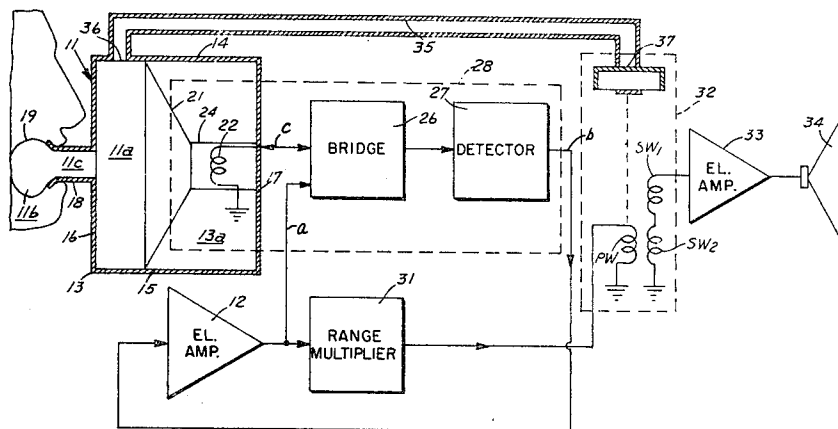


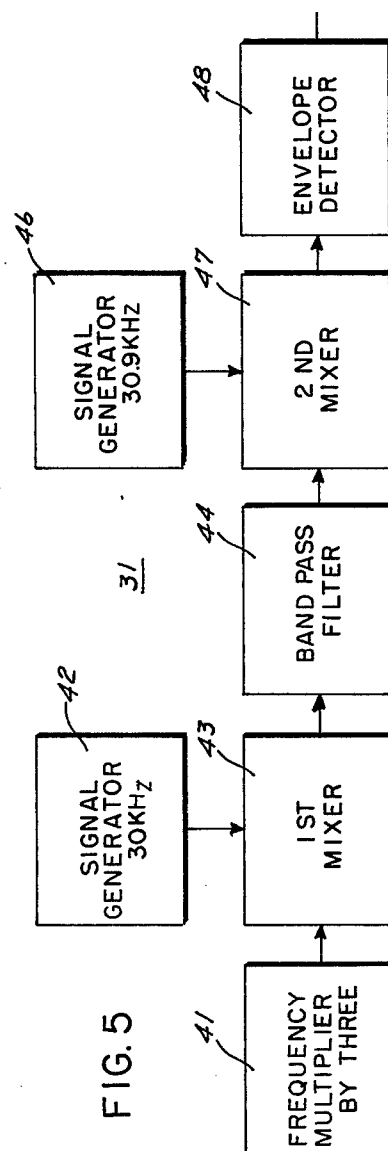
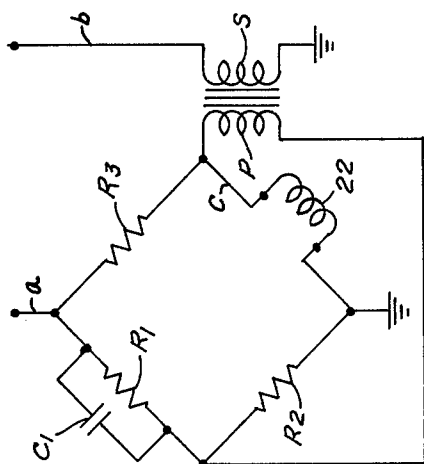
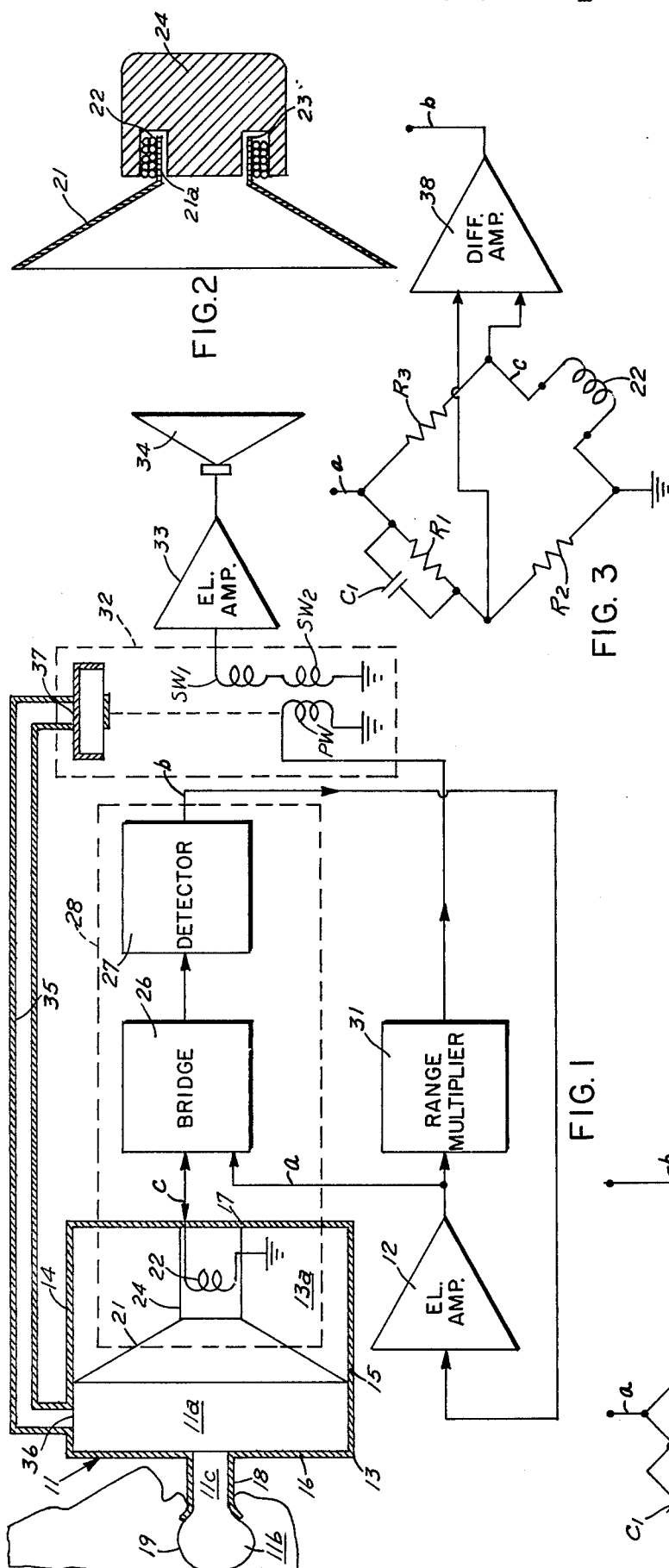
[54] **ORAL CAVITY CONTROLLED
ELECTRONIC MUSICAL INSTRUMENT**[76] Inventor: **Larry A. Spence**, 720 Fairlane, Apt.
D., Longmont, Colo. 80501[22] Filed: **Mar. 21, 1974**[21] Appl. No.: **453,330**[52] U.S. Cl. **84/1.05; 84/1.09; 84/DIG. 10;**
179/1 F; 179/1 M; 179/1 VL[51] Int. Cl. **G10h 3/00**[58] Field of Search **84/1.01, 1.04-1.06,**
84/1.09, 1.1, 1.14, 1.15, 1.24, 1.27, DIG. 10,
DIG. 21, DIG. 26; 179/1 F, 1 J, 1 M, 1 VC, 1
VL, 1 AL[56] **References Cited****UNITED STATES PATENTS**

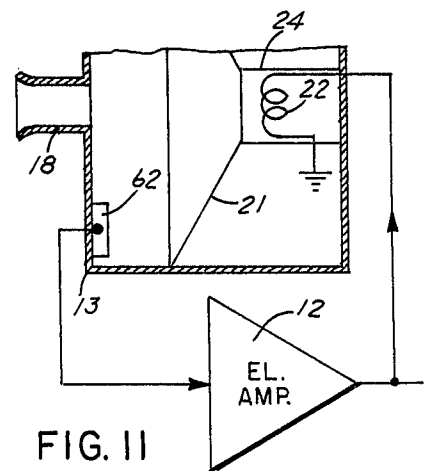
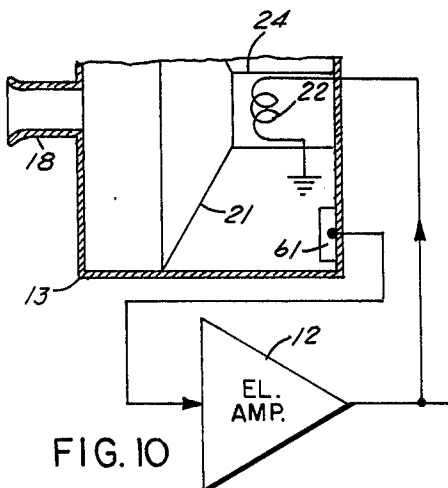
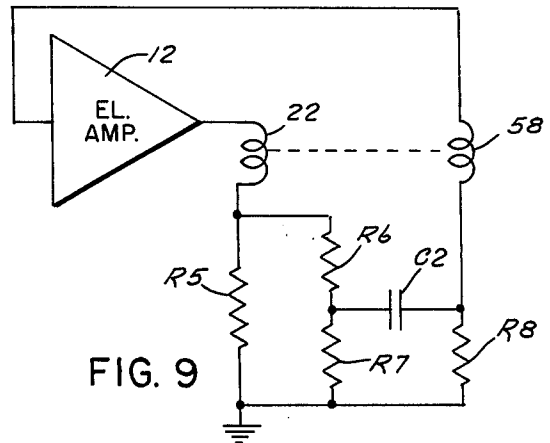
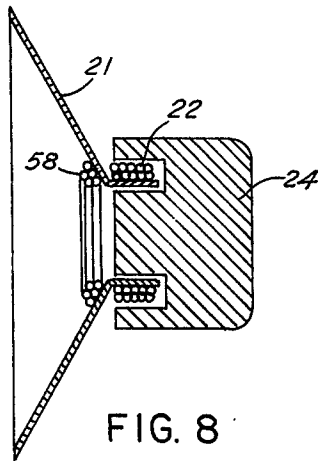
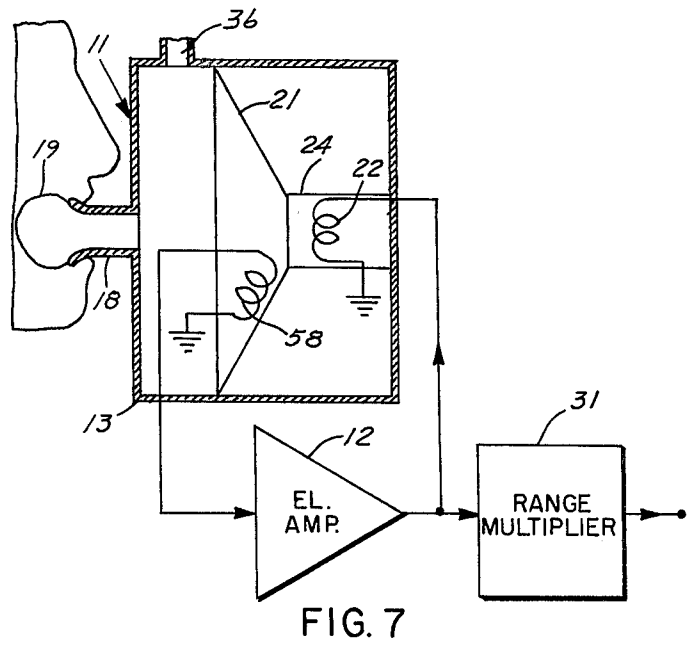
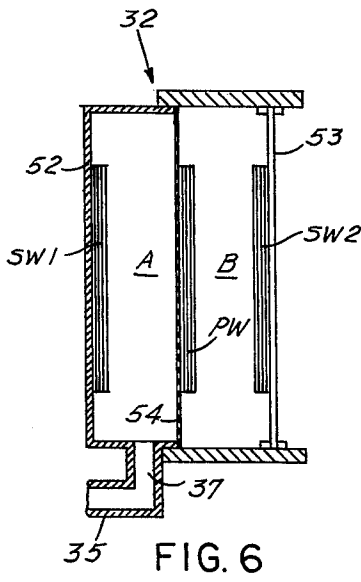
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*Primary Examiner—Richard B. Wilkinson**Assistant Examiner—Stanley J. Witkowski**Attorney, Agent, or Firm—Ancel W. Lewis, Jr.*[57] **ABSTRACT****A method and apparatus for electrically producing**

musical sounds wherein a cavity resonator is formed by a hollow body defining a cavity having a constant configuration with a small opening communicating with the oral cavity of the mouth of a player and a change in the size of the oral cavity changes the resonant frequency and thereby the fundamental frequency of the sound produced. A vibrating cone in a closed chamber produces sound waves in the cavity resonator. An electric amplifier is driven by electric oscillations corresponding to monitored sound energy from the cavity resonator and the amplified oscillations are coupled back to the vibrating member to sustain the motion of the vibrating member. In one form, a coil on the vibrating cone and moving therewith is wrapped on a portion of a magnet producing a back emf to monitor the sound waves in the cavity resonator and also convert the amplified electric oscillations received from the electric amplifier to a physical oscillatory force to drive the vibrating cone. In another form a second sensing coil is mounted on the vibrating cone to move therewith and is inductively coupled to the first coil and magnet to monitor the sound energy. A pressure sensitive volume control facilitates control of the amplitude of the sound output with breath pressure. A range multiplier provides a three octave sound range. In yet further forms, a microphone may be mounted either in a closed chamber part of the cavity resonator opposite the mouthpiece or in a chamber portion of the cavity resonator adjacent and in communication with the mouthpiece to monitor the sound waves therein and provide corresponding electric oscillations that will drive the electric amplifier.

26 Claims, 11 Drawing Figures





ORAL CAVITY CONTROLLED ELECTRONIC MUSICAL INSTRUMENT

FIELD OF THE INVENTION

This invention relates to musical instruments and more particularly to novel and improved electric musical instruments of the type disclosed in an earlier U.S. Pat. No. 3,730,046.

BACKGROUND OF THE INVENTION

In the earlier U.S. Pat. No. 3,730,046 of which the present applicant is patented there is disclosed a musical instrument having, in general, a cavity resonator coupled as an acoustic load across the input and output of an electric amplifier in a closed loop so that the musician's oral cavity determines the fundamental frequency of oscillations of an electronic audio oscillator. The cavity resonator is comprised of a hollow body or casing with an inner cavity wherein the vibrating cone of a loudspeaker forms one wall thereof opposite the mouthpiece and the sounds produced by the vibrating member are emitted directly from the vibrating cone into the surrounding atmosphere. This form utilizes an acoustical channel or tube on the front side of the vibrating cone positioned as close to the oral cavity as possible for transmitting sound waves produced by the vibrating cone so that they may be monitored by a microphone which in turn converts the sound energy to corresponding electric oscillations that are applied to the input of an electric amplifier. There are drawbacks in monitoring the sound waves outside the cavity resonator including the positioning of the microphone and differences in phase and amplitude of the sound being used in the feedback loop to sustain the generation of sound in the cavity resonator. In the use of the vibrating cone as a wall of the cavity resonator, it has been found that it is difficult to equalize pressure on the vibrating cone. In a second embodiment shown in the above-mentioned earlier patent, the hollow body encloses the vibrating cone and the vibrations are monitored by the microphone via an air channel off the mouthpiece and are applied to the electric amplifier with the output of the electric amplifier being applied to a separate speaker which converts the electric oscillations to corresponding sound waves.

Accordingly, it is a general object of this invention to provide improvements and modifications in the electric music apparatus and methods of the earlier U.S. Pat. No. 3,730,046.

Another object of this invention is to provide forms of the present invention that eliminates the necessity of a microphone.

Yet, a further object of this invention is to provide improved methods and apparatus for providing musical sounds that includes the provision of a pressure sensitive volume control that permits the operator to control the amplitude of the sound output with breath pressure and a range multiplier that permits the instrument to have a three octave range.

Yet another object of this invention is to provide a method and apparatus for producing musical sound in which the sound energy is monitored directly within a cavity having a constant configuration and source of sound energy.

Other objects, advantages and capabilities of the present invention will become more apparent as the de-

scription proceeds taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic circuit diagram of an electric musical instrument embodying features of the present invention;

FIG. 2 is a side elevation view of the basic elements of a loudspeaker that may be utilized as the vibrating member, coil and magnet in the circuit diagram of FIG. 1;

FIG. 3 is a schematic circuit diagram of a differential amplifier that may be utilized in the circuit of FIG. 1;

FIG. 4 is a schematic circuit diagram of a transformer that may be utilized in the circuit of FIG. 1;

FIG. 5 is a schematic block diagram of a range multiplier that may be utilized in the circuit of FIG. 1 to accomplish a range of sound output of three octaves;

FIG. 6 is a side elevation view of a volume control transformer and associated pressure chambers that may be used in the circuit of FIG. 1;

FIG. 7 is a schematic circuit diagram of another form of electric musical instrument embodying features of the present invention utilizing a separate sensing coil on the loudspeaker cone;

FIG. 8 is a side elevation view of the loudspeaker with the separate sensing coil in the circuit of FIG. 7;

FIG. 9 is a null circuit that may be used for the circuit of FIG. 7;

FIG. 10 is yet a modified form of electric musical instrument using a microphone in the closed chamber opposite the cavity resonator to monitor the sound energy therein; and

FIG. 11 is a modified form of electric musical instrument using a microphone in the rear chamber of the cavity resonator to monitor the sound energy.

Referring now to the drawings, in FIG. 1 there is shown one form of the present invention which in general is comprised of a cavity resonator generally designated by numeral 11 operatively coupled as an acoustic load across the input and output of an electric amplifier 12 in a closed loop to form in effect an electronic audio oscillator. The basic function of the electric amplifier is to add sufficient electric energy to the system which is transformed into a physical force to sustain the oscillations of the vibrating member 21 in the cavity resonator. The cavity resonator 11 is formed by a hollow body or casing 13 having opposed top and bottom walls 14 and 15, respectively, and opposed front and rear walls 16 and 17, respectively, arranged in a box-like configuration with an inner cavity that confines a mass of air and has a constant configuration communicating with the external surrounding air through a small opening in wall 16 to form the cavity resonator which is also commonly known as a simple Helmholtz resonator. A tubular mouthpiece 18 is formed in the front wall 16 and is sized to receive the lips of a player of the instrument defining a restricted passage opening into the inner cavity through the opening in wall 16 so that with the wall forming the mouth of the player represented at 19 there is provided an oral cavity.

The cavity resonator 11 as referred to herein is comprised of the inner cavity or chambers 11a and 13a in the body 13 separated by the vibrating member 21, and the small opening in wall 16. The oral cavity space 11b and the inner cavity 11a, 13a of the body may be considered as two different oppositely disposed cavity resonators joined by passage 11c. However for the purposes of explaining and defining the present invention,

the cavity 11a and 13a having a constant configuration with the opening in wall 16 is referred to herein as the cavity resonator. The positioning of the player's oral cavity establishes a resonant frequency for the combined cavity of fixed configuration and oral cavity that has a fundamental frequency established by the size of the musician's oral cavity.

Within the hollow body 13 there is mounted the vibrating member 21 shown in the form of a speaker cone of a conventional loudspeaker that will produce mechanical vibrations which in turn produces sound waves in the cavity resonator 11. The sound waves produced by the vibrating cone reflect back and forth in the cavity resonator 11 and oral cavity through the passage 11c at a resonant frequency. It is further noted that the rear wall 17 of the body 13 with the speaker cone 21 forms a closed chamber portion 13a of the cavity resonator that has been found to be effective in equalizing pressure on both sides of the vibrating cone 21. Since the oral cavity of the musician is in communication with the cavity resonator, as the size of the oral cavity changes, the resonant frequency of combined oral cavity and cavity resonator changes and in this way the acoustical load on the vibrating member is changed and the fundamental frequency of the sound output is changed.

As best seen in FIG. 2, a voice coil 22 is wrapped on the inner tubular end portion 21a of the speaker and is affixed thereto the speaker to move conjointly therewith which in turn is fitted inside a slot 23 in the magnet 24. The combination of the cone, coil and magnet is structure that may be found in conventional loudspeakers and a dynamic type loudspeaker is preferred.

In the form shown in FIGS. 1 and 2, the back and forth movement of the vibrating cone moves the coil in the magnetic field produced by the magnet to cause corresponding electric oscillations in the coil (commonly referred to as back emf). In this way the coil can be used to perform two functions. First, it is used to monitor the sound energy produced by the motion of the vibration cone 221 and secondly to convert electric oscillations produced at the output of the electric amplifier 12 to electric energy that will sustain the motion of the vibrating cone. The electric oscillations produced by the back emf in effect are small as compared to the amplified electric oscillations being applied to the coil from the feedback loop via the electric amplifier 12. A particular advantage of this type of monitoring of the sound energy using a coil attached to the vibrating member is there is no need to be concerned with the level or phase of the sound in the oral cavity, since it appears as an acoustic load to the vibrating member and causes its phase and amplitude to change when the size of the oral cavity is varied.

Referring again to FIG. 1, the output of the electric amplifier 12 is shown as connected back to the ungrounded side of the voice coil 22 via the bridge network 26 described hereinafter to form a feedback loop to sustain the vibrating motion of the vibrating cone 21. In this way, the voice coil 22 in operative association with the magnet 24 and cone 21 in effect function as a transducer to convert the amplified electric oscillations back to mechanical vibrations in the cone 21 which in turn produces sound waves in the cavity resonator 11. When the electric signal from the output of the electric amplifier applied to the terminal of the voice coil via the bridge network 26 is of the fundamen-

tal frequency the speaker cone displacement is greater than for any other frequency. Between the coil 22 and the input of the electric amplifier, there is shown in FIG. 1 a bridge network block 26 followed by a detector block 27. The coil, bridge network 26 and detector being enclosed in a dashed block 28 in the feedback loop generally representing a coupling between the cavity resonator and the input of the electric amplifier 12.

A range multiplier 31 is shown coupled to the output of the electric amplifier 12 to provide a three octave sound range for the instrument. The output of the range multiplier 31 is coupled via a volume control 32 to an electric amplifier 33 which in turn is coupled to an output speaker 34 from which the output sound waves or musical sounds are emitted. A pneumatic pipe or tube 35 is shown coupled from an outlet 36 in the chamber 11a of the cavity resonator to an inlet 37 into the pressure chamber in the volume control 32 described more fully hereafter to permit volume (i.e. output sound amplitude) to be controlled by breath pressure.

There are two circuits shown in FIGS 3 and 4 relating to the dashed block 28 of FIG. 1 either of which is suitable for detecting the back emf which again is monitoring the sound energy produced by the motion of the vibrating cone 21.

Referring first to FIG. 3, the bridge network used in both forms is comprised of two legs in parallel with one another, one leg having resistors R1 and R2 in series with one another and the other leg having a resistor R3 and the coil 22 in series with one another with the common connection of R1 and R2 being connected to the input line "a" and with one side of resistor R2 and on side of the coil 22 connected to ground. A differential amplifier 38 has one input connected between resistors R1 and R2 and another input connected between R3 and the coil 22. A capacitor C1 is connected across R1 to compensate for inductive reactance of the coil 22. The output line of the detector represented generally in FIG 1 is the output line of the differential amplifier 38 in FIG. 3. The ungrounded side of the voice coil is designated "c." Since the back emf signal is small compared to the signal being applied to the voice coil 22 by the electric amplifier 12 via bridge network 26, it is detected by the differential amplifier 38 and through the differential amplifier 38 applied back to the input through the differential amplifier 38 applied back to the input of the electric amplifier 12. The output line of the detector 27 is designated "b."

As shown in FIG. 4, a transformer having a primary winding P and a secondary winding S with the primary winding having one side connected between R1 and R2 and the other side connected between R3 and the coil 22 and the secondary winding S will detect the smaller induced emf. In this form as with the form of FIG. 3, the components R1, R2 and R3 are selected such that the induced emf signal as seen at both sides of the transformer is nearly identical when the acoustic loading on the speaker cone is neutral. At the resonant frequency for the cavity resonator the back emf in the speaker coil unbalances the bridge and its output is greatly increased. This peak output becomes the frequency of oscillation for the circuit of FIG. 4 (assuming all the phase errors around the loop have been corrected).

A more detailed block diagram for the range multiplier 31 is shown in FIG. 5. In this circuit there is provided a frequency multiplier 41 that multiplies the frequency at the output of the electric amplifier 12 by three. Typically, the frequency of the electric oscillations at the output of the electric amplifier 12 will be of a square waveform as illustrated in the drawing and in the range of 350 Hz to 700 Hz so that the output frequency of the frequency multiplier 41 ranges from 1050 to 2100 Hz (but is still only one octave).

The output of the multiplier 41 is mixed with a 30 KHz signal provided by a signal generator 42 in a first mixer stage 43. The outputs of the first mixer 43 consist of sum and difference frequencies as well as the original frequency. For example, when the frequency multiplier output is 1050 Hz the sum frequency output is 31,050 Hz the difference frequency is 28,950 Hz and there is also the 1050 Hz output. If a balanced modulator is used the 30 KHz signal does not appear at the output of the first mixer 43.

The output of the first mixer 43 is applied to a band pass filter 44 which permits only the 31,050 Hz to get through unattenuated. This 31,050 Hz signal is mixed with a 30.9 KHz signal supplied by a second signal generator 46 in a second mixer 47 and only the difference frequency falls within the audio range. The output of the second mixer 47 is applied to an envelope detector 48 to provide a relatively pure 150 Hz output from the envelope detector 48. If the output from the frequency multiplier 41 is increased to 2,100 Hz the output of the envelope detector 48 is 1,200 Hz is exactly three octaves above the 150 Hz so that a three octave range is attained. The output of the envelope detector is coupled to the volume control 32 described fully hereinafter. It is understood that the range multiplier 31 could multiply by other than an even integer and is in effect an electric amplifier that amplifies to the extent required for a particular sound range.

Referring now to FIG. 6, the volume control 32 comprises a hollow body with opposed spaced upright walls 52 and 53 with a separate secondary winding coil designated SW1 and SW2 mounted on each wall 52 and 53, respectively. The primary winding PW is mounted on a flexible elastic membrane 54 which divides the housing into two chambers designated A and B of equal volume with the air pressure from the cavity resonator 11 being coupled into chamber A via inlet 37. The coils are wound in a spiral fashion so as to be in the shape of a disc when completed. The volume control transformer is in effect an air core transformer and movement of the membrane 54 in relation to the air pressure moves the primary winding PW in relation to the secondary winding SW1 and SW2 that are connected in series with one another and in this way the electric output from the secondary windings change.

More specifically, the primary winding PW is physically located at a neutral position midway between the secondary windings SW1 and SW2. The two secondary windings are wound in opposite directions and have opposing voltages induced therein from the primary winding PW at the neutral position. When the musician changes the relative position of the primary winding PW relative to the secondary winding as by inhaling or exhaling, there is an unbalancing of the voltage in the secondary windings Sw1 and Sw2.

With the volume control 32 the instrument can be operated without a pressure actuated switch. The oscil-

lations in the control loop are allowed to run continuously, but since the vibrating cone 21 is completely enclosed, this signal is barely audible. The operator is able to separate one note from the next by sudden increase in breath pressure which moves the primary winding PW on and off a null point at the vertical position.

It will be noted that this system can be operated by both inhaling and exhaling since the volume control transformer is "bipolar." This arrangement reduces the amount of condensation on the speaker cone and allows a more continuous flow of music than the form in the earlier patent since the musician need not stop to catch a breath.

OPERATION

In a full sequence of operation for the instrument above described with reference to FIGS. 1 through 6 inclusive, the resonant frequency and thereby acoustic load and the fundamental frequency of the sound output is established in the cavity resonator 11 by the size of the oral cavity 19. The vibration of the vibrating cone 21 produces sound waves in the cavity resonator which are monitored by the coil 22 which produces a back emf in the form of electric oscillations that are applied via the bridge 26 and the detector 27 to the input of the electric amplifier 12, amplified and applied back to coil 22 and in co-operation with the magnet the amplified electric oscillations are transformed to an oscillatory physical force that is applied to the vibrating cone 21 to sustain its vibratory movement. The output of the elastic amplifier 12 is also applied to the range multiplier 31 providing a three octave range output which is coupled to the input of the electric amplifier 33 via the volume control transformer and then to an output speaker 34 which emits the sound into the atmosphere. A change in the pressure in the volume control from breath pressure in the cavity resonator will change the amplitude of the output sound from the speaker 34.

OTHER EMBODIMENTS

Referring now to FIGS. 7 and 8, there is shown another form of arrangement for monitoring the sound energy produced in the cavity resonator 11. In this form there is provided a second sensor coil 58 affixed to the front side of the vibrating cone 24 in a substantially coaxial alignment with the voice coil 22 in the slot 23 of the magnet 24. The sensor coil 58 has one side connected to the input of the electric amplifier 12 and the other side connected to ground and is in the magnet field of the magnet. Any back and forth motion of the vibrating cone will therefore induce electric oscillations in the sensor coil 58 which oscillations are applied to the input of the electric amplifier 12. In this way the sensor coil functions to monitor the sound energy produced by the motion of the vibrating member and provided corresponding electric oscillations.

It is noted that the alternating magnetic field produced by current in the coil 22 will also produce electric oscillations in the sensor coil 58 but it has been found these are usually not significant. In the event it is desired to null out such electric oscillations produced by current in coil 22, these can be nulled out by circuitry shown in FIG. 9, which comprises a parallel circuit comprised of resistors R5 between coil 22 and ground and R6 and R7 between coil 22 and ground, and resistors R6 and R7 being connected across resis-

tor R5. A resistor R8 is connected between coil 58 and ground. A capacitor C2 is connected between coil 58 and resistor R6.

In the operation of the null circuit there is a sample of the current in the voice coil 22 across resistor R5. The amount of magnetic coupling between coils 22 and 58 is a function of the current in coil 22. Across resistors R6 and R7 the voltage is tapped, which voltage is equal and opposite to the magnetically induced voltage which in turn is added in opposite phase via capacitor C1 back to coil 58 to null out the magnetically induced voltage in coil 58.

Referring now to FIG. 10, it is appreciated that instead of using the coil 22 or the sensing coil 58 as a means to monitor sound energy, a microphone 61 may be used that is mounted on the rear wall 17 in the rear chamber of the housing. The microphone functions as a transducer to produce corresponding electric oscillations that are coupled back to the input of the electric amplifier. Finally, it should be observed that as shown in FIG. 11, the microphone is not limited to chamber 13a but a microphone 62 may be mounted on the front wall 16 in the chamber 11a in the resonant cavity to monitor sound energy with the electric output of the microphone 62 being coupled back to the input of the electric amplifier 12.

From the foregoing, it will be appreciated that there is disclosed herein several approaches to or methods of monitoring the sound energy produced by the motion of the vibrating cone and specifically directly within the cavity having a constant configuration and providing corresponding electric oscillations. In the earlier U.S. Pat. No. 3,730,046 this was accomplished by locating the microphone on the front or mouthpiece side of the vibrating cone via an air channel leading from the mouthpiece as close to the oral cavity as possible and detecting sound waves resulting from the mechanical vibrations of the vibrating cone. In the form of FIGS. 1 through 4 of the present invention application, the monitoring is accomplished by using the coil associated with the vibrating cone and more specifically, the voice coil of the loudspeaker attached to the speaker and located in the side of the closed chamber opposite the mouthpiece along with a bridge and detector. In the form of FIGS. 7 through 9, the auxiliary or second sensing coil is physically affixed to the vibrating cone on the same side as the mouthpiece and is inductively coupled to the magnet to perform this monitoring function. Finally, it is appreciated from the embodiments of FIGS. 10 and 11 that a microphone may be installed either in the closed chamber opposite the vibrating cone or in the cavity resonator chamber opposite the oral cavity to accomplish this monitoring function. The monitoring of the sound energy may be considered as detecting the resonant frequency, the fundamental frequency, or the acoustic load on the vibrating member which, or course, changes with the size of the oral cavity of the player. In each instance it should be appreciated that in the present invention the monitoring of the sound energy is directly within the cavity formed by hollow body 11 which has a constant configuration for confining a mass of air and communicating with external surrounding air through a small opening in wall 16 to form a cavity resonator. This sound energy can be monitored so that it is substantially directly in phase with the vibrations of the mass of air so there is essentially no

phase shift when that energy is returned to sustain the oscillations of the vibrating member.

Although the presnet invention has been described with a certain degree of particularity, it is understood that the present disclosure has been made by way of example and that changes in details of structure may be made without departing from the spirit thereof.

What is claimed is:

1. In a method of electrically producing musical sound, the steps of:

confining a mass of air in a first cavity having a constant configuration communicating with external surrounding air through a small opening to form a cavity resonator,

placing the lips of a player over the opening and setting the size of the player's oral cavity to establish a selected resonant frequency for the combined first cavity and oral cavity,

vibrating the confined mass of air in the first cavity to generate sound energy that is transmitted back and forth through the small opening between the first cavity and the oral cavity,

monitoring the sound energy directly within said first cavity to produce electric oscillations corresponding to the monitored sound energy and substantially in phase with the vibrations of the mass of air in the first cavity and at the same time transforming amplified electric oscillations to an oscillatory physical force capable of sustaining the sound energy in the first cavity, and

amplifying the monitored electric oscillations prior to said transformation into electric oscillations.

2. In a method of electrically producing musical sounds as set forth in claim 1 including the further step of changing the size of the oral cavity to change the resonant frequency of the cavity resonator and thereby the sound output.

3. In a method of electrically producing musical sounds as set forth in claim 1 wherein said monitoring and transforming steps are carried out simultaneously.

4. In a method of electrically producing musical sounds as set forth in claim 1 further including the further step of increasing the range of frequency of the monitored electric oscillations followed by the transforming of the electric oscillations of increased range to corresponding sound waves in the atmosphere.

5. In a method of electrically producing musical sounds as set forth in claim 1 further including the step of converting the monitored electric oscillations to corresponding sound waves in the atmosphere.

6. In a method of electrically producing musical sounds as set forth in claim 5 further including the step of applying breath pressure to the first cavity to control the amplitude of the sound energy prior to converting the monitored electric oscillations to sound waves in the atmosphere.

7. In a method of electrically producing musical sound, the steps of:

confining a mass of air in a first cavity having a constant configuration communicating with external surrounding air through a small opening to form a cavity resonator,

placing the lips of a person over the opening and setting the size of the person's oral cavity to establish a selected resonant frequency for the combined first cavity and oral cavity,

vibrating the confined mass of air in the first cavity to generate sound energy that is transmitted back and forth through the small opening between the first cavity and the oral cavity,
 monitoring the sound energy directly within said first cavity to produce electric oscillations corresponding to the monitored sound energy and substantially in phase with the vibrations of the mass of air in the first cavity,
 amplifying the monitored electric oscillations, and transforming the amplified electric oscillations to an oscillatory physical force that is applied to the mass of air in the first cavity to sustain the sound energy in the first cavity and oral cavity.

8. In an electric musical instrument, the combination comprising:
 a hollow body defining a first cavity having a constant configuration for confining a mass of air and communicating with external surrounding air through a small opening in the body to form a cavity resonator, said body having a mouthpiece forming a passage into the first cavity through said small opening, said mouthpiece being adapted to receive the lips of the player so that with the oral cavity of the mouth of the player of the instrument there is formed a resonant frequency for the combined first cavity and player's oral cavity,
 a vibrating member in the first cavity for vibrating the confined mass of air to generate sound energy that is transmitted back and forth between the first cavity and the oral cavity through the small opening, means for monitoring the sound energy directly within said first cavity to produce electric oscillations corresponding to the monitored sound energy and substantially in phase with the vibrations of the mass of air in the first cavity and providing corresponding electric oscillations to an oscillatory physical force capable of sustaining the sound energy in the first cavity, and
 an amplifier for amplifying the monitored electric oscillations.

9. In an electric musical instrument as set forth in claim 8 wherein said vibrating member is the cone of a loudspeaker having a voice coil affixed to the cone and a magnet adjacent the cone on which the voice coil is wrapped.

10. In an electric musical instrument as set forth in claim 8 wherein said vibrating member is mounted in said body and divides the body so there is a closed chamber opposite the mouthpiece to equalize the pressure on the vibrating member.

11. In an electric musical instrument as set forth in claim 8 further including a second electric amplifier to amplify the output of the first mentioned amplifier and a loudspeaker coupled to the second electric amplifier to convert the amplified electric oscillations to corresponding sound waves in the atmosphere.

12. In an electric musical instrument as set forth in claim 9 wherein said voice coil and magnet function to both monitor the vibrations of the vibrating cone and transform amplified electric oscillations to the oscillatory physical force.

13. In an electric musical instrument as set forth in claim 12 further including a bridge circuit coupled between the voice coil and the input of said electric amplifier and detector means coupled to the bridge whereby a resonant vibrating condition in the cavity

resonator causes an unbalance in the bridge that is detected by the detector.

14. In an electric musical instrument as set forth in claim 13 wherein said detector means is a differential amplifier.

15. In an electric musical instrument as set forth in claim 13 wherein said detector means is in the form of a transformer having a primary winding and a secondary winding.

16. In a musical instrument as set forth in claim 9 further including a sensing coil affixed to the vibrating cone and inductively coupled to a magnet, said sensing coil being coupled to the input of said electric amplifier to monitor the sound energy produced by the vibrations of the vibrating cone and provide corresponding electric oscillations.

17. In an electric musical instrument as set forth in claim 16 wherein said voice coil is driven by the amplified electric oscillations at the output of said electric amplifier.

18. In an musical instrument as set forth in claim 17 including a null circuit associated with said voice coil and sensing coil to null out unwanted oscillations in the sensor coil produced by the voice coil.

19. In an electric musical instrument as set forth in claim 8 further including a range multiplier means coupled to the output of the electric amplifier to increase the range of frequency of the amplified monitored electric oscillations.

20. In an electric musical instrument as set forth in claim 19 wherein said range multiplier means includes:

a frequency multiplier for multiplying the frequency of the electric oscillations at the output of the electric amplifier;

a first signal generator for producing a first electric signal of a selected frequency;

a first mixer for mixing the output of the frequency multiplier and said first signal generator to provide sum and difference outputs and the output of the electric amplifier;

a band pass filter coupled to said first mixer to pass either the sum or difference frequency only;

a second signal generator for providing a second electric signal;

a second mixer for mixing the output of the band pass filter with said second electric signal to provide only a difference frequency output that falls within the audio range; and

an envelope detector coupled to the second mixer to provide a relatively pure audio output signal.

21. In an electric musical instrument as set forth in claim 8 further including a volume control means for controlling the amplitude of the electric oscillations from the electric amplifier.

22. In an electric musical instrument as set forth in claim 21 wherein said volume control means includes:

a hollow body with a pair of opposed walls;

a flexible membrane dividing the hollow body into a pair of closed chambers;

means coupling the air pressure in the cavity resonator with that of one of said closed chambers;

a transformer secondary winding mounted on each of said walls; and

a transformer primary winding mounted on said membrane and normally disposed at a null position in relation to said secondary winding, the amplified electric oscillations at the output of said electric

amplifier being coupled to the primary winding whereby increases and decreases in the pressure in the closed chamber as a result of exhaling and inhaling at the mouthpiece moves the primary winding to an off null position causing a change in the amplitude of the electric oscillations in the secondary windings.

23. In an electric musical instrument, the combination comprising:

a hollow body defining a first cavity having a constant configuration for confining a mass of air and communicating with external surrounding air through a small opening in the body to form a cavity resonator, said body having a mouthpiece forming a passage into the first cavity through said small opening, said mouthpiece being adapted to receive the lips of the player so that with the oral cavity of the mouth of the player of the instrument there is formed a resonant frequency for the combined first cavity and player's oral cavity,

a vibrating member in the first cavity for vibrating the confined mass of air to generate sound energy that is transmitted back and forth between the first cavity and the oral cavity through the small opening, transducer means including a coil wrapped on a portion of said vibrating member to move therewith and a magnet with said coil wrapped around a portion of the magnet to transform electric oscillations applied thereto to an oscillatory physical force capable of sustaining the motion of the vibrating member,

a microphone adjacent to the vibrating member and opposite from the mouthpiece to monitor the sound energy produced by the motion of the vibrating member and provide corresponding electric oscillations; and

an electric amplifier driven by the monitored electric oscillations, the amplified electric oscillations being coupled back to said coil and transformed into oscillatory physical forces to sustain the motion of the vibrating member.

24. In an electric musical instrument as set forth in claim 23 wherein said vibrating member is mounted in said body and divides said body so there is a closed chamber opposite the mouthpiece to equalize pressure on the vibrating member, said microphone being mounted in said closed chamber.

25. In an electric musical instrument as set forth in claim 23 wherein said microphone is mounted in said

first cavity.

26. An electric musical instrument comprising:

a hollow body defining a first cavity having a constant configuration for confining a mass of air and communicating with external surrounding air through a small opening in the body to form a cavity resonator, said body having a mouthpiece forming a passage into the first cavity through said small opening, said mouthpiece being adapted to receive the lips of the player so that with the oral cavity of the mouth of the player of the instrument there is formed a resonant frequency for the combined first cavity and player's oral cavity,

a vibrating cone of a loudspeaker in the hollow body separating it into two chambers, said cone vibrating the confined mass of air in the cavity to generate sound energy, said loudspeaker having a voice coil affixed to an inner end portion to the vibrating cone and wrapped on a portion of a magnet, said voice coil and magnet monitoring the sound energy produced by the vibration of the vibrating cone and providing corresponding electric oscillations while at the same time transforming electric oscillations applied thereto to an oscillatory physical force capable of sustaining the motion of the vibrating member,

an electric amplifier having an input and an output, a bridge circuit coupled to the voice coil having a detector with the output of the detector coupled to the input of the electric amplifier, the output of the amplifier being coupled to the voice coil so that the voice coil and magnet transform the amplified electric oscillations to an oscillatory physical force to sustain the motion of the vibrating cone,

a range multiplier coupled to the output of the electric amplifier to increase the frequency range of the amplified monitored electric oscillations,

a volume control responsive to the breath pressure in the cavity resonator and coupled to the output of the range multiplier for controlling the amplitude of the electric amplifier in response to a change in breath pressure,

a second electric amplifier to amplify the output of the volume control, and

an output speaker coupled to the output of the second electric amplifier to change the amplified electric oscillations to sound waves in the atmosphere.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,878,748 Dated April 22, 1975

Inventor(s) Larry A. Spence

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 12, delete "patented" and insert --patentee--

Line 39, delete "shoown" and insert --shown--

Column 3, line 14, delete "resonstor" and insert --resonator--

Line 16, delete "sppeaker" and insert --speaker--

Column 4, line 39, delete "weeen" and insert --ween--

Column 5, line 31, after "Hz" insert --and the 1200 Hz--

Signed and Sealed this

sixteenth Day of September 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks