

June 18, 1957

R. E. WILLIAMS

2,796,534

PHOTO-ELECTRIC TONE GENERATOR.

Filed Jan. 23, 1951

2 Sheets-Sheet 1

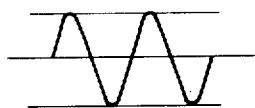


FIG. 1

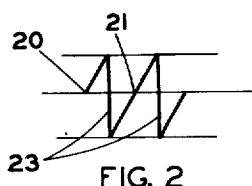


FIG. 2

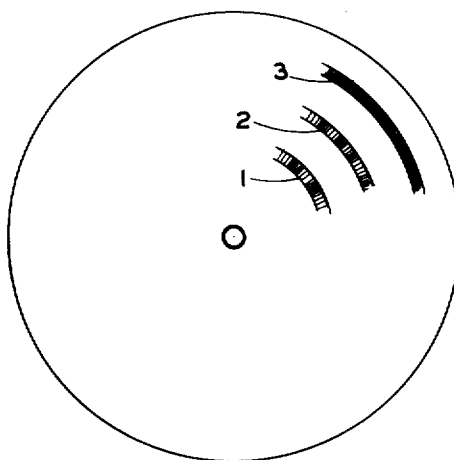
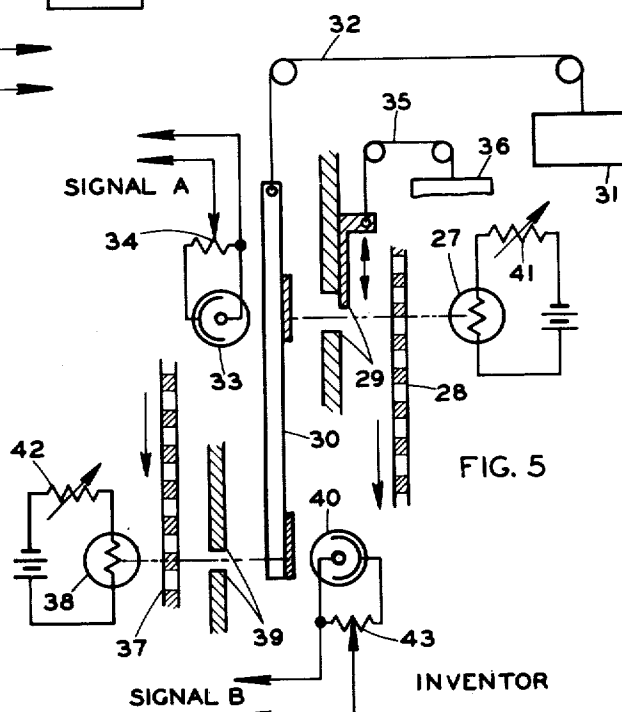
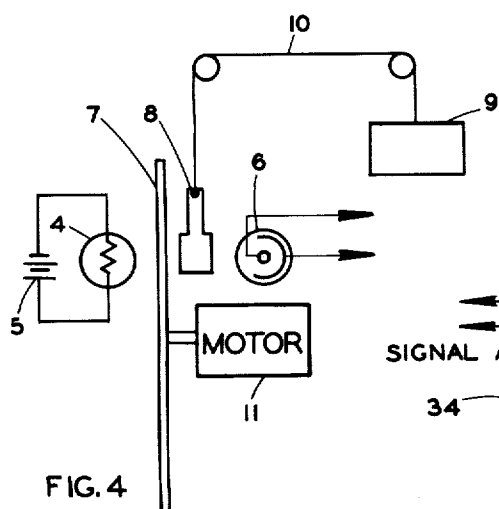


FIG. 3



INVENTOR

Richard E. Williams

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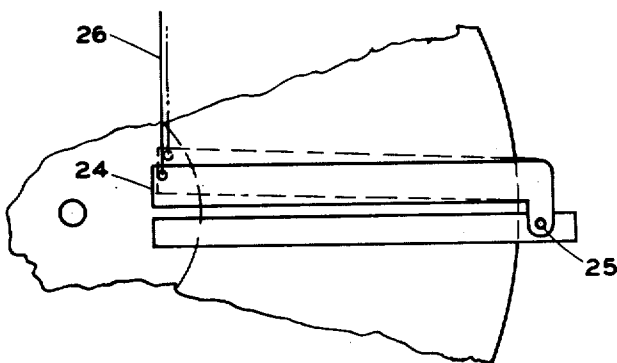
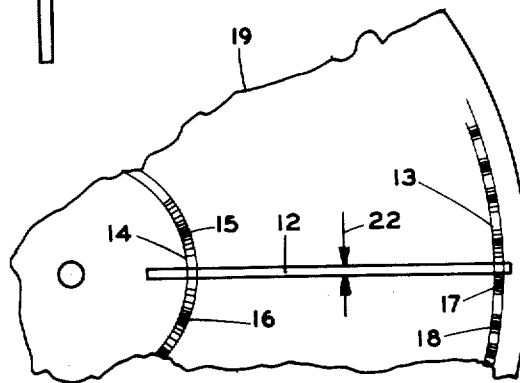
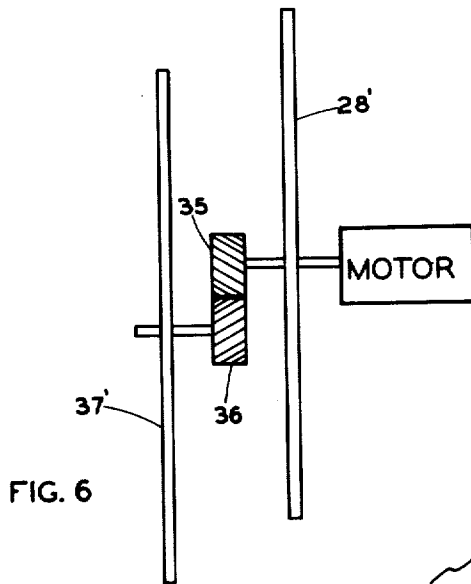
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INVENTOR

Richard E. Williams

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PHOTO-ELECTRIC TONE GENERATOR

Richard E. Williams, Manchester, N. H., assignor to
Wilbespan Research Labs, Inc., Arlington, Va.

Application January 23, 1951, Serial No. 207,285

3 Claims. (Cl. 250—219)

This invention relates to improvements in photo-electric type tone generators in general, and more particularly to those of the type described in my United States Patent No. 2,588,680, granted March 11, 1952.

The type of musical instrument therein described consists of a light source separated from a light sensitive cell by a tone screen cycling at a natural vibrato rate (about 7 C. P. S.) or other basic speed. The nature of this screen, which may be in the form of a disc, belt, or cylinder, is such that it varies the light transmitted from the source to the cell in accordance with desired tones or pitches. Shutters controllably masking endless soundtracks inscribed on the screen provide a means for selecting the tone or combination of tones desired.

The invention herein described provides stop-controlled tone color without requiring substitution of discs.

In addition, means are described for rapidly and simultaneously controlling the harmonic content in a similar manner for a great number of tones.

Again, the invention has for its object means for controlling the ratio of a fundamental to its harmonics in a highly flexible manner.

Further, the invention will be found to reside in a very inexpensive musical instrument capable of operation and tone color similar to that of complex pipe organ installations.

The foregoing and other objects will manifest themselves as the following description progresses, references being had to the accompanying drawings, in which:

Fig. 1 is a sine wave, or a waveform devoid of harmonics;

Fig. 2 is a saw-tooth waveform, or one rich in harmonic content;

Fig. 3 is a view of a disc-type tone screen showing typical soundtrack positioning;

Fig. 4 is an assembly for reproducing tone screen modulations;

Fig. 5 is an assembly similar to that of Fig. 4, but capable of simultaneous controllable scan of two tone screens;

Fig. 6 is a method of driving in an offset manner the tone screens of Fig. 5;

Fig. 7 is a view of a tone screen showing locations of low and high frequency tracks, and scanning slit; and

Fig. 8 is a view of an adjustable scanning slit.

It is well known that the nature or timbre of a musical tone is dependent upon the amplitudes of the harmonics present in that tone. Generally speaking, the less the harmonic content the mellower the tone, and as more harmonics are added, the tone becomes more vivid or acute. Anything capable of controlling the number of harmonics present, or their loudness, will also affect the nature of the tone as perceived by the human ear.

Fig. 1 is a graph of a sine wave, or a tone devoid of any harmonics. If a conventional photo-electric soundtrack were made of this tone, then scanned, a very mellow sound would result. Soundtracks of a plurality of these

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tones can be photographically produced in an endless form on a tone screen disc, Fig. 3, using methods described in my United States patent application, Serial No. 157,390, filed April 21, 1950. Subsequent reproduction of the soundtracks inscribed in this manner would provide a plurality of fundamental, mellow pitches.

If, on the other hand, a saw-tooth waveform such as that shown in Fig. 2 were recorded in the manner described, reproduction of the tone screen soundtracks would result in very acute tones rich in harmonics. Although a saw-tooth waveform is used for purposes of discussion, it is to be understood that any non-sinusoidal waveform has harmonics, and therefore could be used in the fashion described. For this reason the soundtracks or tone screens carrying waveforms containing harmonics will be termed "rich" whereas those carrying sine waves will hitherto be referred to as "fundamental."

The basic mechanism required for the reproduction of photo-electric soundtracks 1, 2, and 3 in Fig. 3 is that shown in Fig. 4 which comprises a light source 4 energized by a voltage source 5 separated from a light-sensitive cell 6 by the rotating tone screen 7 and a soundtrack selecting shutter 8. The shutter 8 is normally coupled to a keyboard key 9 by suitable means such as a cable 10. A relatively constant speed motor 11 drives the tone screen 7. Depression of the key 9 raises the shutter 8 allowing light pulsed by the tone screen soundtrack to reach the cell 6 from the steady-state source 4. The electrical output from the cell 6 is amplified and transduced to sound by conventional methods. This assembly of Fig. 4 will produce tones of one tone color for each soundtrack, and color variation is usually obtained by the removal and substitution of the tone screen 7.

Commonly the cell 6 in Fig. 4 will scan an area of the tone screen 7 shown as the slit 12 in Fig. 7. The higher frequency or pitch is usually at the outer tone screen soundtrack 13, whereas the lowest is at the inner track 14. It is also usual for the lower pitch 14 to have a longer recorded wave length, as indicated by the distance between a node 15 and a subsequent one 16, than the higher pitch 13 indicated by the nodular distance 17 to 18. The actual ratio between these nodular distances 15 to 16, and 17 to 18 is determined by the pitch range involved and the tone screen 19 angular velocity, but is easily computed mathematically once the parameters are known.

The nodular distance or wave length in graph form is the interval from points 20 to 21 in Fig. 2. Now, it is well known that as the scanning slit width 22, in Fig. 7, is increased toward the nodular distance 15 to 16, or 17 to 18, the light pulsations tend to integrate; the steepest wave fronts 23 in Fig. 2 disappearing first. This is equivalent to making the waveform of Fig. 2 more nearly approach that of Fig. 1, or become more sinusoidal in nature. This, in turn, is equivalent to the removal of harmonics or the transition from a rich to a fundamental tone in the case where the soundtrack itself is of a rich composition. This effect is most pronounced when the scanning slit width 22 of Fig. 7 is increased from about $\frac{1}{4}$ to $\frac{1}{2}$ the wave length or nodular distance. Although the apparent loudness of the tone scanned at different widths will vary somewhat, the effect can be predicted and compensated where desired by providing volume control in any conventional manner. A variable-density type soundtrack tends to produce more satisfactory results in a mechanism of this nature, but I have tested other types with considerable success.

Because the nodular distance of the low pitches 15 to 16 is considerably greater than that of the high 17 to 18, and because the harmonic attenuation is proportional to the ratio of the slit width 22 to the nodular distances for each soundtrack, similar attenuation for each pitch re-

quires an adjustable slit arrangement such as that of Fig. 8. Because the movable slit edge 24 is pivoted from the axis 25 in Fig. 8 it can be seen that adjustment of the controlling cable 26 will provide unequal width variation, but similar harmonic attenuation, for the low and high pitches 14 and 13 of Fig. 7. The controlling cable 26 of Fig. 8 can be connected to suitable indexing stops, etc., to provide variable or fixed tone color changes.

A basic photo-electric tone generator with controllable tone color could consist, then, of the top portion of Fig. 5 in which a light source 27 transmits light through a tone screen with rich soundtracks 28, and a variable width slit 29. A key-controlled shutter 30 connected to a key 31 by suitable means 32 can be raised by depression of amplifier and loudspeaker operating from signal A. The photocell 33 is connected with volume control means 34 to sound transducing apparatus such as a conventional amplifier and loudspeaker operating from Signal A. The variable width aperture 29 is manually controllable through mechanical or electrical coupling 35 to a stop tab 36, or other equivalent device. An organ constructed in this manner can produce a great variety of pleasing tones, stop controlled, at a very low cost. The use of electrical formants, or filters, in the associated amplifier arrangement serves to even greater extend the flexibility.

An effective, yet simple, refinement to the above described invention is realized in reference to Fig. 6. Here the rich tone screen 28' is coupled in an offset manner through gears 35 and 36 to a fundamental tone screen 37'. Although an offset arrangement is shown, it is to be understood that common coupling to the same shaft can be used in many ways without changing the nature of the invention disclosed.

Referring again to Fig. 5, it is seen that below the basic lightscreen-cell combination can be placed a similar group consisting of a light source 38, a fundamental tone screen 37 coupled to the original screen 28 as shown in the Fig. 6 method, a scanning slit 39, and a photocell 40. A link between the two groups is provided by the common shutter 30. Normally the basic soundtrack frequencies of the rich screen 28 will be one octave higher than their corresponding soundtracks on the fundamental screen 37. The eventual loudness of the rich tones can be controlled by varying the light 27 intensity by means of a rheostat 41 or a volume control 34. Either changes the amplitude of signal A. Similarly, signal B can be varied with rheostat 42 or volume control 43. These controls 41, 34, 42, and 43 enable the proportional mixing, then, of the fundamental to its harmonics, from "All fundamental" with maximum signal B and zero signal A, through infinite intermediate steps, to "All harmonic" commencing an octave higher with maximum signal A and zero signal B. In addition, it is to be remembered that the richness of signal A is controllable by the adjustable slit 29. Extreme flexibility of tone is possible with such a combination.

For certain uses it may be desirable to use two rich tone screens with two adjustable slits in essentially the same device as described above, I therefore do not wish to limit the scope of my invention to the particular tone combinations described herein, but to any similar substitutions thereof, and combinations containing the basic improvements described.

What is claimed is:

1. A photo-electric tone generator having soundtrack scanning means comprising a light source, a light-sensitive cell, and controllably adjustable light aperture defining means interposed in optical alignment therebetween and having a light aperture therein adapted to pass a beam of light from the source to the cell, and a circular soundtrack record rotatably mounted in the light beam, a plurality of endless complex optical soundtracks of differing basic wave lengths on said record, said aperture having opposite sides defining opposite boundaries of said beam at said record along lines generally radial of said record and across said soundtracks but shaped and arranged to define the distance between said boundaries at each soundtrack as substantially equal to a predetermined fraction of the basic wave length of said sound track corresponding to any particular adjustment of said aperture defining means, said fraction being common to all said sound tracks in any such particular adjustment.

2. In a photo-electric tone generator, light source means and light-sensitive cell means, and controllably adjustable scanning slit means and a relatively moving record having plural complex waveform soundtracks of differing basic wave lengths interposed in optical alignment between said source and said cell, said slit means having opposite side portions defining boundaries of scanning light beam path means for and at said soundtracks crossing said soundtracks substantially orthogonally to the direction of movement thereof, said boundaries at each individual soundtrack being spaced a distance apart in the direction of soundtrack movement substantially equal to a predetermined fraction of the basic wave length of such soundtrack corresponding to any particular adjustment of said scanning slit means, said fraction being common to all said soundtracks in any such particular adjustment.

3. In a photo-electric tone generator, tone generating means comprising a light source, a light-sensitive cell, and light aperture defining means interposed in optical alignment therebetween and having controllably adjustable light aperture means therein adapted to pass a beam of light from the source to the cell, and a moving tone screen mounted in the light beam to be scanned thereby, said tone screen having a plurality of endless complex wave form optical soundtracks of differing basic wave lengths, said aperture means having opposite sides shaped and arranged to define opposite boundaries of said beam at said tone screen along lines across said soundtracks generally orthogonal to the direction of scanning movement thereof, the actual spacing of said boundaries in any given adjustment of said aperture means being greater at soundtracks of longer basic wave lengths.

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