July 17, 1956 G. BAJOLET 2,754,713

PHOTO-ELECTRIC MUSICAL DEVICE

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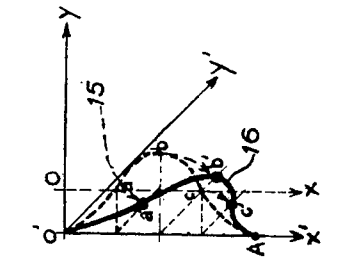


FIG.2

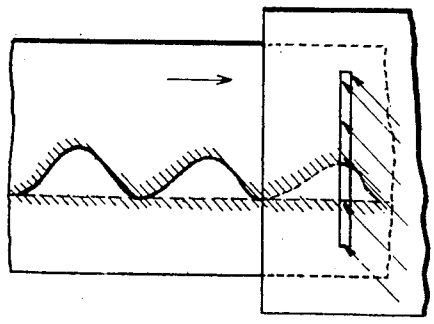


FIG.3

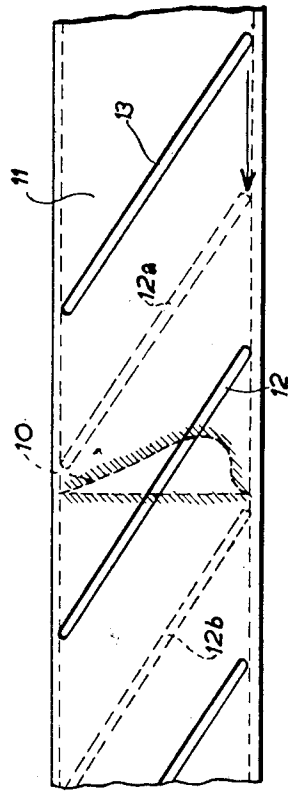


FIG.1

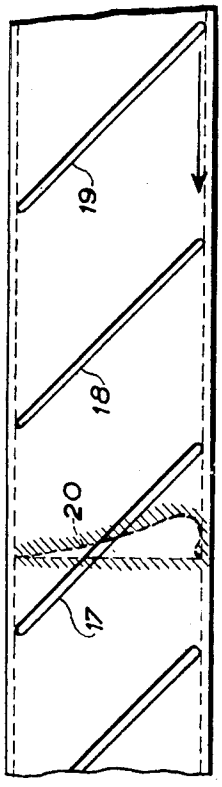


FIG.4

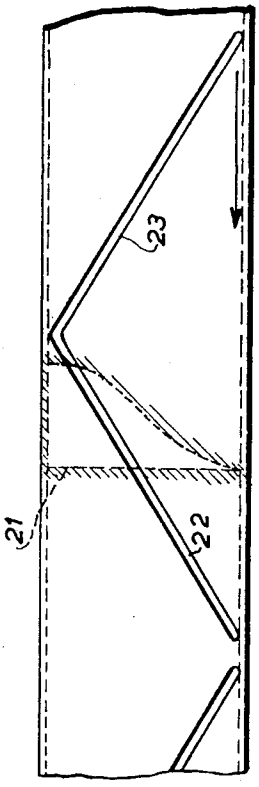


FIG.5

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FIG.7

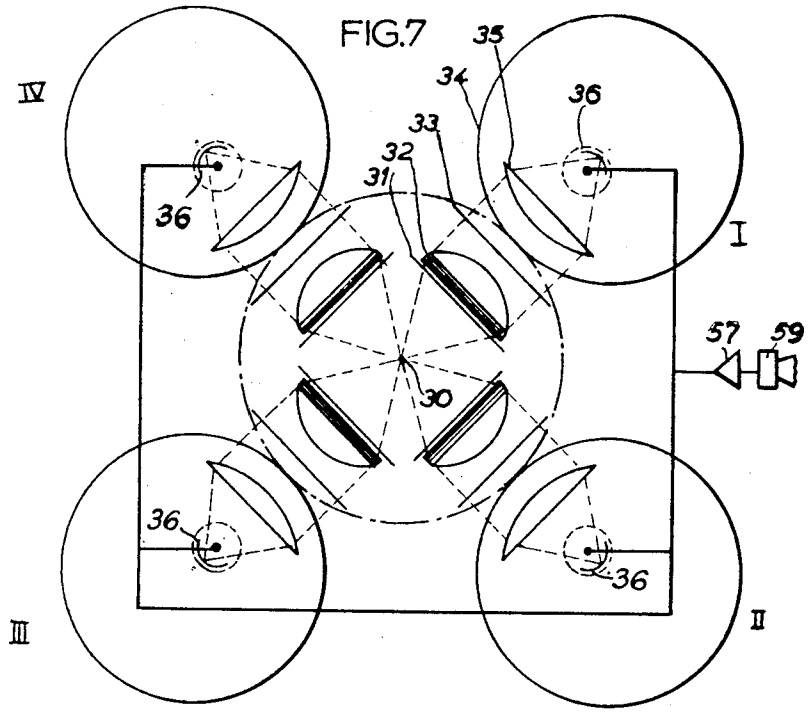
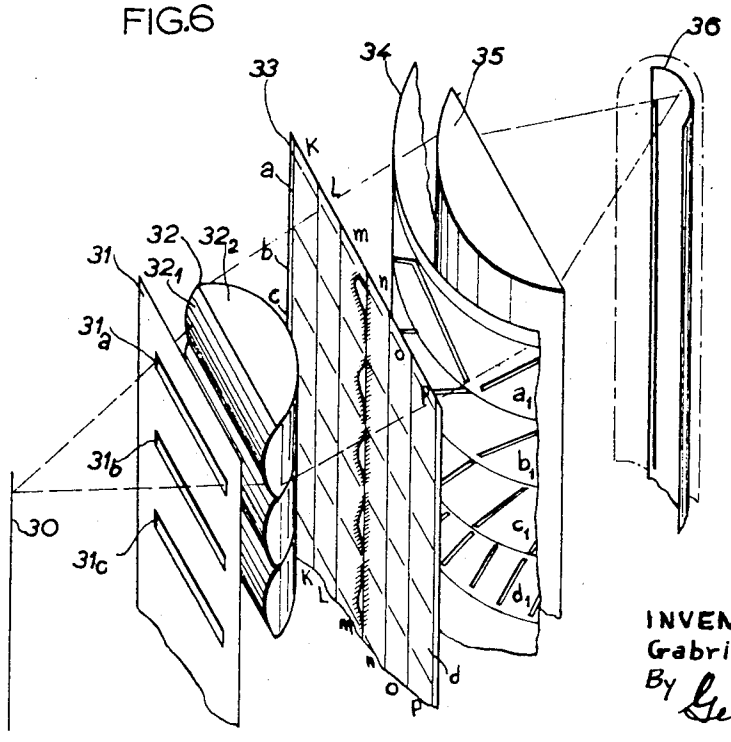


FIG.6



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FIG.10

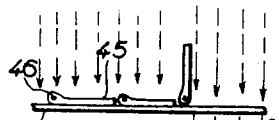


FIG.11

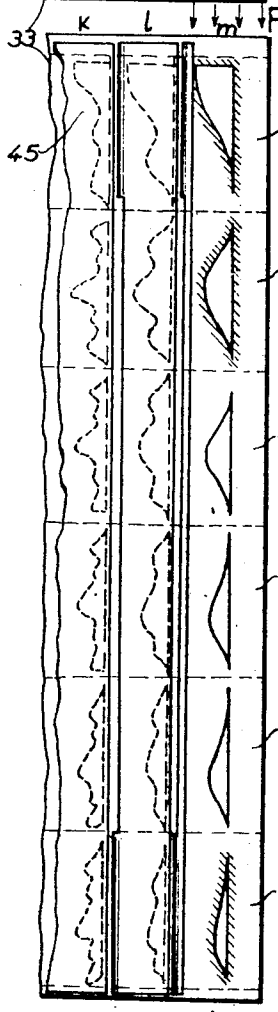


FIG.12

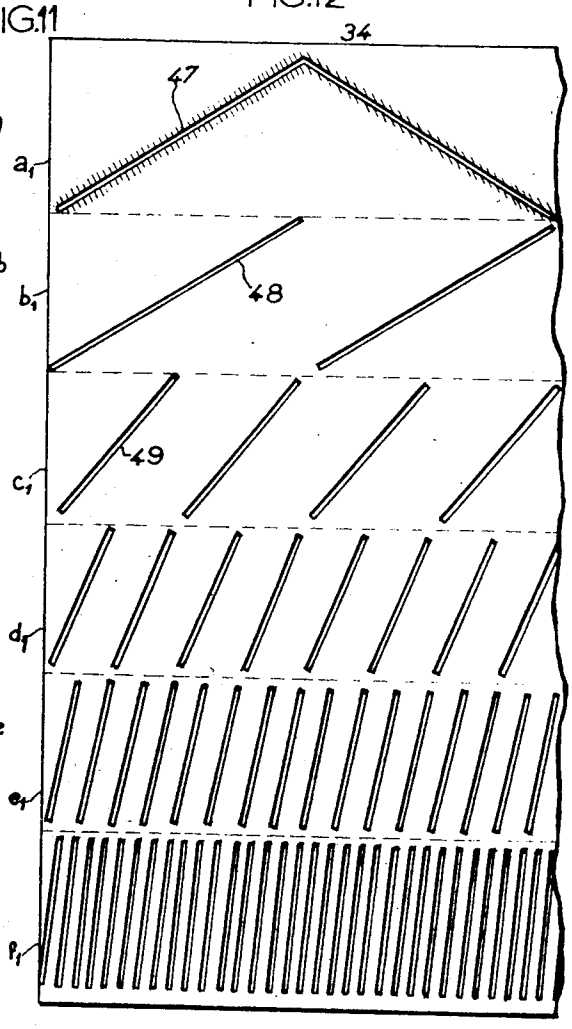
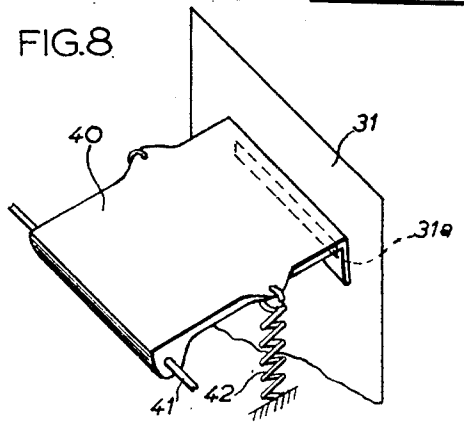


FIG.8



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FIG.13.

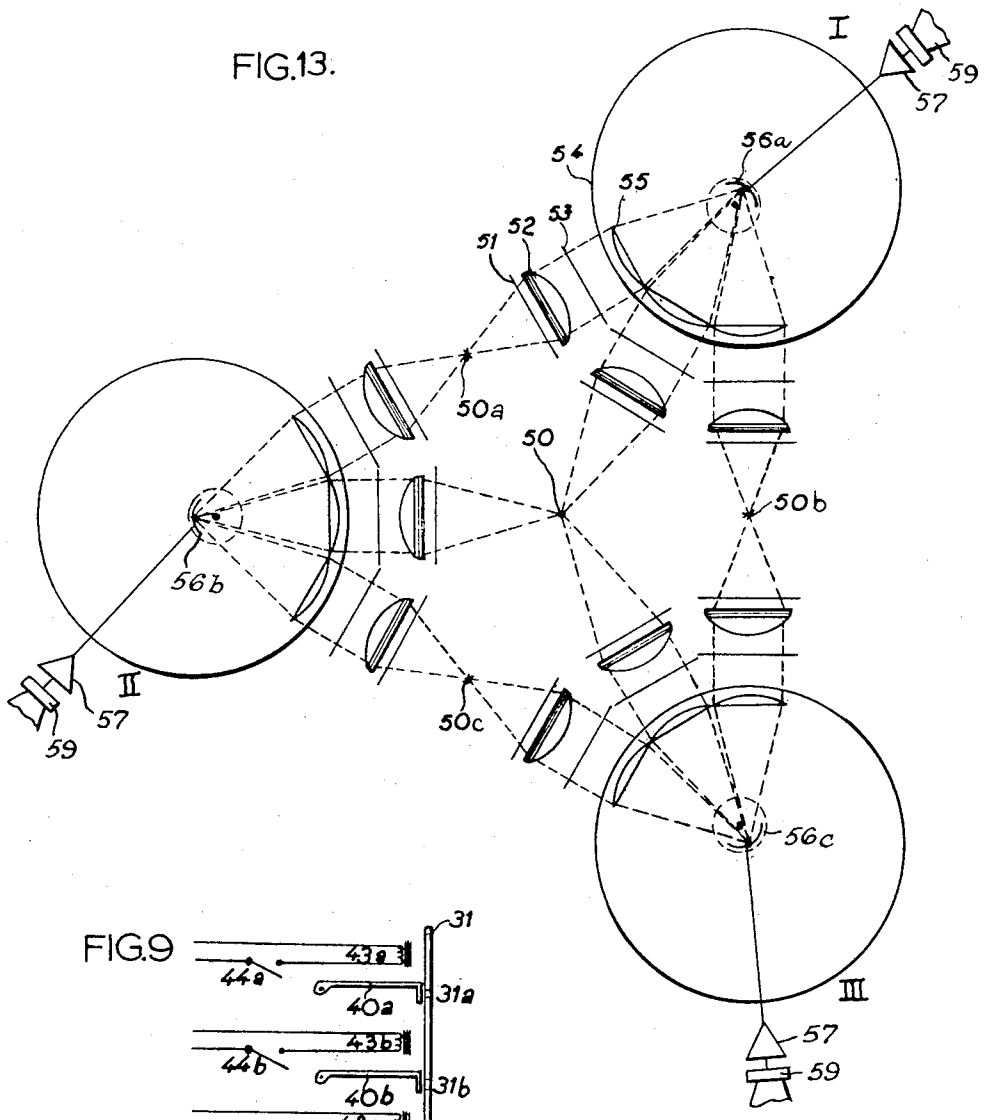
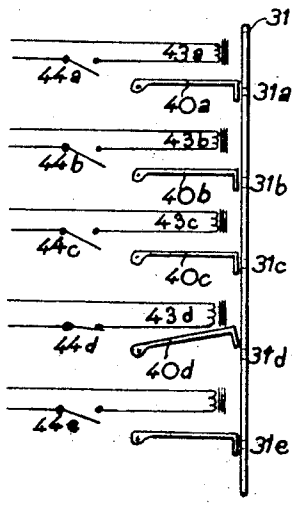


FIG.9



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United States Patent Office

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PHOTO-ELECTRIC MUSICAL DEVICE

Gabriel Bajolet, Haroue, France

Application January 23, 1951, Serial No. 207,412

Claims priority, application France January 24, 1950

10 Claims. (Cl. 84—1.18)

Many methods are known, both electrical and photo-electrical in character, for producing musical sounds, whereby sounds having various known tone qualities, and even new sounds, may be synthetically obtained. Such methods involve the use of comparatively complex means and the construction of electrical or photo-electrical musical instruments having a wide range of possibilities, such as organs for instance, leads to apparatus that is expensive in cost price and delicate of adjustment and maintenance.

It is an object of the present invention to provide a photo-electric method of sound production which is of great simplicity in the means involved in its construction, and very flexible as to its possibilities of producing sounds varying both in pitch and in tone quality or timbre.

The method of the invention essentially consists of analysing, in sections, a stationary beam of light having a selected shape, by means of a rotary cylindrical obturating member or analyser provided with analysing slots extending at an angle to its axis of rotation, projecting the cyclically variable amount of light thus intercepted upon a photo-electric cell, and amplifying, then emitting in the form of sound, the alternating electrical magnitude made available across the terminals of the said photo-electric cell.

In known methods involving the scanning of stationary beams, it has already been suggested to use radial slots formed in a revolving disc, but such an arrangement would be difficult to carry into effect for the stopping of the notes and the production of varied tone qualities.

Moreover, the fineness of definition of the notes is necessarily variable with the scanning radius and generally drops off as the distance from the discs axis of rotation increases.

Owing to the use, as in the present invention, of slots formed angularly and arranged on a cylinder rather than on a disc, the definition remains practically constant at all frequencies. It thus becomes possible to respect the tone quality in every key, both in low and in high pitch. Further, the combination of the cylinder with the angular analysing slot allows of an extraordinarily simple construction for the note control, that is of pitch, on the one hand, and the tone quality selection means on the other.

The method of the invention thus opens up a vast range of new possibilities, not only for the creation of new instruments of extremely restricted size and volume, but also in the fields of study, research and teaching.

Thus, it becomes possible to conceive a laboratory apparatus of very small size for research and teaching, which would display on an oscilloscope the curve being studied and would sound the audible result of such curve. One would thus be able at the same time to show and sound a pure note and its progressive modification resulting from the gradual addition of harmonics to the fundamental note, with or without phase-displacement.

A "pocket-chime" may further be imagined adapted to display on a screen delimiting the scanned beam or "singing screen," the sound of the stroke on the one hand, and the musical sound continuing this initial stroke, on the other.

It becomes above all possible to contemplate the construction of key-board instruments providing intervals according to unusual scales, for example a scale of natural frequencies which are integral multiples of a fundamental frequency f included between $8f$ and $16f$ ($8f$, $9f$, $10f$, . . . $16f$), an octotonal scale following an arithmetical progression which yields new and extremely remarkable musical effects.

It is also possible very easily to construct a keyboard with twenty-four quarter-tones, in demand by many musicians.

From among all possible uses to which the above-defined method may be put, a more specific object of my invention is to provide in an exceedingly compact form a musical instrument capable of reproducing organ music with a practically unlimited fullness and diversity of tone.

The features and advantages of the invention will be apparent from the following disclosure, with reference to the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view showing a device according to the invention for producing a sound having predetermined tone quality and frequency;

Fig. 2 is a diagram showing a form of construction of the orifices for forming the scanned beam;

Fig. 3 diagrammatically shows a method used in sound-cinematography;

Fig. 4 is a view similar to Fig. 1 showing the production of a higer frequency;

Fig. 5 is a similar diagram showing the production of a lower frequency;

Fig. 6 is a diagrammatic perspective view illustrating part of a photo-electric organ according to the invention;

Fig. 7 is a diagrammatic plan view of the instrument of Fig. 6;

Fig. 8 is a detail view relating to a sealing flap;

Fig. 9 is a diagram showing the sealing-flap control;

Figs. 10 and 11 are diagrammatic detail views relating to the singing screen;

Fig. 12 is a developed diagrammatic view of an analyser sleeve;

Fig. 13 is a diagrammatic view similar to Fig. 7 showing a modified embodiment.

Referring to Figs. 1 to 5, there will first be described in a general way, one form of embodiment of the method of photo-electric analysis according to the invention, using means similar to those which are used in the organ to be described hereafter.

In Fig. 1, 10 illustrates the contour of a stationary parallel light beam assumed to be normal to the plane of the figure. Such a beam may be produced by illuminating with a sheet of parallel rays, an opaque screen formed with an orifice having a selected contour and hereinafter designated by the expression "modulating orifice." When an opaque screen 11 formed with a slot 12 extending at an angle to the direction of translation is moved past the beam with a translatory motion, the amount of light flowing through the slot becomes modulated according to a law which depends only on the contour of the beam section, if the motion is uniform. In the case of the figure, it is seen that the degree of illumination ahead of the slot starts from zero, as the slot is in the position 12a, and returns to zero in the position 12b, after having passed through a maximum substantially corresponding to the full-line position 12. It is seen that if a second slot, such as 13 follows immediately after the slot 12, the same cycle of variation is repeated and the number of slots moving per unit time past the modulating orifice will de-

termine the frequency of the alternating phenomenon thus created.

The design of the contour of a modulating orifice may be very simply effected, as suggested by Fig. 2, in the case of a purely sine-wave variation. Starting from a full sine-wave, cycle 15, with the axes Ox, Oy, axes O'x', O'y' are drawn, the axis O'y' having the same angular inclination as the slots, then the rectangular ordinates of each point of the curve 15 are successively projected parallel to the axis O'y', so that the point *a* for example will assume the position *a'*, *b* to *b'*, *c* to *c'*, and so on; the desired curve 16 is thus obtained, defining with the straight portion O'A the contour of a beam suitable for scanning by slots having the stated angular inclination.

The amount of light received ahead of the scanning slot will be subjected to variations about its mean value, according to the—herein purely sine—law represented by the curve 15. It will only be necessary to collect the light which passes through the strip or screen 11 upon a photo-electric cell, and then emit in audible form after amplification the alternating voltage developed across the cell, in order to obtain a sound vibration having the shape imposed by the curve 15.

It will be understood that a similar procedure can be followed for any other form of vibration, other than sinusoidal. Then again, the form of construction described is by no means the only possible one, since it is not essential that the section of the beam be linear along one edge thereof, as shown herein.

It may further be observed that a result similar to that obtained with the method of scanning described, would be produced by displacing past an illuminated slot, a normally opaque film, made transparent within a succession of zones as previously defined; this would come to using a method of modulation employed in sound cinematography.

Fig. 4 is similar to Fig. 1, but shows how the inclination of the slots is increased in order to obtain a higher frequency; three successive slots 17—18—19 occupy herein the same width as the two slots 12—13 in Fig. 1, so that the resulting frequency will be ⅔ times greater and the corresponding sound will thus be the fifth above the basic pitch of Fig. 1, assuming the scanning strip is travelling at the same rate. The contour of the modulating orifice 20 should of couse be so designed as to make allowance for the altered inclination of the scanning slots.

For production of the lower frequencies, it may be desirable to resort to the arrangement shown in Fig. 5. Here, a beam defined by a modulating orifice 21 is scanned in each cycle successively by two slots 22 and 23 of reverse inclination. The inclination of the slots being necessarily very low, the contour of the orifice 21 may be conveniently selected as corresponding to that defined by a semi-cycle of the representative curve of the desired sound, in rectangular coordinates.

The basic means just described have, by way of example, been applied to the construction of an instrument for playing organ music, now to be described with reference to Figs. 6 to 12.

In the form of embodiment shown, the instrument comprises, arranged about a vertical linear light source 30, four groups of similar elements I, II, III and IV (Fig. 7), the group I being illustrated with greater detail in the diagrammatic perspective view of Fig. 6. Starting from the source 30, we find first an obturating screen 31 formed with a series of horizontal slots 31*a*, 31*b*, 31*c*, etc., called "note slots," each of which may be selectively masked and unmasked, as described in greater detail hereafter. Behind each slot is a light condenser 32 cut to the form of a dual lens, that is a lens 32₁ having its axis horizontal, i. e. parallel to the related slot 31 and so placed that its focal line will coincide with said slot, and an outer lens 32₂ so disposed that its focal line coincides with the source 30.

Under such conditions, the rays admitted through any of the slots of the obturating screen 31 are converted, beyond the corresponding condenser 32, into a sheet of light consisting of substantially parallel rays. These sheets impinge on a screen 33, called the singing screen, and respectively illuminate horizontal strips or channels *a, b, c,* etc., formed on said screen. In the perpendicular direction, this screen is divided into a number of vertical columns *k, l, m, n, o, p,* etc., defining with the horizontal strips *a, b, c,* etc., a number of rectangular areas or squares. In each of these squares, a modulating orifice is cut out corresponding in shape to the timbre (tone quality) of a predetermined sound to be obtained. As explained in detail further on, each of the horizontal strips *a, b, c,* etc., corresponds to a predetermined sound pitch or vibration frequency, while each vertical column *k, l, m, n,* etc., corresponds to a given tone quality.

Following the singing screen there is a rotary sleeve 34 called the analysing or scanning sleeve, vertically spaced along which are horizontal strips a_1, b_1, c_1, d_1, etc., respectively facing the horizontal strips *a, b, c, d,* etc., of the singing screen 33. This sleeve provides an opaque screen, and formed in each of the strips a_1, b_1, c_1, d_1, etc., is a series of slots so arranged that the number of slots moving each second past an orifice formed in the singing screen, affords the desired frequency.

Inside the analysing sleeve 34 and in the path of the rays admitted thereinto through the slots, is a light condenser 35 consisting of an axial plano-convex lens so placed as to convert the sheet of parallel rays which has traversed the preceding screens, into a dihedron of light focalized on a photo-electric cell 36, called the collector cell, arranged within the sleeve.

As shown in Fig. 7, four assemblies similar to the one described are disposed about the central source 30 and the rotary sleeves or drums 34 are adapted to be driven, e. g. by friction through a set of smooth gears and from a synchronous motor, at an appropriate constant speed.

In a preferred form of embodiment, a small synchronous motor is mounted on the end of each sleeve, with a high-frequency alternator which may be individual to each motor, or common to all, and with a different number of poles for each synchronous motor. This provides a convenient means for achieving strictly constant speed ratios in the drive of the respective sleeves.

The assembly further includes an amplifier actuated by the cells 36, one or more sound-emitters or loudspeakers driven from said amplifier, a keyboard of any suitable type the keys of which control the sealing of the slots in the screen 31, and a set of registers controlling the obturation of the columns in the singing or talking screen 33.

Figs. 8 and 9 show the device for obturating the note slots in the obturating screen 31. In front of each of the slots 31*a*, 31*b*, 31*c*, there is a so-called note-flap 40 pivoted on a pivot 41 and retained in sealing position by return-springs 42. Associated with each flap is an electro-magnet 43, each magnet being supplied from a common source, not shown, by a circuit comprising switches 44 actuated from corresponding keys. Thus in Fig. 9, the flap 40*d* controlling the slot 31*d* is raised by the closure of the related switch 44*d*. This results in a full illumination of the entire horizontal strip *d* of the singing screen 33 (Fig. 6).

On the singing screen 33 (Figs. 10 and 11), long narrow flaps 45 pivoted on hinges such as 46, seal or uncover selectively the vertical columns *k, l, m,* etc., i. e. the whole rank of notes having a common tone quality, thus performing the function of the reglette or stop-rod of a pipe organ. In Fig. 11 for instance, the modulating orifices of the column *k* provide the tone known as "dulciane," the column *l* provides the "bourdon" tone, and the column *m* the "cor-de-nuit" tone. On the strip *a* the orifices shown represent half cycles and these, scanned by the zigzag analysing slots 47 (Fig. 12) of the analyser sleeve 34, will sound the deeper notes.

Five further octaves are obtained by the following

strips *b, c, d,* etc., respectively scanned by the horizontal channels b_1, c_1, d_1, etc. of the analysing sleeve; the slots 48 sound the octave above the note sounded by the slots 47, as a full cycle of a slot **48** corresponds to a half-cycle of the slot **47**; the slots **49** of the strip c_1 sound the second octave, since there are two slots **49** registering with one slot 48, and so on. The modulating or singing orifices of each horizontal channel are of course constructed with due allowance for the inclination of the corresponding analysing slots according to the method previously described with reference to Fig. 2.

I shall now describe the arrangement for simultaneously producing the different notes of the musical scale which it is desired to obtain.

As applied to the so-called equally tempered scale, the twelve semi-tones of the conventional scale are divided into four groups of three frequency values, as summarized in the following table:

Table I

Group	First Zone		Second Zone		Third Zone	
	Note	Frequency	Note	Frequency	Note	Frequency
I	C	f	F	$\frac{4}{3}f$	G	$\frac{3}{2}f$
II	E flat	$f.2^{1/4}$	A flat	$\frac{4}{3}f.2^{1/4}$	B flat	$\frac{3}{2}f.2^{1/4}$
III	F sharp	$f.2^{1/2}$	B	$\frac{4}{3}f.2^{1/2}$	C sharp	$\frac{3}{2}f.2^{1/2}$
IV	A	$f.2^{3/4}$	D	$\frac{4}{3}f.2^{3/4}$	E	$\frac{4}{3}f.2^{3/4}$

It will be seen that each group includes a basic frequency and two further frequencies bearing a simple harmonic relationship with said basic frequency. In the first group, for instance, there is C as the basic note, and with it F, the musicians' major fourth, at 4/3 the basic frequency, and the musicians' major fifth, equal in frequency to 3/2 of the basic frequency. Each moving sleeve 34 will accordingly be divided vertically into three zones: a first zone giving the basic frequencies; a second zone under the first giving 4/3 times this frequency, and a third zone under the second and giving the 3/2 of the said basic frequency. Each zone is divided into a number of octave strips or channels in the same way as the strips a_1, b_1, c_1, etc., of Fig. 12, the inclination of the slots in each strip being gradually increased together with the number of slots around the periphery.

The sleeve **34** of group I, Figs. 6 and 7, will thus provide for the emission of twenty-one frequencies corresponding to all of the C's, F's, and G's, of a seven-octave key-board. The sleeve of group II will in the same way sound all the E flats, A flats and B flats; the sleeve of group III will sound all the F sharps, B's and C sharps; and the sleeve of group IV, all the A's, D's and E's.

Correspondingly, the singing screen **33** in each of its vertical columns will display the various notes of a given timbre. Thus, the column *m* (Fig. 11) will for instance sound successively, working upwards: C^{-1}, C^1, C^2, C^3 . . . (1st zone); F^{-1}, F^1, F^2, F^3 . . . (2nd zone); G^{-1}, G^1, G^2, G^3 . . . (3rd zone).

The various timbres (flute, bourdon, diapason, clarion, and so on), are aligned on parallel lines and on a common horizontal channel such as *a, b, c,* etc.

Each collector cell **36** may, in order to facilitate construction, be divided into a plurality of partial cells suitably grouped at the input into of a pre-amplifier stage. Such a stage may be associated with each of the groups I to IV. The pre-amplifiers are then followed by a sonorizing amplifier, of any suitable type, driving one or more loud-speakers or sound-emitters.

The timbre (tone quality), and to a certain extent also the relative volume of each tone, may be controlled by

the design of each modulating orifice. However, the amplitude of the sound volume, that is the total sound energy actuating the surrounding atmosphere per unit time, will be adjusted by acting on the overall gain of the amplifier.

Such an instrument (exclusive of the sound-emitter or loud-speaker and the keyboard) has been constructed for experimental purposes with a size of 41 x 41 x 55 cm., a feat which hardly requires emphasis as to its advantages, when compared to other constructions of similar type. The very great simplicity of the means used, ease of operation and maintenance and absence of any fine adjustment, are further worthy of note. The quality of the sounds obtained is remarkable and the cost price of the apparatus is exceedingly low.

Of course, the invention is not restricted to the forms of embodiment illustrated and described, by way of example only.

Thus, Fig. 13 illustrates a modified embodiment of a photo-electric organ, differing from the construction described in that the cross like arrangement of the groups I to IV in Fig. 5, about the central source **30**, is herein replaced by a triangular arrangement which may in some instances be preferable.

Spaced around the central source **50**, there are three side sources **50***a*, **50***b*, **50***c*, arranged, as shown, at the apices of an equilateral triangle centered at said central source, and allowing illumination of three groups of elements **51**, **52**, **53**, **55** respectively similar to the elements **31**, **32**, **33**, **35**, of the previously discussed type and associated with a common analyser sleeve **54**, the modulated light from each of the triple groups I, II, III thus constituted being collected by collector cells **56**^{a}, **56**^{b}, **56**^{c} to each of which an amplifier **57** and a sound emitter **59** is connected.

This arrangement makes possible a threefold utilization of each analyser sleeve **54**, and accordingly yields three times as many possibilities as concerns the singing screen **53**, with one collector cell less and only three side sources more.

In this case therefore, there will be had a different distribution of the twelve semi-tones of the conventional scale into three groups of four frequencies each, rather than four groups of three frequencies, as shown in the Table II hereafter. The singing screens **53** and the analysing sleeves **54** are consequently divided in the vertical (or axial) direction into four zones of *n* channels each, *n* being the number of octaves in the keyboard.

Table II

Group No.	First Zone	Second Zone	Third Zone	Fourth Zone
I	C (f)	D $\left(\frac{9}{8}f\right)$	F $\left(\frac{4}{3}f\right)$	G $\left(\frac{3}{2}f\right)$
II	E	F sharp	A	B
III	G sharp	A sharp	C sharp	D sharp

To pass from the frequencies in group I to those in group II and from those of group II to those of group III, the multiplying factor here is obviously $2^{1/3}$ instead of the factor $2^{1/4}$ as in the preceding instance.

What I claim is:

1. In a sound production device having means for converting light into sound, an opaque singing screen having a modulating orifice of selected contour formed therein for passage of light therethrough, means for projecting through said orifice a light beam so as to be received by said converting means, a scanning member, and means for supporting said scanning member and said singing screen for movement of one relative to the other in a given direction at constant speed and generally parallel to the plane of said orifice, the contour of said orifice being defined by the amplitude-time curve of the sound wave to be obtained with the time axis of said

curve perpendicular to the line of relative movement of said scanning member and said screen and the amplitude axis of said curve inclined at a given angle to said line of relative movement, said scanning member providing a series of scanning slots in spaced relation along said line of relative movement and brought into register in succession with the light beam through said orifice in said relative movement of said scanning member and said screen intermittently to project light of said beam through said slots and through said orifice, said slots being inclined to said line of movement substantially at said given angle.

2. In a sound production device having means for converting light into sound, a stationary opaque singing screen having a modulating orifice of selected contour formed therein for passage of light therethrough, means for projecting through said orifice a light beam with substantially parallel rays so as to be received by said converting means, and an opaque sleeve rotatable upon an axis which is parallel to the plane of said orifice of said singing screen, the contour of said orifice in its plane being defined by the amplitude-time curve of the sound wave to be obtained with the time axis of said curve parallel to the axis of rotation of said sleeve and the amplitude axis inclined at a given angle to the plane perpendicular to said axis of said rotation of said sleeve passing through the point of origin of said curve, said sleeve being provided with a series of scanning slots peripherally uniformly spaced in said sleeve about said axis of rotation and each extending on the periphery of said sleeve between said plane passing through said origin of said curve and a plane parallel thereto passing through the other end of said contour curve, said slots being inclined to said parallel planes at the same angle as said given angle of inclination of said amplitude axis to said plane through said origin of said curve.

3. In a sound producing device the apparatus as defined in claim 2 in which said orifice is provided with a contour upon rectangular coordinates in the form of one half the cycle of the desired sound with the large portion of said orifice opening adjacent one of said parallel planes, said scanning sleeve being provided with at least a pair of slots inclined oppositely to each other with respect to the direction of rotation of said sleeve and in relation to said parallel planes, each of the slots of said pair having its length extending substantially between said parallel planes.

4. In a sound production device having means for converting light into sound, a linear light source for directing light toward said converting means, a stationary obturating screen facing said light source and provided with a series of note slots which are disposed in spaced relation respectively in planes perpendicular to the length of said light source, means adapted selectively to mask and unmask the respective note slots, a plurality of light condensers disposed so as respectively to convert the rays passing through said note slots into beams of substantially parallel rays, a stationary opaque singing screen having modulating orifices formed therein for the passage of said light beams therethrough from the respective note slots and the corresponding condensers toward said converting means, and a cylindrical opaque sleeve rotatable upon the axis of said cylinder which is parallel to the length of said light source and provided with a series of scanning slots peripherally uniformly spaced in said sleeve about the said axis of rotation and disposed generally in the respective planes of said light beams passing through said note slots and through the respective orifices, said modolating orifices being defined by the amplitude-time curves of the sound waves to be obtained with the time axes of said curves parallel to said axis of rotation of said sleeve and the amplitude axes of said curves inclined at given angles to the periphery of said sleeve, said scanning slots being inclined to the planes of the respective beams and to the peripheral movement of said sleeve substantially at said given angles.

5. In a sound production device the apparatus as defined in claim 4, said singing screen providing a plurality of said modulating orifices arranged in said screen in a plurality of parallel channels and a plurality of parallel columns respectively perpendicular to said channels, each of said channels corresponding to a given pitch of sound and each of said columns corresponding to a given timbre, said rotatable sleeve having its axis parallel to said columns, said scanning slots of said sleeve being spaced along annular strips peripherally on said cylinder and respectively generally in planes perpendicular to said axis of rotation, said channels being disposed in the planes of said strips so that said scanning slots corresponding to each channel are successively brought into register with the orifice of said channel, means supported adjacent said columns and adapted to selectively obturate said columns, means disposed adjacent said obturating screen for individually opening and closing said note slots to transmit and to intercept light therethrough from said source, and means for driving said sleeve substantially at a constant speed.

6. In a sound production device having means for converting light into sound, a light source, a stationary opaque obturating screen facing said light source and provided with a series of parallel note slots in spaced relation therein transversely of said slots, light condenser means disposed so as to convert the rays passing through each note slot to a sheet of substantially parallel rays, a stationary opaque singing screen having a plurality of modulating orifices arranged in a series of channels and a series of columns, said channels being disposed in said screen perpendicular to said columns, each of said channels corresponding to a given pitch of sound and each of each columns corresponding to a given timbre, said channels in said singing screen respectively being disposed in the sheets of light passing through said note slots, an opaque sleeve rotatable upon an axis which is parallel to said columns of said singing screen and provided with a plurality of scanning slots spaced uniformly peripherally of said sleeve along annular strips respectively generally in the planes of said sheets of light and so that said slots in each strip successively are brought into register with the orifices of the respective channels upon rotation of said sleeve, means for selectively masking and unmasking said note slots, means for selectively masking and unmasking said columns of said orifices, and means disposed within said rotatable sleeve so as to receive the light passing through said scanning slots for transmitting the light energy received thereby to means connectible thereto for converting light into sound.

7. An instrument for production of music comprising a central linear light source, a plurality of groups of devices arranged symmetrically about said light source, each group comprising in succession in the direction proceeding from said light source an obturating screen carrying a series of note slots disposed in spaced parallel relation in the direction parallel to said light source for passing light from said source therethrough, a plurality of light condensers disposed in relation to said slots respectively to receive the light passing through said slots, a singing screen providing a plurality of modulating orifices distributed in columns parallel to the length of said light source and in channels perpendicular to said columns, each of said channels corresponding to a given pitch of sound and each of said columns corresponding to a given timbre, each of said channels being disposed to receive light passing through a note slot and a condenser, an opaque sleeve rotatable on an axis parallel to said light source and provided with a series of scanning slots spaced uniformly peripherally on said sleeve about said axis of rotation for each of said channels of said singing screen for receiving light passing through the orifices of the respective channels, means for selectively masking and unmasking said note slots, means for selectively masking

and unmasking said columns of said orifices, and means disposed within said rotatable sleeve so as to receive the light passing through said scanning slots for transmitting the light energy received thereby to means connectible thereto for converting light into sound.

8. An instrument as defined in claim 7 wherein four of said groups provide the notes of the equally tempered scale, all the C's, F's, G's in the first group, all the E flats, A flats, B flats in the second group, all the F sharps, B's, C sharps in the third group and all the A's, D's, E's, in the fourth group.

9. An instrument for photo-electric production of music comprising about a central linear light source three similar side sources of light at the apices of an equilateral triangle centered at said central source, said central and side light sources being adapted to illuminate three triple groups of light transmitting and intercepting devices disposed symmetrically about said sources, each group of devices comprising side by side three obturating screens, each screen having a plurality of note slots, three series of light condensers respectively corresponding to said note slots, three singing screens carrying modulating orifices distributed in columns and channels, each said channel being individually illuminated by one of said condensers, a rotary analyzing sleeve for each group of devices and carrying a plurality of series of scanning slots respectively opposite to said channels, a photo-electric cell within said sleeve, light condenser means adapted to focalize on said cell the light passing through said orifices of said three singing screens and through said scanning slots into said sleeve, and sound emitter means respectively connected to and controlled by the three cells of said three triple groups.

10. An instrument as defined in claim 9 wherein the three triple groups produce all the notes of the equally tempered twelve semi-tone scale respectively all the C's, D's, F's and G's in the first group, all the E's, F sharps, A's, B's in the second group and all the G sharps, A sharps, C sharps, D sharps in the third group.

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