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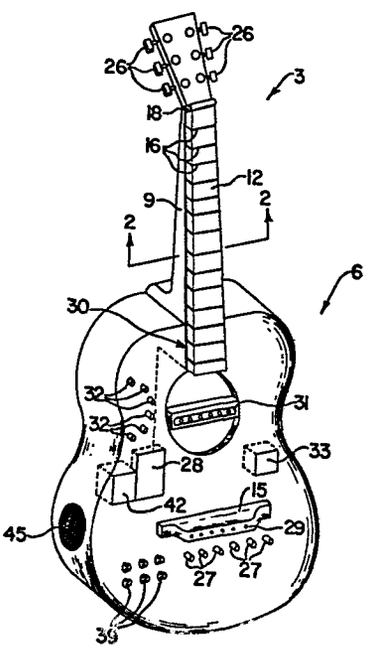
(54) Electronic stringed musical instrument.

(57) A electronic stringed instrument which uses electrical resistance wires as strings to control the frequency of electrically generated sounds. By shorting a string at selectable points along its length a variable voltage output is obtained and converted into a pre-determined frequency. A fretted instrument provides a means to incrementally control the voltage output and a non-fretted type instrument with a conducting fingerboard can provide a means to variable control the voltage output. A separate current source may be provided for each string to facilitate chord playing and a control for the intensity and harmonic content of the signals is provided. An internal power supply and speaker may also be employed to make the instrument readily portable.



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Electronic Stringed Musical Instrument

THIS INVENTION relates to electronic stringed musical instruments and more specifically, to the use of resistance wires as strings which control the frequency of electronically generated sounds in such instruments.

A variety of techniques are known for controlling the sound effects of electronic musical instruments. US-A-3,624,584 describes an arrangement in which the resistance in a Wien-bridge oscillator in an electrical circuit associated with a musical instrument is variable and US-A-3,626,350 discloses a means to produce a portamento chord by utilizing this principle.

US-A-3,948,137 discloses an arrangement which allows the player of an instrument utilizing a voltage controlled oscillator to control sound effects by providing wave form, filter and gain controls.

US-A-4,235,141 discloses an instrument wherein an apertured insulating strip is inserted between an electrically conducting strip and a resistive strip to allow only contact points at predetermined locations, thereby producing a tone at discrete selected values of frequency.

Electrically synthesized music is becoming an increasingly popular art form and substantial technological advances have been made in this field. In the past, however, most of these advances could only be utilized in a keyboard type instrument and have not been available for musicians skilled primarily in the playing of stringed instruments.

One attempt to provide a voltage controlled electronic stringed instrument is described in US-A-4,038,897. As described a guitar or other

fretted instrument may be used to produce input signals for a voltage-controlled tone generator. Alternatively, the guitar may be used in the conventional fashion, the instrument being switchable between these two forms. Each string-fret pair has an assigned musical tone. Voltages analogous to said tones are applied to the frets and such voltage is applied to the strings when the strings are moved to contact the frets.

Such a system has several major limitations. Firstly, the system is limited to fretted stringed instruments. Additionally, complicated wiring of resistors to each fret is required in order to provide each fret with the desired voltage value. Finally, providing the voltage to electrically conducting frets appears to foreclose the possibility of playing chords without fret segmentation.

There remains, therefore, a need for a stringed electronic instrument which provides for effective frequency control in either fretted or unfretted string instruments and a means for playing chords whether or not frets are desired.

According to one aspect of the invention, there is provided an electronic musical instrument comprising a body, a fingerboard attached to said body and having an electrically conducting upper surface, a plurality of spaced resistance wire strings disposed adjacent to said upper surface, means for electrically energizing said strings, means for attaching said strings to said instrument in relative spaced relationship with respect to said conductive upper surface of the fingerboard whereby displacing a string to contact said conductive surface at differing points along the string's length varies the resistance in an electrical circuit thereby providing a means to variably control the circuit's output voltage, and means for converting said output voltage into a predetermined frequency.

According to a further aspect of the invention there is provided an electronic musical instrument comprising a body, a fingerboard attached to said body having an electrically insulating upper surface and having a plurality of spaced conducting frets attached across said insulating surface at desired points along its length, a plurality of spaced resistance wire strings disposed adjacent to said upper surface, means for electrically

charging said strings, means for attaching said strings to said instrument in spaced relationship with respect to said frets whereby displacing a string selectively to contact differing frets along the string's length varies the resistance in an electrical circuit thereby providing a means to incrementally control the circuit's output voltage, and means for converting said output voltage into a predetermined frequency.

The desired frequencies may be produced by a voltage to frequency converter or any other suitable circuits. In use of the invention a variable voltage output that controls frequency is obtained by supplying a constant electrical current to a string and shorting the string at various points along its length to output a desired voltage. The output voltage depends upon the point along its length at which the string is shorted. The mode of shorting operation employed depends upon the type of stringed instrument. In a guitar or other fretted instrument the resistance strings can be shorted at any selected fret to provide a means to incrementally control the voltage output of the instrument. In a violin or other non-fretted instrument the surface of the fingerboard facing the strings can be made of an electrical conducting material so the resistance strings can be shorted at any point providing a means to variably control voltage output.

Desirably, each string is provided with a separate current source but all strings are referenced to the same grounding point. The frets or, in the case of a non-fretted instrument, the entire conducting surface of the neck are also grounded. The non-grounded end of each string is connected to a current source. The voltage drop produced when each string is grounded is detected so that the strings do not interfere with each other at the frets and consequently, chords can be played.

In the past, most voltage-controlled electronic instruments employed Wien-bridge oscillators or similar circuits which required relatively high resistance values for the control element. The present invention, however, utilizes a voltage-to-frequency converter circuit which can be controlled by relatively low resistance values as the voltage can be amplified before conversion, making possible the use of low resistance wires as the control elements. Furthermore, the high stability of the resistance, the constant current sources, and the precision of commercial voltage-to-frequency

converters will make this instrument of professional quality.

Preferably, means are provided for controlling the intensity and harmonic content of the signals produced. More specifically, suitable attenuators and filters that may be controlled by one of a player's hands while the other presses the strings to produce the desired frequency are provided. Wound resistance wire strings may be provided for low notes, and the invention provides such a string and a method for producing the same.

Conveniently, an internal power supply and speaker may be provided to make the instrument readily portable.

Desirably, a frequency counter is integrated into the instrument's electrical circuit to facilitate tuning.

It is further contemplated that combining the electrical and mechanical string-produced sounds may have potential for expanding the instrument's artistic possibilities.

In a further aspect, the invention provides a method to proportionally control the loudness of sounds generated by an electronic instrument relative to the intensity of vibration of a vibrating string, comprising the steps of: detecting the vibration of a string with an electro-magnetic pickup, amplifying and rectifying the output of said pickup to derive the intensity envelope voltage of said vibration, and utilizing said envelope voltage to control loudness by means of a voltage controlled amplifier.

In another aspect, the invention provides a method to proportionally control the loudness of sounds generated by an electronic instrument relative to the pressure applied to a pressure transducer, comprising the steps of: providing a plurality of pressure transducers, applying pressure to said transducers, and utilizing the voltage output of said transducers to control loudness by means of voltage controlled amplifiers.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, an embodiment of the invention will be described, by way of example, with reference to the

accompanying drawings, in which:

FIGURE 1 is a schematic view of one form of instrument of the invention including an electrically insulated fingerboard and conducting frets;

FIGURE 2 is a cross-sectional view of the fingerboard shown in Figure 1 taken through the line 2-2 of Figure 1;

FIGURE 3 is a schematic circuit diagram of a circuit to provide a suitable constant source for an instrument;

FIGURE 4 is a cross-sectional view of a portion of a wound resistance wire string; and

FIGURE 5 is a block diagram illustrating the various steps involved in converting changes in string resistance into frequency signals of desired quality characteristics.

As used herein, in the absence of a clear, express indication to the contrary, the terms "string" and "strings" refer to either straight or wound electrically conductive resistance wires and the terms "conducting" and "insulating" refer respectively to a material's capacity to conduct or to resist the conduction of an electrical current.

In summary, the present invention provides a stringed musical instrument capable of varying the input voltage to an electrical circuit which converts the voltage to a frequency to produce a responsive musical tone. The voltage (V) in the circuit is dependant upon two variables, current (I) and resistance (R) according to the relationship V=IR. It is preferred, but not required, to provide the instrument with a constant current source of power which results in a linear relationship between the voltage and resistance. The instrument's strings provide resistance elements in the circuit. By urging a string against a conducting surface at different points along the string's length the circuit's resistance and the resulting voltage change can be effectively controlled and varied.

Referring more specifically to Figures 1 and 2 (wherein, for clarity of illustration, the strings have not been shown), one embodiment of the present invention in the form of a guitar type fretted instrument 3 is shown. The instrument 3 has a body 6 having any convenient shape and preferably is made of a rigid, electrically insulating, material. One end of a neck 9 is secured to the body by conventional means. The neck 9 is also preferably an insulator but both the neck and body may be conductors if desired. A rigid insulating fingerboard 12 is attached to the neck 9. A hardboard or rigid plastics material would be a suitable material to construct the fingerboard 12. An insulating bridge 15 is also so secured to the body 6, as to provide a means to elevate the strings a slight distance above the fingerboard 12.

A plurality of conducting frets 16 are embedded across the fingerboard 12 at desired points along its length. The fret spacing may remain essentially the same as in regular guitars, and, as will be described further hereinafter, the current can be adjusted to correspond respective frets to the same notes as would be found in a conventional instrument. The frets 16 are preferably made from a hard conducting metal such as stainless steel. Embedded at the end of the fingerboard 12 farthest from the body 6 is a rigid conducting shorting bar 18 to support the strings a slight distance above the uppermost fret 16. The shorting bar 18 is electrically grounded.

The frets 16 are electrically connected to one another and to the electrically grounded shorting bar 18 by a conductive connecting wire 30, as shown in Figures 1 and 2. The frets 16 may be connected together and to the shorting bar 18 by any other suitable means, such as by a conducting strip mounted under the insulating fingerboard 12 which contacts each of said frets 16 and the shorting bar 18.

The strings (not shown) are attached to the instrument by conventional means and, as mentioned, are supported above the frets at one end by the insulating bridge 15 and at the other end by the shorting bar 18. The strings are tuned mechanically by adjusting their tension using appropriate tuning keys 26 in the usual fashion. Electronic tuning of each string is accomplished by turning a potentiometer knob 27 suitably wired into the circuit by conventional means. A frequency counter 33 may also be

integrated into the circuit to facilitate tuning.

A constant current power source and amplifier circuit 28 (also illustrated schematically in Figure 3) is connected to each string at or near the bridge 15 by any suitable means. It is preferable to make such connections at points 29 on the bridge 15 to avoid interference with the mechanical vibration of the strings. Points 29 may also serve as the input to an amplifier.

It is contemplated that an optional internal power supply 42 and speaker 45 could also be provided to make the instrument more portable.

Preferably, the resistance value of each string is maintained below 1000 ohms so that the changes in resistance due to finger contact do not play a perceptive role, unless such an effect is desired. Contacting a string to a chosen fret will complete an electrical circuit and create a desired voltage output which is then converted into a frequency signal by means well known in the art. Such voltage-to-frequency converters are now available as commercial intergrated circuits.

It will be appreciated by those skilled in the art that by eliminating the frets and replacing or covering the insulating fingerboard with a sheetlike conducting fingerboard, a violin type non-fretted instrument will function essentially as described above. With this embodiment continuous variability of pitch can be achieved.

Means may also be provided for controlling the harmonic content and intensity of the signals produced. First, the pitch or fundamental frequency is selected by means of a particular string. Harmonic frequencies are then selected by color control registers 39.

It is contemplated that the loudness can be effectively controlled in one of two ways. In one embodiment, the strings may be plucked or banged as in conventional instruments. In this case an electromagnetic pickup would be placed below each string as is done in conventional electric guitars. The output of the pickup 31 may then be amplified and rectified to derive the desired intensity envelope of the vibration, which is proportional

to loudness. This loudness envelope voltage would then be used to control the loudness of the electronic sound by means of voltage controlled amplifiers.

In an alternative embodiment suitable pressure transducers 32, which can respond properly and rapidly to finger pressure, could be manipulated by the player's free hand to control loudness. The pressure transducers 32 could be in the form of buttons, perhaps one to control each string or any combination of strings. The voltage from these transducers would be applied through a voltage-controlled amplifier to control loudness. The separate control of the duration and loudness of each note in a chord thereby made possible by the use of this method, allows for greater flexability and creative potential.

Figure 3 shows a schematic circuit diagram of a typical circuit to provide a suitable constant current source for this instrument and for first stage of amplification. A constant reference voltage $-V_Z$ is determined by means of a Zener diode 80 and a resistor 81. A resistor network R_3, R_2 and R_T apply a fraction of this voltage to the non-inverting input of an operational amplifier 82. The inverting input of the operational amplifier is connected to a resistor R_1 in which the voltage drop is proportional to the current I_S which flows through a controlling field-effect transistor 83 and a string 84 with an effective resistance R_S. The voltage drop over R_S is $I_S R_S$. The resultant voltage, $I_S R_3$, is fed to an operational amplifier 85, the gain of which may be adjusted by means of a variable control 86. The value of the constant current I_S can be adjusted by means of a tuning control 87 through the relationship $I_S = V_Z R_3 / R_1 (R_2+R_3+R_T)$.

Figure 4 represents a cross-sectional view of a string 79 wound with resistance wires that is suitable for producing low notes. The string 79 has a core of steel wire 75. A well insulated resistance wire 77 is tightly wound onto core wire 75. The whole string 79 has been dipped into a suitable resin (such as epoxy) to tightly fixate the insulation 78 in order to prevent electrical contact towards the core and between the turns of the resistance wire 77 that may result from abrasion due to internal flexing. The insulation 78 has been removed from an outer surface of the string, for example, by sanding, so that the string can make electrical contact with the frets 16.

Figure 5 is a block diagram showing the various steps involved in one suitable method of converting voltage signals into frequency signals of desired wave characteristics. As a string 39 is pressed to contact a fret 40 an electrical circuit is completed. The resistance of the portion of the string now included in the circuit will alter the voltage in the circuit according to V=IR. By pressing the string to contact other frets (not shown) different voltage outputs can be obtained. The voltage signal is then amplified by the operational amplifier circuit 45 as shown. As indicated in block 50 of Figure 5, the amplified voltage signal obtained by the above described method is then converted into a frequency signal. Depending on the type of voltage-to-frequency converter employed the output frequency signal may be a sine wave or some other wave form. This output frequency signal may then be inputted into a wave shape former shown in block 55. After a desired wave form is obtained, the basic frequency signal may be filtered to remove undesired "harmonics" in the circuit as is indicated by block 60. Block 65 shows a selectable mixer which can be used to combine the frequency signals to produce various coloration of the sound. The output of the mixer is then attenuated as desired by a suitable circuit to control loudness, as shown by block 70.

The features disclosed in the foregoing description, in the following claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

CLAIMS

1. An electronic musical instrument comprising a body, a fingerboard attached to said body and having an electrically conducting upper surface, a plurality of spaced resistance wire strings disposed adjacent to said upper surface, means for electrically energizing said strings, means for attaching said strings to said instrument in relative spaced relationship with respect to said conductive upper surface of the fingerboard whereby displacing a string to contact said conductive surface at differing points along the string's length varies the resistance in an electrical circuit thereby providing a means to variably control the circuit's output voltage, and means for converting said output voltage into a predetermined frequency.

2. An electronic musical instrument comprising a body, a fingerboard attached to said body having an electrically insulating upper surface and having a plurality of spaced conducting frets attached across said insulating surface at desired points along its length, a plurality of spaced resistance wire strings disposed adjacent to said upper surface, means for electrically charging said strings, means for attaching said strings to said instrument in spaced relationship with respect to said frets whereby displacing a string selectively to contact differing frets along the string's length varies the resistance in an electrical circuit thereby providing a means to incrementally control the circuit's output voltage, and means for converting said output voltage into a predetermined frequency.

3. An instrument according to claim 1 or claim 2, wherein each string is operatively associated with an independant electrical circuit.

4. An instrument according to claim 1, claim 2 or claim 3, wherein said musical instrument has means for electrically energizing said strings and a speaker both fixedly secured thereto.

5. An instrument according to any one of claims 1 to 4, wherein said electrically energizing means is arranged to provide a constant electrical current.

6. An instrument according to any one of claims 1 to 5, wherein each string has a resistance value less than 1,000 ohms.

7. An instrument according to any one of claims 1 to 6, wherein a frequency counter is intergrated into said electrical circuit.

8. An instrument according to any one of claims 1 to 7, including a means for controlling the intensity and harmonic content of the frequency signal produced.

9. An instrument according to claim 8, wherein said means for controlling intensity and harmonic content is attached to said body so as to allow control thereof by a player's free hand.

10. An instrument according to any one of claims 1 to 9, further comprising means for proportionally controlling the loudness of the electronically generated sounds relative to the intensity of vibration of a vibrating string, said means comprising an electro-magnetic pickup for detecting the vibration of a string; means for amplifying and rectifying the output of said pickup to derive the intensity envelope voltage of said vibration; and a voltage controlled amplifier for utilizing said envelope voltage to control loudness.

11. An instrument according to any one of claims 1 to 9, further comprising means for proportionally controlling the loudness of the electronically generated sounds relative to the pressure applied to a pressure transducer, said means comprising a plurality of pressure transducers, and at least one voltage controlled amplifier that responds to the output voltage of said transducers to control the loudness.

12. A method to proportionally control the loudness of sounds generated by an electronic instrument relative to the intensity of vibration of a vibrating string, comprising the steps of: detecting the vibration of a string with an electro-magnetic pickup, amplifying and rectifying the output of said pickup to derive the intensity envelope voltage of said vibration, and utilizing said envelope voltage to control loudness by means of a voltage controlled amplifier.

13. A method to proportionally control the loudness of sounds generated by an electronic instrument relative to the pressure applied to a pressure transducer, comprising the steps of: providing a plurality of pressure transducers, applying pressure to said transducers, and utilizing the voltage output of said transducers to control loudness by means of voltage controlled amplifiers.

14. A wound string for a voltage controlled stringed instrument which utilizes resistance wires as strings to control the frequency of electronically generated sounds, comprising a core, resistance wire insulated and generally tightly wound about and attached to said core, said insulation having been removed from an outer surface of said wound string.

15. A wound string according to claim 14, wherein said core is steel wire.

16. A method for producing a wound string for a voltage controlled stringed instrument which utilizes resistance wires as strings to control the frequency of electronically generated sounds, comprising the steps of tightly winding insulated resistance wire about a core, dipping said wound string into a suitable resin, and removing said insulation and resin from an outer surface of said wound string.

17. A method for producing a wound string according to claim 16, wherein said core is a steel wire.

18. A method for producing a wound string according to claim 16 or claim 17, wherein said resin is epoxy or polyurethane.

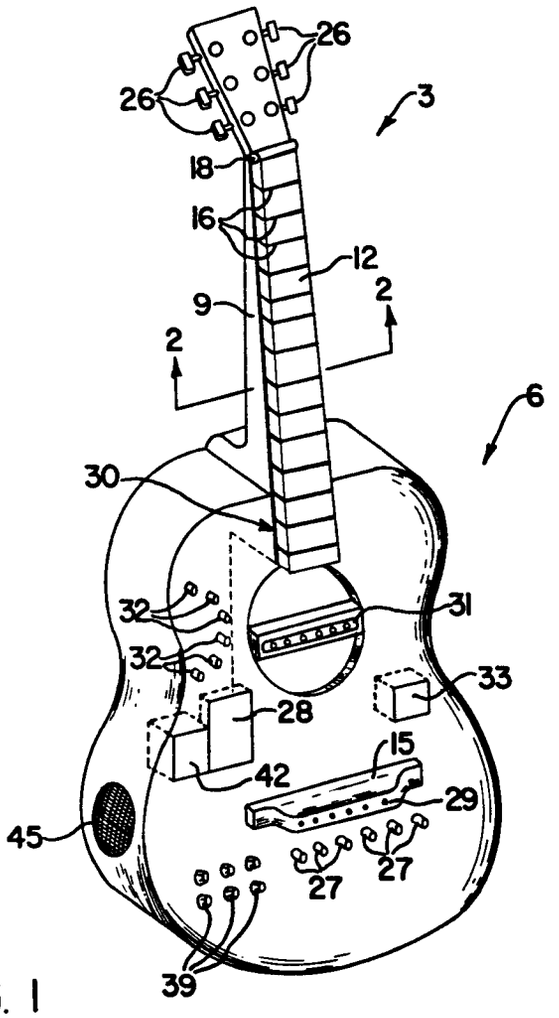


FIG. 1

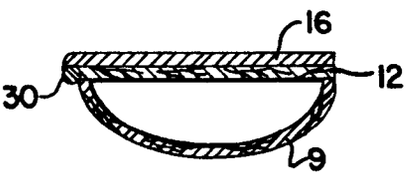
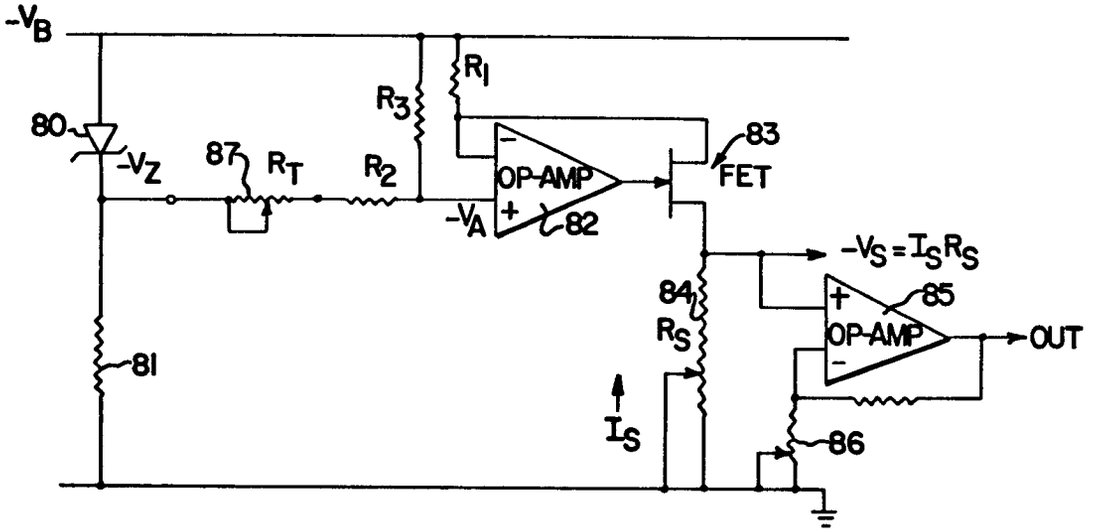


FIG. 2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R1
R3
80
-VZ
87
RT
R2
OP-AMP
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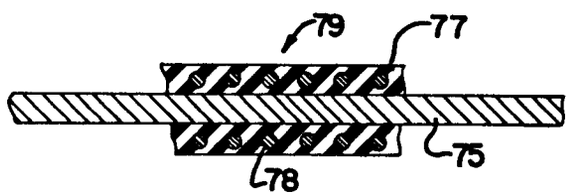
FET
-VA
82
-VS = IS RS
84
85
RS
OP-AMP
OUT
81
IS
86

FIG.3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77
75
78

FIG.4

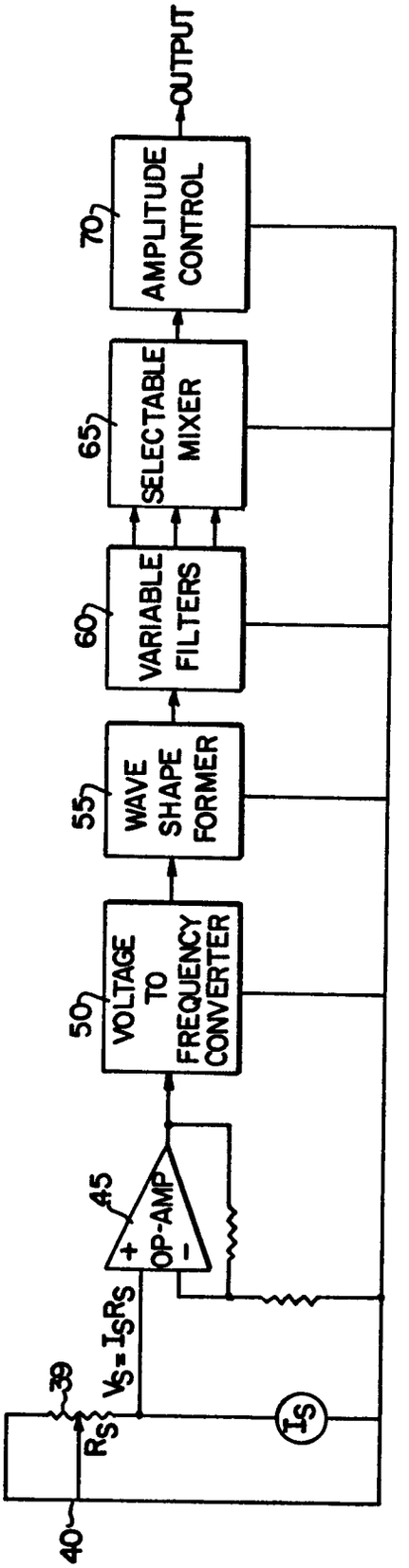
OUTPUT
70
AMPLITUDE CONTROL
65
SELECTABLE MIXER
60
VARIABLE FILTERS
55
WAVE SHAPE FORMER
50
VOLTAGE TO FREQUENCY CONVERTER
45
OP-AMP
+
−
39
$V_S = I_S R_S$
R_S
I_S
40

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

0145814
Application number

EP 83 30 6525

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X	US-A-4 306 480 (F. EVENTOFF) * Column 2, lines 65-68; column 3; column 4, lines 1-43; figure 1 *	1,3-5, 8,9	G 10 H 1/32 G 10 H 5/00 G 10 H 3/18
A	FR-A-2 039 534 (R. WOLTZ) * Page 4, lines 10-32; figures 2-4 *	1	
A	US-A-3 673 304 (A. DUDAS) * Column 1, lines 39-68; column 2, lines 1-10; figures 1-5 *	1,3	
A	US-A-3 742 114 (R.G. BARKAN) * Column 1, lines 9-42, 54-68 *	1,2,8-10	

TECHNICAL FIELDS SEARCHED (Int. Cl. ³)

G 10 H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-03-1985	PULLUARD R.J.P.A.

CATEGORY OF CITED DOCUMENTS

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