

[54] **CIRCUIT ARRANGEMENT CAPABLE OF CONTINUOUSLY VARYING TONE COLORS FOR ELECTRICAL MUSICAL INSTRUMENTS**

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[58] Field of Search 84/1.01, 1.11, 1.19, 84/1.24, DIG. 10, 1.09, 1.1, 1.12, 1.21, 1.27, 366, 444

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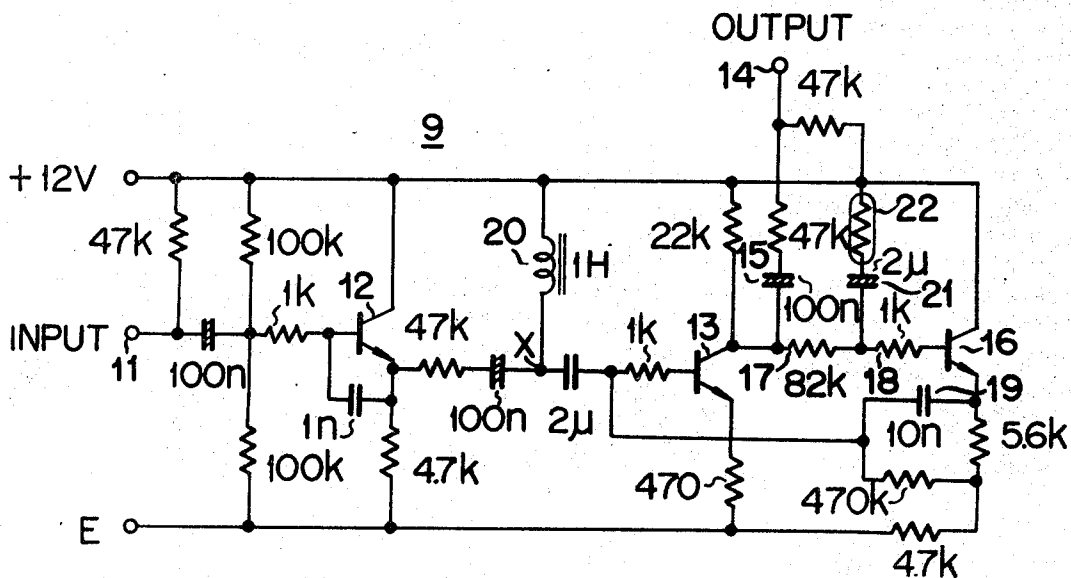
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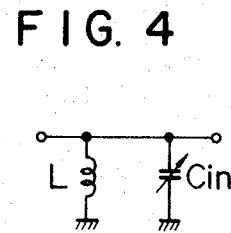
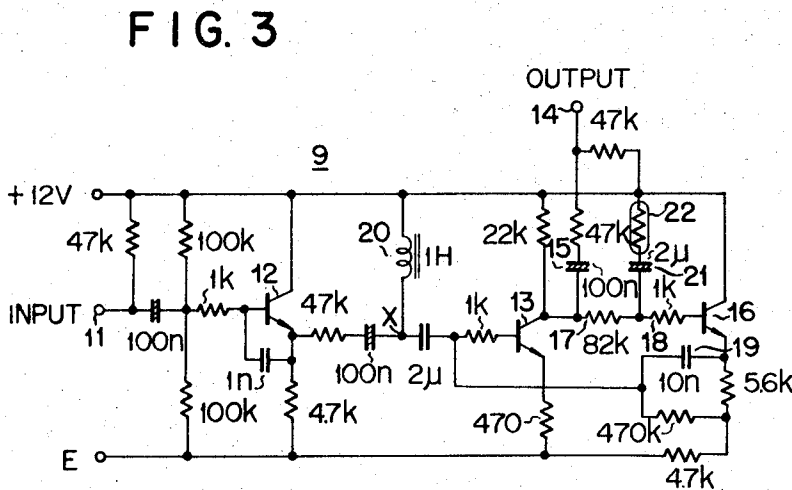
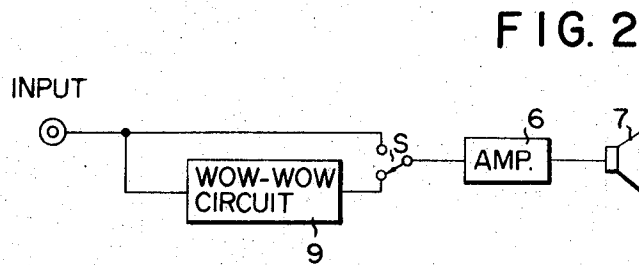
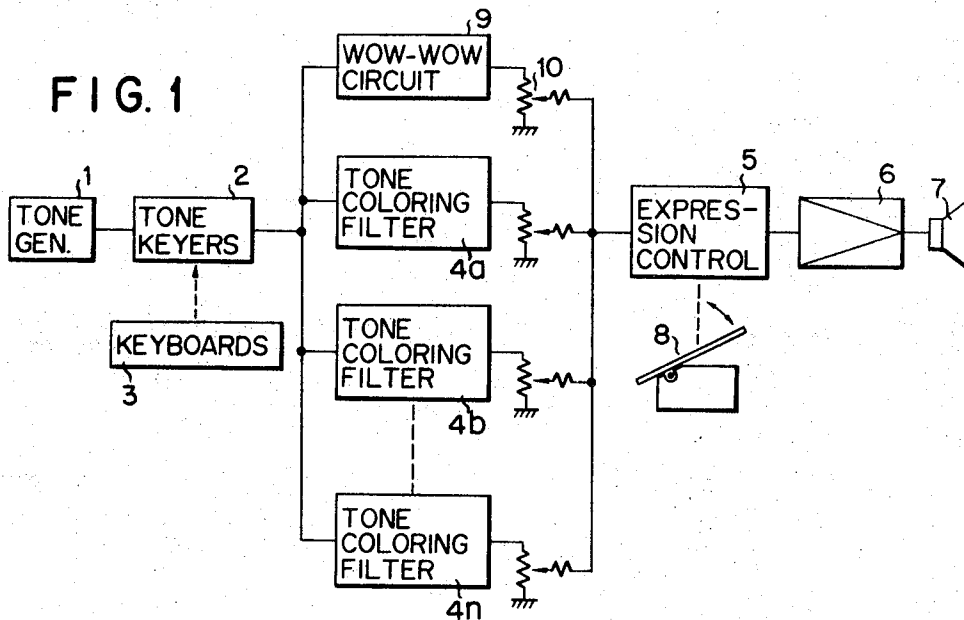
Primary Examiner—Richard B. Wilkinson
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[57] **ABSTRACT**

A circuit arrangement connected between tone signal generators and a loud-speaker so as to continuously vary tone colors by successively changing the relatively narrow frequency bands of tone signals transmitted from the tone generators to the loud speaker over a relatively broad frequency range of tone signals. There are supplied tone signals to a variable gain amplifier having a feedback reactive impedance element disposed between the output and input with the magnitude of a reactive input impedance controlled by the Miller effect. To constitute a resonance circuit or filter jointly with the feedback reactive input impedance of the amplifier there is connected to the input terminal of the variable gain amplifier a fixed reactive impedance element or a feedback reactive impedance element associated with another variable gain amplifier. The variable gain amplifier has its gain continuously and reciprocally controlled by a potentiometer or photoconductive element which is controlled by a pedal operated with player's foot, thereby continuously varying the frequency band of tone signals transmitted from the tone signal generators to the loud-speaker to obtain the so-called wow-wow effect.

4 Claims, 13 Drawing Figures





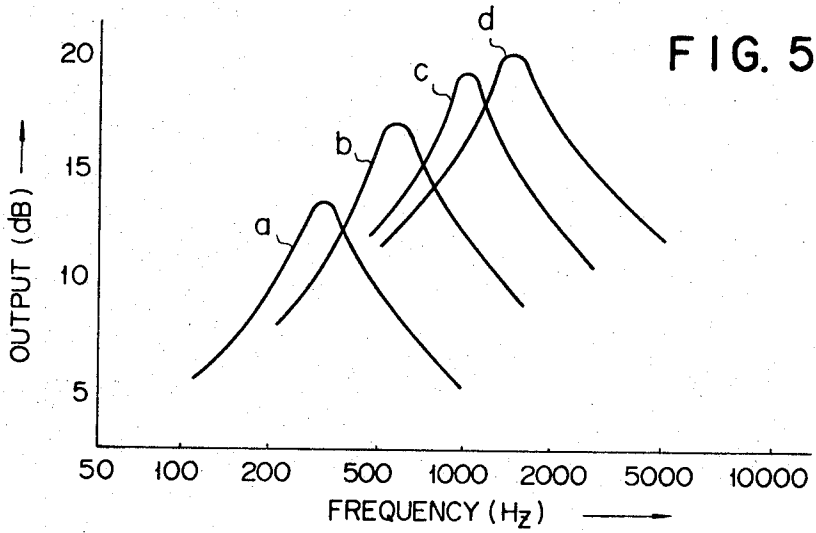


FIG. 6

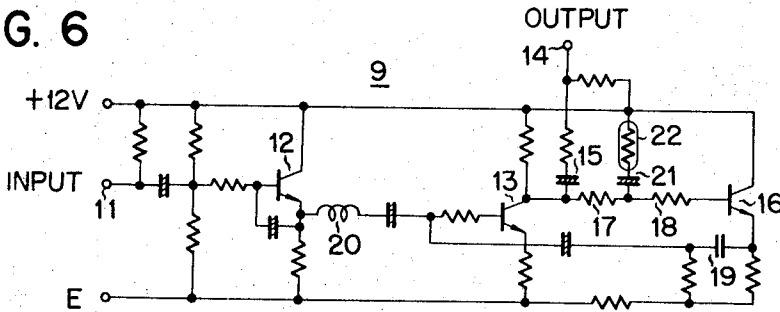


FIG. 7

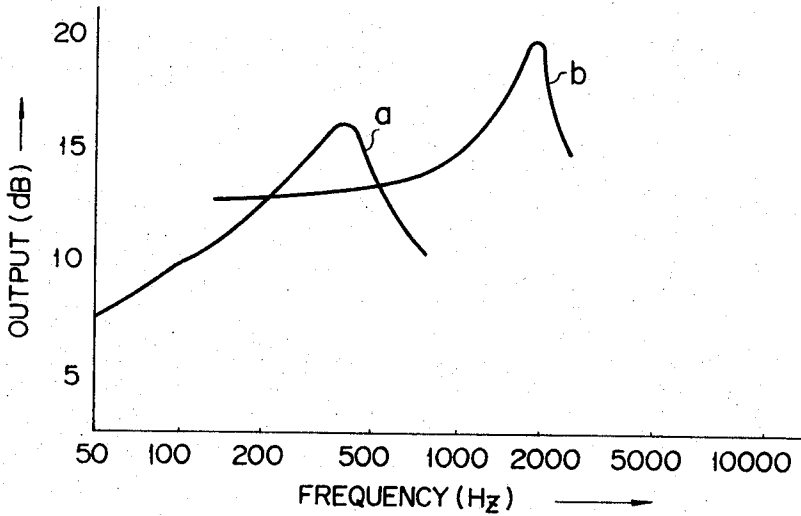


FIG. 13

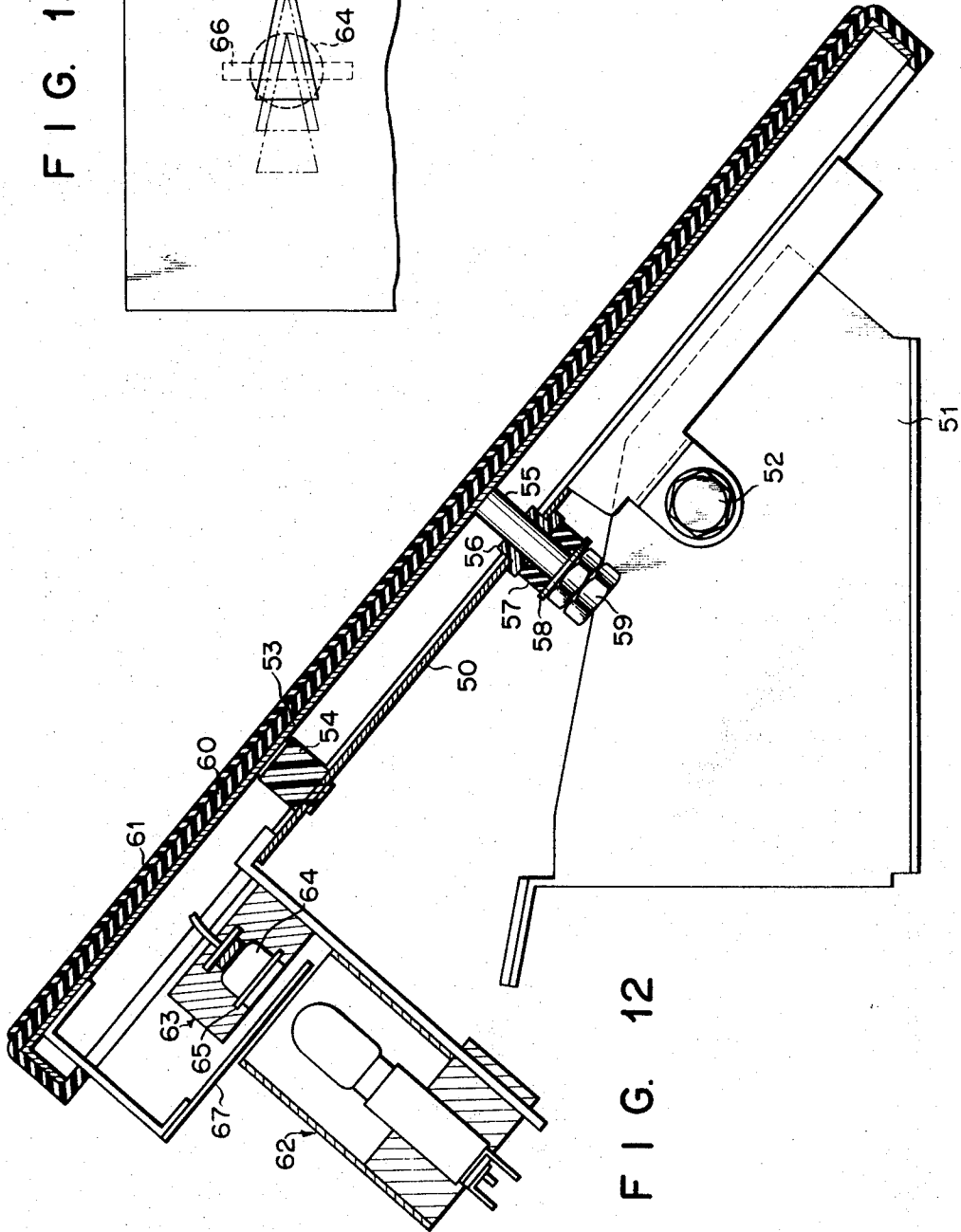
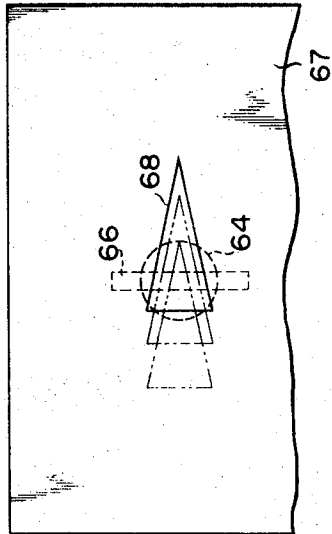


FIG. 12

CIRCUIT ARRANGEMENT CAPABLE OF CONTINUOUSLY VARYING TONE COLORS FOR ELECTRICAL MUSICAL INSTRUMENTS

BACKGROUND OF THE INVENTION

This invention relates to electrical or electronic musical instruments and more particularly to a circuit arrangement enabling a player to vary tone colors continuously by a simple operation during performance on such instrument.

In an electrical musical instrument, for example, an electronic organ, there are supplied tone signals from tone generators to tone coloring filters selectively by keyboard operation to be converted to musical tone signals having tone colors like those of, for example, flutes, or string instruments. In this case, such musical tone signals may be further modulated in amplitude or frequency so as to obtain various musical effects. However, the formation of such tone colors or the generation of musical effects is carried out entirely by operation of predetermined switches, making it impossible for a player to vary tone colors continuously as he desires during performance, namely, to obtain the so-called wow-wow effect.

The wow-wow effect is attained by picking up only tone signals having a relatively narrow frequency band from among those having a relatively broad frequency band and continuously shifting the picked up narrow band over the entire predetermined frequency range. Such wow-wow effect if favorably applied to not only electronic organs but also other electrical musical instruments such as an electric guitar.

SUMMARY OF THE INVENTION

It is accordingly the object of this invention to provide a circuit arrangement adapted for use with electronic or other electrical musical instruments which is capable of reliably realizing the wow-wow effect.

According to this invention, a circuit for generating the wow-wow effect is connected between tone signal generators and loud-speaker. In an embodiment of the invention, the wow-wow effect circuit includes a variable gain amplifier impressed with tone signals and a feedback reactive impedance element connected between the output and input of the amplifier. The reactive input impedance of the amplifier varies with the Miller effect, that is, the magnitude of a gain obtained by the amplifier. When, therefore, there is connected to the input of the amplifier a reactive impedance element constituting a resonance circuit or filter with the feedback reactive impedance element, then the frequency band of tone signals to be transmitted from the tone signal generators to the loud-speaker varies with the magnitude of gain of the variable gain amplifier. The gain of the amplifier is adjusted by controlling A.C. impedance circuit connected to the input of the amplifier. Control of the A.C. impedance can be continuously carried out by a pedal operable with a player's foot, simplifying the attainment of the wow-wow effect.

In another embodiment of the invention, there are provided two parallel variable gain amplifiers which have corresponding feedback reactive impedance elements jointly constituting a resonance circuit. These amplifiers are so designed that when one of them has a large gain, the other presents a small gain. Accordingly, the magnitudes of the apparent reactive input impedance of the amplifiers vary in the same direction,

enabling the resonance frequency of the resonance circuit constituting the frequency range of tone signals to be transmitted from the tone signal generators to the loud-speaker to be controlled over a broad range. These two variable gain amplifiers themselves are controlled in the same way as previously described.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an electronic organ system utilizing this invention;

FIG. 2 is a block diagram of a wow-wow effect imparting amplifier-loudspeaker system according to the invention;

FIG. 3 represents the arrangement of a wow-wow circuit according to an embodiment of the invention;

FIG. 4 is an equivalent circuit diagram to that of FIG. 3;

FIG. 5 is a characteristic diagram showing the properties of the circuit of FIG. 3;

FIG. 6 is a modification of FIG. 3;

FIG. 7 shows a characteristic diagram of the properties of the circuit of FIG. 6;

FIG. 8 represents the arrangement of a wow-wow circuit according to another embodiment of the invention;

FIG. 9 is a characteristic diagram showing the properties of the circuit of FIG. 8;

FIG. 10 indicates the arrangement of a wow-wow circuit according to still another embodiment of the invention;

FIG. 11 is a characteristic diagram illustrating the properties of the circuit of FIG. 10;

FIG. 12 is a schematic sectional view of an expression pedal used to obtain the wow-wow effect; and

FIG. 13 is a drawing for explaining the operation of the expression pedal of FIG. 12.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a block diagram of an electronic organ system including an wow-wow circuit. Tone signals with a relatively broad frequency band produced by tone generators 1 are selectively conducted by operation of keyboards 3 through tone keys 2 to tone coloring filters 4a to 4n to be converted to musical tone signals. Outputs of the filters 4a to 4n are connected to a loud-speaker 7 through an expression control 5 and amplifier 6. The expression control 5 is, as is well known, controlled by the pedal 8 of an electronic organ to change sound volumes.

There has been roughly outlined the arrangement of the known electronic organ system. According to the present invention, there is further provided a wow-wow circuit 9 between the tone keys 2 and expression control 5. Output of the wow-wow circuit is connected to the expression control 5 through a variable resistor 10. When there is not required to produce the wow-wow effect, the variable resistor 10 has only to be so adjusted as to obtain no output from the wow-wow circuit 9. The wow-wow circuit 9 may be controlled, as described later, by the expression pedal 8.

This invention is applicable to not only an electronic organ but also other electrical musical instruments such as an electric guitar. FIG. 2 schematically illustrates the arrangement of an amplifier-loudspeaker system for such electric musical instruments. Output from a source of tone signals such as an electric guitar (not shown) is supplied to the amplifier 6 by switching

means 5 directly or through the wow-wow circuit 9. Output of the amplifier 6 is connected to the loud-speaker 7. In this case, too, the wow-wow circuit 9 may be controlled by the pedal means operable by player's foot.

Also in an electronic organ, the wow-wow circuit may be inserted between the output side of the tone coloring filters and the input side of the expression control, in an selectively connectable manner as in FIG. 2.

FIG. 3 illustrates the arrangement of the wow-wow circuit 9 according to an embodiment of this invention. Tone signals supplied to the input terminal 11 are amplified by a transistor 12, the emitter output of which is coupled to the base of a transistor 13. The collector output of the latter transistor 13 is connected to the output terminal 14 of the wow-wow circuit 9 through a coupling capacitor 15. The collector output of transistor 13 is coupled to the base of another transistor 16 through resistors 17 and 18. The emitter output of transistor 16 is connected to the base of the aforesaid transistor 13 through a feedback impedance element or capacitor 19. There is connected a choke coil 20 between point x on a signal passage extending from the emitter of transistor 12 to the base of transistor 13 and a predetermined referential potential point. Between the junction of resistors 17 and 18 and the power voltage line (A.C. ground) are connected in series a capacitor 21 and a photoconductive element 22 whose resistance varies with the amount of light projected thereon, thereby constituting a variable A.C. impedance circuit.

The photoconductive element 22 is controlled, as later described, by pedal means operable by player's foot to have its resistance continuously varied. The resultant change in the A.C. input impedance of the transistor amplifier 16 enables it to act as a variable gain amplifier.

The feedback capacitor 19 renders the apparent input impedance of the amplifier 13 capacitive. The input capacitance C_{in} of the input impedance may be expressed by the following equation based on the well known Miller effect.

$$C_{in} = C(1 + A_1 A_2)$$

where:

C = actual capacitance of the feedback capacitor 19

A_1 = gain of the amplifier 13

A_2 = gain of the amplifier 16

Since the gain A_2 of the amplifier 16 is variable as previously described, the input capacitance C_{in} is also variable. Accordingly, the choke coil 20 with an inductance L connected to the input of the amplifier 13 and the input capacitance C_{in} of the amplifier 13 jointly constitute, as shown in FIG. 4, parallel resonance circuit having a resonance frequency f of $\frac{1}{2}\pi \sqrt{LC_{in}}$.

Since C_{in} is variable, the resonance frequency f is also variable. As can be easily understood, the foregoing arrangement may be deemed as equivalent to the connection of the resonance circuit having frequency selectivity between the input terminal 11 and output terminal 14 of the wow-wow circuit 9. The frequency band of tone signals transmitted from the input terminal 11 to the output terminal 14 of the wow-wow circuit 9 varies, as illustrated in FIG. 5, according to the resistance of the photoconductive element 22.

Referring to FIG. 5, the curve *a* represents the property of the wow-wow circuit 9 when the photoconductive element 22 had a resistance of 470 kilohms, and

the curves *b*, *c* and *d* denote those obtained with resistances of 47 kilohms, 4.7 kilohms and 470 ohms respectively.

As apparent from FIG. 5, the wow-wow circuit of FIG. 3 picks up only tone signals having a relatively narrow frequency band from among those having a relatively broad frequency band and conducts them to the output terminal 14 thereof. The frequency band of the former tone signals is continuously shifted over a relatively broad frequency range under the control of the variable gain amplifier 16, thereby providing the wow-wow effect.

In FIG. 3, the choke coil 20 and input capacitance C_{in} jointly constituted a resonance circuit by being disposed in parallel with each other. As shown in FIG. 6, however, they may form a low pass filter. To this end, the choke coil 20 is connected between the output of the amplifier 12 and the input of the amplifier 13. In this case, there is provided a low pass filter assuming an inverted L shape.

FIG. 7 shows the characteristics of the wow-wow circuit of FIG. 6. The curve *a* denotes the property of the wow-wow circuit when the photoconductive element 22 had a resistance of 470 kilohms and the curve *b* that obtained with the resistance of 470 ohms.

Control of the photoconductive element 22 can be conveniently effected by the horizontal operation of the expression pedal 8 which controls the volumes of sounds by its vertical movement as illustrated in FIG. 1. There will be later described the mechanism by which the expression pedal 8 is made to move in a horizontal plane.

In the foregoing embodiment, one of the two reactive impedance elements jointly constituting a resonance circuit was rendered variable. However, it is possible to make both reactive impedance elements variable so as to broaden the range of varying resonance frequency.

There will now be described the latter case by reference to FIG. 8. Input signals are supplied to the base of the transistor amplifier 12 through the input terminal 11. The emitter output of the transistor amplifier 12 is coupled to the base of the transistor amplifier 13. The collector output of the latter amplifier 13 is connected to the output terminal 14 through another transistor amplifier 30. The collector output of the transistor 13 is connected to the base of a first stage transistor 32, a component of a two-stage amplifier 31. The emitter output of the first stage transistor 32 is connected to the base of a second stage transistor 33. Between the emitter of transistor 33 and the base of transistor 13 is connected to the feedback capacitor 19. The emitter output of the first stage transistor 32 forming part of the aforesaid first two-stage amplifier 31 is connected to the base of a first stage transistor 36, a component of a second two-stage amplifier 35 through a transistor 34. The emitter output of the transistor 36 is connected to the base of a second stage transistor 37 forming part of the second two-stage amplifier 35. Between the emitter of transistor 37 and the base of transistor 13 is connected the feedback inductor 20. The collector output of the transistor 13 is coupled to the base of the first stage transistor 36 included in the second two-stage amplifier 35. Between the base of the first stage transistor 32 included in the first two-stage amplifier 31 and the power voltage line is connected a variable A.C. impedance circuit consisting of the capacitor 21 and photoconductive element 22. As in the preceding embodi-

ment, control of the intensity of light projected on the photoconductive element 22 converts the first two-stage amplifier 31 to a variable gain amplifier.

Referring to the second two-stage amplifier 35, the base of the transistor 36 is supplied with output from the collector of the transistor 13 and output from the collector of the transistor 34. The latter output is controlled in level by the variable gain amplifier 31 and has its phase inverted from the output of the transistor 13 by the transistor 34 itself. Accordingly, when the variable gain amplifier 31 has a large gain, input signals to the second two-stage amplifier 35 decrease in level, or vice versa. Namely, the second two-stage amplifier 35 is controlled by the gain of the variable gain amplifier 31 and acts as a second variable gain amplifier whose gain varies with the gain of the variable gain amplifier 31 in reverse relationship.

The capacitor 19 connected between the output of the first variable gain amplifier 31 and the input of the amplifier 13 provides apparent capacitive input impedance to the amplifier 13. The apparent capacitance C_{in} may be expressed by the following equation:

$$C_{in} = C(1+A_1A_2)$$

The inductor 20 connected between the output of the variable amplifier 35 and the input of the amplifier 13 provides apparent inductive input impedance to the amplifier 13. The apparent inductance L_{in} may be indicated by the following equation.

$$L_{in} = L/(1+A_1A_3)$$

where:

L = actual inductance of the inductor 20

A_3 = gain of the second two-stage variable gain amplifier 35 of the other; said

Since the gain A_1 of the amplifier 13 is fixed, the small gain A_2 of the amplifier 31 decreases C_{in} and the large gain A_3 of the amplifier 35 reduces L_{in} . The resonance frequency f obtained by C_{in} and L_{in} may be expressed by the following equation:

$$f = \frac{1}{2\pi} \sqrt{L_{in}C_{in}}$$

The gain A_2 of the first variable gain amplifier 31 and the gain A_3 of the second variable gain amplifier 35 vary in opposite directions, causing the capacitance C_{in} and the inductance L_{in} to change in the same direction. Thus the resonance frequency can be broadly varied in succession by continuously changing the resistance of the photoconductive element 22. FIG. 9 represents variation in the resonance frequency.

There will now be described by reference to FIG. 10 a wow-wow circuit according to still another embodiment of this invention. The collector output of the transistor 13 is connected to the inputs of the first and second two-stage amplifiers 31 and 35. Output of the first amplifier 31 is connected to the input of the transistor 13 through the feedback capacitor 19. Output of the second amplifier 35 is connected to the input of the transistor 13 through the feedback inductor 20. Between the inputs of the first and second amplifiers 31 and 35 is connected a potentiometer 40 provided with a slidable arm 41, which is connected to the power voltage line through a capacitor 42.

When, in FIG. 10, the slidable arm 41 lies at the uppermost part of the potentiometer 40, the A.C. input impedance of the first amplifier 31 is most reduced with the resultant smallest gain. At this time the second

amplifier 35 has the largest A.C. input impedance, that is, a maximum gain. Conversely, when the slidable arm 41 is brought to the lowermost part of the potentiometer 40, the first amplifier 31 has the largest gain and the second amplifier 35 the smallest gain. Obviously, therefore, control of the slidable arm 41 enables the gain of the first amplifier 31 and that of the second amplifier 35 to vary in opposite directions. Thus the wow-wow circuit of FIG. 10 acts in the same way as that of FIG. 8.

FIG. 11 represents the characteristics of the wow-wow circuit of FIG. 10. The curve a shows the characteristics of the circuit when the slidable arm 41 lies at the lowermost part of the variable resistor 40, and the curve b those which appear when the arm 41 stands at the uppermost part of the resistor 40.

There will now be described by reference to FIGS. 12 and 13 the expression pedal adapted for use with an electronic organ to obtain the wow-wow effect. To a stand 51 is fitted a first base plate 50 so as to rotate vertically by means of a horizontal shaft 52. The expression of an electronic organ is controlled by the vertical rotation of the base plate 50 resulting from the operation of player's foot. To simplify the drawing of FIG. 12, there are omitted the known mechanical and electrical means for controlling the expression by the aforesaid vertical movement of the base plate 50. Above the base plate 50 is disposed a second base plate 53 through a slidable spacer made of, for example, polyethylene. To the underside of the substantially central part of the second base plate 53 is fitted a vertical shaft 55 so as to penetrate the first base plate 50. Numeral 56 represents a bearing made of synthetic resin for the vertical shaft 55, 57 a rubber ring having a spring action, 58 a washer and 59 a nut. Thus the second base plate 53 can rotate about the vertical shaft 55 in a horizontal plane, namely, vertically as viewed from the surface of the drawing paper. The second base plate 53 may be covered with a rubber cover 60 and a rubber plate 61 provided with a plurality of grooves, so as to be rotated in a horizontal plane simply by the operation of player's foot.

On the underside of the forward end of the first base plate 50 are spatially disposed a light source section 62 and a light receiving section 63. The light receiving section 63 includes a photoconductive element 64 and a plate 65 positioned ahead thereof which is perforated with a slit 66 shown in FIG. 13. Further to the underside of the forward end of the second base plate 53 is fitted a plate 67 which is inserted between the light source section 62 and the light receiving section 63 and is bored with, for example, a triangular slit 68 illustrated in FIG. 13. It will be apparent, therefore, that the rotation of the second base plate 53 in a horizontal plane around the shaft 55 enables the light from the light source section 62 to be projected on the photoconductive element 64 through the triangular slit 68 of the plate 67 in varying intensity.

In the case of an electric guitar, the vertical rotation of the pedal can produce a wow-wow effect. In the case of an electronic organ, the wow-wow effect can be obtained by the operation of a knee lever, in place of the pedal means.

What is claimed is:

1. An electrical musical instrument comprising: means for generating tone signals having a relatively broad frequency band;

loud-speaker means for converting said tone signals to audible sounds;
 circuit means connected between said tone signal generating means and loud-speaker means to pick up only tone signals having a relatively narrow frequency band from among those having said relatively broad frequency band and transmit the former tone signals from said tone signal generating means to said loud-speaker means, said circuit means including a variable gain amplifier whose gain varies in accordance with the magnitude of an A. C. input impedance, and a reactive impedance element connected between the output and input of said amplifier to provide an apparent reactive impedance to said amplifier according to the magnitude of its gain;
 a foot operated pedal movable in a horizontal plane; means in the gain circuit of said amplifier and connected to said foot operated pedal for continuously controlling the gain of said amplifier in response to horizontal movement of said pedal thereby successively to shift the relatively narrow frequency band of tone signals transmitted from said tone generating means to said loud speaker means over said relatively broad frequency range of tone signals;
 said circuit means further including first amplifier means for amplifying tone signals; second amplifier means connected to the output of said first amplifier means; third amplifier means connected to the output of said first amplifier means; a variable A.C. impedance circuit connected to the inputs of said second and third amplifier means and controlled by said gain varying means to cause either of the second and third amplifier means to have a larger gain than the other; a first reactive impedance means connected between the output of said second amplifier means and the input of said first amplifier means to provide said first and second amplifier means with a first apparent reactive input impedance whose magnitude varies with the gain of said second amplifier means; and a second reactive impedance means connected between the output of said third amplifier means and the input of said first amplifier means to provide said first and third amplifier means with a second apparent reactive input impedance whose magnitude varies with the gain of said third amplifier means and constitute a resonance circuit with said first apparent reactive input impedance.

2. An electrical musical instrument according to claim 14 wherein said A.C. impedance circuit includes a potentiometer provided with a slidable arm and connected between the input terminals of said second and third amplifier means and a capacitor connected between said slidable arm and an A.C. grounded point.

3. An electrical musical instrument comprising:
 means for generating tone signals having a relatively broad frequency band;
 loud-speaker means for converting said tone signals to audible sounds;
 circuit means connected between said tone signal

generating means and loud-speaker means to pick up only tone signals having a relatively narrow frequency band from among those having said relatively broad frequency band and transmit the former tone signals from said tone signal generating means to said loud-speaker means, said circuit means including a variable gain amplifier whose gain varies in accordance with the magnitude of an A.C. input impedance, and a reactive impedance element connected between the output and input of said amplifier to provide an apparent reactive impedance to said amplifier according to the magnitude of its gain;
 a foot operated pedal movable in a horizontal plane; means in the gain circuit of said amplifier and connected to said foot operated pedal for continuously controlling the gain of said amplifier in response to horizontal movement of said pedal thereby successively to shift the relatively narrow frequency band of tone signals transmitted from said tone generating means to said loud-speaker means over said relatively broad frequency range of tone signals;
 said circuit means further including; first amplifier means for amplifying tone signals; second amplifier means connected to the output of said first amplifier means; a variable A.C. impedance circuit connected to the input of said second amplifier means to be controlled by said gain varying means so as to vary the gain of said second amplifier means; means for drawing out output from said second amplifier means whose phase is reversed from that of output of said first amplifier means; third amplifier means connected to the output of said first amplifier means and said means for drawing out output whose phase is reversed from that of output of said first amplifier means to have the gain of said third amplifier means itself varied apparently in reverse relationship from said second amplifier means; a first reactive impedance means connected between the output of said second amplifier means and the input of said first amplifier means to provide said first and second amplifier means with the first apparent reactive input impedance whose magnitude varies with the gain of said second amplifier means; and a second reactive impedance means connected between the output of said third amplifier means and the input of said first amplifier means so as to supply said first and third amplifier means with the second apparent reactive input impedance whose magnitude varies with the gain of said third amplifier means and constitute a resonance circuit jointly with the first reactive impedance.

4. An electrical musical instrument according to claim 3 wherein said A.C. impedance circuit includes a series connection of a capacitor and a variable resistor, said capacitor being connected between the input terminal of said second amplifier means and an A.C. ground point, and said variable resistor being a photoconductive element whose resistance varies with the intensity of light projected thereon.

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