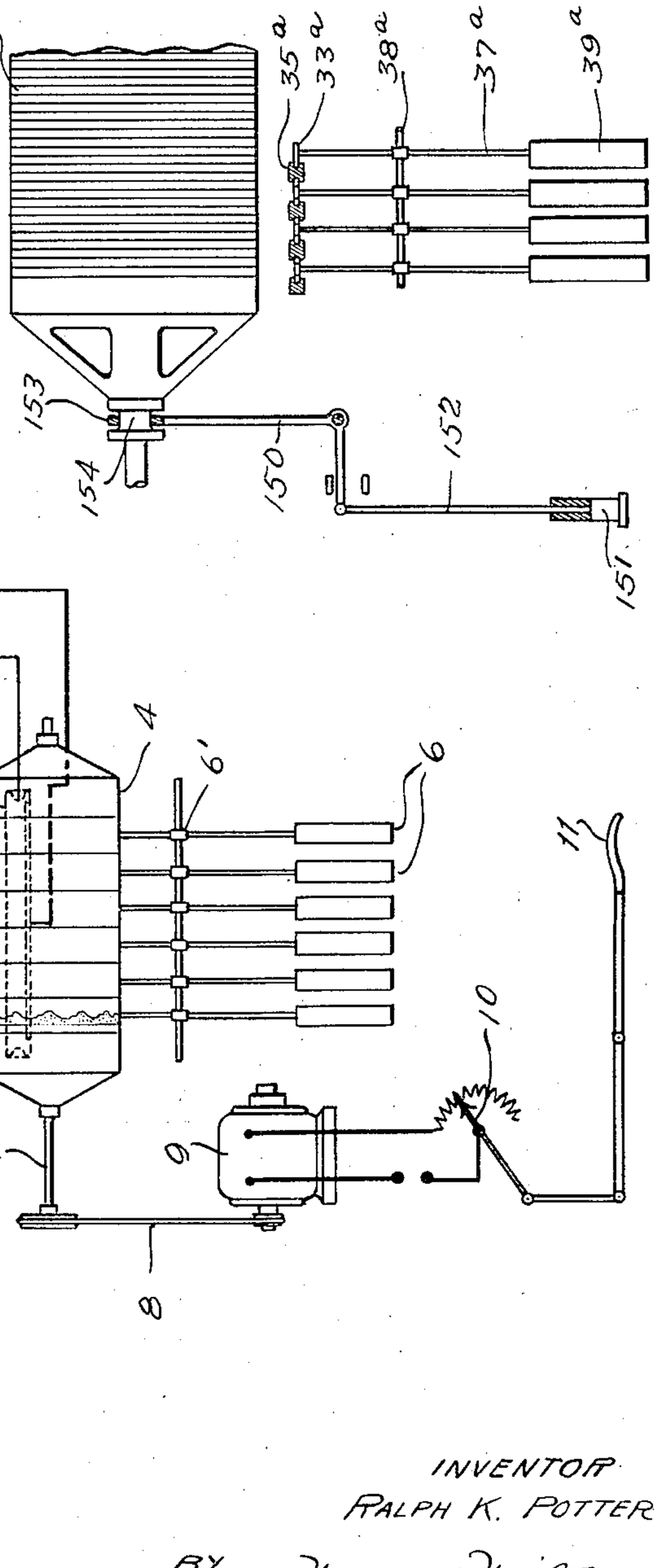

Fig. 4a

Fig. 2.

Fig. 2a.

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July 31, 1928. 1,678,872

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METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS

Filed Jan. 2, 1926 6 Sheets-Sheet 2

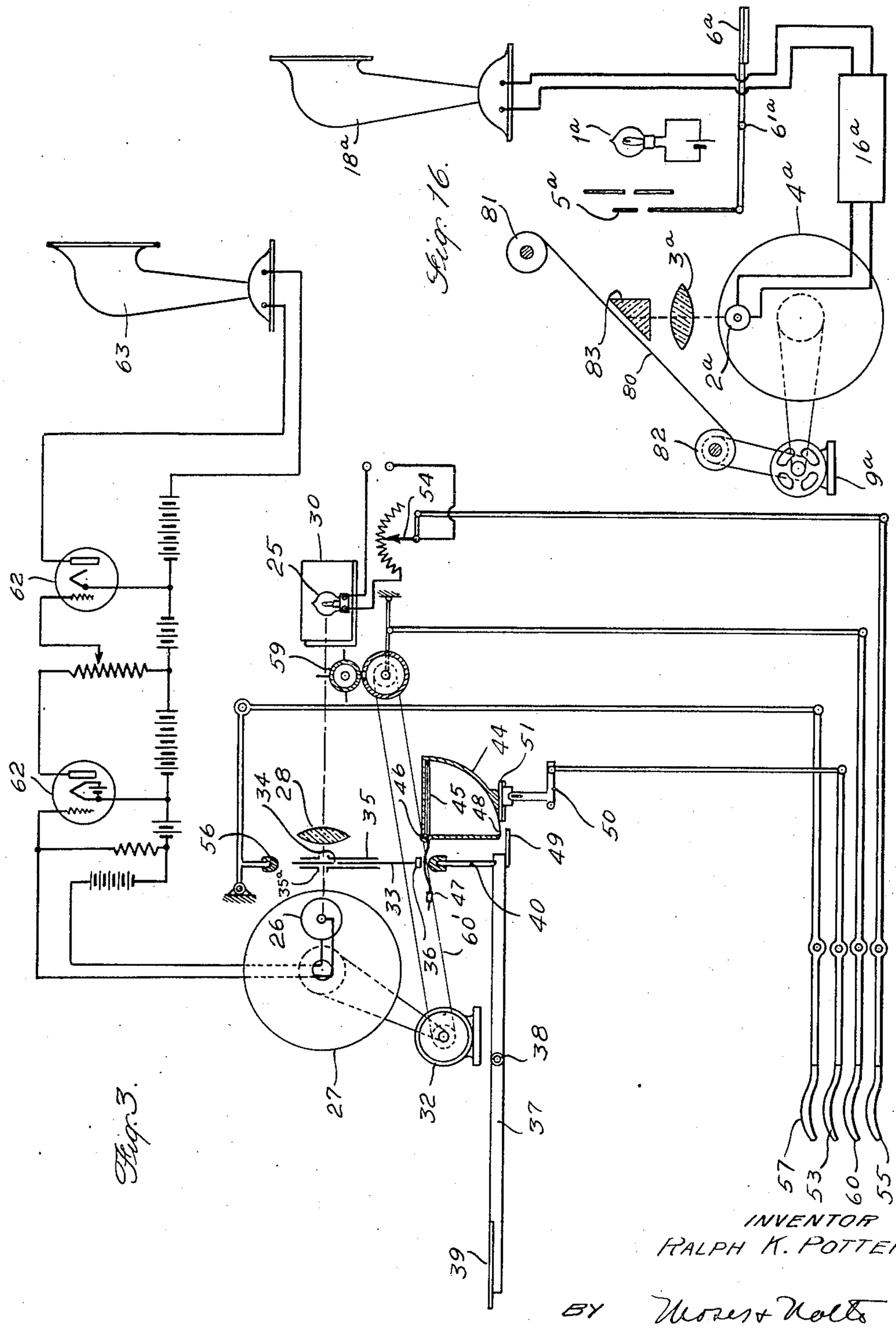

Fig. 3.

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July 31, 1928. 1,678,872

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METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS

Filed Jan. 2, 1926 6 Sheets-Sheet 3

Fig. 5b.

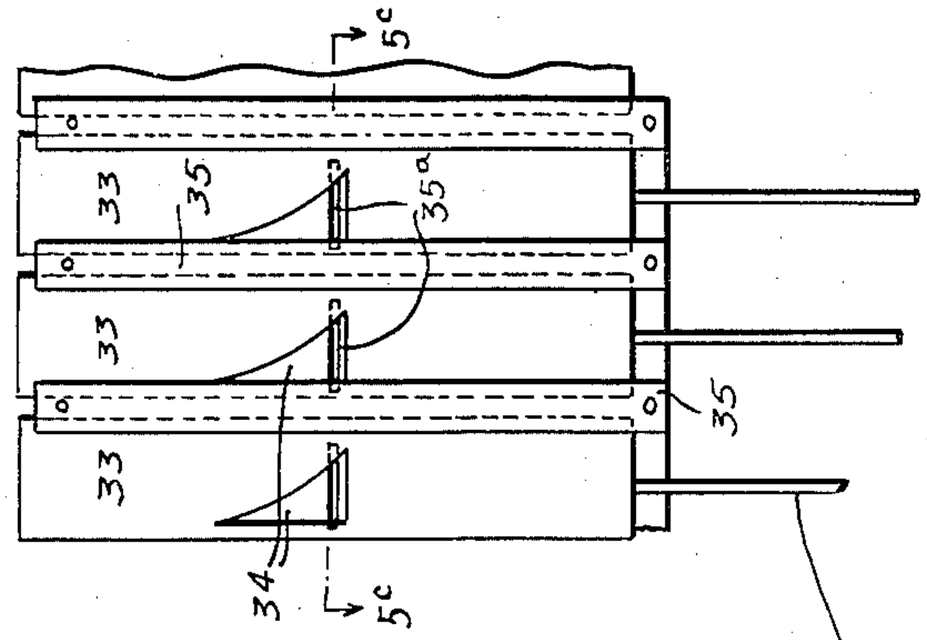
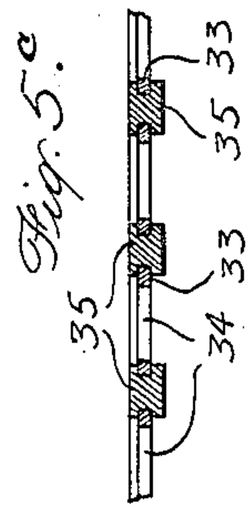


Fig. 5a.



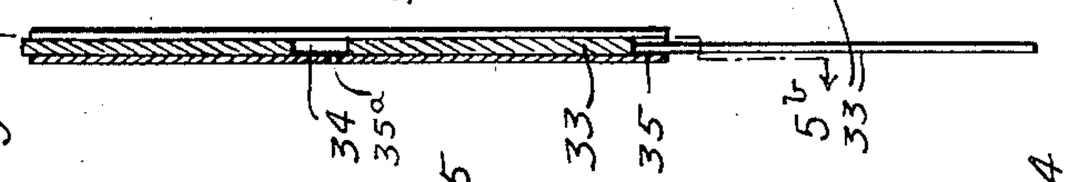
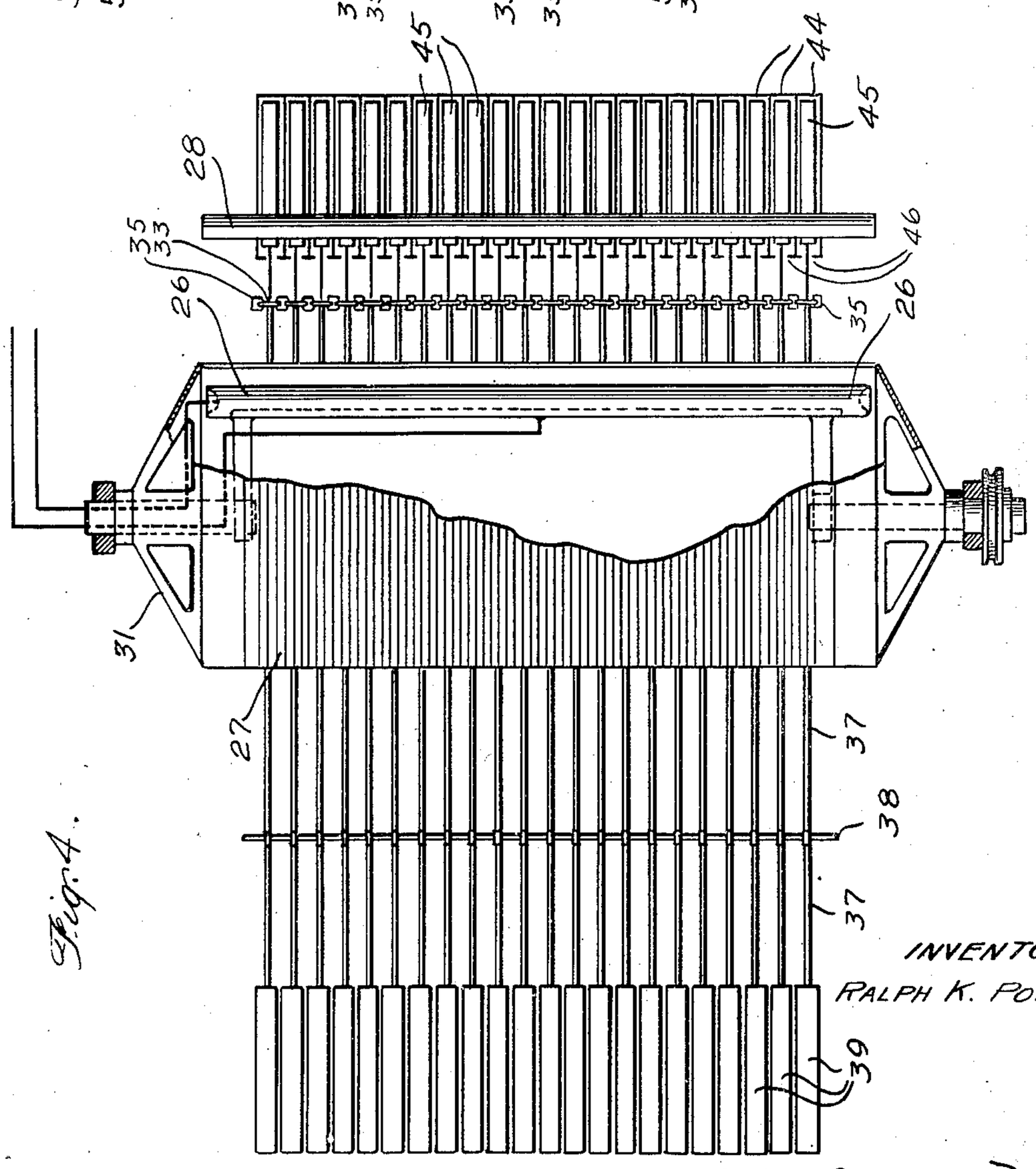


Fig. 4.



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July 31, 1928. 1,678,872

R. K. POTTER

METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS

Filed Jan. 2, 1926 6 Sheets-Sheet 4

Fig. 8.

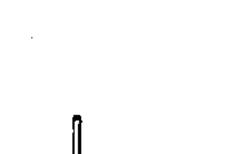

Fig. 7.

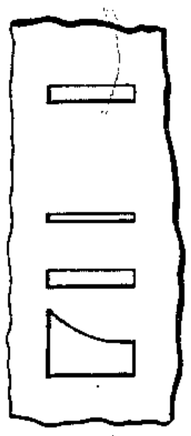

Fig. 12c.

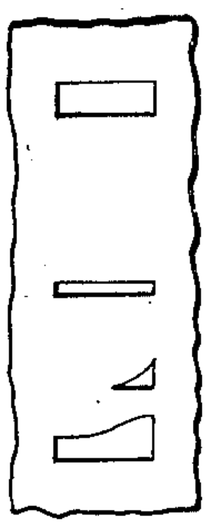

Fig. 12d.

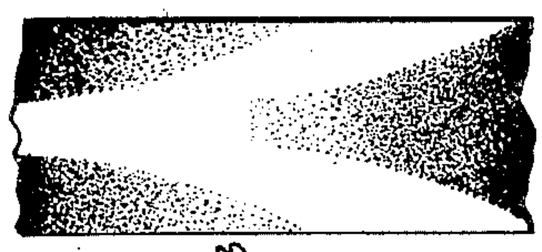

Fig. 12b.

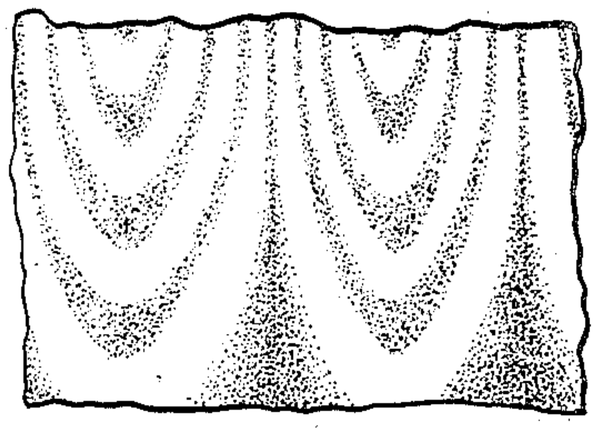

Fig. 11.

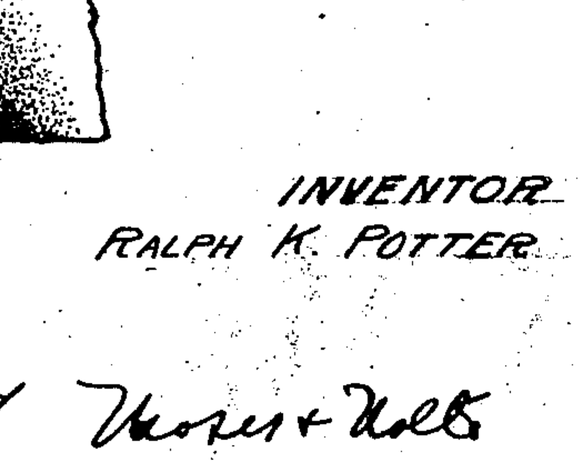

Fig. 12a.

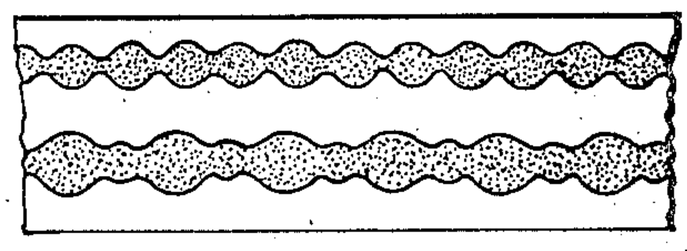

Fig. 10.

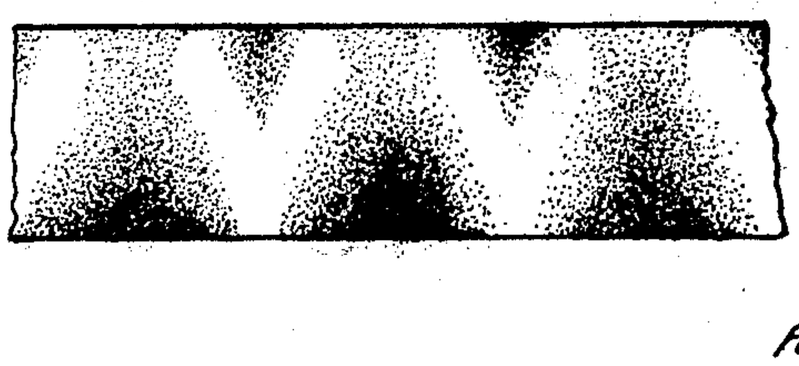

Fig. 9.

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July 31, 1928. 1,678,872

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METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS

Filed Jan. 2, 1926 6 Sheets-Sheet 5

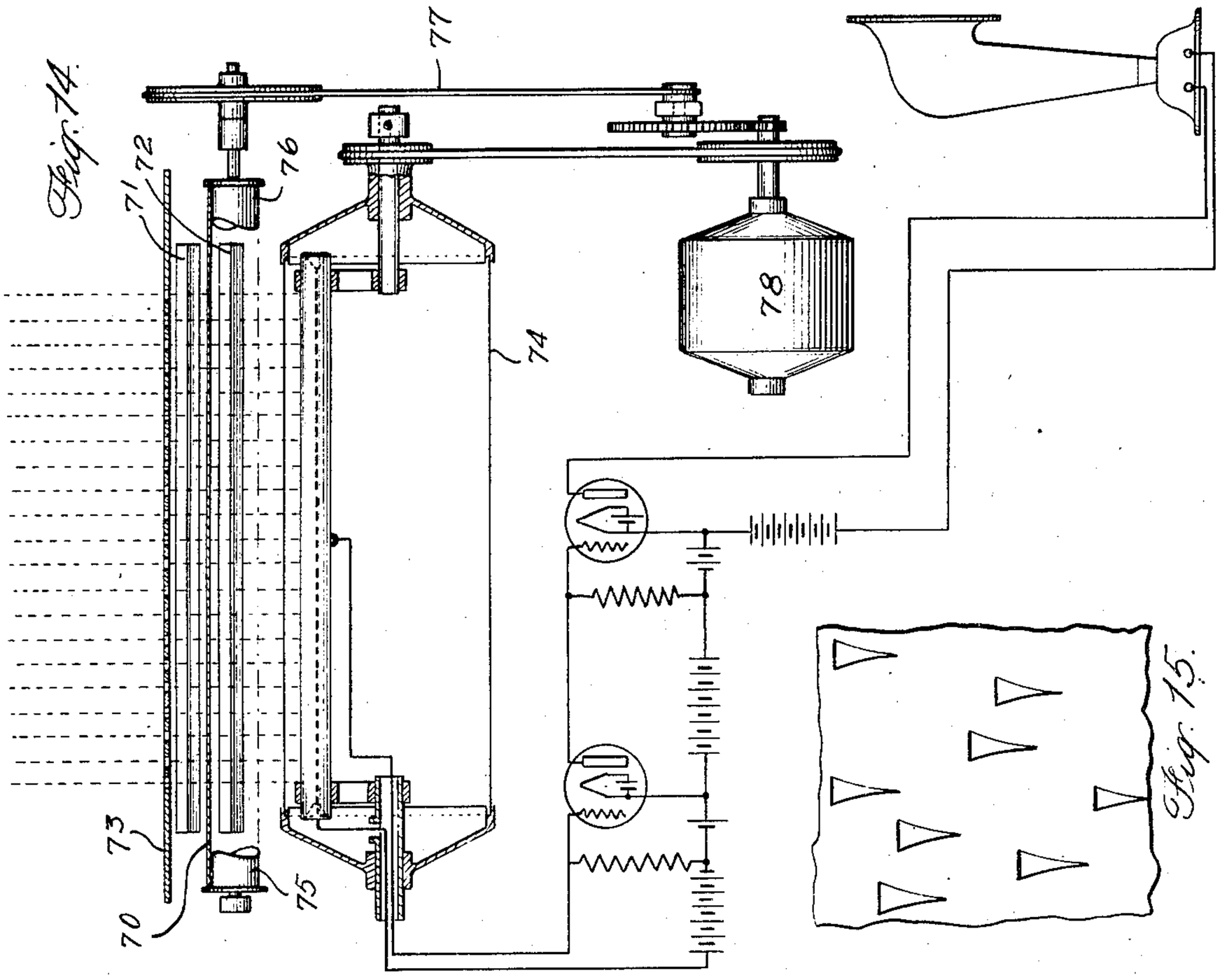

Fig. 14.

Fig. 15.

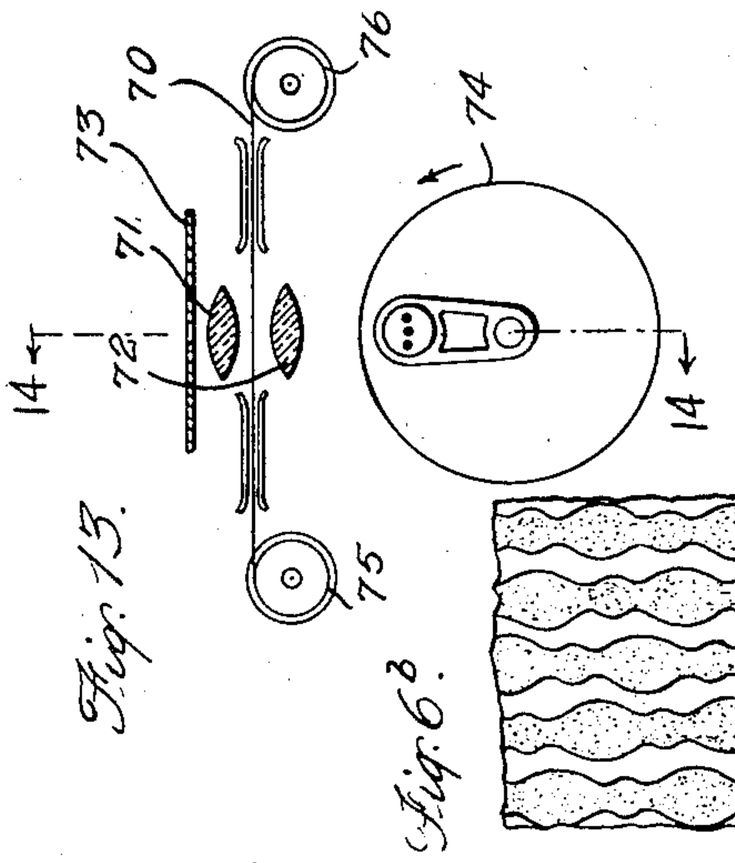

Fig. 13.

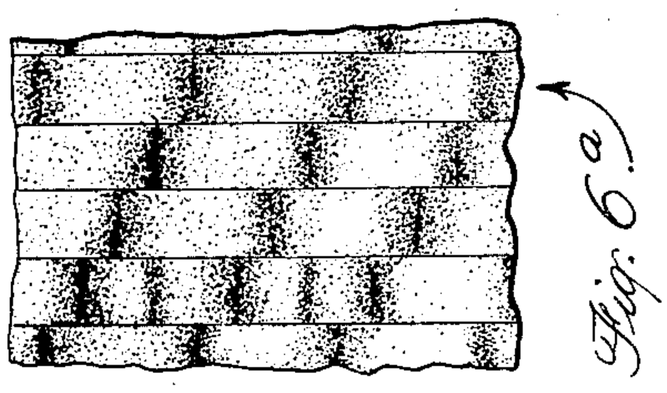

Fig. 6a.

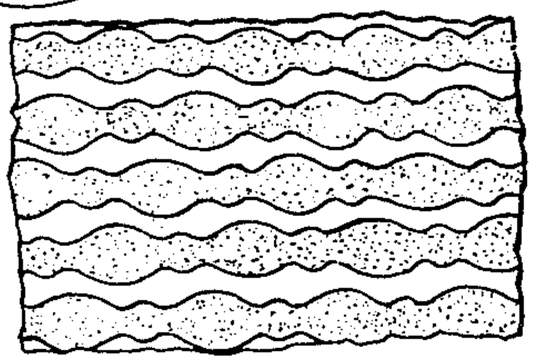

Fig. 6b.

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July 31, 1928. 1,678,872

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METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS

Filed Jan. 2, 1926 6 Sheets-Sheet 6

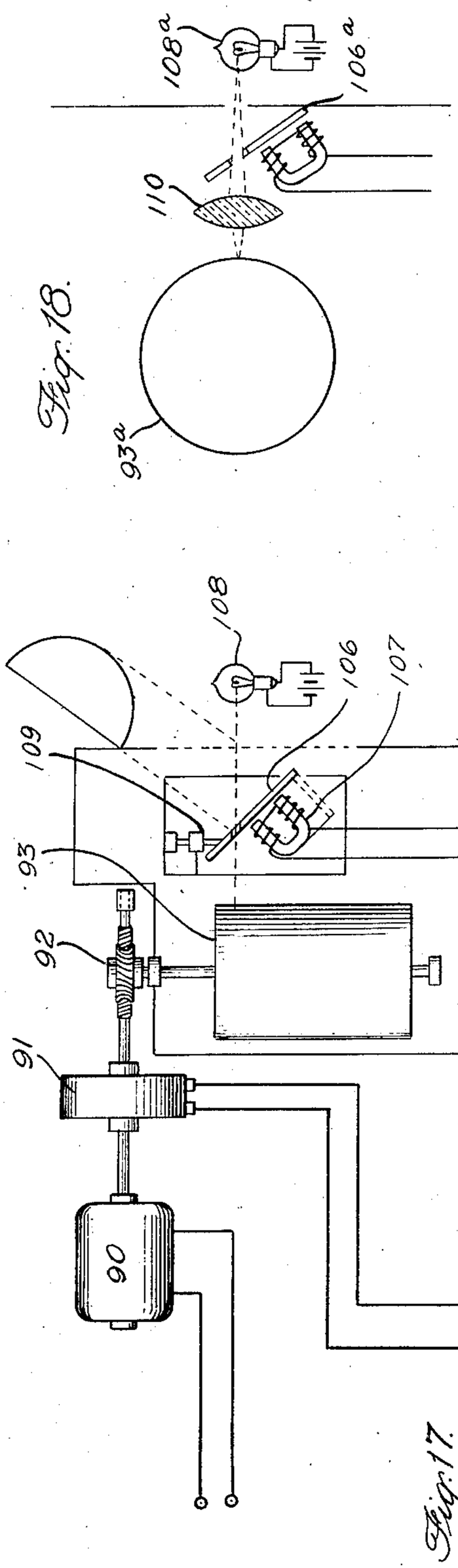

Fig. 18.

Fig. 17.

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Patented July 31, 1928. 1,678,872

UNITED STATES PATENT OFFICE.

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METHOD AND APPARATUS FOR PRODUCING MUSICAL SOUNDS.

Application filed January 2, 1926. Serial No. 78,733.

My present invention relates to the production of musical sounds and more particularly is concerned with means for synthesizing tones of simple or complex quality whereby not only tones of existing musical instruments may be faithfully simulated, but tone effects produced which are different from those of existing instruments. The invention also contemplates the production of a musical instrument capable of rendering musical compositions either manually or by the instrumentality of player records. The invention also contemplates means for making such records which shall be relatively simple and inexpensive, and available to the musical public. The various objects of the invention will be more clearly perceived as the description proceeds and the novel features of the invention will be particularly pointed out in the claims.

In order that the reader may be aided in grasping the problem at hand, a few words may be said regarding the composition of musical sounds or tones. The fabric of such tones is, in its general aspect, very intricate. Upon analysis, however, it proves to be built up of a mixture of pure tones which are present in varying quantities. As is well known, a pure tone is a rather dull and colorless sound to the ear and the auditor's emotional response to musical tones depends largely upon the composition of the tone mixture reaching the ear. It will therefore be seen that the invention involves the problem of putting together the fundamental and various overtones making up the composition of musical sounds of the desired quality.

In carrying out my invention I make use of a light sensitive cell and employ means for varying the intensity of light directed on the cell in such a manner as to generate within it, a current having all the characteristics corresponding to the quality, pitch and volume of the sound wave to be produced, so that it is only necessary to conduct the current suitably amplified, to a sound producing mechanism of the usual type for the translations of such electric current or impulses into sound.

For a fuller comprehension of the invention reference will now be had to the accompanying detailed description taken with the annexed drawings; in which:

Figure 1 illustrates my invention in a relatively simple form;

Figures 2^a and 2^b show alternative forms of screen used in Figure 1 for varying the light intensity;

Figure 3 shows the application of my invention to an instrument having further refinements and capable of rendering other effects than the instrument shown in Figure 1;

Figure 4 is a plan view, with parts broken away, of the device shown in Figure 3;

Figure 4^a shows a portion of the drum having thereon a light intensity varying screen which is capable of being shifted longitudinally, bringing different portions of the indicating bands opposing the screen into operation;

Figures 5^a, 5^b, and 5^c show details of the shutter mechanism;

Figures 6^a and 6^b show alternative forms of screens similar to Figures 2^a and 2^b for varying the light intensity;

Figures 7 and 8 are sectional views of a type of light sensitive cell employed;

Figures 9, 10, and 11 illustrate details of further types of intensity varying screens;

Figures 12^a to 12^d inclusive show different forms of shutter screen employed to give various musical effects in combination with the light intensity varying screens;

Figure 13 is a sectional view of a device for automatically rendering musical compositions;

Figure 14 is a view in section taken along line 14—14 of Figure 13;

Figure 15 shows a portion of a player record used;

Figure 16 shows an apparatus for making records of the type shown in Figure 15;

Figure 17 shows one means for producing the light intensity varying screens the form in Figure 17 producing the type of screen in which the opaque portions are of uniform thickness, but of varying width; while

Figure 18 shows a modification for obtaining screens of the type in which the opaque portions vary in thickness.

Referring now to Figure 1, which best illustrates the principle of my invention, a source of light 1 is arranged to be directed upon a light sensitive cell 2, a cylindrical lens 3 being a convenient aid for this purpose. Cell 2 has the property of passing a current therethrough in accordance with the intensity of light falling upon an exposed portion of it. It will now be apparent that if the light intensity be varied in the proper manner, a current will be set up in the cell 2, which, when suitably amplified and translated into sound, will give a musical note or a sequence of notes, forming a desired musical composition. In the elementary form shown, this means for varying the light intensity consists of a screen 4 having a plurality of sections, corresponding to different notes and adapted, when moved relatively to cell 2, to vary continuously the intensity of light directed upon such cell. A suitable key and shutter mechanism is provided which will determine which section of screen 4 shall be effective and when. In other words, the mechanism about to be described will determine the pitch and quality of the note or notes and their sequence. In the form shown in Figure 1, I have shown a screen 3′, subdividing the main light beam from source 1 into a plurality of individual beams and apertured shutters 5 therefor, each actuated by a key 6 pivoted at 6′ so that when a key 6 is depressed, light from the apertured screen 3 will be passed to cell 2 through a corresponding section of the intensity varying screen 4. Screen 4 may take on a variety of forms but preferably, and as shown, it is of cylindrical shape, enclosing cell 2. I show appropriate means for rotating cylindrical screen 4, consisting of a shaft 7, belt 8, motor 9, a speed control 10 for the motor and a pedal 11 for operating the control. The impulses set up in cell 6, which is operated under a suitable potential by means of battery 15, are amplified to the desired degree by means of thermionic tubes 16 and 17, the amplified current being translated into sound by means of a loud speaker 18. It will be understood that the light sensitive cell and the current amplifying and sound producing units are per se well known in the art and will need no further description.

The form of moving screen 4, which determines the variation in light intensity, will now be described. As shown, screen 4 consists of a plurality of endless, transparent sections each of which corresponds to a note of fundamental pitch. It will be understood that if it be desired to reproduce a note consisting of a pure tone without overtones, let us say, it would simply be necessary to make the individual section of screen 4 of alternate, regularly spaced transmitted light and dark portions of a pattern to vary the light beam sinusoidally. On the other hand, it will usually be desirable to produce a tone of more complex quality, in which case the individual section of screen 4 will be of a correspondingly more complex pattern. Two forms of light varying screen are represented, one as shown in Figure 2ª, in which the relatively opaque portions are of constant width but of varying translucency, and the other as shown in Figure 2ᵇ, in which the relatively opaque portions are of constant translucency but of varying width. Thus, the pattern of the section shown in Figure 2ᵇ will bear a simple relation to the resultant curve formed by superimposing graphs representing the fundamental tone and the various overtones composing a note, and combining such graphs into a single curve. It will be understood that this is not an explanation of how the screen sections are preferably obtained, but is given merely to set forth the nature of the pattern of such sections. It will furthermore be apparent that these sections composing the screen 4 determine the fundamental pitch and quality of the tone or note, and can be made either to simulate the sound of a given instrument or a combination of instruments, or of other tone combinations heretofore unknown. In the form shown in Figure 1, the pitch of the instrument as a whole it will be noted may be varied by means of pedal 11.

In Figures 3 to 6ᵈ I have shown an instrument which may be played like a piano, and which may simulate the tones thereof, or may have a tone quality modified as desired. As in the preceding instance, I may employ a light source 25, a light sensitive cell 26, a light intensity varying screen 27, and a lens 28 all arranged similarly to the device of Figure 1. In addition, I may employ a reflector 30 for accomplishing an efficient distribution of the light. Screen 27 consists of a plurality of sections (corresponding, for example, to the keyboard of a piano), as shown in Figure 4, the screen being mounted upon a suitable revolvable framework 31 and rotated by means of a motor 32 and appropriate belt and pulley mechanism. The individual sections of screen 27 may be of a form similar to those shown in Figures 2ª and 2ᵇ, or may be of the special forms shown in Figures 9 to 11, which will be more particularly described hereinafter. An appropriate key and shutter mechanism is provided for each section of screen 27, and inspection of Figure 3 will reveal that when this key and shutter mechanism is operated, light will be admitted to the corresponding section of screen 27, and the variation in intensity produced by such section will produce an excitation of cell 26 corresponding to a particular note. The specific key and shutter mechanism shown will now be described.

As shown, a slide 33 is provided, having an aperture 34, slide 33 working within a guideway 35 having an opening 35ª therethrough for admitting light to screen 27. Slide 33 is preferably provided at its lower end with a head 36 of suitable buffing material. A lever 37, pivoted at 38 and having a key portion 39, carries an upright 40, having a buffer of felt or other material 41. Thus, when key 39 is depressed, the slide 33 will be shot upward in a manner similar to the hammer of a piano and will admit light to the corresponding portion of screen 27. As will be apparent it will be desirable to retard the descent (or ascent) of the slide 33 to a variable degree in order that the note produced may last for a varying period, depending upon the length of time the key 39 is depressed. As one means of accomplishing this, I have shown a dashpot 44 for each key, in each of which is provided a vane 45 pivoted at 46 and provided with a balancing weight 47. Each dashpot 44 has a valve opening 48 which is closed to a varying degree by means of a valve 49 attached to lever 37, so that when the key 39 reaches the end of its travel downward, the valve opening 48 will be closed. Thus, when key 39 is held down, the descent of the slide 33 will be effectively retarded by the vane 45 working within the closed pot 44. However, when key 39 is released, valve 48 is opened and slide 33 is allowed to return instantly to its initial position. It will further be observed that when key 39 is struck lightly, the slide 33 will be given only a relatively short travel upward, whereby only a portion of aperture 34, which preferably is of tapering shape, as shown, will be effective in passing light to the screen 27. Hence, a note of less volume will be produced when the key is struck lightly than when it is struck strongly.

My invention thus far described is susceptible to a number of controls for the regulation of various elements necessary or desirable in the rendering of a musical composition. For example, when it is desired to retard the descent of all the slides, and thus produce an effect which is analogous to the operation of the loud or sustaining pedal of the piano, this may be accomplished by means of a bell-crank 50, operating a valve 51 closing all of the openings of dashpots 44, and operated by means of a pedal 53. A pedal 55 operates a rheostat 54 in the circuit of lamp 25 and operation of this pedal by thus reducing or increasing the intensity of the light serves to diminish or augment the volume of tone delivered by the instrument. Thus the volume of tone of the instrument may be regulated within wide limits by this means. A further means of controlling the volume of sound consists of a stop bar 56 which limits the upward travel of the slides 33, and which is operated by means of a pedal 57. It may be noted, however, that by using certain of the screens herein described, control of the volume by the stop bar will alter the quality of the music, as well as the volume, because of the fact that different portions of the apertures 34 will come into operative position. The effect of this will be gone into more fully below. A further means of varying the tone quality is shown in a "tremolo-shutter" 59 which operates in the path of the light beams from source 25, and which is placed in operative position by means of pedal 60. As shown, "tremolo-shutter" 59 consists of a pair of vanes, which, when rotated by means of a belt 60′ from motor 32, intercept the light in rapid succession. It will be evident that other tonal effects may be produced and that other means may be provided to produce such effects, as before described. It will also be noted that the pitch of the instrument is also determined by the speed of motor 9, and exact regulation of the pitch of the instrument as a whole may thus be readily had by regulation of the motor.

The light sensitive cell is shown in Figures 7 and 8 and extends the full length of the cylindrical screen 27. As has been explained in connection with Figure 1, the impulses generated in cell 26 are suitably amplified and translated into sound by means of vacuum tubes 62 and sound producing unit 63.

Thus far means have been shown and described whereby the envelopes of such a complex musical note, as that of a piano, for example, can be produced, but nothing has been said concerning the transient change in quality over the life of this note. In certain instruments, such as the piano, this transient change in quality occurs, particularly for the lower notes, and thus the fundamental in a low, gradually fading piano note may die away rapidly, leaving a relatively large amount of upper-harmonics in its wake. My present invention is well adapted to simulate this condition. As has been previously pointed out, the light intensity varying screens have recorded thereon the means for producing harmonics, as well as the fundamental tone. Instead of the harmonics and fundamental tone being superimposed, as in the case of Figures 2ª and 2ᵇ, they may be separated, as shown in Figures 9 and 10, or preferably a number of such harmonics may be separated and placed side by side, each forming a continuous band, as shown in Figure 11. Now, if a slide, having an aperture shaped as in Figure 12ª be employed, in combination with screen shown in Figure 9, for example, it would be evident that different harmonics will be admitted as the triangular shaped aperture

moves across the light beam. When the screen shown in Figure 11 is used, an apertured slide, as shown in Figures 12[c] and 12[d], may be used, which will employ certain overtones and exclude others, depending upon the effect desired or the instrument to be simulated.

In Figure 4[a] I have illustrated means for utilizing light intensity varying screens of the type shown in Figure 11. In this form of the device the light intensity varying screen 27[a] is of the type shown in Figure 11, in which the several harmonics or overtones of each note are represented by bands placed side by side. The cylindrical frame on which the screen 27[a] is mounted is similar to that shown in Figure 4, except for the fact that means are provided for longitudinally shifting the cylinder so as to bring into play certain of the harmonic bands to the exclusion of others. As shown, this means comprises a bell crank lever 150 operatively attached to a stop 151 by means of a rod 152. Bell crank 150 is in turn joined to the cylinder by means of a fork 153 working in a groove 154. It will be evident that by manipulating the stop 151 different overtones will be made effective whereby different instrumental effects may be obtained in a manner analogous to an organ provided with a number of stops.

It will be thus apparent that the tonal quality of the note may be widely varied by employing screens having apertures of different shapes. It will also be evident that different series of these apertured screens may be assigned to different key boards, as in the case of the pipe organ, for example.

In Figure 12[b] I have shown a shutter or light valve which is particularly adapted for use with the light intensity varying screen shown in Figure 10, and in which the light transmitting portions are formed by gradually decreasing the opacity of surrounding dark portions. This form, then, permits the configurations of the light intensity varying screen to be brought into play gradually.

Many changes in the forms of apparatus thus far described will suggest themselves to those skilled in the art, for example, a multiplicity of light sources may be used and the playing of the instrument accomplished by the control of the individual light sources. In this case the apertured shutter could be dispensed with, or a multiplicity of light sources might be used in combination with a multiplicity of apertured shutter members, one light source being assigned to each section of the moving light intensity control screen.

The instrument thus far described is readily adapted for the use of player records and a simple form of instrument played by records will now be described. Referring to Figures 13 to 15 it will be seen that in place of the apertured slides 33 of Figures 3 and 4, there is provided a moving apertured screen or record 70 and in the place of the slotted guides 35 is provided a pair of concentrating cylindrical lenses 71 and 72 and a slotted screen 73. The apertured slides 33 of Figure 3 have not been shown, inasmuch as they perform no function when the player record is used. A moving intensity varying screen 74, which may be similar to any thus far described, is also used. The other elements of the apparatus are essentially the same as shown in Figure 3 and their description need not be repeated. Means are provided for driving the rolls 75 and 76 upon which the record winds and unwinds respectively, such means consisting of appropriate belt and pulley arrangement denoted generally by 77 connected preferably to a driving motor 78 which also operated the light intensity varying screen 74.

Means for making the player records may now be described. Referring to Figure 16 there is shown a light source 1[a], a light sensitive cell 2[a], a light intensity varying screen 4[a], an apertured shutter 5[a], a motor 9[a], amplifier and loud speaking units 16[a] and 18[a], a key 6[a], all of which may be substantially similar to the corresponding elements shown in Figure 1. In addition, however, I may provide a screen 80 having a photo-sensitive surface, said screen being contained upon rollers 81 and 82, the latter of which is driven by motor 9[a]. Now, in the path of each beam from the source 1[a], I preferably provide a prism 83, which reflects a portion of the light downward onto the moving screen 4[a], aided by a concentrating lens 3[a], analogous to lens 3 of Figure 1. Prism 83, however, passes a portion of the light directly onto the sensitized surface 80, whose movement is synchronized with that of the screen 4[a]. It will now be seen that when the instrument is played, a faithful reproduction of the effect of each key 5[a] will be had on screen 80 upon the photographic development of the latter, whereupon it will be adapted for use as a player record in the instrument of Figures 13 and 14. It will be seen, therefore, that my invention admirably lends itself to the producing and playing of player records.

It now remains to describe the means for producing the light intensity varying screen sections, and I have shown such means in Figures 17 and 18. As shown, a motor 90 drives an alternating current generator 91 and through suitable gearing 92 a recording drum 93, upon which is fitted a transparent cylindrical film having a photo-sensitive surface. Alternating current generator 91 may be a very simple device of the electromagnetic, variable resistance type or other well known types. It will be evident that

every time the drum 93 makes one complete revolution, the alternating current generator 91 will make a definite number of revolutions and generate a definite number of cycles. By proper adjustment of the gearing 92, the generator 91 may be made to generate a certain whole number of cycles during each complete revolution of the drum 93.

It will be evident that having now an alternating current of simple sinusoidal form and of the proper frequency, it will be possible to generate therefrom harmonics of the desired order, whereupon both the harmonic and fundamental currents may be combined and by suitable apparatus caused to register their effect upon a sensitized screen. Accordingly, I provide means for producing these harmonics in the form of vacuum tubes 95, 96, and 97 connected, as shown. The separate outputs from generator 91, tubes 95 and 96 may be passed through amplifiers 98, 99, 101 respectively. The outputs from the transformers mentioned may then be combined in a suitable transformer having secondaries 102, 103, 104 in series and a final amplification given by amplifier 105. The composite amplified current may now be conducted to a light valving device, comprising a diaphragm 106 constituting the armature of electro-magnet 107. Light is now admitted from a source 108 through the aperture determined by the diaphragm 106 and a non-vibrating, adjustable member 109 and directed upon the rotating drum 93 bearing the photo-sensitive surface. Obviously, the variation in light produced by the vibrating diaphragm will record on the drum 93, a trace similar to Figure 2[b] of constant shade and varying width.

In Figure 18 I show a detail of an alternative means comprising a light source 108[a], vibrating diaphragm 106[a], concentrating lens 110, and cylinder 93[a], bearing a sensitized surface as before. It will be seen that this arrangement will generate a band of uniform width but varying shade. It will also be evident that separate generators 91 may be used for producing both the fundamental and harmonics, instead of the vacuum tubes shown.

After a complete record of one kind is built up an indefinite number of copies may be easily made by means available in the photographic art. For example, copies of the screen just described may be made by passing a beam of light through the original and directing it against the surface of the photographic copy. This copy may, in the case of a cylinder, be placed concentrically inside or outside the original with the beam of light directed along a radius. Obviously many variations of such a process are possible.

Many advantages inhere in the musical devices of the above described invention, among which may be mentioned the following: (1) The instrument may be constructed so as to produce notes of familiar quality with their transient quality variations, and also to produce novel tone effects. (2) The same keyboard may be employed to play the notes of different instruments by the simple expedient of changing the light intensity varying screen or screens, while on the other hand the notes of other instruments may be made available on a single keyboard by the employment of more than one such screen. Thus there may be had in a single instrument at relatively low cost, the tone quality of high grade musical instruments. (3) The operation of the instrument is unaffected by weather conditions and should remain "tuned" indefinitely. (4) The instrument may be so built as to be light and compact. For example, a "piano" might be carried about by a single individual, or a "pipe organ" may require no more space than the keyboard of the present instrument. (5) The keyboard of the instrument may be located at a different point from the source of sound, or a number of such sources may be distributed as the output of the instrument is primarily electrical. (6) If the player desires, he may operate the instrument by using a pair of headphones without disturbing anyone in the same room. (7) In the use of the instrument in connection with radio broadcasting, the electrical output of the instrument may go directly to the modulator tubes without the necessity of employing a microphone to translate the sound waves. Thus, the side tone, echo effects, and inherent noises which the microphone introduces are eliminated. Obviously when used for this purpose, the instrument can be played regardless of the noise in the room, and the output broadcast entirely free from such surrounding noise. (8) The instrument may be played by record, as well as manually.

It will be understood that many changes in the construction of the instruments thus far described may be made by those skilled in the art without departing from the spirit of my invention or the scope of the appended claims, and that furthermore many instruments other than the ones specifically described may be built, embodying the principle of the invention herein described and claimed. Moreover various changes may be made in the described methods of making and reproducing the player records, and the light intensity varying screens.

What I claim is:

1. The steps in the method of producing musical sounds, which consist in simultaneously directing a beam of light upon a light sensitive cell, varying the intensity of said beam in accordance with the fundamental

tone and overtones of the note or notes being played, cutting off the portion of said beam producing the fundamental tone of a given note before cutting off those producing the overtones of said note.

2. In combination, a screen, a light source, a light sensitive cell, means to move said screen across a beam of light from said source, said screen comprising a plurality of groups of alternate relatively opaque portions and relatively transparent portions, each group corresponding to a note of fundamental pitch and overtones thereof such that when a group of said portions is moved across said beam, the light of said beam will be intercepted in a regular sequence so as to produce a current in said cell corresponding to a note having a fundamental pitch and overtones, and means for determining the composition of said note comprising a shutter mechanism interrupting portions of said beam to the exclusion of other portions.

3. In an instrument for rendering musical composition and simultaneously making a record of said composition as played by the performer, a source of light, a photo-electric cell, means for directing a light beam from said source thereupon, screen means between said source and said cell capable when moved relatively to said source of light, of varying the intensity of said beam so as to produce a current in said cell corresponding to a note of fundamental pitch, means for producing relative movement of said screen means and said light beam, a sound producing mechanism for converting the electric impulses set up in said cell to audible notes, light valves in the path of said beam, key mechanism for controlling said valves, means for directing a light beam determined by said key mechanism upon a sensitized surface to make a record of the key sequence.

4. A screen comprising a continous band of light and dark portions, said portions being arranged so as to be capable, when moved across a beam of light, of varying said beam in accordance with a given musical note.

5. A screen comprising a continuous band of light and dark portions representing a fundamental tone, together with overtones, said portions being arranged so as to be capable, when moved across a beam of light, of varying said beam in accordance with said fundamental tone or overtones of a complex note.

6. In an apparatus of the type described, a photo-sensitive screen, a light valving device controlling an aperture, a light source directing a beam of light through said aperture, electro-magnetic means actuating said valving device, a source of electrical impulses corresponding to a desired musical note for actuating said electro-magnetic means, and means for moving said screen with respect to said light beam.

7. An instrument comprising a source of light, a light sensitive cell, means for directing a light beam from said source thereupon, screen means between said source and said cell capable when moved relatively to said source, of varying the intensity of said beam so as to produce a current in said cell corresponding to a note of fundamental pitch, means for producing relative movement of said screen means and said light beam, a light valve in the path of said beam and means for controlling said valve to produce a sequence of notes determined by said screen means, said control means comprising a key in operative connection with said valve and having damper means whereby to accomplish a slow return of said valve to its initial position.

8. An instrument comprising a source of light, a light sensitive cell, means for directing light beams from said source thereupon, screen means between said source and said cell having groups of light interrupting bands thereon, each group corresponding to a fundamental tone and overtones thereof such that when moved relatively to said source of light, said screen will vary the intensity of said beams so as to produce a current in said cell corresponding to notes of fundamental pitch and overtones thereof, means for producing relative movement of said screen means and said light beams, light valves in the path of said beams and means for controlling said valves to produce a sequence of notes determined by said screen means, said valve control means comprising keys in operative connection with said valves, means for controlling the return of said valves to their initial position, and the shutters having apertures, said shutters normally intercepting said beams, means for moving said shutters to open position, said apertures having at least one dimension of varying extent whereby different members of a group of bands of said screen means corresponding to a given note will be cut off before others during the life of said note.

9. In a musical instrument in which the sound producing mechanism comprises a light sensitive cell, a source of light therefor, a screen interposed between the cell and the light source such that when said screen is moved across the light beam from said source, the light of said beam will be intercepted in regular sequence so as to produce a current in said cell corresponding to a note having fundamental pitch, means for translating said current into sound, means for varying the sound of said note comprising means for varying the intensity of said light source.

10. In a musical instrument in which the

sound producing mechanism comprises a light sensitive cell, a source of light therefor, a screen interposed between the cell and the light source such that when said screen is moved across the light beam from said source, the light of said beam will be intercepted in regular sequence so as to produce a current in said cell corresponding to a note having fundamental pitch, means for translating said current into sound, means for varying the sound of said note comprising means between said source and said screen for interrupting said beam at a more or less regular rate to produce tremolo or analogous effects.

11. An instrument comprising a source of light, a light sensitive cell, means for directing a light beam from said source thereupon, screen means between said source and said cell capable when moved relatively to said source of varying the intensity of said beam so as to produce a current in said cell corresponding to a note of fundamental pitch, means for producing relative movement of said screen means and said light beam, a light valve in the path of said beam and means for controlling said valve to produce a sequence of notes determined by said screen means, said control means comprising a key in operative connection with said valve, and means for regulating the travel of said valve, said means being controllable by the operator of the instrument.

12. An instrument comprising a source of light, a light sensitive cell, means for directing a light beam from said source thereupon, screen means between said source and said cell capable when moved relatively to said source, of varying the intensity of said beam so as to produce a current in said cell corresponding to a note of fundamental pitch, means for producing relative movement of said screen means and said light beam, a light valve in the path of said beam and means for controlling said valve to produce a sequence of notes determined by said screen means, said control means comprising a key in operative connection with said valve and having damper means whereby to accomplish a slow return of said valve to its initial position, and means independent of said keys for holding said valve in light transmitting position.

13. A screen comprising groups of bands of alternate light transmitting and light retarding portions such that when said bands are moved in a direction parallel to their length across a beam of light, said beams will be interrupted in regular sequence so as to produce a musical sound, said bands being arranged side by side, one of said bands of the group representing a note of fundamental pitch and frequency, the other of said bands representing overtones of said note.

14. In combination with a screen as recited in claim 13, a light source, a light sensitive cell, means to move said screen between said source and said cell, and a shutter mechanism for determining the composition of the note to be produced, said mechanism comprising a shutter member having apertures therein registering with certain of the bands of a group corresponding to a given note whereby the overtones of the produced note may be determined by said member.

15. An instrument comprising a source of light, a light sensitive cell, means for directing light beams from said source thereupon, screen means between said source and said cell, such that when moved across said light beams, said screen will vary the intensity of said beams so as to produce a current in said cell corresponding to notes of fundamental pitch and overtones, means for combining the fundamental and overtone producing portions of said screen corresponding to a given note, means for producing relative movement of said screen means and said light beams, light valves in the path of said beams and means for controlling said valves to produce a sequence of note determined by said screen means, said valve control means comprising keys in operative connection with said valves, said control means permitting the fundamental of such given note to die away before the overtones thereof.

16. In a device of the character described, the combination of a source of light, an elongated light sensitive cell, and a screen interposed between said source and said cell, said screen being in the form of an endless band and being capable of varying the current in said cell in accordance with a predetermined frequency.

17. In a device of the character described, the combination of a source of light, an elongated light sensitive cell, and a screen interposed between said source and the cell, said screen being in the form of a cylinder about said light sensitive cell and being capable of varying the current in said cell in accordance with a predetermined frequency.

18. In a device of the character described, the combination of a source of light, a light sensitive cell, means interposed between said source and the cell, capable of varying the current in said cell in accordance with predetermined frequencies, light valves for controlling the light falling on said screen and means for varying said frequencies to produce changes in the harmonic composition of the note during the life thereof to simulate the tone of known instruments or to produce other tonal effects.

19. In a device of the character described, the combination of a source of light, a light sensitive cell, means interposed between said source on the cell, said means being capable

of varying the current in said cell in accordance with a plurality of predetermined frequencies, and manual means for selecting a given sequence of frequencies.

20. In an instrument for making a record suitable for use in a device for translating light variations into sound waves, a source of light, light valves in the path of the light from said source, key mechanism for controlling said valves and means for directing light passed by said valves upon a sensitized surface to make a record of the key sequence.

21. An instrument comprising a source of light, a light sensitive cell, means for directing light from said source thereupon, screen means between said source and said cell capable when moved relatively to said source, of varying the intensity of said light so as to produce a current in said cell of a given frequency, means for producing relative movement of said screen means and a beam from said light, means for controlling the light admitted to said screen and means for controlling the frequency of said current and hence the pitch of the sound corresponding thereto when said current is translated into sound comprising means for varying the speed of movement of said screen means.

22. A screen comprising a continuous band of light and dark portions of photographically determined light retarding material, said portions being arranged so as to be capable when moved across a beam of light, of varying said beam in accordance with a given musical note.

23. In a device of the character described, the combination of a source of light, a light sensitive cell, means interposed between said source and the cell, capable of varying the current in said cell in accordance with predetermined frequencies, light valves for controlling the light falling on said screen and means for varying the amplitude of said frequencies.

24. The method herein described, which consists in varying a single beam of light of constant cross section in accordance with the fundamental tone and overtones of a complex note and causing said beam of light to bring about corresponding changes in an electric current.

25. An instrument comprising a source of light, an elongated light sensitive cell, means for directing a plurality of light beams from said source thereupon, a screen forming an endless band surrounding said cell and having a plurality of light modifying bands thereon such that, when moved relatively to said source of light, said bands will vary the intensity of said beams so as to produce currents in said cell corresponding to notes of given pitch, means for producing relative movement of said screen and said light beams, light valves in the path of said beams and means for controlling said valves.

26. A musical instrument according to claim 25, in which said means for controlling the valves comprise keys operatively connected to said valves for opening and closing same.

In testimony whereof I have affixed my signature to this specification.

RALPH K. POTTER.