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[54] **ANIMATION CIRCUIT FOR A MUSICAL INSTRUMENT**

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[51] **Int. Cl.**.....**G10h 1/04,** G10h 1/06

[58] **Field of Search**.....84/1.11, 1.19, 1.2, 1.22, 1.23, 84/1.24, DIG. 2, 1.01, 1.12, 1.21, 1.13, 1.26; 331/37, 38, 40

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[57] **ABSTRACT**

A plurality of tone generators respectively provide a fundamental frequency and even harmonics of the fundamental frequency to a first signal translating circuit of a musical instrument. The musical 12th or third harmonic, of the fundamental frequency is fed to a second transistor circuit which is interconnected with and shares a common output with the first transistor circuit so that the harmonics of the fundamental frequency beat with the added 12th signal component to obtain an animated effect, which simulates a nominally in-tune pair of vibrating strings. Simultaneous energization of the transistor circuits is provided by a control circuit which is responsive to a direct current keying voltage to render the transistor circuits operative to provide a percussive output envelope, and responsive to an alternating keying voltage to render the transistor circuits operative to provide a sustained output envelope.

10 Claims, 2 Drawing Figures

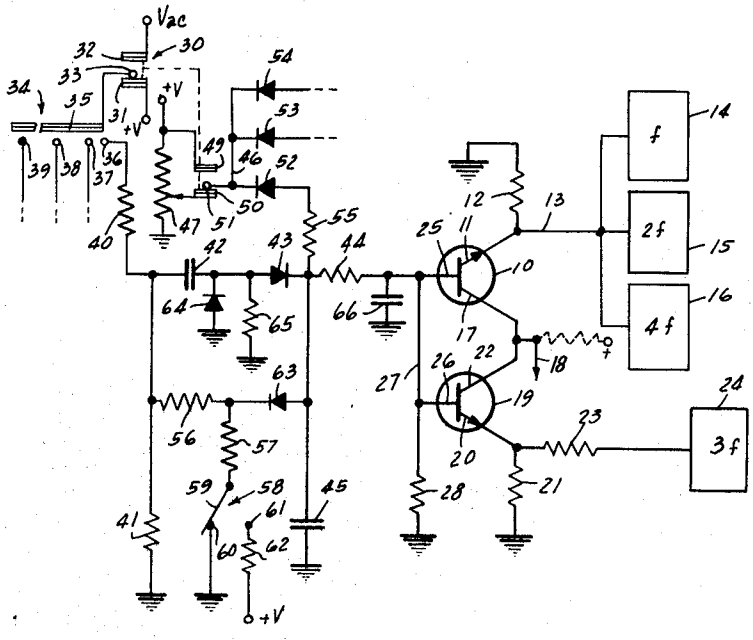


Fig. 2

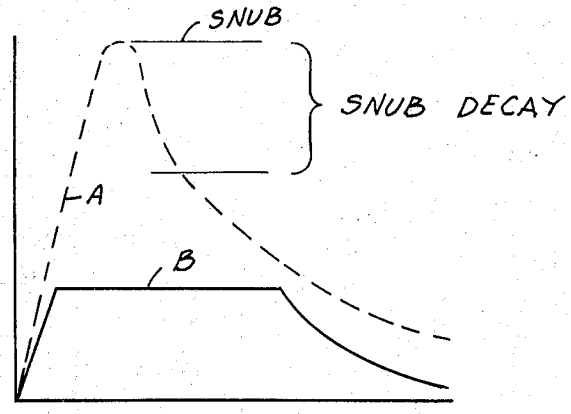
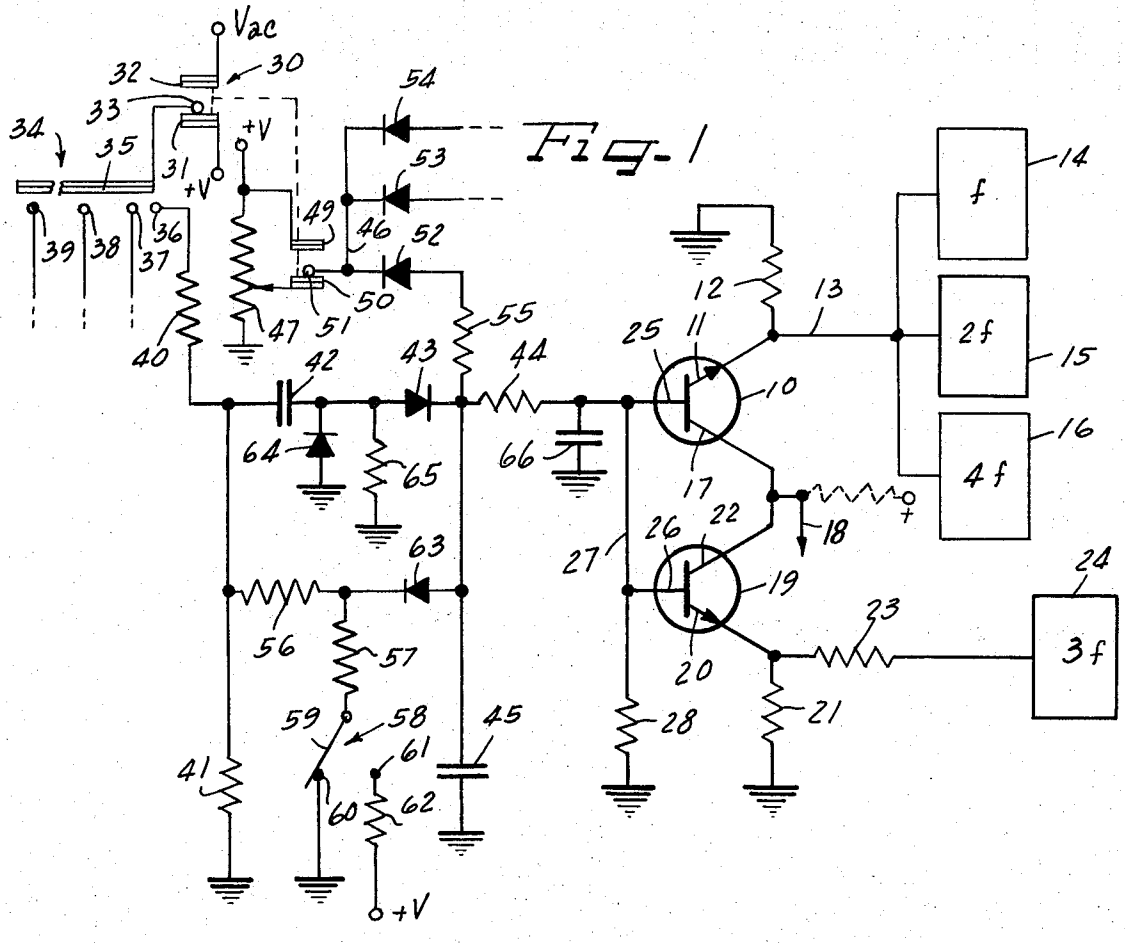


Fig. 1



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ANIMATION CIRCUIT FOR A MUSICAL INSTRUMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a circuit for reproducing tones in a musical instrument, and more particularly to a circuit for enriching a fundamental frequency by providing an animation of the fundamental frequency.

2. Description of the Prior Art

Heretofore, tone reproduction circuits for providing percussive output signals have generally included a circuit which is responsive to a direct current voltage to either open a gate for the output of an oscillator, or to energize an oscillator, for a certain interval of time. Such circuits are generally constructed and the components thereof dimensioned to provide either a percussive output envelope or a sustained level output envelope for the output of the oscillator; however, the content of these envelopes includes only the pure tone produced by the oscillator.

SUMMARY OF THE INVENTION

An animation circuit for a musical instrument employs a pair of transistor circuits for providing from standard pure electronically generated tones an output signal which includes a fundamental frequency and a plurality of changing harmonics thereof which effect an animation of the fundamental frequency. A first transistor circuit includes an input for receiving a first tone signal including the fundamental frequency and even harmonics of the fundamental frequency. The animation effect is provided by a second transistor circuit which is interconnected with the first transistor circuit and has an input terminal for receiving a second tone signal including the third harmonic of the fundamental frequency at a level of from 1:60 to 1:20 that of the first tone signal. The two transistor circuits share a common output whereat the harmonics of the fundamental frequency beat to provide a rolling or animated effect similar to that provided by two or three nominally in-tune piano strings which are struck by a piano hammer. The level range of 1:60 to 1:20 for the 12th with respect to the fundamental frequency defines the proportions wherein the animation is noticeable, but not so strong as to be undesirable, and the preferred ratio is 1:30 to provide animation that is felt and not necessarily heard.

A key switch of the musical instrument is selectively provided with either a direct current potential or an alternating current potential by a tab switch and circuit means are connected between the key switch and the transistor circuits for simultaneously enabling the transistor in response to either the direct current potential or the alternating current potential to provide an output envelope which is either percussive or non-percussive, respectively. The direct and alternating potentials are selectively applied to all key switches of the instrument so that the same key switch may utilize a single contact for playing the instrument in the percussive and non-percussive modes.

The frequency of the alternating current potential is in the range of from 1 -100 KHz, the preferred frequency being 40 KHz in that the frequencies above the audio range avoid modulation at the output, require small filtering elements, lie above the frequency response of the circuits so as to be ineffective if there is any leakage and provide a more linear attack slope or leading edge of the output envelope due to the better integration available at higher frequencies. Also, signals below 100 KHz do not present radiation problems.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic circuit diagram of an animation circuit for a musical instrument constructed in accordance with the principles of the present invention; and

FIG. **2** is a graphical illustration of a percussive envelope and a non-percussive envelope without attention to scale.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1** there is illustrated an animation circuit which includes a pair of transistor circuits. A first of these transistor circuits comprises a transistor **10** having an emitter **11** which is connected to ground by way of a resistor **12**. The emitter **11** serves as an input electrode for the first transistor circuit and is connected by way of a conductor **13** to a plurality of tone signal generating means **14**, **15** and **16**. A first generating means **14** provides a fundamental frequency *f*, a second generating means **15** provides the second harmonic **2***f* of the fundamental frequency and a third generator means **16** provides the fourth harmonic **4***f* of the fundamental frequency to the emitter electrode **11** of the transistor **10** by way of the conductor **13**. The transistor **10** also includes a collector electrode **17** which is connected to a suitable biasing potential by way of an output terminal **18**.

A second transistor circuit includes a transistor **19** having an emitter electrode **20** which serves as an input terminal for the second transistor circuit. The emitter electrode **20** of the transistor **19** is connected to ground by way of a resistor **21** and is connected to a fourth tone signal generating means **24** by way of a resistor **23**. The fourth tone signal generating means provides the musical twelfth of the fundamental frequency, that is the third harmonic of the fundamental frequency based on an equitempered scale or three times the fundamental frequency, i.e. **3***f*. The transistor **19** also includes a collector **22** which is in common with the collector **17** of the transistor **10** to the output terminal **18**.

The transistors **10**, **19** have respective base electrodes **25**, **26** which are connected together by a conductor **27** and connected to ground by way of a resistor **28**. The two transistors **10**, **19** are therefore normally conditioned non-conductive by virtue of the ground potentials appearing at their respective emitters and bases by way of the resistors **12**, **21** and **28**. The application of a positive potential at the respective bases **25**, **26** of the transistors **10**, **19** renders the transistors operative as transistor circuits and as amplifiers so that an output signal is provided at the output terminal **18**, which output signal includes the base frequency *f* and a constant changing of harmonics of the base frequency

due to the beat provided by the harmonics of the base frequency. The constantly changing harmonics provide a rolling or animated effect much like that obtained with a pair of nominally in-tune vibrating strings.

The transistor circuits are, as mentioned above, amplifier circuits. The signal amplification of these circuits is dependent upon the magnitude of the keying signal applied to the respective bases **25, 26**; therefore, the transistor circuits may be utilized in different modes of operation to provide different envelopes for the output signal including a percussive envelope and a non-percussive envelope. Inasmuch as the animation circuit finds advantageous application in musical instruments having manually operated key switches, such as electronic pianos and organs, it is desirable that the various operational modes of the transistor circuits be made independent of the playing keys of an instrument and that selection means be provided to selectively determine the operational mode of the transistor circuits and provide the musician the flexibility of choosing at will his desired mode of operation. In order to accomplish the foregoing, a selection switch **30**, such as a tab switch, is provided for selecting the type of keying signal which is to be provided to the translating circuits. The selection switch **30** includes a contact **31** which is connected to a direct current potential V, a contact **32** which is connected to an alternating current potential Vac, and a contact **33** which is connected in common to all of a plurality of key switches of the musical instrument. Here, the plurality of key switches is referenced **34** and is represented by an extended contact **35** for selectively contacting any of a plurality of other contacts **36–39**. As illustrated in the drawing, the selection switch **30** is positioned to provide the direct current potential V to the switch contact **35** by way of the contacts **31, 33** of the selection switch **30**. With the switches so connected, engagement of the contacts **35, 36** will render the transistor circuits operable to provide an output signal at the output terminal which includes the fundamental frequencies *f* animated by constantly changing harmonics thereof. The envelope of the output signal at the output terminal **18** will have the shape illustrated by the broken line A curve of FIG. **2**.

The selection switch **30** and the key switches **34** form part of an keying circuit for providing the desired keying signal to the signal transistor circuits. The enabling circuit includes first circuit means for providing a transient enabling signal in response to the application of the direct current potential V to the switch contact **36** upon engagement of that contact by the switch contact **35**. The first circuit means comprises a resistor **40** and a resistor **41** connected between the contact **36** and ground as a voltage divider. A capacitor **42** is connected by one of its terminals to the junction between the resistors **40, 41** and by another of its terminals to the anode of a diode **43**. The cathode of the diode **43** is connected by way of a resistor **44** to the bases **25, 26** of the transistors **10, 19**. The initial positive potential shift across the capacitor **42** is fed by way of the diode **43** and the resistor **44** to the bases **25, 26**. A second capacitor **45** is connected between the cathode of the diode **43** and ground. As the capacitor **42** begins to charge, the capacitor **45** also begins to charge over a path including the capacitor **42** and the diode **43**. The capacitor **42** charges rapidly and the rise in potential at the cathode of the diode **43** reverse biases the diode. This positive potential is also effective by way of a resistor **55** to forward bias a diode **52** connected to a snub bus **46**. The snub bus **46** also has other diodes **53, 54** connected thereto for utilization by other animation circuits. The snub bus **46** is connected to a contact **51** of the selection switch **30**, which is in turn connectable to the direct current potential V by way of a switch contact **49**, or to a portion of that potential by way of a switch contact **50** which is connected to a tap of a potentiometer **47**. The fast voltage rise at the cathode of the diode **43** and the conduction of the diode **52** is effective to provide a peak for the transient keying signal, which peak is effective to produce a corresponding peak of the envelope of the output signal as illustrated in the broken line curve A of FIG. **2**.

The capacitor **45** is partially discharged through the snub circuit until the potential applied to the anode of the diode **52** is below the potential of the cathode of that diode. Further discharge of the capacitor **45** is over a first path including the resistor **44** connected to the bases **25,26** of the transistors **10, 19** and the base-emitter circuits of these transistors. This provides the decaying trailing edge of the envelope of the output signal.

A second discharge path for the capacitor **45** is available by way of a diode **63** having its anode connected to the capacitor **45** and its cathode connected to ground by way of a resistor **57** and contacts **59** and **60** of a switch **58**. The switch **58** may be a pedal-operated sostenuto switch and include another contact **61** which is connected by way of a resistor **62** to a positive direct current potential. Operation of the switch **58** to engage the switch contact **59** with the switch contact **61** effects a reverse bias across the diode **63** to provide an extended decay of the charge on the capacitor **45**. In addition, the cathode of the diode **63** is connected to ground potential by way of a resistor **56** and the resistor **41** which is effectively in parallel with the resistor **57**. The trailing edge of the envelope of the output signal may therefore be controlled by controlling the rate of discharge of the capacitor **45** at levels below the snub decay of the keying signal.

A resistor **65** is connected between the junction of the capacitor **42** and the diode **43** and ground and provides an additional charging tap for the capacitor **42**. A diode **64** is connected in shunt with the resistor **65** and poled to maintain the right-hand terminal of the capacitor **42** above ground potential.

The keying circuit also comprises second circuit means for providing a substantially constant level enabling signal for the transistor circuits. The second circuit means includes a number of components of the first circuit means means described above, which components function in a different manner with respect to an alternating current energizing signal. To operate in a non-percussive mode, the musician will operate the selection switch **30** to the position opposite that illustrated in FIG. **1** wherein the contact **32** engages the contact **33** and supplies an alternating current voltage to the contact **35** of the key switches **34**. The alternating current voltage has a frequency in the range of from **1KHz-100KHz** and is preferably above the audio range to prevent detrimental effects in the musical instrument in case of leakage of the alternating signal. Further, a

high frequency signal is preferred to eliminate any possibility of modulation of the output signal. The alternating wave is also preferred to be non-sinusoidal and have an inward 50—50 power distribution for enhanced subsequent rectification and filtering.

The operation of a key switch to engage the contact **35, 36** presents the alternating wave across the voltage divider of the resistors **40, 41**. The positive half cycle of the alternating wave is passed by the capacitor **42** to the anode of the diode **43** and by way of the diode **43** to the junction of the cathode of the diode **43**, the capacitor **45**, the resistor **44** and the resistor **55**. The negative half cycle of the alternating wave is passed by way of the resistor **56** to the cathode of the diode **63** and then to the same junction as the positive half cycle of the alternating wave. At this junction, therefore, the alternating wave has undergone full wave rectification by the diodes **43, 63**.

The positioning of the selection switch **30** for the non-percussive mode causes the contact **50** to disengage from the contact **51** and the contact **49** to engage with the contact **51** to place the direct current supply potential V on the snub bus **46** and, hence, on the cathode of the diode **52**. The supply potential is relatively high with respect to the rectified alternating wave and is therefore effective to maintain the diode **52** in a reverse biased condition. The initial rapid decay of the percussive mode of operation is therefore eliminated in the non-percussive mode of operation.

The capacitor **45** functions to provide a filtering or smoothing integration of the rectified wave in cooperation with the high impedance now offered by the snubbing circuit and the smooth wave is applied by way of the resistor **44** as a substantially constant level keying signal to the respective bases **25, 26** of the transistors **10, 19**. A capacitor **66** is connected to the bases **25, 26** of the transistors **10, 19** and provides a low impedance path to ground for any high frequency components in the enabling signal.

Upon release of the key switch and disengagement of the contacts **35, 36**, the capacitor **45** discharges over the aforementioned discharge paths including the transistor circuits, the resistor **57** and the resistors **56** and **41**. The discharge interval is, however, shorter in the non-percussive mode of operation in that the capacitor **45** does not obtain as great a charge as it does in the percussive mode of operation. The keying signal presented to the signal translating circuits has a trailing edge determined by the discharge of the capacitor **45**, and the trailing edge is effective to provide a delay in the trailing portion of the envelope of the output signal as illustrated by the non-percussive envelope B of FIG. **2**.

Referring specifically to FIG. **2**, it is apparent that the signal components included within the percussive envelope A are constantly undergoing level changes as compared to the signal components included within the non-percussive envelope B in which the signal components are available for a substantial interval without any decay effect. Operation in the percussive mode therefore simulates the strike tone and damped vibratory oscillation of nominally in-tune strings and non-percussive operation causes an ensemble to be provided to a voice frequency to provide a chorus affect.

An animation circuit constructed as disclosed herein and as illustrated in FIG. **1** of the drawing employed a direct current potential of twenty volts, and alternating current voltage of 12 volts peak-to-peak at 40 KHz and NPN transistors in conjunction with the following tabulated values of circuit components.

Resistors (Ohms)		Capacitors (Mfd.)	
12	4.5K	42	0.27
21	35K	45	0.27
23	220K	66	0.01
28	See Note*		
40,62	1K		
41,55	100K		
47	10K		
56	50K		
57	1M		
65	500K		

*Note:This resistor is a factory tailored component selected for optimum operating conditions and generally in the range of from 2.2 to 6.8M.

While the invention has been disclosed with reference to a specific embodiment, many changes and modifications may become apparent to those skilled in the art without departing from the spirit and scope of the invention, and it is to be understood that I wish to include within the patent warranted hereon all such changes and modifications as may reasonably and properly be included within the scope of my contribution to the art.

What I claim is:

1. An animation circuit for a musical instrument, comprising:

a. first generating means for providing a first tone signal including a fundamental frequency and harmonics of the fundamental frequency;

b. second generating means for providing a second tone signal including the third harmonic of the fundamental frequency and at a fixed signal level ratio in the range of 1:60 to 1:20 with respect to the first tone signal;

c. a first transistor circuit having an output terminal and having an input terminal connected to said first generating means for receiving the first tone signal;

d. a second transistor circuit having an output terminal connected to the output terminal of said first transistor circuit to provide a common output terminal, and having an input terminal connected to said second generating means for receiving the second tone signal; and

e. a keying circuit connected to said first and second transistor circuits, said keying circuit being operable to cause simultaneous operation of said first and second transistor circuits whereupon the harmonics of the fundamental frequency beat at said common output terminal to produce an animated output signal including the fundamental frequency and changing harmonics of the fundamental frequency.

2. An animation circuit according to claim **1**, wherein each of said first and second transistor circuits each have a transistor which includes:

a. first electrode forming said input terminal for receiving the respective tone signal, and

b. a second electrode connected to the like electrode of the other transistor circuit to form said common output terminal.

3. An animation circuit according to claim 2, wherein each of said first and second transistor circuits comprises:

a. a third electrode included in said transistor connected to the like electrode of the other transistor; and

b. biasing means connected to each of said first and third electrodes for normally conditioning said first and second transistor circuits to a non-conductive condition.

4. An animation circuit according to claim 1, wherein said keying circuit comprises:

a. a further input terminal for receiving a non-sinusoidal alternating voltage; and

b. rectifier and filter means for integrating the alternating voltage to provide a keying signal of substantially constant level for controlling said first and second transistor circuits.

5. An animation circuit according to claim 4, wherein said rectifier and filter means comprises:

a. a filter capacitor connected to said first and second transistor circuits;

b. a first diode connected to said first capacitor and to said first and second transistor circuits and poled in a first direction; and

c. a second diode coupled between said further input terminal and said capacitor and poled in a second direction.

6. An animation circuit according to claim 5, wherein:

a. said keying circuit comprises a second capacitor connected to ground in shunt relation to said first capacitor and effective to shunt high frequency signals to ground.

7. An animation circuit according to claim 1, wherein said keying circuit includes:

a. first circuit means responsive to direct current potentials to provide a peaked keying signal for said first and second transistor circuits;

b. second circuit means responsive to alternating current potentials to provide a non-peaked keying signal for said first and second transistor circuits;

c. a first terminal for receiving a direct current potential;

d. a second terminal for receiving an alternating current potential;

e. normally open switch means connected to said first and second circuit means; and

f. selection means connected between said switch means and said first and second terminals for selecting the type of potential for operating said keying circuit.

8. An animation circuit according to claim 1, wherein said keying circuit comprises

a. a further terminal for receiving a non-sinusoidal alternating wave;

b. a rectifier circuit connected to said first and second transistor circuits; and

c. switch means operable to connect said further terminal to said rectifier circuit for controlling said first and second transistor circuits.

9. An animation circuit according to claim 1, wherein the animated output signal is proportional to the keying signal and wherein said keying circuit comprises:

a. a first terminal for receiving a dc-voltage;

b. a second terminal for receiving a non-sinusoidal alternating voltage;

c. circuit means operable in response to a dc-voltage to provide a peaked keying signal and responsive to an alternating voltage to provide a constant level keying signal; and

d. switch means operable to selectively connect said first and second terminals to said circuit means.

10. An animation circuit according to claim 9, wherein said switch means comprises:

a. selection switch means operable to selectively connect said first and second terminals to said circuit means; and

b. normally open switch means interposed between said selection switch means and said circuit means and operable to render the animation circuit operable in response to the selected direct or alternating voltage to provide a corresponding peaked or constant level energization of said first and second transistor circuits.

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