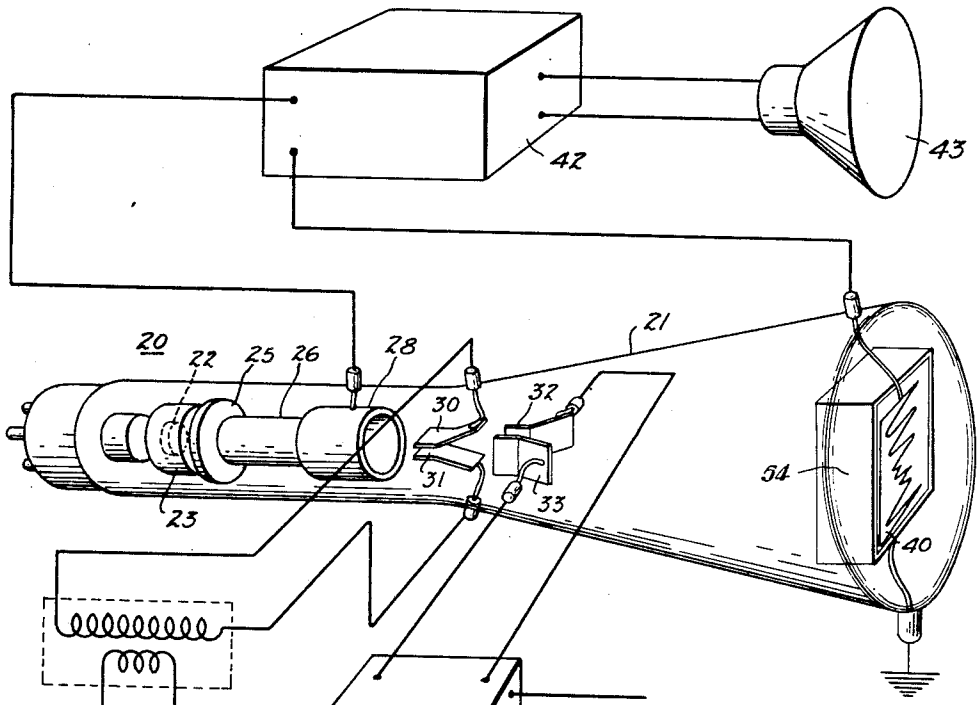
Feb. 21, 1939. A. A. KUCHER 2,148,166

REPRODUCING APPARATUS AND METHOD

Filed Feb. 24, 1936 3 Sheets-Sheet 1



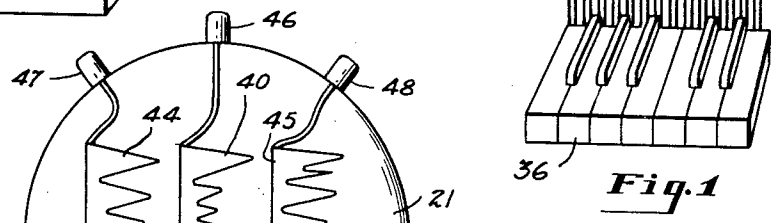


Fig. 1

Fig. 2

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REPRODUCING APPARATUS AND METHOD

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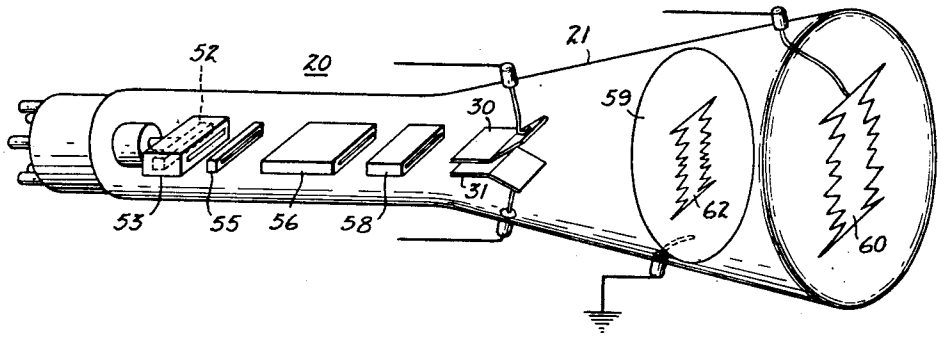

Fig. 3

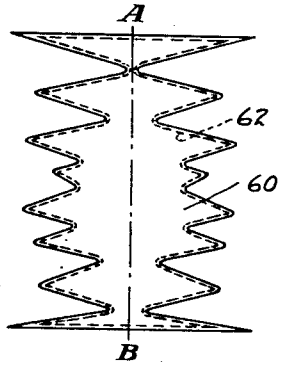

Fig. 4

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REPRODUCING APPARATUS AND METHOD

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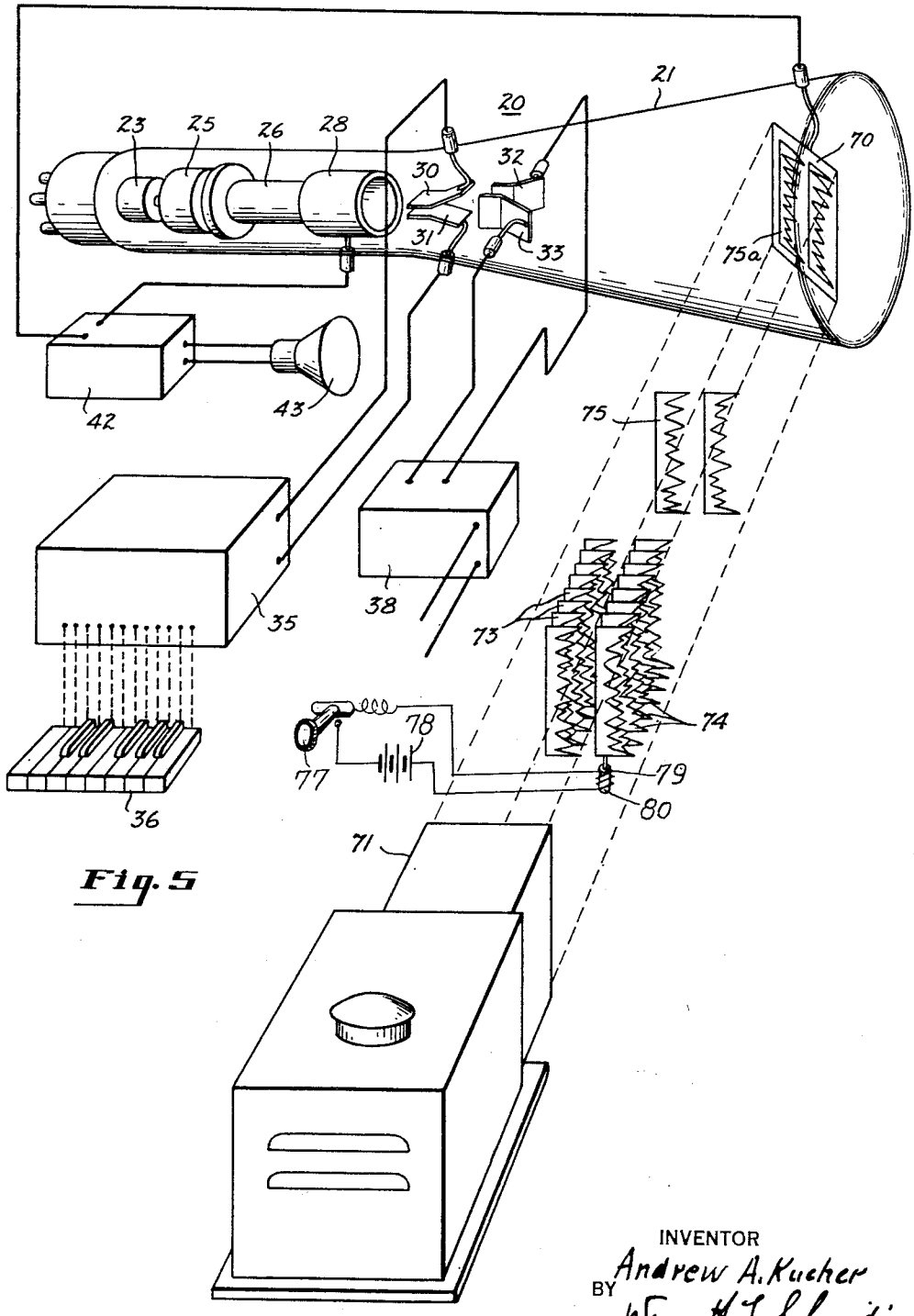

Fig. 5

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REPRODUCING APPARATUS AND METHOD

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16 Claims. (Cl. 84—1)

The present invention relates to the art of reproducing sound and particularly to reproducing complex musical tones. My invention contemplates the use of a pattern or patterns each comprising approximately one complete cycle of the complex tone of a musical instrument from which all the complex notes of that instrument can be reproduced, or, the pattern may be approximately one complete cycle of complex synthetic combination of pure tones from which the entire musical scale can be reproduced.

This pattern is formed of conductive material and the excitation thereof is varied by imposing or concomitantly superimposing impulses of the fundamental frequency or frequencies of the complex note or notes to be reproduced. This variation of excitation is utilized to modulate a speaker through an amplifier.

In the embodiments selected to illustrate the present invention, there is employed a cathode ray tube in which the electronic stream emission thereof is arranged to scan the conductive pattern at the fundamental frequencies of the notes to be reproduced so as to vary the excitation of the pattern.

One of the objects of the present invention is to provide a method of and apparatus for producing a complex musical tone by applying complex electrical impulses to each of the recurring or successive fundamental impulses of the note to be reproduced.

Another object of the present invention is to successively sweep a pattern, having the character of the complex tones to be reproduced, with an activating stream or beam at the frequencies of the fundamental of the tone or tones to be reproduced.

A further object of the present invention is to provide a cathode ray tube in which the emission thereof impinges on a pattern of conductive material and in which the emission is oscillated so as to scan or sweep the pattern and thus modulate the current flow through the conductive material.

In carrying out the above objects, it is a further object of the invention to connect the pattern and emission in suitable circuit with an amplifier so as to reproduce tone of the character from which the pattern was formulated.

Another object is to provide a cathode ray tube having a plurality of deflecting means for oscillating the emission, one of the deflecting means being arranged to oscillate the emission transversely of the oscillation imposed by the other deflecting means. One of the deflecting means causes the emission to scan the conductive pattern at a fixed frequency above the audible range and the other deflecting means causes the emission to scan the conductive pattern transversely of the first mentioned deflecting means at selected or concomitantly superimposed selected frequencies within the audible range.

A still further object is to provide for changing the pattern as desired so as to selectively reproduce tones of different characters. In carrying out this object, it is a further object of the present invention to employ a conductive plate of light sensitive properties so that its sensitiveness to electronic emission can be varied in accordance with the illumination thereof.

Further objects and advantages will be apparent from the following description, reference being had to the accompanying drawings wherein preferred forms of embodiment of the present invention are clearly shown.

Fig. 1 is a view in perspective showing one form of the cathode ray tube together with a diagrammatic connection with a sound reproduction apparatus;

Fig. 2 is an end view of the tube showing a plurality of tone patterns;

Fig. 3 is a view showing another type of shielding means used in conjunction with a "plane" type of cathode ray tube;

Fig. 4 is an end view of the tube shown in Fig. 3 showing the screen or shield and the conductive pattern; and

Fig. 5 is a perspective view showing another embodiment of the invention in which the shadow of the pattern is cast on light sensitive conductive material.

Referring first to Fig. 1, there is shown a cathode ray tube **20** including the glass envelope **21** that surrounds and seals the inclosed elements of the tube. The cathode **22** is surrounded by heater **23**. The emission of the cathode is then passed through an electrode **25** that accelerates the movement of the electronic stream and then through an electrode **26**, which latter focuses or concentrates the emission into a more condensed form, a high voltage electrode **28** further accelerates the movement of the emission. All of the electrodes form an electron gun and have the same general shape and in this manner the emission is in what may be termed "in a line".

Two fields are provided for deflecting the emission, for example, two sets of deflector plates are provided, one set being indicated as plates **30** and **31**, and the other set including plates **32** and **33**. The plates **30** and **31** are arranged to de-

flect the emission passing therebetween vertically while the plates 32 and 33 are arranged to deflect the emission passing therethrough transversely of the first deflection and, as is herein shown, are adapted to deflect emission horizontally. Suitable oscillating means are connected with the respective deflector plates 30 and 31 and deflector plates 32 and 33 for creating the electrostatic fields. Either the first set of deflector plates or the second set of deflector plates may be energized at a fixed frequency and the other set operated at selected or concomitantly superimposed selected frequency. In the specific embodiment herein shown, the plates 30 and 31 are connected with an oscillator for producing selected or concomitantly superimposed selected frequencies. This oscillator is herein shown at 35. Only one oscillator circuit, including the primary coil thereof, is shown. It is to be understood that an oscillator circuit, including its primary coil, is to be included for each note to be reproduced, thus in effect a plurality of oscillators, one for each note is provided and the frequencies at which the oscillators operate are controlled by a key manual such as a piano manual 36. For example, if the middle key of A is depressed the frequency impressed on the deflector plates 30 and 31, through corresponding the oscillator 35, will be 440 cycles per second. In a like manner any note or combination of notes, such as a chord, desired can be transferred to the deflector plates 30, 31 at its, or their, own frequency or frequencies. It is of course understood when keys are depressed to produce a chord, the frequencies imposed upon deflector plates 30 and 31 will be concomitantly superimposed. Likewise in the embodiment shown in Fig. 1, the deflector plates 32 and 33 are connected to an oscillator 38 of fixed frequency. Preferably the frequencies of oscillations imposed to the emission by plates 30 and 31 are within the audible range while the frequency imposed by plates 32 and 33 to the emission by the oscillator 38 is above the audible range.

It will be apparent, therefore, that the oscillating electrostatic field across deflector plates 30 and 31 will cause the cathode emission to oscillate vertically while the oscillating electrostatic field across the deflector plates 32 and 33 causes the electrode emission to oscillate transversely, and as herein shown, horizontally. This moving or oscillating emission is arranged to scan a pattern 40 of character form. It is apparent to those familiar with oscillographs that the width, height and the reflected position of the emission may be controlled by various control means commonly employed in oscillographs. With this in mind, the extent of oscillation of the emission is held as not to be less than nor greatly in excess of the dimensions of the pattern.

The pattern may be formed of a plate fabricated in several different ways. The plate shown in Fig. 1 is conductive material such as nickel. Still another means is to coat the end of the tube with conductive material in character pattern. The profile of the pattern traces one complete cycle including the complex intensity relationship of the component harmonics of a musical instrument or synthetic combinations of audible frequencies.

The cathode ray emission impinging on the pattern is arranged to sweep the pattern both vertically and horizontally, the deflector plates 30 and 31 causing vertical sweeps, preferably downwardly, at frequencies in the audible range, and the plates 32 and 33 causing horizontal sweeps at a relatively high frequency, for example, one million times per second. The resultant component of the relatively high horizontal sweeps and the relatively low vertical sweeps, of audible frequencies, cause a scanning of the entire pattern within the audible frequency range.

The activation of the conductive pattern 40 varies according to the area thereof being impinged by the emission. As the emission sweeps horizontally at a high frequency and in recurring vertical sweeps, the activation of the pattern is varied in accordance with the character formation of the pattern. The conductive pattern 40 is in circuit with an amplifying means diagrammatically shown at 42 through the emission of the cathode which impinges the pattern. The amplifier is connected with a loud speaker 43. The pattern is disposed so that the controllable sweep, i. e., the sweep with audible frequencies, is lengthwise with the traced cycle.

The oscillator characteristic is an important factor in satisfactory tone reproduction. If the scanning is of sine wave character, for example, both downwardly and upwardly at varying velocity, then, in that event, the pattern should be interpolated so as to reproduce the character of tone desired. However, it is desirable to use pattern of true cycle character, i. e., a pattern formed in exact outline of a complex note of a selected musical instrument as recorded by an oscillograph, and in order to simulate continuous scanning, it is necessary to cause the cathode emission to sweep the character pattern at a uniform velocity downwardly and, after one sweep is completed, to instantaneously return for the subsequent recurring sweep. The impressed audible oscillation on the deflector plates is, therefore, in the nature of a saw tooth as distinguished from a sine wave. Therefore, the oscillators to be used in conjunction with this apparatus will have the character of providing continuous scanning. Thus it will be seen that by applying the fundamental recurring impulses of the tone or tones to be reproduced over the pattern, the activation of the conductive character is varied and then by transmitting this variation of activation to an amplifier connected with a loud speaker, the modulations will be amplified so that tones, having the character of the pattern, can be reproduced through the loud speaker.

Fig. 2 shows an embodiment of the invention in which three conductive plates 40, 44, and 45 are utilized. Each plate is a conductive pattern of approximately one cycle of a complex tone. Each may represent the complex tone of a different instrument, for example, a piano, a violin and a horn. It is, of course, understood that any number of these patterns may be used in connection with one cathode ray tube and all may be scanned simultaneously at one frequency or concomitantly by superimposed frequencies within the audible range so that choirs of each instrument can be reproduced simultaneously. A circuit lead is taken from each pattern for connecting the same with amplifying means 42 and these leads are shown at 46, 47, and 48.

In Fig. 3 another embodiment of the invention is illustrated. In this tube, only one set of deflector plates 30 and 31 is provided. These plates create the controllable frequency across the electrostatic field and are connected so as to be controlled by a manual 36 as in Fig. 1. Deflector plates 30 and 31 are so disposed that the line ray emission from the cathode will be oscillated hori-

zontally when the tube is in the position shown. The element **49** is a screen or shield of conducting material for grounding out stray emission. This screen has a slit **51** therethrough that allows only the emission that is to be utilized in activating the pattern **50** to pass therethrough.

In Fig. 3 another embodiment of the invention is disclosed. Here a cathode ray tube, of the type in which the emission is in a "plane" as distinguished from a "line", is employed. The electron gun elements **52**, **53**, **55**, **56**, and **58** are provided for the same purpose as elements **22**, **23**, **25**, **26**, and **28**, respectively, of Fig. 1 but are of elongated rectangular shape so as to emit electrons in a "plane" instead of the usual "line". Here again, only one set of deflector plates **30** and **31** is employed and these plates are connected as in Fig. 1. A shield or screen **59** is interposed between a conductive plate **60** and the deflector plates **30** and **31**. This shield **59** is formed of conductive material and is grounded or the current is led off in any desirable manner. The shield **59** is perforated as at **62** so as to form a mask conforming to character of tone to be reproduced. Although it is not necessary, the plate **60** and perforation **62** are shown allochiral in form, that is, the profile of the portion to the left of letters A, B, (see Fig. 4) constitutes approximately one complete cycle of a complex tone and the profile of the portion to the right of said letters is a mirror image of said tone. Referring to Fig. 4 in which the dotted lines indicate the character aperture **62** in shield **59** and the full lines indicate the plate **60** of conductive material, it will be noted that the plate **60** is large enough so that the emission, passing through the pattern **62**, always impinges on conductive material.

It will be seen that as the plane emission, which passes through aperture **62**, scans the conductive plate **60** downwardly, the activation of the plate **60** will be varied in accordance with the character formation of aperture **62** and thus the emission impinged surface of plate **60** is in character pattern form, and this variation of activation of the plate **60** is transmitted to the amplifier **42** in the same manner and for the same purpose as in Fig. 1. It will be understood that the conductive plate **60** may be any desired shape in this embodiment provided its width and length are sufficient to receive the entire width and length of the emission passing through the aperture **62**, also, it will be understood that shield **59** can be omitted if desirable or, if desirable, other shielding means such as the shield **54** shown in Fig. 1, can be used for grounding out unnecessary emission. When the shield **59** is omitted the conductive plate **60** is fashioned as an exact character pattern.

From the foregoing it can be readily seen that a plurality of character shaped apertures can be cut into shield **59** for the purpose of reproducing different tone characters, such as, piano, violin, horn, etc., tone characters.

Still another form of the invention is illustrated in Fig. 5. In this figure the electron gun and the two sets of deflector plates are the same as that shown in Fig. 1. The conductive element **70** in this embodiment is not only electrically conductive but it also embodies light sensitive properties such as caesium on silver oxide. The conductive material **70** is such that its sensitiveness to the electronic stream is varied in accordance with the degree of illumination thereon. It is apparent, therefore, that if the shadow is of irregular contour, the sensitiveness of the conductive element **70** to the sweeping electronic stream is varied in accordance with the irregular formation of the shadow. Now, as an example, if the shadow is in the form of a complex musical tone character, the impulses received from the element **70** are varied as the emission scans the element and this variation in impulses will correspond to the formation of the shadow so that the impulses when transmitted to an amplifier and loud speaker will reproduce tones having a character of the shadow. It is understood that there may be imposed more than one vertical sweep frequency simultaneously so as to reproduce a group of complex notes or tones simultaneously such as a chord.

For the purpose of illustrating one form of the invention I have shown a light projector **71**, preferably of the parallel ray type, and between the source of this light and the plate **70**, there are disposed one or more series of character patterns **73** and **74**. It will be seen that when a character **75** is projected into the ray, the shadow thereof will fall upon the element **70** as at **75***a*. One, or a series, of these patterns may be provided and if desirable they may be placed in row formation as shown. Any suitable means may be employed for bringing the pattern into and out of the light path. Such means can be mechanical, electrical, etc., and can be operated by stops similar to those employed on organ manuals. In the specific embodiment I have shown, one **77** of a series of stops. This particular stop **77** like all of the other stops are connected in electrical circuit with a source of current **78**. When the stop is pulled, it will complete a circuit through an electro-magnet **79**. A solenoid core **80** is actuated by the electro-magnet **79** and is arranged to move the pattern **75** into the light path. Of course when the stop **77** is pushed inwardly the circuit to the electro-magnet **79** is interrupted and the particular pattern will fall out of the light path.

It is apparent from the foregoing that the true tones of one or more instruments may be reproduced. The most pleasing tones when once recorded into a pattern are available and can be reproduced by an instrument which can be manufactured at a much lower cost than the parent instrument. The reproducing instrument can be made much smaller, for example, the exact tone of a concert grand piano can be reproduced by an instrument, the maximum length of which is only slightly longer than the key manual of a piano. Another example is this same reproducing instrument can be utilized for producing all the notes of a bass viol, violin-cello, viola, and violin, and, all of these notes can be reproduced selectively individually or selectively concomitantly through the use of a single pattern by varying the frequency or frequencies of the electrostatic fields across plates **30** and **31**.

While the forms of embodiment of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

I claim:

1. The method of selectively reproducing sounds of complexed character which method comprises imparting oscillation to the emission of a cathode ray tube at selected frequencies of the fundamental of the sound to be reproduced, causing the oscillating emission to scan a conductive element excitable in the form of a complex character graphically depicting other of the timbre characteristics of the tone to be repro-

duced, and modulating a sound reproducing means by an amplifier by the electrical variation generated at the conductive element.

2. The method of selectively producing variations of electrical impulses in recurring cycles which when amplified to produce a tone, which method comprises, causing oscillating emission of a cathode ray tube to impinge upon a conductive element excitable in the form of a complex character graphically depicting other of the timbre characteristics of the tone to be reproduced, and varying the impulses from the plate by varying the frequency of oscillation of the emission.

3. The method of selectively producing variations of electrical impulses in recurring cycles which when amplified to produce tones of various pitch comprises, causing oscillating emission of a cathode ray tube to impinge upon a conductive element excitable in the form of a complex character graphically depicting other of the timbre characteristics of the tone to be reproduced, and varying the impulses from the plate by varying the responsiveness of the plate impinged and varying the frequency of oscillation of the emission.

4. Mechanism for producing complex musical tones comprising electrical conductive means excitable in complex character form including graphically, certain of timbre characteristics of the tone to be reproduced; means for exciting said conductive means; and means for applying successive fundamental frequency excitations, of the tones to be reproduced, to the conductive means.

5. In a cathode ray tube, a tube, a cathode therein, means for focusing the emission of the cathode, a plurality of means for oscillating the emission, an oscillator for impressing impulses on one of said last means at a fixed frequency, oscillating means for impressing impulses on the other of said last means at one or more selected frequencies, one of said last means oscillating the emission transversely of the other, and a conductive means disposed so that the oscillated emission impinges thereon.

6. The method of producing complex musical tones which comprises exciting electrical conductive means embodying light sensitive properties, casting a shadow in the form of a complex character graphically depicting, certain of the timbre characteristics of the tone to be reproduced, onto the conductive means so as to cause variation of excitation of the conductive means in accordance with the complex character of the shadow, and applying successive fundamental frequency excitations of the tones to be reproduced to the conductive means, and modulating a sound reproducing means by an amplifier through the electrical variations generated at the conductive means.

7. Mechanism for producing complex musical tones comprising an electrical conductive means embodying light sensitive properties; means for exciting said conductive means; means for casting a shadow in the form of a complex character graphically depicting, certain of the timbre characteristics of the tone to be reproduced, onto said conductive means for causing varying of the excitation of the conductive means in complex character form; and means for applying successive fundamental frequency excitations, of the tones to be reproduced, to the conductive means.

8. Mechanism for producing complex musical tones comprising an electrical conductive means embodying light sensitive properties; means for exciting said conductive means, said exciting means including a cathode ray tube, the emission thereof impinging on said electrical conductive means; means for casting a shadow in the form of a complex character graphically depicting, certain of the timbre characteristics of the tone to be reproduced, onto said conductive means for causing varying of the effect of the emission; and means operable at one or more frequencies of the fundamental tones to be reproduced for oscillating the emission at the fundamental frequencies.

9. A musical instrument for producing the musical tones of a scale, comprising a cathode ray tube, an electron gun, electron deflectors, an oscillator for each fundamental frequency in the musical scale connected to one of said deflectors, key means associated with the oscillators for impressing one or more of said fundamental frequencies upon one of the deflectors, said deflector being adapted to deflect the emission in one direction, the other of said deflectors being adapted to deflect the emission transversely of the first, means for continuously impressing a frequency above the audible range to the second deflector, an electrically conductive form of complex character impinged by the emission, said character including graphically, other of the timbre characteristics of the tones to be reproduced, an amplifier, a circuit including the amplifier, the emission and the conductive form, and a loud speaker connected with the amplifier for audibly reproducing the character form in repeating cycles at one or more impressed fundamental frequencies.

10. The method of producing a complex musical tone which comprises first producing fundamental impulses of the tone to be reproduced and then impressing complex impulses, including other of the timbre characteristics of the tone to be reproduced, upon each of the fundamental impulses.

11. The method of producing a complex musical tone which comprises first producing fundamental impulses of the tone to be reproduced and then modifying the fundamental impulses by impressing complex impulses, including other of the timbre characteristics of the tone to be reproduced, upon the fundamental impulses.

12. The method of producing complex musical chords which comprises first producing fundamental impulses of the tones of the chord to be reproduced and then impressing complex impulses, including other of the timbre characteristics of the tones to be reproduced, upon each of the fundamental impulses.

13. The method of producing complex musical chords which comprises first producing fundamental impulses of the tones of the chord to be reproduced and then modifying the fundamental impulses, including other of the timbre characteristics of the tones to be reproduced, by impressing complex impulses upon each of the fundamental impulses.

14. The method of producing a complex musical tone which comprises first producing fundamental impulses of the tone to be reproduced and then impressing these impulses upon the deflector means of a cathode ray tube to cause the emission of the tube to scan a conductor having the pattern of a complex tone, including other of the timbre characteristics of the tone to be reproduced, and then impressing the impulses derived from the pattern upon an amplifier.

15. In combination, means for producing fun-

damental impulses; and means for modifying the fundamental impulses comprising, a tube, a cathode therein, means for focusing the ray emission, a conductive means of character form, including other of the timbre characteristics of the tone to be reproduced, impinged by the emission, and means for impressing the fundamental impulses on said emissions for oscillating the latter.

16. In combination, means for producing fundamental impulses; and means for modifying the fundamental impulses comprising, a tube, a cathode therein, means for focusing the ray emission, a conductive means of character form, including other of the timbre characteristics of the tone to be reproduced, impinged by the emission, and means for impressing variable frequency fundamental impulses on said emission simultaneously for oscillating the latter.

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