Oct. 10, 1950 R. M. TINK 2,525,156

METHOD OF AND MEANS FOR ELECTRICALLY GENERATING TONES

Filed Jan. 31, 1949 2 Sheets-Sheet 1

Fig. 1.

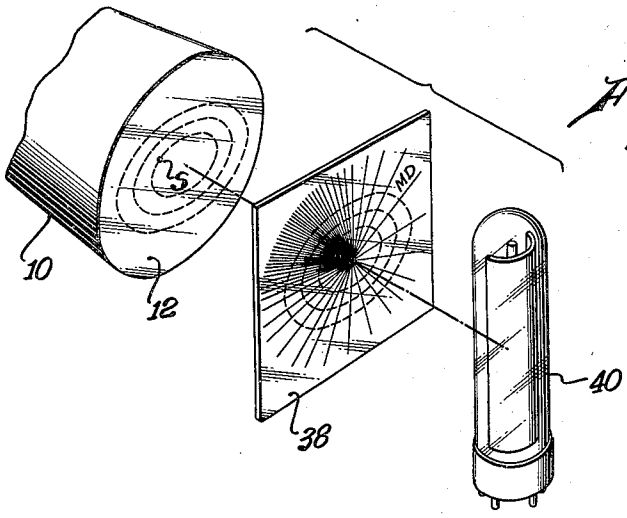


Fig. 2.

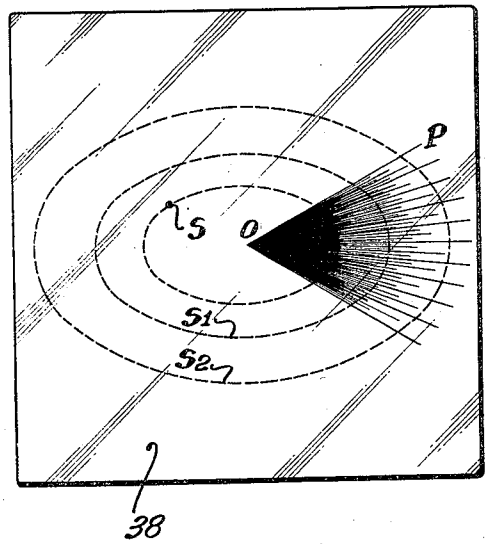
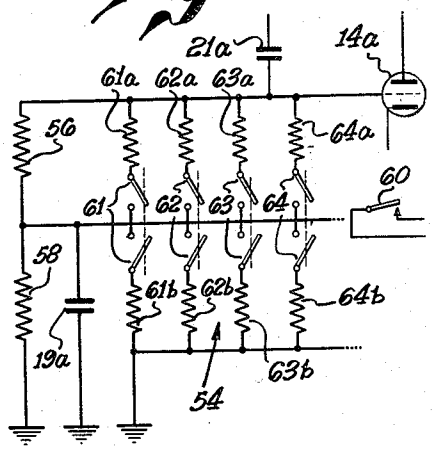


Fig. 4.



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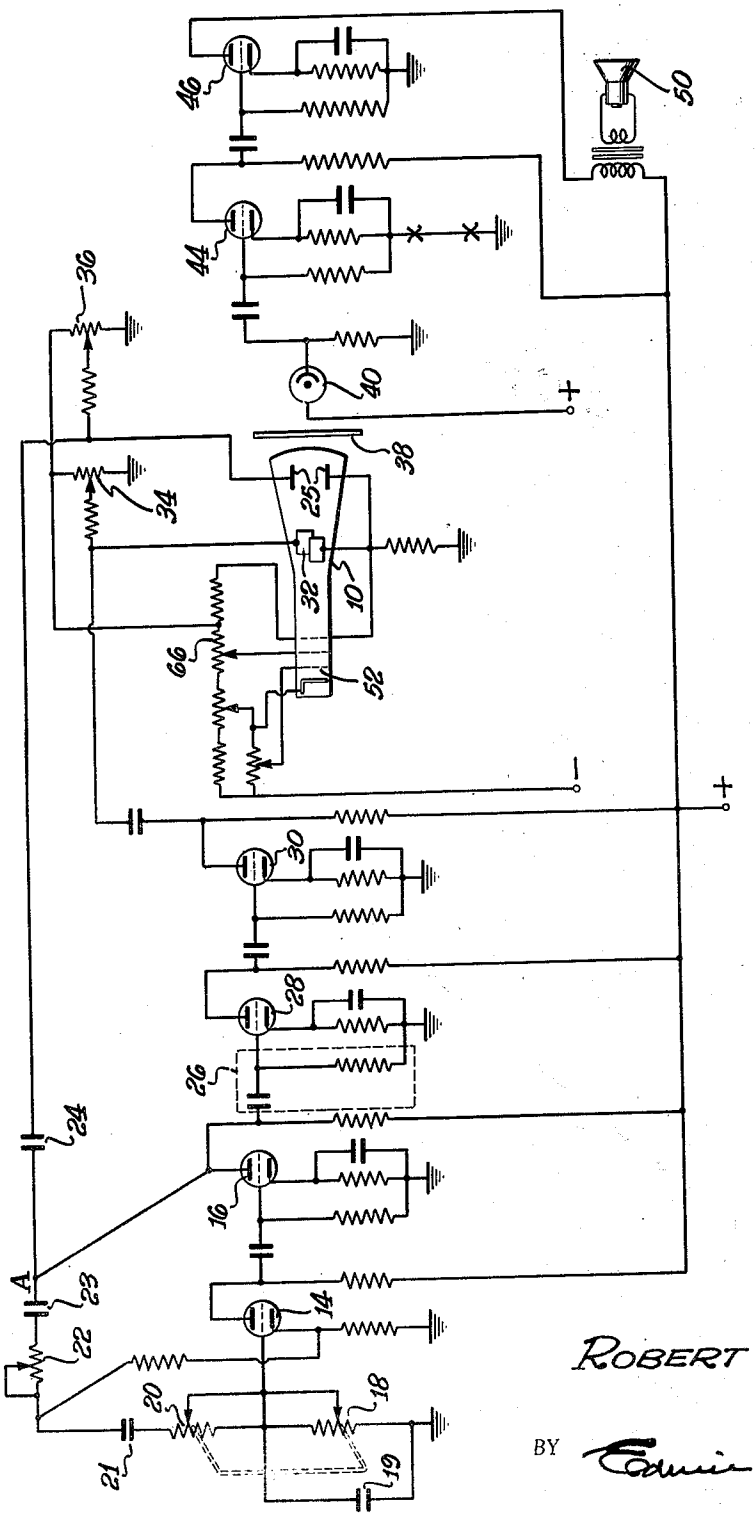

Fig. 2.

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METHOD OF AND MEANS FOR ELECTRICALLY GENERATING TONES

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Application January 31, 1949, Serial No. 73,851

3 Claims. (Cl. 84—1.18)

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My invention relates to a method of and means for the production of sounds by electrical means and has for its general object the production of tones having the characteristic overtones or harmonics of specific musical instruments so that the manipulator of an instrument incorporating my invention can produce from a loudspeaker music which appears to be played by a particular musical instrument such as a violin or piano although no such instrument has been used in the production of the sound.

It will be understood, of course, that my invention is not limited to producing such sounds with frequencies of 25 to 30,000 cycles per second, which is the range of the average ear, but also with frequencies above or below this range since the factor of frequency is one dependent on the adjustment of the electrical means. Further, the tone characteristics, though primarily made by using musical instruments to provide a tone control element, can also be produced by utilizing other than musical instruments to produce the tone control element.

In known sound reproducing apparatus the characteristics of the original sound are caused to vary the amount of light falling upon a light sensitive cell which through appropriate electrical and optical elements produces a photographic plastic or magnetic record of the sound which can be used to reproduce the original sound, such apparatus can therefore produce only the original sound. Electrical instruments are also known, arranged to produce by electrical means, an approximation of the sound produced by some particular instrument such as that of a wind organ. It is, however, broadly new, to the best of my knowledge, to provide a method and means whereby a piece, for instance, played upon a keyboard arranged to cover the musical scale of three octaves below middle C and four octaves above middle C, will audibly render the piece in the characteristic tone of any predetermined instrument or instruments although no such instruments are actually played.

It is an object of my invention to cycle a spot of light at a fundamental frequency, by electrical means, through a predetermined path while keeping it at a constant distance from a light pickup device and project the spot through an element having light transmitting properties imparting to the light transmitted through said element onto the light pickup device, the characteristic tone of a particular predetermined instrument so that the output of said light sensitive element will, when suitably amplified and coupled to an audio system, render the sound as though produced by the particular instrument.

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It is a further object of my invention to cycle a spot of light at a fundamental frequency by electrical means through a predetermined path at a constant distance from a light sensitive element, and to position between the spot of light and the light sensitive device a translucent element the opacity of which is adjusted to impart a predetermined tone value to the transmitted light which is varied with the position of the path of the spot of light relative to said tone control element.

It is a still further object of my invention to cycle a spot of light at a fundamental frequency and project the spot of light through a tone control element onto a light pickup element, controlling the tone of the reproduced sound by controlling the size of the spot of light.

Further features and objects of my invention will hereinafter appear from the following specification taken in conjunction with the accompanying drawings which illustrate embodiments of the invention at present deemed preferable my me.

In the accompanying drawings:

Fig. 1 is a diagrammatic representation of the essential components of the apparatus required to carry out my invention.

Fig. 2 is a front elevation drawn on an enlarged scale of a typical tone imparting element constituting an important element of my invention.

Fig. 3 is an electrical circuit diagram showing a suitable arrangement for carrying out my invention.

Fig. 4 shows a modification of the oscillator portion of the circuit shown in Fig. 3 to adapt the invention to use as a musical instrument.

In Fig. 1 the numeral 10 indicates a cathode ray tube having a screen 12 formed by a phosphor having an extremely short afterglow but permitting the formation of a brilliant sharply focussed light spot S. Such tubes are commercially available provided with screens having an afterglow of from $1/1000$ sec. to as little as $1/1{,}000{,}000$ sec. The light from spot 3 traverses a translucent tone generator 38 and activates a light sensitive device such as photo tube 40.

A sharply focussed spot of light S is formed and moved in a predetermined closed path on the screen by the electrical circuit of Fig. 3 which is provided with power by a resistance-capacity oscillator comprising tube 14, adjustable resistors 18, 20, 22, and capacities 19, 21, and 23, and amplifier 16.

The alternating voltage generated by the oscillator at a frequency determined by the setting of the resistor is imposed through capacity 24 on

deflecting plate 25 of cathode tube 10, and through phase shifting network 26 and amplifiers 28 and 30 to deflecting plates 32 of cathode tube 10, but 90° out of phase with the voltage impressed on plate 25. The voltages on the deflecting plates, as determined for plate 25 by the ratios of resistors 18, 20, and 22, and for plate 32 by network 26 and gain of amplifiers 28, 30, are adjusted to produce a sweep path of spot S on the fluorescent screen which will have a predetermined shape and will be constant at the particular frequency at which the oscillator is initially set. It will be assumed that in the usual case the shape of the path swept out by the spot will be an ellipse with its axes intersecting at the center of the screen, the axis increasing in length with increase in frequency, but as later shown the shape of the swept path and its location on the screen may be varied by the initial setting of the oscillator to give other than true harmonics of the fundamental frequency.

An increase in the frequency of the oscillator will impress a greater voltage on deflector plate 32 due to network 26 thus increasing one axis of the ellipse while the length of the other ellipse is increased by causing the ratio of the value of resistor 20 to the value of resistor 18 to decrease by proper ganging of those resistors, or other appropriate means.

The light of spot S which is focused by adjusting resistor 66, traverses the tone generator 38 and is caused to fall on a light sensitive element 40 which may be a phototube of any suitable construction.

The tone generator 38, as shown in detail in Fig. 2 comprises a translucent rigid element in which the opacity of the element along the swept path of the spot S, cycling at the fundamental frequency, has been arranged as later described, so that the wave form of the voltage generated by the photo tube 40 accurately reproduces the wave form or "tone" of the preselected musical instrument or other source of sound to be reproduced. Such a tone as previously described will consist of the note corresponding to the particular fundamental frequency accompanied by a greater or less number of harmonics thereof according to the characteristics of the particular instrument. A further characteristic of instruments is that the number of harmonics accompanying a note of any particular frequency, is often not constant throughout the scale but varies with frequency of the note played and this variation should also be accurately reproduced to give a true reproduction of the tones at different frequencies of the notes of each particular instrument. It will be understood that a separate tone control element is required for each instrumental tone.

In Fig. 2 the fluctuations in the wave form of an instrument is represented by the closeness of the spacing of the lines OP per degree angle of the path traversed by the light spot, and variations in the number of harmonics by the depth of shading of the lines. Only a segment of the opacity changes in a cycle has been indicated since this is sufficient to clearly convey the theory underlying the function of the tone generator member. It is to be remembered that the higher the frequency of the sound, the further from the center of the tone generator will be the path of the spot S as at S1 and S2 but the wave form will remain constant though the character of the tone or timbre due to the accompanying harmonics may change as for instance in a flute where the harmonics are much more pronounced at the lower than the higher notes as indicated by the shading along trace S as compared with the shading along trace S2.

The tone generator may be constructed in various ways, two of which will be given by way of example.

A graph of the characteristic wave form of a violin for instance in the form of a variable density track, is first obtained and the electrical circuit set at the fundamental frequency and adjusted to produce the predetermined path of a sharply focused spot of light on the cathode tube 10 screen as previously described, the transparent plate being positioned closely adjacent the screen on the axis of the screen and photo tube. The line followed by the spot S passing through the screen is then carefully painted over with layers of translucent paint until the variation of opacity along the path reproduce accurately the variations of the variable density track, the overall density of the layers of paint being adjusted to give a desired voltage from the photocell. By repeating the process described through a desired range of successive frequencies the whole scale of frequencies to be played can be provided with the correct tone generating path for each frequency. Obviously, the tone generator may be constructed to produce tones different from the correct musical tones, as desired, by suitable variation of the opacity of the tone generator.

Another way in which the tone generator may be constructed is to produce a desired tone by setting the oscillator into operation at a particular frequency and observing the wave form obtained by modulating the grid 52 of cathode tube 10, by known means, with a combination of harmonics of the oscillator frequency of such magnitude and phase relationship that the brightness of the spot is varied to produce the fundamental tone and harmonics which may be checked by comparison on an oscilloscope with the tone of that note as played by the instrument the tone of which is to be duplicated and also shown on the oscilloscope, or by comparison by ear of the tone of the instrument playing a note of the same frequency, and the note was emitted by the loudspeaker. It will be noted that by this method distortion caused by the speaker may be compensated for, within limits, by adjusting the system until the reproduced tone accurately corresponds to that of the actual instrument. Next a photosensitive film mounted on a rigid transparent plate is placed in the position which will be occupied by the tone generator element, and the light variations of the spot S in following the fundamental note trace will be recorded on the film which is then developed and printed giving a positive record of the wave form of that note. By carrying out this procedure for notes of different frequencies a composite tone generator element can be produced covering the whole of the translucent member.

It will be noted that the tone generator element can be used to obtain a phase shift since the phase relationship between the oscillator alternating voltage and the phototube output can be changed by rotating the tone generator element about its center. An important use for such a phase shift function would be where phase shift must remain the same with frequency change and where the amplitude must be constant.

The incorporation of a bank of switches arranged like the keyboard of a piano is illustrated in Fig. 4 whereby the striking of the keys sets up

a voltage at A of the correct frequency of the musical note associated with each key.

In Fig. 4 the switch keyboard **54** is positioned in the circuit of Fig. 3 replacing elements **18**, **19**, and **20** of the oscillator. Resistors **56**, **58**, and capacity **19***a* serve to maintain the oscillator in operation at the lowest frequency but signals are not placed on the loudspeaker until operation of any key which operates to close switch **60** in the connection to ground of amplifier **44** between points *x*—*x* as indicated in the circuit of Fig. 3, and is also closed by a dummy key (not shown) which puts the tone of lowest frequency on the loudspeaker. Keys **61**–**64** operate double pole single throw switches which bring into the oscillator circuit resistors **61***a*, **61***b*–**64***a*, *b*, the resistors being of correct ratio to one another as to set up an alternating voltage of the correct frequency at A of the circuit of Fig. 3 to produce the correct musical note from the loudspeaker. By the use of a tone generator member of the proper characteristics for any predetermined instrument, it will be evident that a melody played on the switch keyboard will result in the loudspeaker emitting the melody with the characteristic tone of the selected instrument.

It will be evident that by using several tone generator elements made to impart the tone of various predetermined instruments, and arranging the tone generating elements so that any desired one may be brought into operation, the theme could be apparently played by any one of the instruments. Many other variations in arrangement will be apparent to those skilled in the art.

It will be understood that the voltage generated by the phototube may be amplified in any suitable manner, as shown in Fig. 3 for instance, by amplifiers **44** and **46**, the output of the amplifier being transformed coupled to loudspeaker **50**.

It will be evident that novel effects may be obtained by providing sweep paths for the light spot which are not symmetrically arranged on the screen of the cathode tube by adjustment of the deflector plate voltage controls **34**, **36**. Another way of producing novel effects is by varying the size of the spot of light by adjusting the focus control **66** of the cathode ray tube **10**.

While I have particularly described preferred embodiments of my invention it is to be understood that various changes and modifications may be made in the embodiments described without departing from the scope of the invention as intended to be defined by the appended claims.

What I claim is:

1. Means for producing sounds of a predetermined frequency and wave form, comprising: a resistance-capacity oscillator having means for adjusting the frequency of the alternating voltage produced by said oscillator; a cathode ray tube having means to deflect the cathode rays beam in two directions perpendicular to one another and a screen with very short after glow characteristics; an electrical circuit imposing said alternating voltage directly upon the deflecting means effective to deflect the beam in a first direction, a phase shifting network through which the voltage is also applied to the deflecting means effective to deflect the beam in the second direction, the voltage supplied to said latter deflecting means being 90° out of phase with the voltage imposed on the first mentioned deflecting means, the deflecting means being effective to cycle a spot of light in a plurality of closed paths on the fluorescent screen of the tube, each path corresponding to a different frequency of the voltage applied to the deflecting means of the cathode ray tube; a translucent screen mounted adjacent the screen of the cathode tube so that the light from said light spot is projected through the screen; the opacity of which along the path of the light passing therethrough is modified to impart to said light the predetermined wave form; a light responsive element producing a voltage corresponding to the light incident on said element and positioned to receive the light traversing said transparent screen; and sound producing means operated by the output of said photo-tube.

2. Means for electrically producing sounds having a predetermined tone and of different frequencies, comprising: a resistance-capacity oscillator having a plurality of resistors; switches arranged to provide a keyboard, the closing of each switch placing in the oscillator circuit resistors the ratios of which are adjusted to produce a given frequency of the alternating voltage generated by the corresponding to that of a musical note, a cathode ray tube having means to deflect the cathode ray beam in two directions perpendicular to one another and a screen with very short after glow characteristics; an electrical circuit imposing said alternating voltage directly upon the deflecting means effective to deflect the beam in a first direction, a phase shifting network through which the voltage is also applied to the deflecting means effective to deflect the beam in the second direction, the voltage supplied to said latter deflecting means being 90° out of phase with the voltage imposed on the first mentioned deflecting means, the deflecting means being effective to cycle a spot of light in a plurality of closed paths on the fluorescent screen of the tube, each path corresponding to a different frequency of the voltage applied to the deflecting means of the cathode ray tube; a translucent screen mounted adjacent the screen of the cathode tube so that the light from said light spot is projected through the screen, the opacity of which along the path of the light passing therethrough is modified to impart to said light the predetermined wave form; a light responsive element producing a voltage corresponding to the light incident on said element and positioned to receive the light traversing said transparent screen; and sound producing means operated by the output of said photo-tube.

3. Means as set forth in claim 2 and in addition comprising resistors always in circuit when the circuit is in operation to maintain the oscillator in operation to generate an alternating voltage of a fundamental frequency; a loudspeaker, and an auxiliary switch closed by the closing of any switch and operative to place the loudspeaker in the electrical circuit.

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