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ELECTRONIC MUSICAL INSTRUMENT

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Fig. 1.

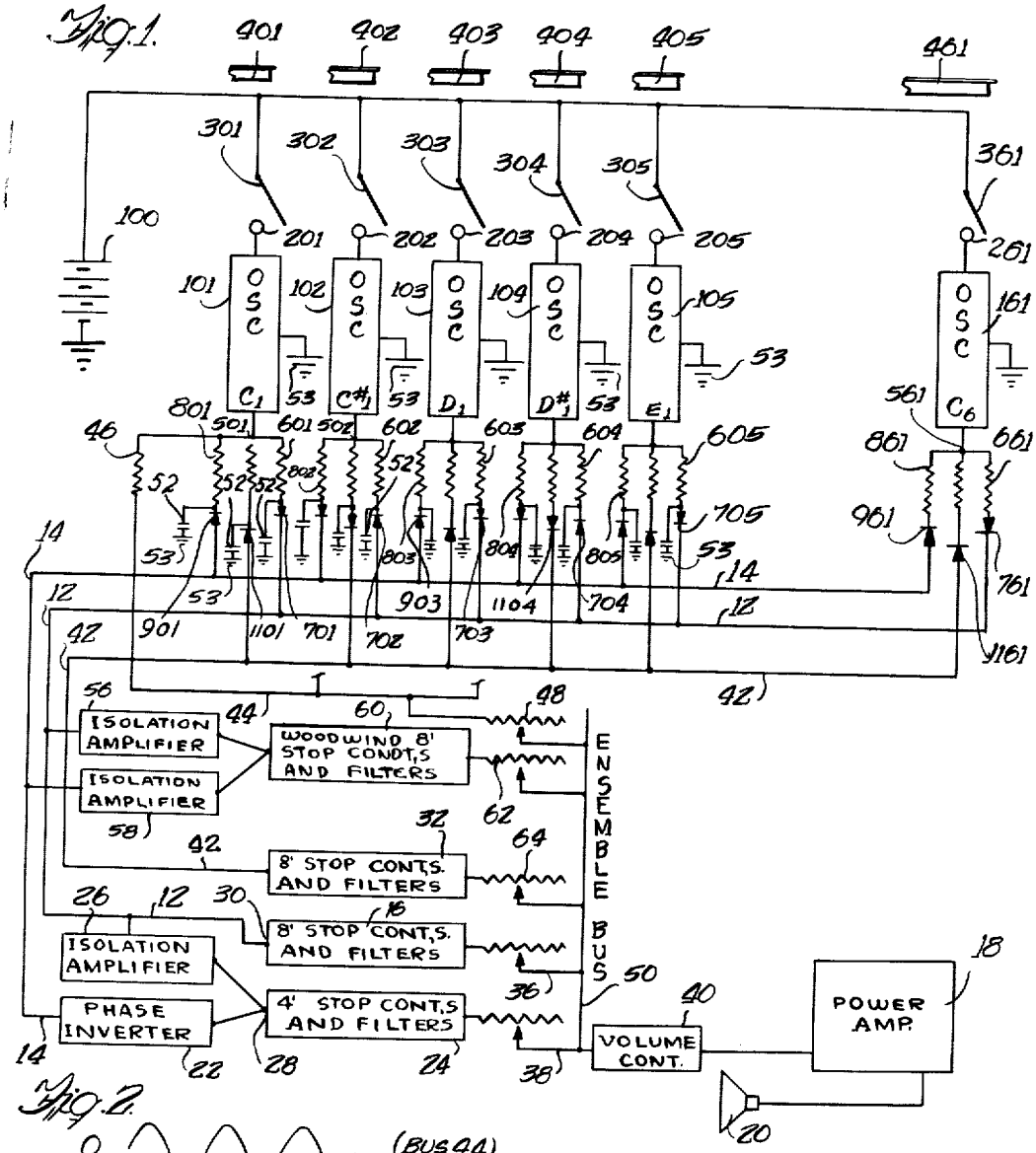
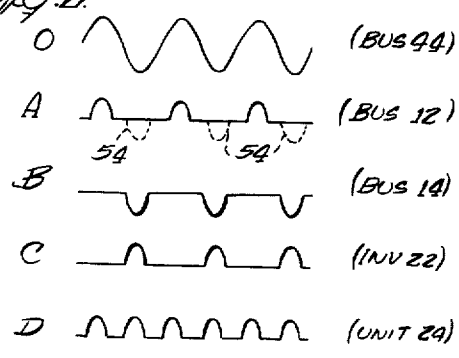


Fig. 2.



Inventor
Richard H. Peterson
Donald H. Sweet
Attorney.

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ELECTRONIC MUSICAL INSTRUMENT

Richard H. Peterson, 10108 Harnew Road E., Oaklawn, Ill.

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My invention relates to electronic organs of the type employing oscillators that are not normally in oscillation but that are rendered operative by the application of activating potential, by means of switches controlled by the playing keys of the instrument. Such instruments commonly employ a multiplicity of individual oscillators such as one for each note of the musical scale, or for each two or three adjacent notes, throughout the desired range.

Octave coupling is frequently employed in such instruments, such that a given playing key on the organ can be made to sound two or more octavely related oscillators simultaneously. This, of course, means that the total number of oscillators must exceed the number of organ keys by twelve if the coupler effect is desired throughout the complete range of the keyboard. Complicated key switching is also required because a separate key switch contact is necessary for each of the octavely-related oscillators. Further, since the octave coupler effect is not always desired, it is necessary to have additional switch means in series with each "octave" oscillator switch contact so that the circuit can be opened and the octave coupler shut off when not desired. Another disadvantage of obtaining the octave coupler effect by combining signals from two octavely-related oscillators, is that there is no simple way of controlling the ratio of the intensities of the two pitches.

It is one of the objects of this invention, therefore, to provide an organ including an oscillation-generating system in which a single set of oscillators, controlled by a keyboard, each key of which operates only one switch contact, can produce music having a "normal" or "unison" pitch, plus an additional "octave" pitch, and in which both the unison and the octave pitch can be varied as to tone quality and intensity by means of conventional stop switches, or the like.

In the accompanying drawings:

FIGURE 1 is a schematic wiring diagram indicating the significant features of the invention; and

FIGURE 2 is a diagram of certain wave shapes typical of the signals produced.

Referring to FIGURE 1, I have indicated oscillators **101, 102, 103, 104, 105 . . . 161**, of a type that are normally not in oscillation until rendered operative by the application of activating potential to an input terminal, such as the terminals identified **201, 202, 203, 204, 205 . . . 261.**

A source of suitable activating potential is indicated at **100**, and has one terminal connected to the key switches **301, 302, 303, 304, 305 . . . 361.** The other terminal of each of the aforementioned key switches is connected to the keying terminal of its oscillator. Associated with each of the switches is a playing key **401, 402, 403, 404, 405 . . . 461.** Depressing any of these keys operates its associated switch, with the result that the corresponding oscillator is rendered operative so that it will produce an output signal of the corresponding pitch at its output terminal, such as the terminal identified **501.** These oscillators may be of any of several types; one suitable type of oscillator being more fully described in U.S. Patent 2,649,006.

Referring now to oscillator **101**; connected to the output terminal **501** is a first signal distorting circuit including protective resistance **601** and a rectifying device **701.** The output of this distorting circuit is connected to the bus bar **12**, which is common to the outputs of all the

similar distorter circuits associated with the other oscillators. Because of the rectifying action of rectifier **701**, whenever the oscillator **101** is oscillating, a voltage with the wave form indicated by curve A in FIGURE 2 will appear on the bus bar **12.** Also connected to the output terminal of oscillator **101** is a second similar distorting circuit consisting of protective resistor **801** and another rectifier **901.** This circuit is connected to a second tone collecting bus bar **14.**

Because the rectifier **901** is connected in reverse polarity as compared to rectifier **701**, the wave form appearing on bus bar **14** will be the wave form indicated by curve B in FIGURE 2.

Bus bar **12** is connected to the rectangle **16**, which is a suitable assembly of stop controls and tone filters of any conventional form, and may be of the type more fully illustrated in the patent to Winston Kock, U.S. Patent No. 2,212,292. The output of this stop control and filter system is fed into the input of a conventional translating system consisting of the power amplifier **18** and the loudspeaker **20.** Bus bar **14** is connected to the input of a phase inverter **22.** This phase inverter may be of any well-known type, and may be for example, a vacuum tube amplifier of the usual configuration, it being well known in the art that the output signal from a conventional vacuum-tube amplifier is reversed in phase from its input by 180 electrical degrees. The output of this phase inverter **22** is connected to the input of a second group of **4'** stop controls and filters **24.** Bus bar **12** is also connected to the input terminal of the four foot stop control and filter system **24** through a suitable isolation amplifier, or isolation impedance **26** such that the signal on the bus bar **12** will be transmitted to the 4' filters **24** but that any signal appearing at terminal **28** from the output of the phase inverter **22** will not be transmitted through the isolation device **26** back to the terminal **30,** which is the input terminal of the 8' stop control and filter unit **16.** It will now be noticed that there are two signals arriving at terminal **28** whenever any oscillator is activated. It will be further noted that the combined signal will be of a wave form indicated by curve D of FIGURE 2, and that this wave form has a pitch one octave higher than the signal appearing on either bus bar **78** or bus bar **14.** This "octave" signal may now be subjected to the usual filtering in unit **24** and may be fed in any desired proportion to the output circuit including power amplifier **18** and loudspeaker **20.**

A maximum flexibility involves adjustment means at **38** for the output of unit **24**, and at **36** for the output of unit **16.** In practice, such adjustment means is physically embodied as an integral part of its unit **24** or **16.** Subsequently the signals are controlled by the overall volume control at **40**, which is used by the player of the instrument during playing to secure the desired expression.

In the drawing, the insignia "8' Stop Controls" and "4' Stop Controls" are used as part of the conventional terminology for all organs. According to this terminology, with an "8' Stop" operated, when the key corresponding to the middle "C" on the piano is depressed, the instrument delivers a note having the frequency of middle "C." Operating a "4' Stop" on the organ causes the same key to sound a note C one octave higher with a frequency twice as great. In conventional organs, stops of either or both footages may be operated, as well as other stops that add other pitches.

One particularly suitable application for the invention described is in connection tone generators for producing the lowest, or pedal, tones of an organ. In addition to the advantage that additional oscillators are not required in order to produce both the fundamental and the octavely related, or first, overtone is the advantage that the unison and octave tones are always in the same phase relationship

with one another since they are from the same basic oscillator. This is especially important because of the limitations inherent in loudspeaker equipment when attempting to create loud, low-pitched tones. If the octave and unison pitches are not locked in constant phase relationship, progressive phase shift will generate a beat between the two pitches, with resultant undulations in the loudness level of sound emanating from the loudspeaker. The fact that the peak loudness under such conditions is substantially greater than the average loudness means that the loudspeaker and amplification equipment must be capable of reproducing, without distortion, power levels over a greater range, and considerably in excess of the power levels required in a system according to the invention.

In some cases it is desirable to obtain the unison pitches from a completely separate bus bar such as the bus bar **42**, which is supplied with signals from the output of the oscillators through additional separate rectification distorter circuits **1101, 1102, 1103, 1104, 1105** up to **1161** including protective resistors and rectifiers. In this way, the intensity of the signal appearing on bus bar **42** can be made different for each oscillator by appropriate adjustment of the value of the protective resistors of the circuits.

By deriving the octave oscillation from buses **12** and **14**, and the 4′ stop unit **24**, and the fundamental frequency from bus **42** and 8′ stop unit **32**, the intensity ratio between the unison oscillation from bus **42** and stop unit **32**, and the octave oscillation from stop unit **24**, can be adjusted differently for each individual note, but both oscillations stay in constant phase relationship because they originate in the same oscillator. This adds to the constant phase relationship stressed in the preceding paragraph, convenient means for decreasing the intensity of the unison pitch while increasing the intensity of the octave pitch to produce a signal having the correct total volume, but still keeping within the power handling capabilities of the amplification and reproducing equipment.

The oscillator delivers the wave form O of FIGURE 2 and the distorting circuit **601—701** delivers an oscillation of the same frequency, having the form of curve A of FIGURE 2. Because the rectifier **901** is connected in reverse polarity compared with rectifier **701**, the distorter circuit **801—901** will deliver an oscillation according to curve B of FIGURE 2. Subsequently, passage of the curve B through the phase inverter **22** will generate an oscillation coming from the phase inverter according to curve C. Delivery of curve A and curve C to the terminal **28** will cause that terminal to experience the oscillation of curve D. In this way there is derived, from the single output terminal of the oscillator **101** an oscillation D having twice the frequency of the original oscillation. But terminal **30** is still delivering curve A by itself to the 8′ stop unit **16**.

The wiring of the instrument as a whole makes major portions of its function as an antenna affected by electrical interference, commonly called "static," such as from turning electric lights on and off near the organ, which usually produces a click, or from a sputtering contact in an electric light, or the use of an electric shaver.

By connecting approximately half of the diodes **701, 702**, etc. in one sense and the other half in the opposite sense, all radio frequency static impulses reaching the bus **12** function half in one direction and half in the other and cancel each other out. Similarly, the diodes **901, 902**, etc. are opposite and cancel out in the bus bar **14**. The diodes **1101, 1102**, etc. must in every instance be connected in the same sense as the diodes **901, 902**, etc. This makes it possible to gather signals from all three bus bars at the same time, but bus bar **42** will usually be used only for pedal notes where individual adjustment of intensity for each note is needed. In all instances, the absolute phase of the rectifiers is of no significance. The sole requirement is that bus bars **12** and **14** be fed in opposite phases from each oscillator.

It will be obvious that an indefinite number of additional coupling circuits may receive signal from the same oscillator terminal, such as the distorting circuits of Patent 2,649,006. Two very useful additional circuits are indicated in FIGURE 1.

For pure flute tones, the bus bar **44** receives signal curve O of FIG. 2, through a simple protective resistance **46**. Each oscillator has one of these circuits, but only the one for oscillator **101** is illustrated in the drawing, to reduce the complexity of the drawing. The composite signal has its relative volume adjusted by resistor **48**, and then passes to the final or "ensemble" bus **50**.

The distorting circuits delivering to bus bars **12, 14**, and **42** are each provided with individual biasing means in the nature of capacitors **52** connected from a point between the rectifier and the protective resistance to the same ground **53** as the oscillators. This causes the excursions or "humps" in curves A, B, C and D to be considerably narrower than a duplicate of a half wave shape of curve O, but only slightly less in peak amplitude.

Because of this narrowing, woodwind notes of excellent quality can be produced by assembling curves A and B, to add to curve A the downward excursions indicated at **54** in dotted lines in FIGURE 2. The structure required includes only an additional isolation amplifier **56** receiving curve A from bus **12**; a second isolation amplifier **58** receiving curve B from bus **14**, and a combining 8′ stop unit **60** with its input terminal experiencing curve A with the dotted line downward excursions **54** of FIGURE 2.

In this reassembled curve all even numbered harmonics are substantially eliminated by cancellation, and the wave shape delivered to unit **60** is very rich in all the odd numbered overtones, which are the overtones characteristic of the woodwind instruments. This means that unit **60** has more than half its work already done for it, and the further distortion in unit **60** can be much less, and correspondingly more accurate and delicate. Unit **60** delivers through adjustment resistor **62** to the final bus bar **50**.

Bus bar **42**, carrying the individually adjusted low notes, has its own independent 8′ stop unit **32** and adjustment resistor **64**.

Others may readily adapt the invention for use under various conditions of service, by employing one or more of the novel features involved, or equivalents thereof. As at present advised, with respect to the apparent scope of my invention, I desire to claim the following subject matter:

1. In an electronic musical instrument of the type comprising: a multiplicity of electrical oscillators adapted to generate electrical currents of frequencies corresponding to the pitches of the notes of the musical scale, but normally not in oscillation; a keying terminal operatively associated with each oscillator; a source of activating potential; a key and a key-operated switch operatively associated with each of said keying terminals, and with said potential source, for delivering activating potential to initiate and maintain oscillation of each oscillator as long as the key switch for said oscillator remains closed; an output terminal operatively associated with each oscillator for delivering signal whenever said oscillator is activated; and transducer means for translating a received signal into sound; the improved circuitry between said oscillator output terminal and said transducer, comprising: first and second tone-collecting bus bars; a plurality of distorting circuits for each oscillator connected to receive the signal therefrom; one of said distorting circuits having a rectifier in it and connecting the output terminal of said oscillator to said first bus bar; a second one of said distorting circuits having a rectifier in it and connecting said output terminal to said second bus bar; said first and second distorting circuits having their rectifiers connected to rectify the signal in opposite senses; translating means operatively connected to said second bus bar for translating signal from said second bus bar into musical sound; a phase inverter connected to receive signal from said first

bus bar; means for combining the output signal from said phase inverter with the signal from said second bus bar; and operative connections from said combining means for delivering the signals emanating from said combining means to said transducer means.

2. A combination according to claim 1, in which the transducer means for translating signal from said second bus bar and the transducer means for translating signal from said combining means are one and the same.

3. A combination, according to claim 1, having an additional flute bus bar; an operative connection from each oscillator for delivering the signal from said oscillator to said additional bus bar in substantially undistorted form; and transduced means operatively connected to said flute bus bar for translating the composite signal on said flute bus bar into sound.

4. In an electronic musical instrument of the type comprising: a multiplicity of electrical oscillators adapted to generate electrical currents of frequencies corresponding to the pitches of the notes of the musical scale, but normally not in oscillation; a keying terminal operatively associated with each oscillator; a source of activating potential; a key and a key-operated switch operatively associated with each of said keying terminals, and with said potential source, for delivering activating potential to initiate and maintain oscillation of each oscillator as long as the key switch for said oscillator remains closed; an output terminal operatively associated with each oscillator for delivering signal whenever said oscillator is activated; and transducer means for translating a received signal into sound; the improved circuitry between said oscillator output terminal and said transducer, comprising: first and second tone collecting bus bars; a first group of distorting circuits comprising a multiplicity of distorting circuits, one operatively associated with the output terminal of each oscillator and each including a separate rectifier; all said first group distorting circuits being connected to first bus bar to deliver signal thereto; a second group of distorting circuits, one operatively associated with the output terminal of each oscillator and each including a separate rectifier; said second group of distorting circuits being connected to deliver signal to said second bus bar; all the rectifiers of said first group of distorting circuits being connected to rectify the signal in one sense, and all those of said second group to rectify the signal in the opposite sense; a phase inverter connected to receive the composite signal from said first bus bar; means for combining the composite signal from said phase inverter and the composite signal from said second bus bar; and operative connections from said combining means for delivering the signals emanating from said combining means to said transducer means.

5. A combination according to claim 4, in which the relative signal intensity of the signals from said first and second distorting circuits for the same frequency, is such that when delivered to said combining means, the intensity ratio is substantially one to one.

6. A combination according to claim 1, in combination with a third bus bar; a third group of output circuits connected to each of a plurality of said oscillators for delivering signal to said third bus bar; and translating means operatively connected to said third bus bar for translating the composite signal from said third bus bar into musical sound.

7. A combination according to claim 6 in which the output circuits delivering signal to said third bus bar also alter the wave shapes of the signals they receive from said oscillators.

8. A combination according to claim 6 in which the output circuits of said third group for tones of relatively low pitch are adjusted to deliver unison signal of reduced intensity; the intensity decreasing from each tone to the next lower tone.

9. In an electronic musical instrument of the type comprising: a multiplicity of electrical oscillators adapted to

generate electrical currents of frequencies corresponding to the pitches of the notes of the musical scale, but normally not in oscillation; a keying terminal operatively associated with each oscillator; a source of activating potential; a key and a key-operated switch operatively associated with each of said keying terminals, and with said potential source, for delivering activating potential to initiate and maintain oscillation of each oscillator as long as the key switch for said oscillator remains closed; an output terminal operatively associated with each oscillator for delivering signal whenever said oscillator is activated; and transducer means for translating a received signal into sound; the improved circuitry between said oscillator output terminal and said transducer, comprising: a bus bar; a first group of distorting circuits each connected to receive signals from the output terminal of one of said oscillators, and each including a rectifier; all the rectifiers of said first group of distorting circuits being connected to rectify the signal in the same sense; a second group of distorting circuits, each connected to receive signal from the output terminal of one of said oscillators, and each including a rectifier connected to rectify the signal in the opposite sense to the rectifiers of said first group; connections from all of said distorting circuits to said bus bar; and operative connections from said combining means for delivering the signals emanating from said combining means to said transducer means.

10. A combination according to claim 9 in which the number of distorting circuits in each group is approximately the same as in the other group.

11. In an electronic musical instrument of the type comprising: a multiplicity of electrical oscillators adapted to generate electrical currents of frequencies corresponding to the pitches of the notes of the musical scale, but normally not in oscillation; a keying terminal operatively associated with each oscillator; a source of activating potential; a key and a key-operated switch operatively associated with each of said keying terminals, and with said potential source, for delivering activating potential to initiate and maintain oscillation of each oscillator as long as the key switch for said oscillator remains closed; an output terminal associated with each oscillator for delivering signal whenever said oscillator is activated; and transducer means for translating a received signal into sound; the improved circuitry between said oscillator output terminal and said transducer, comprising; first and second tone-collecting bus bars; a first group of distorting circuits comprising a multiplicity of distorting circuits, one operatively associated with the output terminal of each oscillator and each including a separate rectifier; all of said first group of distorting circuits being connected to first bus bar to deliver signal thereto; a second group of distorting circuits, one operatively associated with the output terminal of each oscillator and each including a separate rectifier; said second group of distorting circuits being connected to deliver signal to said second bus bar; all the rectifiers of said first group of distorting circuits being connected to rectify the signal in one sense, and all those of said second group rectify the signal in the opposite sense; two isolation amplifiers, one receiving signal from each of said bus bars; a blending terminal connected to the outputs of both amplifiers to experience the superposed oscillations of both bus bars; the combined oscillations of said terminal being rich in all the odd numbered harmonics of the basic oscillator frequency and substantially devoid of the even numbered harmonics; and operative connections from said combining means for delivering the signals emanating from said combining means to said transducer means.

12. In an electronic musical instrument of the type comprising: a multiplicity of electrical oscillators adapted to generate electrical currents of frequencies corresponding to the pitches of the notes of the musical scale, but normally not in oscillation; a keying terminal operatively associated with each oscillator; a source of activating

potential; a key and a key-operated switch operatively associated with each of said keying terminals, and with said potential source, for delivering activating potential to initiate and maintain oscillation of each oscillator as long as the key switch for said oscillator remains closed; an output terminal associated with each oscillator for delivering signal whenever said oscillator is activated; and transducer means for translating a received signal into sound; the improved circuitry between said oscillator output terminal and said transducer, comprising: first and second tone-collecting bus bars; each oscillator having a plurality of distorting circuits; one of said distorting circuits having a rectifier in it and connecting the output terminal of said oscillator to said first bus bar; a second one of said distorting circuits having a rectifier in it and connecting said output terminal to said second bus bar; said first and second distorting circuits having their rectifiers connected to rectify the signal in opposite senses; a phase inverter connected to receive signal from said first bus bar; means for combining the output signal from said phase inverter with the signal from said second bus bar; and operative connections from said combining means for delivering the signals emanating from said combining means to said transducer means.

13. In an electronic musical instrument: oscillator means for generating a substantially sine curve signal; rectifier means connected to receive said signal and acting in one sense, for passing a predetermined fraction of each excursion of said original signal in one direction; separate rectifier means connected to receive said original signal and acting in the opposite sense, for separating substantially the same fraction of each excursion of said original signal in the opposite direction; a phase inverter for inverting one of said rectified signals, whereby the excursions of both rectified signals are of the same polarity; and combining means for superposing the rectified and the reversed signals to form a combined signal having twice the fundamental frequency of the original sine wave, retaining even harmonics of said original signal, and devoid of odd harmonics of said original signal.

14. In an electronic musical instrument, a multiplicity of signal sources tuned to the pitches of the semi-tones of the musical scale; each source having two rectifier circuits connected to it in opposite senses and adapted to receive the signal from said source and separate similar fractions of the signal excursions in opposite directions; a first bus connected to receive the separated fractions of the positive excursions from all said sources; a second bus connected to receive the separated fractions of the negative excursions from all said sources; a phase inverter connected to receive the composite signal on one of said buses and invert said composite signal; a combining means for superposing the signals on both buses; and transducer means for translating the combined signal into acoustic sound.

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