June 16, 1936. J. H. NUTTALL 2,044,223

METHOD OF AND APPARATUS FOR PRODUCING AND REPRODUCING SOUND

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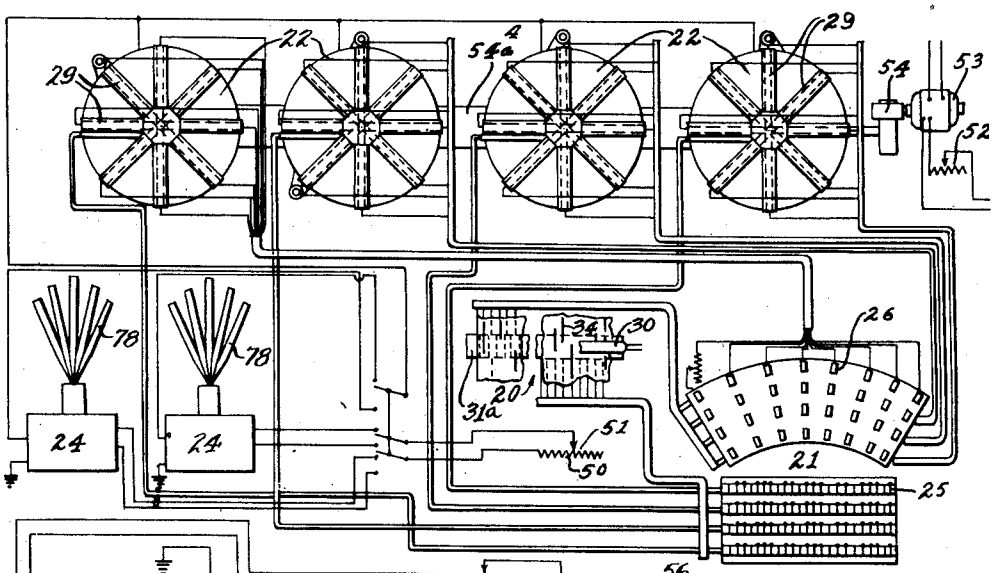


Fig. 1.

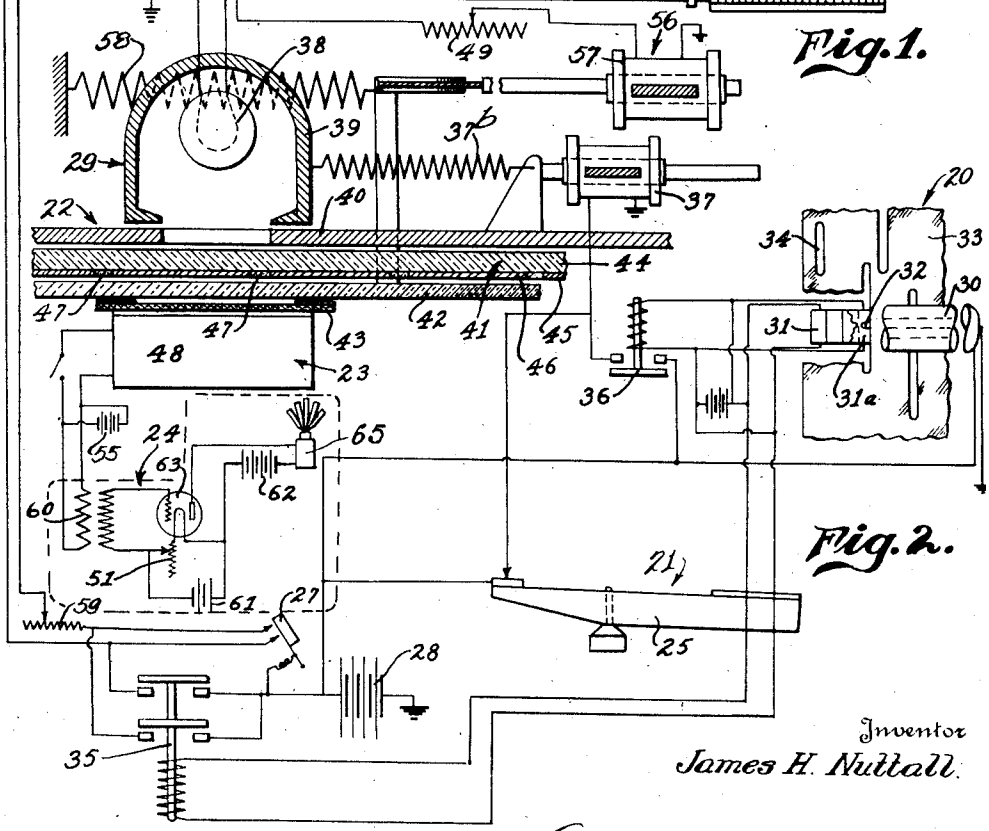


Fig. 2.

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METHOD OF AND APPARATUS FOR PRODUCING AND REPRODUCING SOUND

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Fig. 3.

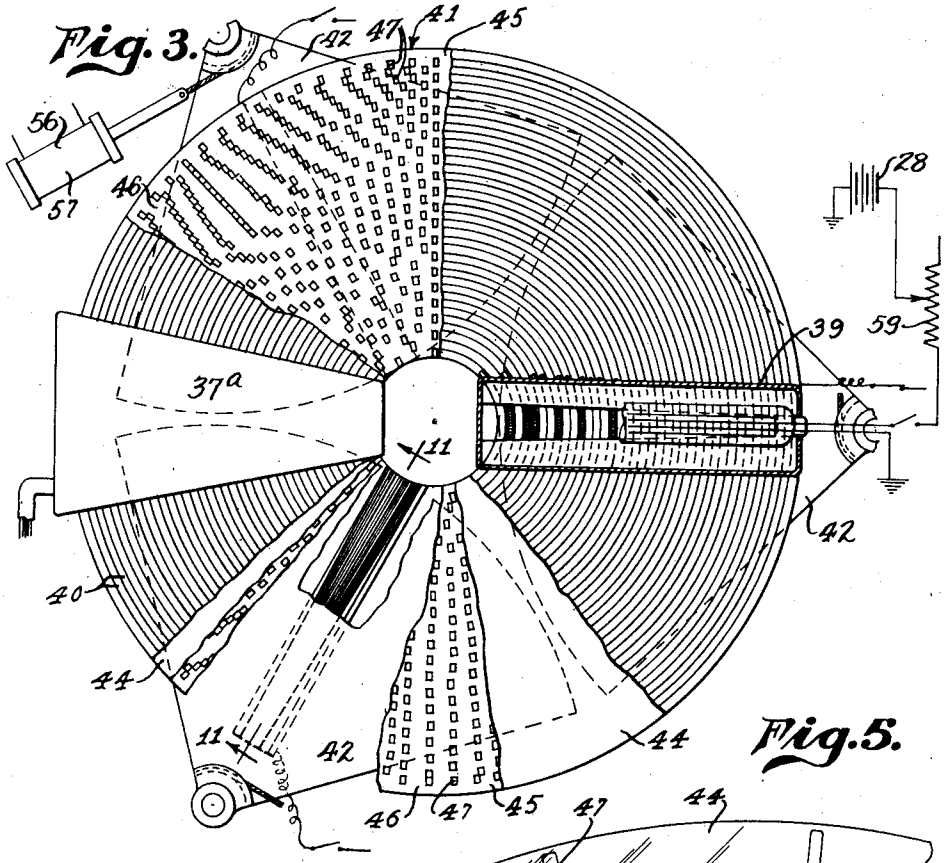


Fig. 5.

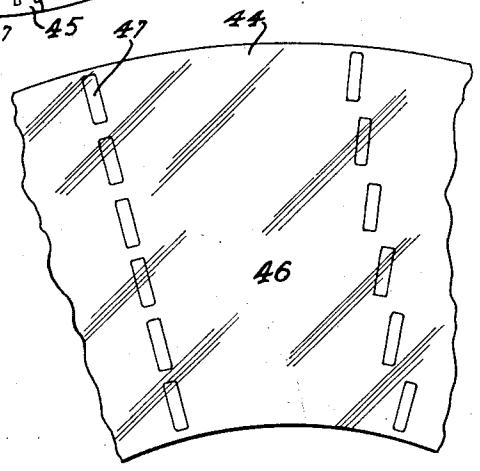
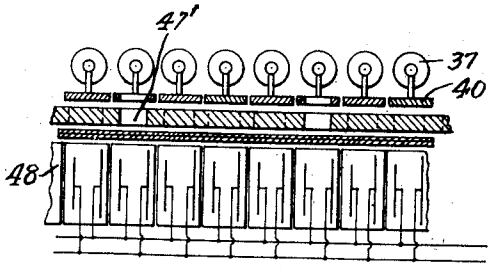


Fig. 4.



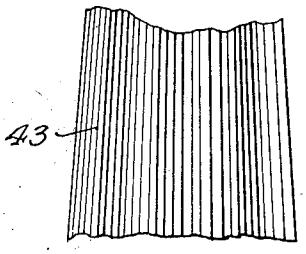


Fig. 6.

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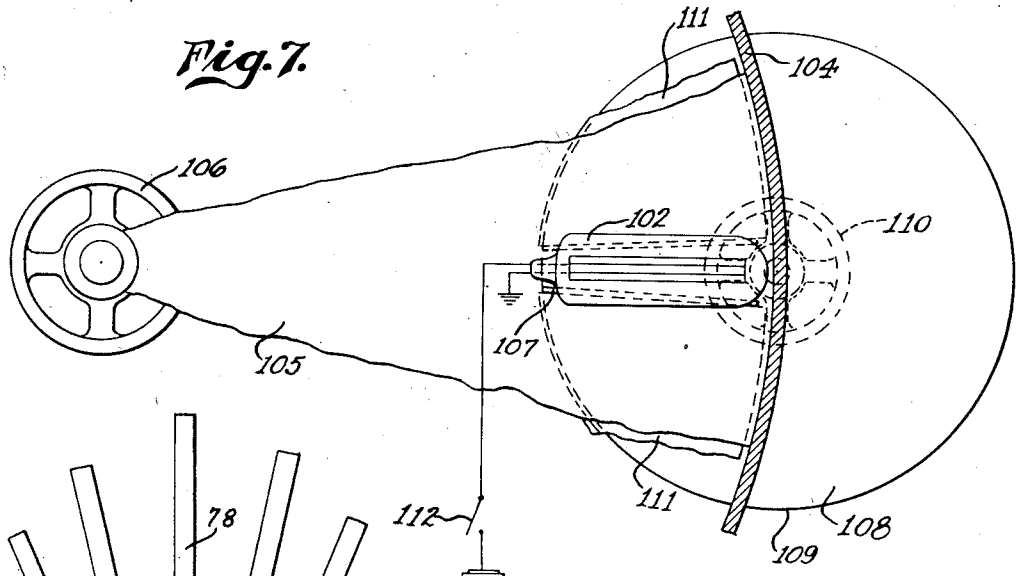
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METHOD OF AND APPARATUS FOR PRODUCING AND REPRODUCING SOUND

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Fig. 7.



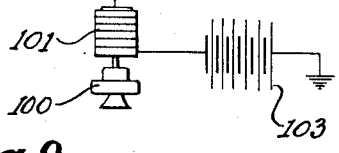


Fig. 8.

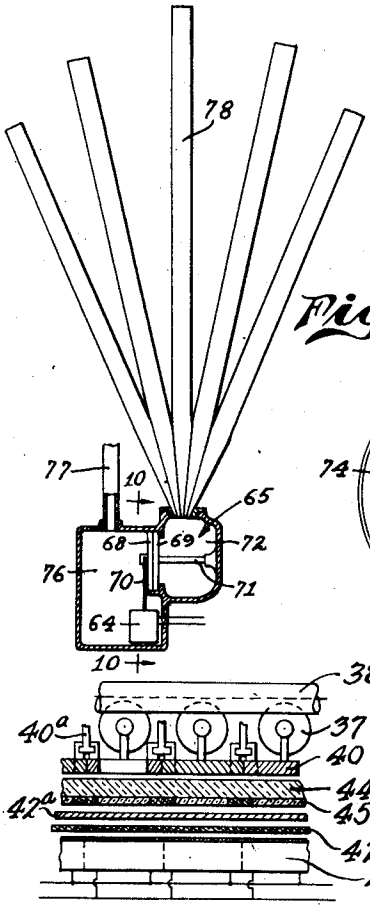


Fig. 9.

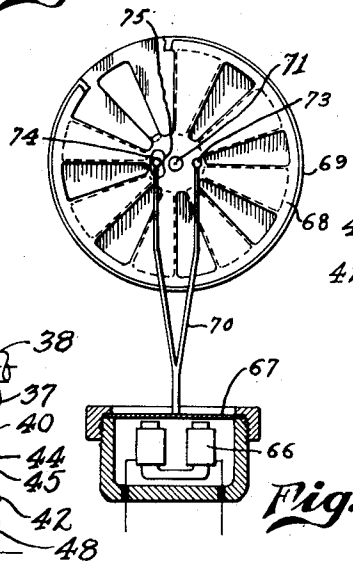


Fig. 10.

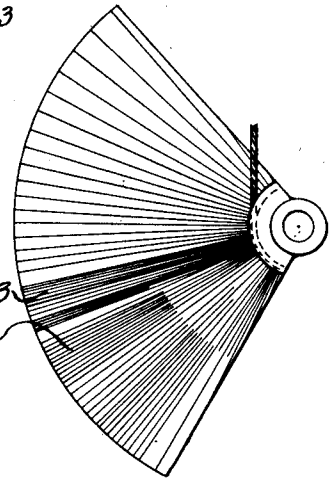


Fig. 11.

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METHOD OF AND APPARATUS FOR PRODUCING AND REPRODUCING SOUND

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Fig. 12.

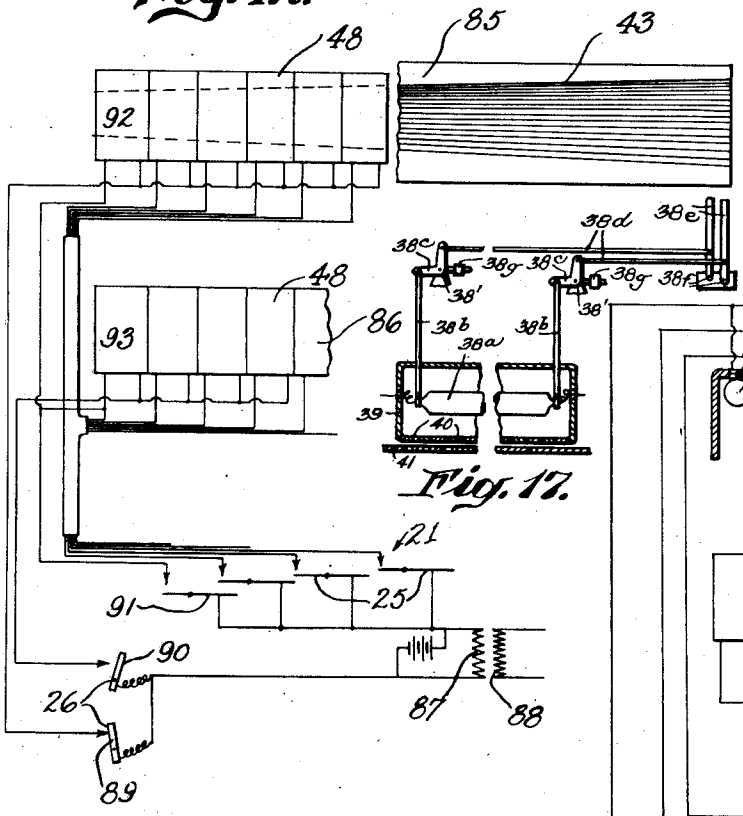


Fig. 17.

Fig. 15a.

Fig. 15b.

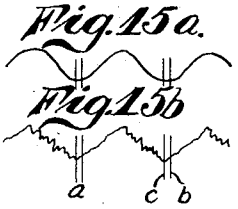


Fig. 13.

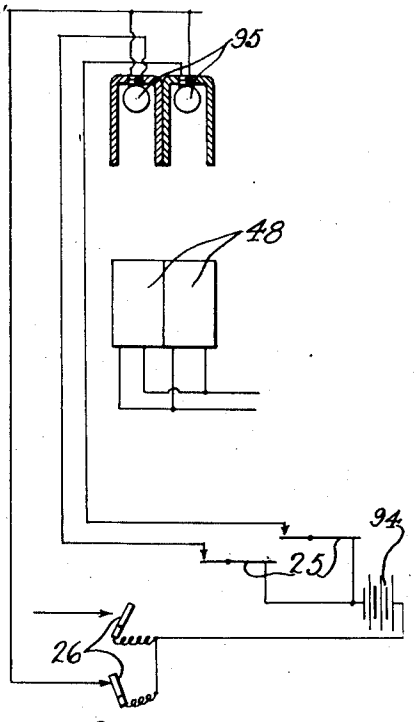


Fig. 16a.

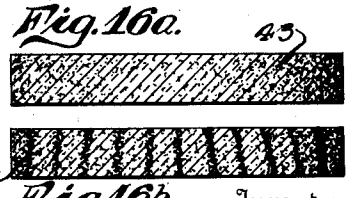


Fig. 16b.

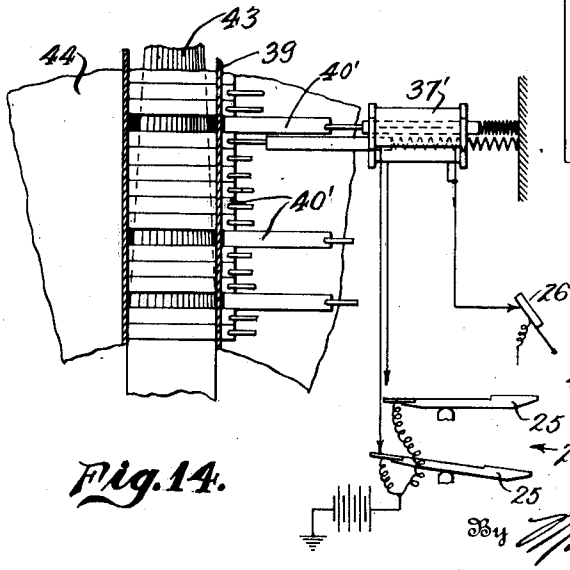


Fig. 14.

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Patented June 16, 1936 2,044,223

UNITED STATES PATENT OFFICE

2,044,223

METHOD OF AND APPARATUS FOR PRODUCING AND REPRODUCING SOUND

James H. Nuttall, Glendale, Calif.

Application October 25, 1928, Serial No. 314,940

26 Claims. (Cl. 84—1)

This invention relates to musical instruments and has for its principal objects the production of light waves of varying intensities corresponding in vibrations to those of the sound which it is desired to produce, and the conversion of the light waves so produced to sound, and the provision of a mechanism for producing sounds by such a process of tonal quality and pitch as determined by automatic control means or hand operation.

In one phase it is particularly directed to the process of and apparatus for producing light waves of predetermined frequency, intensity and sequential variation, entirely under the control of the operator, in contrast to apparatus now in use for reproduction of sound through the medium of light and photography.

Further objects are to produce such a mechanism which may be contained in small space, which will be simple to construct, maintain and operate, and by means of which any desired combination or sequence of pitches and tone qualities may be obtained.

It has for a further object the faithful reproduction of a desired sound or tone at any pitch desired.

Another object is the method of sound production consisting in impressing the vibrations upon a moving air stream and in varying the movement of this airstream in synchronism with the vibrations.

Another object is to provide such an instrument whereby the tonal quality produced may be easily changed to meet various requirements, and whereby an infinite variety may be obtained by simple substitutions.

Another object is to produce such manufactured sound waves of pure tone quality and pitch without mechanical noise.

With these and other objects in view the invention comprises the process and apparatus for the production of light waves of predetermined variation, amplitude, and period and the conversion of such waves into sound, all as illustrated in the accompanying drawings and as will be finally pointed out in the claims.

With the foregoing and other objects in view, my invention consists in certain novel features of construction and arrangement of parts that will hereinafter be more fully described and claimed and illustrated in the accompanying drawings, in which:

Fig. 1 is a diagrammatic arrangement of the invention for automatic and associated manual production of music or sound.

Fig. 2 is a more detailed diagrammatic representation of this invention.

Fig. 3 is a fragmentary plan view of one of the light wave producing units.

Fig. 4 is a transverse section through a modified form of the light wave production and conversion device.

Fig. 5 is an enlarged fragmentary detail of the pitch determining disk.

Fig. 6 is a fragmentary detail illustration of the tone determining film.

Fig. 7 illustrates a means of producing the tone film of Fig. 6.

Fig. 8 illustrates a means for obtaining a variation in tone effect.

Fig. 9 illustrates a resonant tonal producing and amplifying device.

Fig. 10 is a section on line 10—10 of Fig. 9.

Fig. 11 is a fragmentary section on line 11—11 of Fig. 3.

Figs. 12 and 13 illustrate modified forms of tone-quality control.

Fig. 14 illustrates a modified form of pitch control.

Figs. 15*a* and 15*b* represent forms of musical vibrations.

Figs. 16*a* and 16*b* represent sections through tone films.

Figure 17 is an illustration of additional tone regulating means.

Referring now to Figs. 1 and 2, which illustrate a preferred form of my invention, I provide an automatic control means **20**, a manual control means **21**, a light wave producing means **22**, means for converting the light waves formed by the means **22** to electrical waves comprising converting means **23**, and a sound producing mechanism **24**.

The automatic means **20** and the manual means **21** may operate in conjunction, or either may be operated separately, the means **21** being illustrated as an organ keyboard comprising a series of keys **25** for the control of the pitch of the sound produced, and which may be arranged in banks comprising manuals and pedals, as in the usual organ keyboards.

For controlling the tone quality and character a series of stops **26** are provided and each of these stops is shown as including a switch **27** interposed between a source of current supply **28** and a tone determining means **29**.

Preferably I may provide a series of light wave producing means **22**, as shown in Fig. 1, each of such wave producing means having associated therewith a plurality of tone determining means

29 all connected and controlled from a common source incorporating the automatic control means 20 and the manual control means 21 so that I may simultaneously produce through the operation of the various stops a succession of sounds of different tone quality or by the operation of the various manuals produce simultaneously separate melodies or accompaniments in different or similar tone quality. To such effect I may, as shown diagrammatically in Fig. 1, connect one bank of stops 26 to the tone determining means 29 upon one of the means 22 and another bank of stops to the means 29 upon another light wave producing means 22, and I may control one of the means 22 from one of the keyboards and another of the means 22 from another of the keyboards.

I may also prefer to provide several of the sound producing units 24 which may be situated in various parts of an auditorium and to which I may switch some or all of the sounds.

The automatic control means is best illustrated in Fig. 2, and includes a source of light 30, a series of light sensitive cells 31, positioned so as to receive light energy from the source 30, as through an opening 32 in the cell covering 31a.

An opaque strip 33 of flexible material, such as paper, metal or film, and provided with light passages such as transparent portions or openings as at 34 is adapted to pass between the light source and the cells 31, and as the light openings 34 in the strip 33 pass over the openings 32 rays from the light are transmitted to the cells 31 generating a current variation therein.

Certain of the cells 31 are connected to relays shown diagrammatically at 35, and others are each connected to a relay as 36. It will be understood that each of the cells 31 is connected to a separate relay, only two of such relays being shown in the drawings for the sake of simplicity.

The current variation generated in the cells 31 operates to close either one of the relays 35 or one of the relays 36, depending upon the particular cells exposed to the light rays.

Any of the relays 35 operates to close the circuit between the source of current supply 28 and one of the tone determining means 29, producing the same effect as the stop 26. The relay 36 operates to close the circuit between the source of current supply 28 and a means 37 for effecting the pitch control operation. This relay closes the circuit between the same members that are closed by the operation of a corresponding key 25, there preferably being a relay 35 for each stop 26 and a relay 36 for each key 25.

The light wave producing means 22 may comprise a source of light energy 38, a semi-confining shield 39 for such light, a series of pitch shutters 40 movably mounted on guides 40a and adapted to be controlled by a series of means 37, shown diagrammatically as electrically operated solenoids resisted by tensile springs 37b, and adapted to close the opening in the shield 39 at certain points to prevent the passage of light to the conversion means 23. A housing 37a is provided for means 37.

A vibration producing device 41 is interposed between the pitch shutters 40 and the conversion means 23. A secondary shutter 42 is interposed between the vibration producing device 41 and a tone film 43, also between the light source 38 and the conversion means 23. An opaque shutter 42a may be also provided controlled by one of the means 37 and an associated stop 26.

The vibration producing means 41 is illustrated in Figs. 2, 3 and 5, as comprising a disk 44 of transparent material covered with an emulsion 45 having an opaque portion 46 and a series of transparent portions 47.

The disks may also be made of any opaque material, such as paper, metal, rubber or other composition and the light openings provided by appropriately spaced perforations, as at 47', Fig. 4.

Referring now to Figs. 3 and 5, it will be seen that these transparent portions 47 form a series of light openings arranged in concentric rings of the disks 44, and the spacing of the openings in each of such rings being equal and the spacing of the openings in each successive ring being different.

As illustrated, the number of light openings per ring doubles at each thirteenth ring moving outwardly from the center, representing a pitch an octave higher. Intermediate rings are provided with openings to represent the intermediate note, that is the twelve rings would represent the twelve half tones of each octave.

Practical consideration may necessitate grouping various ranges on each disk, that is, on any one disk every third or fourth note may be an octave higher instead of by steps of twelve, intermediate tones appearing on other disks revolving at other speeds. This is to secure more accurate pitch production with a minimum number of perforations.

For each ring of openings there is one of the pitch shutters 40. Thus shutter 40 may extend entirely around the disk as shown in Figure 3, so as to control the transmission of light to one of the light sensitive cells 48 of each of the conversion means 23, or may be a shutter as illustrated in Fig. 14, at 40' and control the light energy over but one of the cells 48.

As the disks 44 are rotated at predetermined speeds, light from the source 38 passes through any of the shutters 40 which are open and in a series of rays or beams passes through the openings 47 and across the tone film 43 onto the cells 48 producing a series of light vibrations, the frequency of which depends upon the speed of the disk 44 and the spacing of the light openings 47. Inasmuch as these light rays pass through the tone film 43 in their passage across the cells 48, they are modified by the shading of this tone film to produce the vibrations desired in the light ray for the final tone character.

Obviously I may provide one disk 44 for each octave or for any number of octaves and provide a series of such disks rotated at various speeds to provide for the range of pitches desired, all of the disks being identical in construction and spacing of light openings, resulting in greater economy of manufacture.

I also provide means for varying the speed of rotation of the disk for changing the key or pitch of the whole range included on that disk. Such speed changing devices are of numerous kinds and well known in the various arts and are therefore but diagrammatically illustrated.

In Fig. 1 I show a variable resistance speed control 52 on the driving member 53. One of the motors 53 may be provided for each of the disks 44 and the motors properly synchronized driving each disk through appropriate gearing 54; or the various disks may all be driven from one of the motors 53 and a single set of gearing 54 and the various units connected by driving connections, as at 54a.

It is thus possible with such a speed changing device to simply and easily change the pitch of

the whole instrument to that of any other instrument played with it at the will of the operator. Pitch is unaffected by temperature variations or other natural phenomena, but is entirely dependent on speed of rotation of the disks. The whole compass may, however, be as above described raised or lowered at will.

The stops **26** and asscciated switches are shown interposed in the circuit supplying current to the light source **30**, and this same circuit controls the supply to the operating means **56** shown as a solenoid **57** connected to the shutter **42**. For simplicity of illustration, a tension spring **58** is shown to bring the shutter back to an opaque portion thereof when the circuit is open. Other stops may control a resistance **49** in this circuit, whereby the shutter action may be controlled to bring an intermediate portion over the tone film. With the resistance all out of the circuit, the shutter will move through its full range to place a transparent portion in the light path. Thus as certain of the stops **26** each control such a shutter over a tone film, means is provided for throwing in or out of action any tone control means **29** desired by manipulation of these stops controlling both the light source **30** and the shutter **42**. Others of the stops **26** control resistance **49** and others a resistance **59** controlling the light intensity.

The shutter **42** is preferably in the form of a shaded disk or segment, as illustrated in Fig. 8, in which the various portions of the shutter adapted to be interposed between the light rays and the conversion means **23** vary in light transmitting quality from a transparent portion to an opaque portion, so that by varying the resistance **49** various portions of the shutter may be brought into the path of the light rays to vary their effect upon the cells **48** and hence upon the final sounds produced.

Various shadings may be used upon this shutter to obtain the desired effects, such as by having the portion overlying the cells corresponding to the bass notes semi-transparent, while the portion covering the higher note cells fully transparent a dimuendo effect is produced in the bass notes. Tone films also may be mounted thereon. Other desired modifications may be introduced by suitable shadings of this shutter, such as indicated by the shading of the illustration. Similar effects may be obtained by providing for the movement of the light source **38** toward and away from the means **23** so as to give a greater or less intensity of light or the lights may be tilted to give a graduation effect between the various pitches, a means for this purpose being diagrammatically shown in Figure 17. The light source **38***a* is supported at each end by links **38***b*. These links are each attached to an arm of a bell crank **38***c* pivoted as at **38'** to any stationary portion of the instrument. Another arm of the bell crank is connected by links **38***d* to a lever **38***e* pivoted at **38***f* within reach of the operator. Counterweights **38***g* attached to extensions of the bell crank arms may be used to counterbalance the weight of the light source and its connections and make operation easier.

Such mechanism will produce variation in the volume of sound produced from each tone determining means **29**, so that certain parts of the music may be produced in varying tone volume.

I also provide a volume control means **50** for controlling the volume of sound produced from any or all of the sound producing mechanisms **24**. Such volume control may comprise a variable resistance **51** interposed in the amplification circuit in the usual manner.

The cell **48** may be any of the types of light sensitive cells whereby changes in intensity of rays from the light source **38** produce similar changes in electrical energy transmitted therethrough from a source **55**. Selenium and chlorine cells are examples.

The current so produced fluctuates electrically in the same manner as the light rays fluctuate which have been impressed upon the cell **48** and these variations are amplified by well known radio amplification means illustrated diagrammatically as transformers **60**, A and B batteries **61** and **62** and tubes **63**. It will be understood that any appropriate amplifying circuit may be used.

This amplified current is conducted to the power unit **64** of a specially constructed loud speaker **65**, illustrated in Figs. 9 and 10. This loud speaker comprises the usual electro-magnet **66** and is shown with a diaphragm **67**. The armature type of speaker may be used in the same manner. This diaphragm **67** controls the motion of two concentric disks **68** and **69** through a bifurcated connecting link **70**. The disks **68** and **69** are adapted to oscillate upon a shaft **71** at the entrance to the sound chamber **72** of this speaker. One prong of the link **70** connects through a pin **73** with one of the disks and the other prong connects with a pin **74** fixed to the disk **69** on the opposite side of the central axis from the pin **73**.

The pin **74** passes through a slot **75** in the disk **68** and allows for relative movement of the disks. These disks are interposed between a chamber **76**, adapted to be continuously supplied with air under pressure through a pipe **77**, and the chamber **72**; and are provided with a series of segmental openings so arranged that in the rest position of the diaphragm **67** the openings of one disk are closed by the uncut portion of the other disk.

As the diaphragm **67** is vibrated the disks **68** and **69** oscillate, permitting the openings to overlap to a greater or less degree, depending upon the amplitude of the oscillations and thus effect a vibratory air flow from the chamber **76** to the chamber **72**, setting up a dynamic air vibration. The sound waves produced by the diaphragm or armature of the speaker are therefore impressed upon a moving air column which in itself is given a vibratory flow by the opening and closing of the openings. This flow variation being synchronized with the sound waves provides an amplifying effect and gives a true reproduction of the music of wind instruments. In place of the disks, either plain or intermeshing shutters, or oscillating ported tubes or cones may be employed in a like manner.

Connected to the chamber **72** are preferably five sound pipes **78** of varying lengths, the lengths being such that resonant effects are produced for all tones, that is it has been determined that if the lengths of these pipes are in the ratio of eight feet, seven feet seven inches, seven feet three inches, six feet eleven inches and six feet seven and one-half inches approximately, that one of these five will provide resonance for all pitches.

An ordinary cone or loud speaker air column may, however, be employed where the added volume or resonant effect is not needed.

Referring again now to the means **22**, and the disk **44** comprising a portion of such means, above the shutters **40** are placed a series of radially extending light chambers, each formed by the light shield **39** and containing the light **38**. Directly

beneath each of these chambers and beneath the disk 44 is located one of the means 23 comprising a series of light sensitive cells 48, there being one of these cells for each of the concentric rings of light openings 47. If, however, it is desired to play single notes one cell alone adapted to be exposed to the light rays from all rings would be sufficient. The cells 48 may be continuously energized by a battery 55, or other current source.

Other means of the tone control are diagrammatically illustrated in Figs. 12, 13 and 14.

Referring to Fig. 12, two of the converting means 23 are shown at 85 and 86 respectively, each having light sensitive cells 48 and a tone film 43. In this method of control the keys 25 are interposed within the light sensitive cell circuits.

All of the cells 48 for each pitch are connected in parallel and the key switch 25 is thus in series and controls all of the cells of the pitch which it represents. The other leads from the cells 48 for each of the means 23 are connected together and the combined circuit is led through tone control stops 26 to the sound producing mechanism 24, diagrammatically represented by the primary coil 87 of a transformer 88, the secondary of such transformer being connected to the usual amplifying apparatus, as previously designated. Thus stop 89 will bring into play the converting means 85 and stop 90 the converting means 86.

While only two of the converting means 23 and associated stops 26 are illustrated it will be understood that any number may be so connected. Thus upon pressure of the key 91 the particular cells 92 and 93 of the converting means 85 and 86 and of similarly situated cells of other converting means will be connected through the key 91 to one side of the transformer coil 87. However, inasmuch as the stop 90 is open, and the stop 89 is closed, any light energization of cell 93 will not affect the transformer 88 while all energization of the cell 92 will be transmitted directly to the transformer 88 and hence through the amplification means to the sound producing mechanism 24.

In Fig. 13 the keys 25 are in circuit between a source of current supply 94 and the light sources 95, there being one of the light sources for each of the light sensitive cells 48, thus controlling the pitch of the note produced by providing a light source which is energized only upon pressure of the proper key.

The return lines from the light sources pass through control stops 26 in the same manner as in Fig. 12, the stops, however, in this case controlling the banks of light sources rather than the banks of cells.

In Fig. 7 is illustrated a means of producing the so-called tone film. Supposing that it is desired to produce a certain tone effect, such tone effect may be originally produced in any pitch and is received by a microphone shown diagrammatically at 100, which, through a variable resistance 101 varies the intensity of a light source 102 which receives its energy from a source of current supply 103.

The light source 102 is placed within a light shield 104, within which is placed a rotatable disk 105 controlled by a motor or other means 106 and which contains a transparent or slotted portion 107 through which a narrow band of light may be directed upon a sensitized film 108 also mounted upon a disk 109 which is rotated by means 110, which may be a motor or other power driven apparatus.

The motors 106 and 110 may be synchronized so that desired relative speeds of rotation are obtained.

Additional light shields 111 are provided for restricting the exposed portion of the sensitized film 108.

It will be readily apparent then as the slot is rotated past the openings in the disk 111 that a segment of the sensitized film will be exposed through the slot 107, the speed of rotation being varied to correspond with the pitch of the note being reproduced so that one complete period is recorded upon the film and this segment is later developed and removed and a reproduction thereof may be used as the tone film 43.

A hand switch 112 may be provided for closing the light circuit when the desired quality of tone is being sounded.

It is also obvious that other methods may be used to produce this tone film, in fact means may be used to so shade the tone films either mechanically or manually that any desired effect can be produced.

It will be apparent that a tone film so produced will vary in translucent properties across the segment and by properly proportioning the disks for producing this film and the speeds during this production, in accordance with the spacing of the light openings on the disk 44, a tone film is produced which, when in position under the disk 44, will have upon it one complete tone period in the distance between the light openings of the various rings above it and on the disk 44. That is, the circumferential distance between the light openings of any ring will equal the corresponding length of one vibration period on the tone film segment beneath the particular ring of openings.

The relation between the relative rotations of the disks 105 and 109 and the spacing of the concentric rings of transparent portions 47 of the disks 44 may be so related that a period on the tone film will exactly correspond to the spacing of the light openings 47 in the ring, which will be directly above it when used as a tone film, or the period may be lengthened or reduced by any of the well known photographic processes to the desired size; likewise by various photographic processes vibrations may be superimposed or other variations made. Films may also be used in combination to produce double effects or compound vibrations.

The principle of the tone film is illustrated in Figs. 15*a*, 15*b*, 16*a* and 16*b*. Fig. 15*a* is a diagrammatic showing of a pure tone vibration, Fig. 15*b* of an instrumental tone, embodying the basic pure tone with variations and harmonics. A sound such as illustrated in Fig. 15*a* would produce some such film emulsion as illustrated by the section of Fig. 16*a* in which the stippling illustrates variation in translucence. A sound as similarly shown in Fig. 15*b* would produce some such film as shown in the section Fig. 16*b*.

It is obvious that a light beam passed across this film would impress upon a cell beneath varying light intensity corresponding to light transmitting qualities the various portions of the film, and that a single ray passing over this film would vary its intensity in its passage in the same sequence and proportionate variation as the vibrations of the original sound used to produce the film. Also it will be apparent that the pitch of the tone produced will entirely depend upon the number of rays passed over this film per second regardless of the pitch used to produce the original tone film.

Only one complete sound wave record is preferably used, although any number may be used by suitably spacing the beams traversing the film, such as by changing the speed of the disk **44** or by varying the spacing of the light openings of this disk.

This tone film is an important element of this invention as it provides for the imposing of any desired light variation upon the elemental series of light rays to produce a final tone of the character desired. And further the periodicity of the tone film variation is determined by and must therefore exactly correspond to that of the spacing and speed of the light beams delivered through the disks **44**. It is given to each of the beams in turn in exactly the same manner.

In order to provide for the intermittency of the beams, so that the sound produced will be the result of a continuous vibration, the tone film would be cut, or be made effective the width of the light beam more than one single complete vibration or an even multiple thereof. That is, in Fig. 15*b* the effective portion exposed to the beam would be between the lines *a* and *b* while a single vibration would be represented by the distance *a* to *c*. The distance *b* to *c* would be the width of the light beam. These distances vary, as before stated, along the length of the tone film to accommodate the variation of the spacing of the light openings in the successive circles of the disks **44**.

Thus as one beam is coming onto the tone film along the portion represented by *b* to *c* another beam is passing off of the film on the same portion of the vibration adjacent *a*. If one beam is one third the way on, the other is one third off, so that the total light affecting the cell is the same at all times as if one beam were continuously acting on it through the tone film, and the vibrations of the cell are continuous and without interruption.

Such construction provides for a true production of both the pitch and tone quality.

It will be readily observed that simple changes may be made throughout the instrument to produce an almost infinite variety of music. Changes in speed of the disks **44** will change the pitch range of the entire instrument, changes in gearing may be made to change the range of any one or more of the light wave producing means **22** alone. Insertion of new tone films **43** or shutters **42** will change the quality of tone for the particular stop **26** without affecting any other part of the instrument.

Corresponding changes on other musical instruments involve extensive alteration; such as on an organ, for instance, in regard to pitch, every individual pipe must be changed and separately tuned. Change of the tone quality produced by a particular stop necessitates the replacement of every individual tone producer with associated wind chests and other parts to suit the new effects installed. Such changes involve great expense. In this invention the same changes involve merely the adjustment of speed of the disks **44** for the pitch change and the insertion of a new tone film **43** of the required quality for the stop change.

It will be understood that minor changes in the size, form and construction of the various parts of my improved musical instrument may be made and substituted for those herein shown and described without departing from the spirit of my invention, the scope of which is set forth in the appended claims.

I claim as my invention:

1. A musical instrument including a light source, means for converting light variations into sound and adapted to receive rays from said source, means for producing predetermined frequencies of such rays, means for varying such rays in accordance with a predetermined tone quality and means interposed between said light source and said converting means for varying the intensity of the rays to vary the volume of the sound.

2. A musical instrument including a light source, means for converting light variations into sound, a movable member interposed between said light source and the converting means, said member being provided with transparent portions and opaque portions, whereby light beams are intermittently traversed over the converting means upon movement of the member, means for effecting a predetermined sequence of energy variation in the rays during such traverse, and a second member adapted to be interposed between the first member and the converting means for varying the intensity of each beam during its passage over the converting means.

3. A musical instrument including a light source, means for converting light variations into sound, a movable member interposed between said light source and the converting means, said member being provided with transparent portions and opaque portions, whereby light beams are intermittently traversed over the converting means upon movement of the member, means for effecting a predetermined sequence of energy variation in the rays during such traverse, a second member of variable translucency adapted to be moved between the light source and the converting means to vary the intensity of the light beams, and means for controlling the movement of said second member.

4. A musical instrument including a light source, a plurality of means for converting light variations to sound, means for traversing a successive series of light beams of predetermined frequency across said converting means, means for producing predetermined sequences of variation in light energy of such beams during their passage across said converting means, and means for selectively determining the character of such variation.

5. An automatic musical instrument including a series of light sensitive cells, means for intermittently exposing certain of said cells to the light source, a sound producing device, electrical connections between the cells and the sound producing device, whereby exposure of certain of said cells to the light source will produce certain frequencies of energy applications to said sound producing device, and electrical connections between the cells and the sound producing device whereby exposure of others of the cells will cause a variation in such energy applications to give a definite tone quality to the sound thus produced.

6. A musical instrument including a means for generating intermittent light rays, means for converting light variations to sounds, means for selectively varying the frequency of the rays, a separate means for creating a pre-determined sequence of variation of the quantity of light received by the converting means during its exposure to each ray, said variation bearing a fixed relation to the frequencies of each ray.

7. A musical instrument including means for

generating intermittent light rays at a plurality of frequencies, means for converting light variations into sound, and means for selectively predetermining the quantity of light energy received by the converting means at certain frequencies in one degree and that at certain other frequencies in another degree.

8. A musical instrument including means for generating intermittent light rays at a plurality of frequencies, means for converting light variations into sound, means for selectively predetermining the quantity of light received by the converting means at certain frequencies in one degree and that at certain other frequencies in another degree, and means for selectively controlling said last named means.

9. Means for varying the quantity of light in each of a series of rays of variable frequencies comprising a member interposed in the path of such rays, and a light record thereon of a particular tone quality, each portion of said record bearing a definite relation to the frequency of the rays affected thereby, whereby each ray passes through the same intensity variations in time sequence proportionate to its time or exposure to said record.

10. A musical instrument including a light source, a rotatable disk provided with opaque portions and with a plurality of series of circumferentially spaced transparent portions, means for converting light variations into electrical variations and exposable to light rays passing through such transparent portions, and a radial film between said light source and said converting means having a tone record thereon adapted to vary the energy of light rays passing through a plurality of said circumferential series of transparent portions, each portion of said tone record bearing the same relation to the circumferential spacing of said transparent portions affected thereby.

11. An automatic musical instrument comprising a series of sound generating units, means for causing such units to produce sound, relays for controlling the admission of the electricity to said means, a light source, a light sensitive cell, electrical connections between such light sensitive cell and said relays, and means for automatically controlling the admission of light to said cell.

12. A musical instrument including a plurality of light sources, a plurality of light sensitive cells adapted to receive light from such sources, a rotatable disk interposed between the light sources and the cells and an operating shutter controlling the passage of light to the cells, said shutter being provided with spaced transparent portions and opaque portions whereby the light flow between the light sources and the cells may be simultaneously controlled.

13. A musical instrument comprising means for generating intermittent light rays, means for converting light vibrations into sound vibrations and resonators associated with the converting means, said resonators including pipes of column lengths substantially in the proportions of 192, 182, 174, 166 and 159 adapted to produce resonance on all pitches of the musical scale.

14. An automatic musical instrument including a series of sound generating units, electrically operated means for controlling the pitch of the sound produced thereby, electrically operated means for controlling the quality of the tone produced thereby, a source of electrical energy, a light source, a series of light sensitive cells, electrical connections between certain of said cells and the means for controlling the pitch, electrical connections between others of said cells and the quality controlling means and means for controlling the exposure of said cells whereby the quality and pitch of the sounds produced may be simultaneously varied in a predetermined manner.

15. A tone film for varying the energy in a series of light rays including a segmental body of variable translucency, the sequence of translucency variation being constant in ratio along various circumferential lines.

16. In combination with a source of light and a means for converting light to sound in a musical instrument, an opaque disc having light openings therein arranged in circumferential series, the series having different numbers of openings therein, means for rotating said disc, and a stationary member adapted to change the energy of the light passing through such openings of a plurality of series in the same sequence of variation during its exposure thereto.

17. In a musical instrument, a source of energy, means for converting energy variations into sound, a series of means adapted to transpose constant energy from such source into pulsations representing a musical tone and to energize said converting means therewith, driving means for said transposing means, connections between said driving means and said transposing means of various ratios, whereby similar transposing means will produce various ranges of pitch.

18. A musical instrument as described in claim 1, and including means for selectively controlling said intensity varying means to control the volume of sound.

19. A musical instrument including a light source, means for converting light variations into sound and adapted to receive rays from said source, means for producing predetermined frequencies of such rays, means for varying such rays in accordance with a predetermined tone quality, and means interposed between said light source and said converting means for selectively varying the character of said tone quality.

20. A musical instrument including a light source, means for converting light variations into sound and adapted to receive rays from said source, means for producing predetermined frequencies of such rays, and means for varying such rays in accordance with a predetermined tone quality, said last named means including a member having a representation of a tone quality thereon adapted to vary the energy of the light rays in accordance with such tone quality, said means being movable into and out of position affecting such rays.

21. A musical instrument including a light source, means for converting light variations into sound, means for generating light rays of a plurality of predetermined frequencies, a plurality of means each adapted to vary the energy of rays of a plurality of frequencies in accordance with a predetermined tone quality prior to reception by said converting means, and means for selectively rendering effective any of said energy varying means.

22. A musical instrument including a light source, means for converting light variations into sound, means for generating light rays of predetermined frequencies, a plurality of means

each adapted to vary the energy of such rays in accordance with a predetermined tone quality, means for rendering effective any of said energy varying means, and means for simultaneously controlling the conversion to sound of rays of predetermined frequencies as affected by a plurality of said energy varying means.

23. A musical instrument including a light source, means for converting light variations into sound, means for generating light rays of predetermined frequencies, a plurality of means each adapted to vary the energy of such rays in accordance with a predetermined tone quality prior to reception by said converting means, and means for rendering independently effective a plurality of said energy varying means.

24. A musical instrument including a light source, means for converting light variations into sound and adapted to receive light energy from said source, means for generating a plurality of groups of light rays each group of a plurality of predetermined frequencies, means for varying the energy of each of such groups of rays in a manner representative of a predetermined tone quality, and means for simultaneously controlling the conversion of light energy from a plurality of such groups to sound.

25. A musical instrument including a plurality of light sources, means for converting light variations to sound and adapted to receive light from such sources, a plurality of means for intermittently varying the light energy received by said converting means in a predetermined manner, means for creating a predetermined frequency of such variation, and control means adapted to simultaneously permit the passage of light energy from a plurality of such light sources to the converting means, and means for selectively controlling the energy varying means to render effective desired ones thereof.

26. A musical instrument including a plurality of light sources, converting means adapted to receive light from such sources and to convert variations therein to sound, a rotatable disc interposed between the light sources and the converting means and having a series of circumferential series of light openings therethrough, and a shutter including spaced opaque portions each controlling the passage of light from a light source to the converting means, whereby the reception of light by the converting means from all sources is simultaneously controlled.

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