United States Patent [19]

Niinomi

[11] **3,749,809**

[45] **July 31, 1973**

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

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[30] **Foreign Application Priority Data**

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Oct. 5, 1970 Japan 45/98536

[52] **U.S. Cl.** **84/1.24**, 84/1.11, 84/1.19
[51] **Int. Cl.** **G10h 1/02**
[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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Primary Examiner—Richard B. Wilkinson
Assistant Examiner—Stanley J. Witkowski
Attorney—Solon B. Kemon et al.

[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

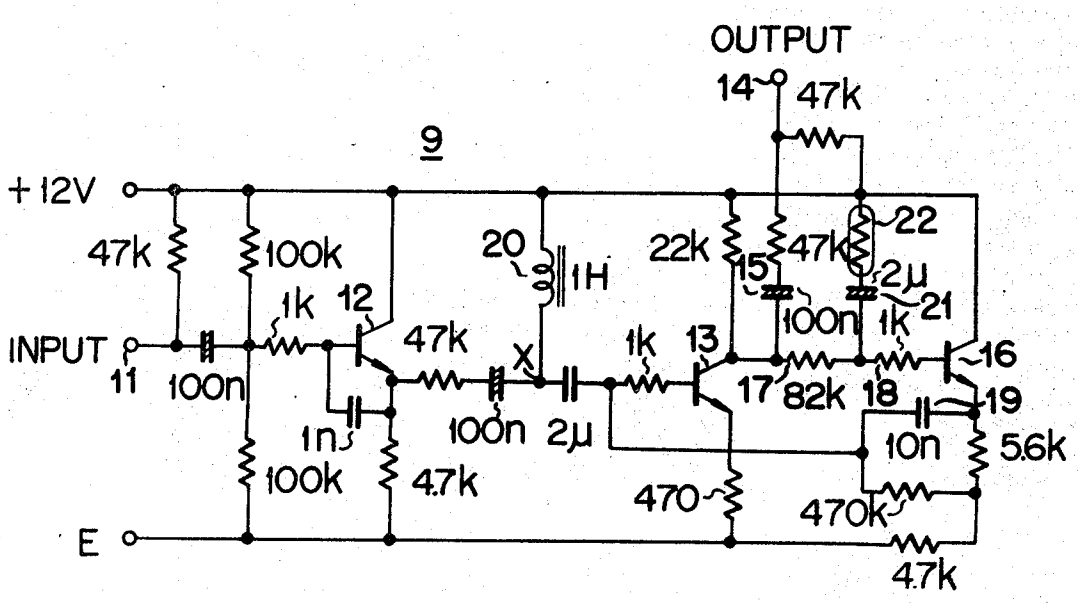


FIG. 1

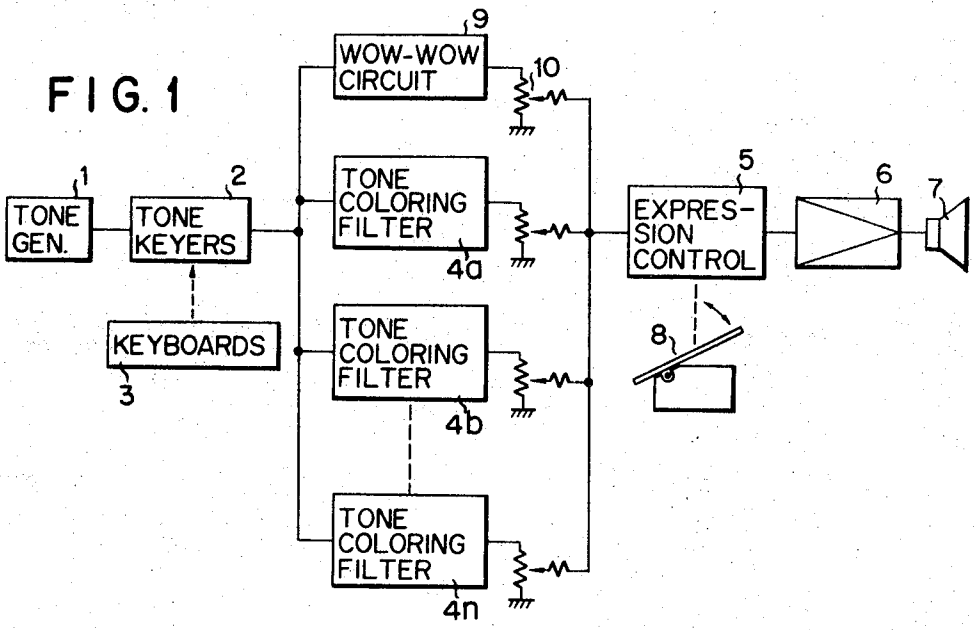


FIG. 2

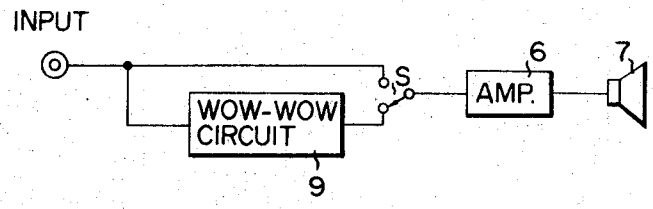


FIG. 3

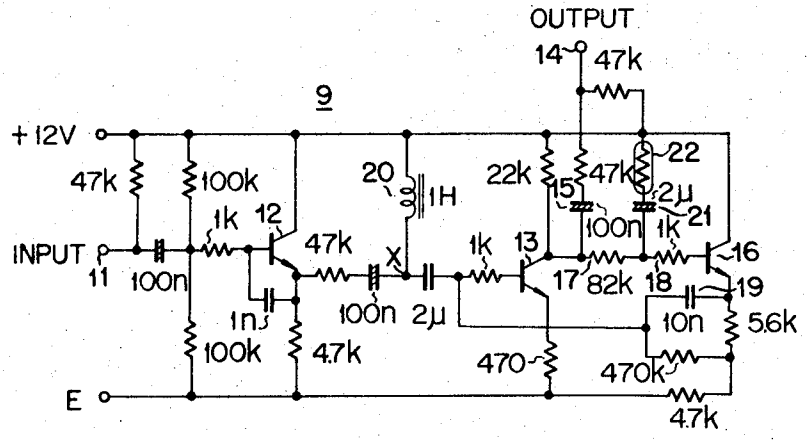


FIG. 4

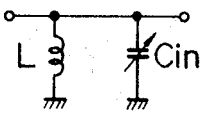


FIG. 5

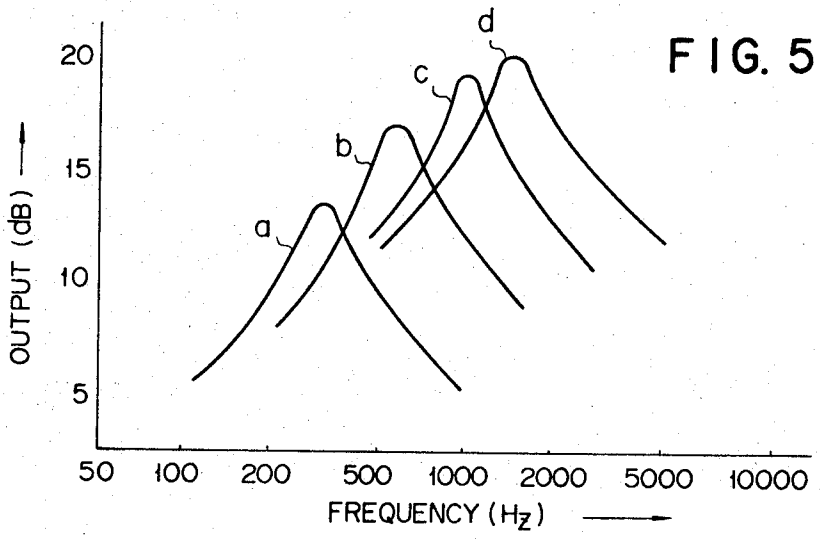


FIG. 6

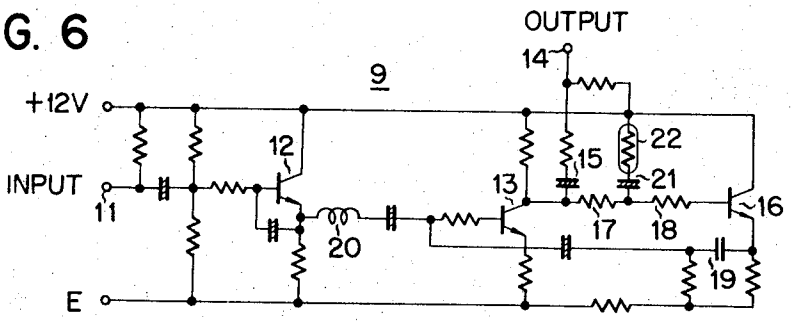
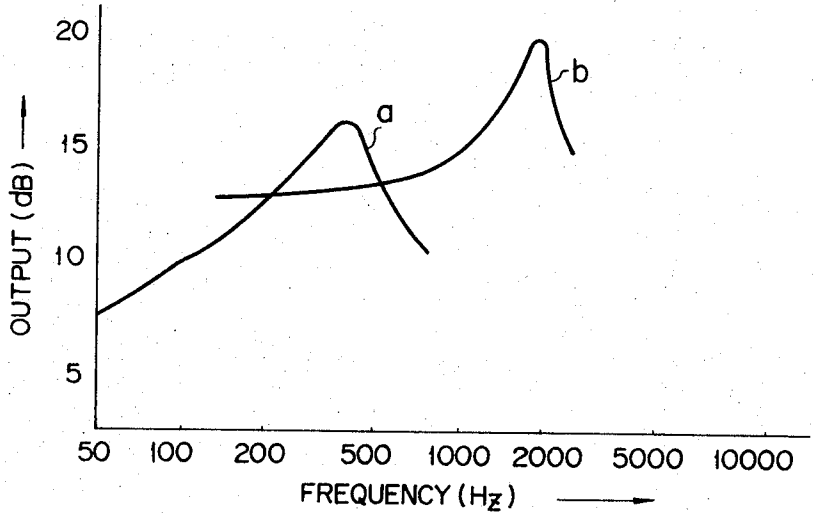


FIG. 7



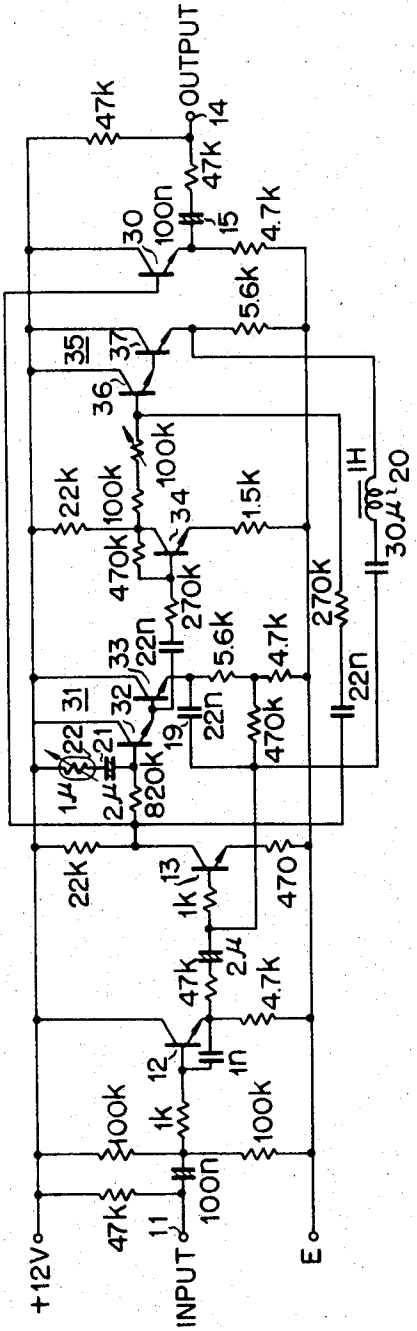

+12V
INPUT
11
47k
100n
100k
1k
12
1n
100k
47k
2μ
4.7k
1k
13
22k
470
820k
2μ
1μ
21
22
31
32
33
22n
19
22n
470k
5.6k
4.7k
22n
470k
270k
270k
1.5k
22k
100k
100k
34
36
35
37
5.6k
30
100n
15
4.7k
47k
47k
14
OUTPUT
9
1H
30μ
20

FIG. 8

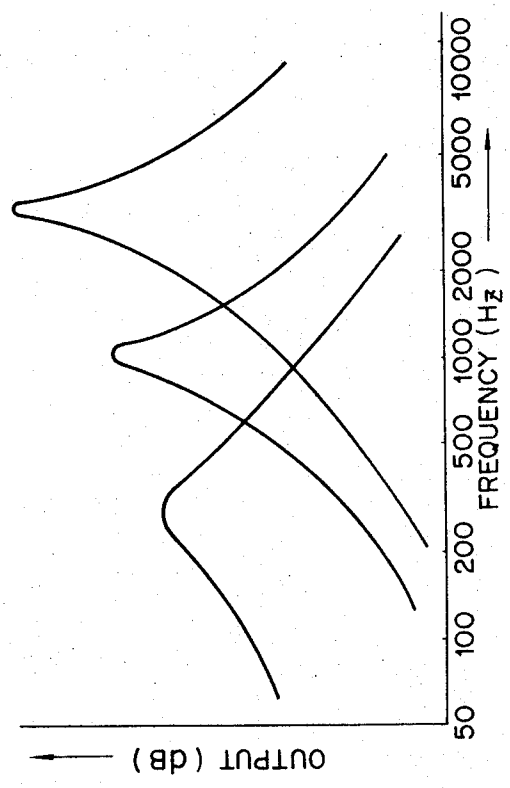

OUTPUT (dB)
50
100
200
500
1000
2000
5000
10000
FREQUENCY (Hz)

FIG. 9

FIG. 10

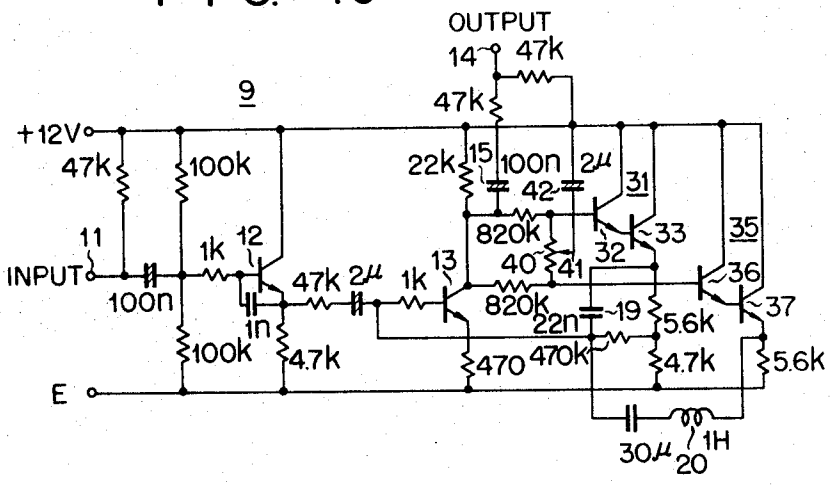

OUTPUT
14
47k
47k
9
+12V
47k
100k
22k
15
100n
2μ
42
31
820k
33
35
11
INPUT
1k
12
32
40
41
36
100n
47k
2μ
1k
13
820k
37
1n
22n
19
5.6k
100k
4.7k
470
470k
4.7k
5.6k
E
30μ
20
1H

FIG. 11

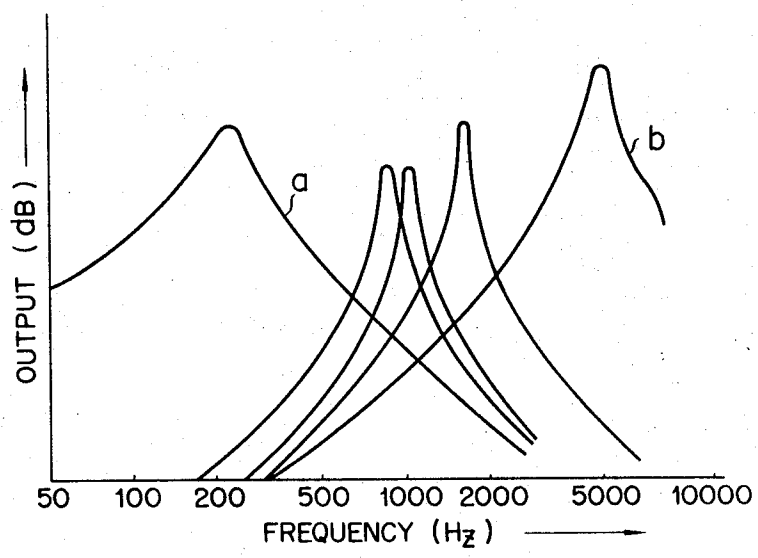

OUTPUT (dB)
a
b
50
100
200
500
1000
2000
5000
10000
FREQUENCY (Hz)

FIG. 13

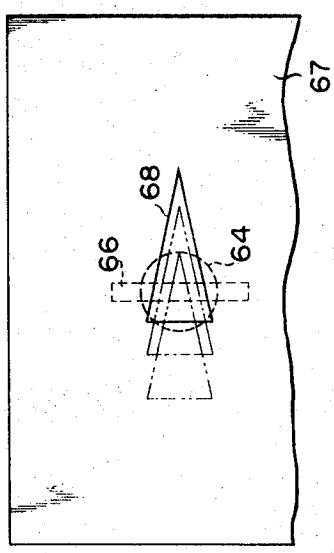


FIG. 12

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 PREFEERED 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 keyers **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 loudspeaker **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 keyrs **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 S directly or through the wow-wow circuit **9**. Output of the amplifier **6** is connected to the loudspeaker **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 conected 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 Cin of the input impedance may be expressed by the following equation based on the well known Miller effect.

$$Cin = C(1+A_1 \cdot A_2)$$

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

Since Cin 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 beween 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 kiloohms, and the curves *b*, *c* and *d* denote those obtained with resistances of 47 kiloohms, 4.7 kiloohms 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 Cin 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 kiloohms 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 Cin may be expressed by the following equation:

$$Cin = C(1+A_1 \cdot A_2)$$

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 Lin may be indicated by the following equation.

$$Lin = L/(1+A_1 \cdot A_3)$$

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 Cin and the large gain A_3 of the amplifier **35** reduces Lin. The resonance frequency f obtained by Cin and Lin may be expressed by the following equation:

$$f = \frac{1}{2\pi} \sqrt{Lin \cdot Cin}$$

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 Cin and the inductance Lin 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 amplifilers **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 f 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 theother; a first reactive impedance means connected between the output of said second amplifier means and the input of sai 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 insturment 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 orizontal 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 amplfier 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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