June 13, 1967 R. B. SCHRECONGOST 3,325,747

PLURAL FREQUENCY MUSICAL INSTRUMENT OSCILLATOR

Filed April 14, 1966

Fig. 1.

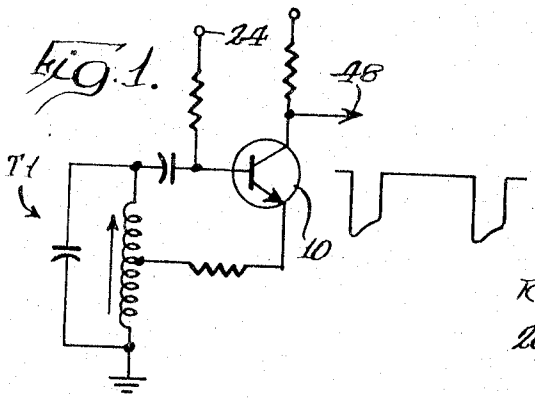


Fig. 6.

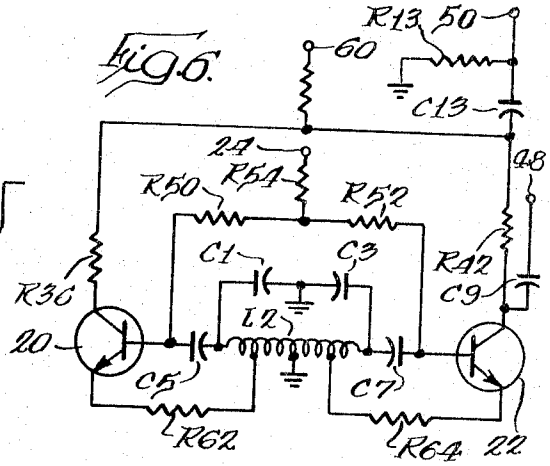


Fig. 2.

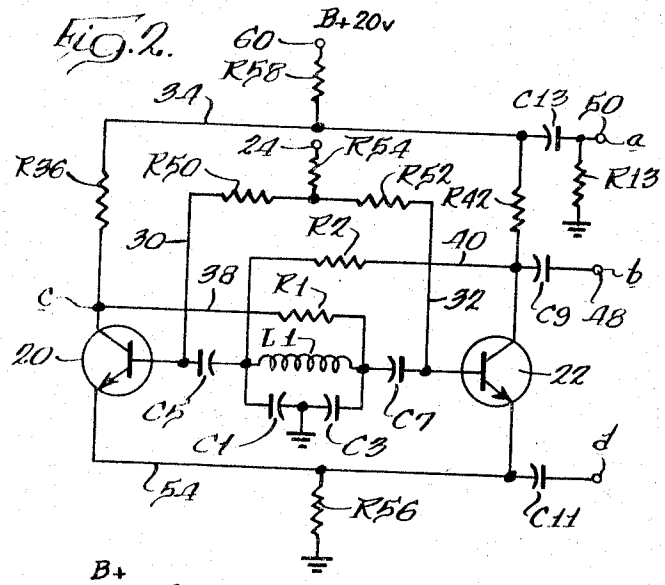
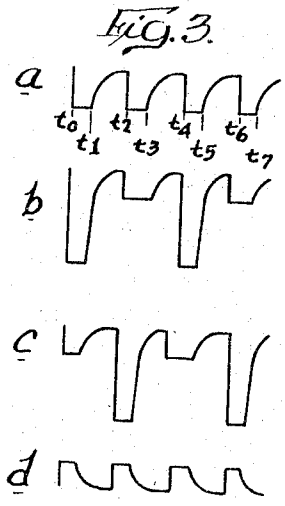


Fig. 3.



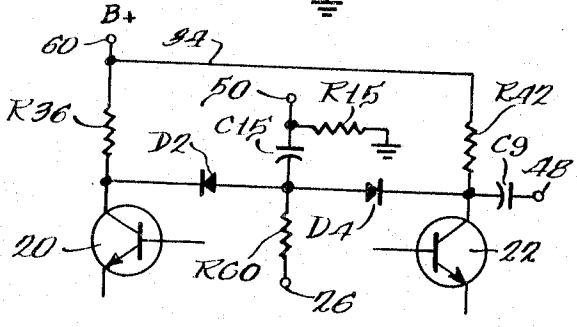
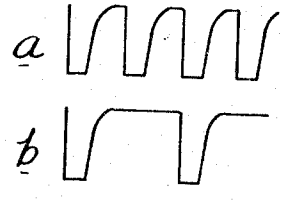


Fig. 4.

Fig. 5.



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3,325,747

PLURAL FREQUENCY MUSICAL INSTRUMENT OSCILLATOR

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Filed Apr. 14, 1966, Ser. No. 542,626
15 Claims. (Cl. 331—60)

The present invention relates to electrical musical instruments, electric organs for instance, primarily as concerned with the generation of musical tone signals.

In such instruments there must be present in some form a source for each tone frequency the instrument is called upon to play. In the past many schemes have been devised for accomplishing this including the use of individual electronic oscillators, one for each note, rotating tone wheels, photoelectric scanning systems and so on.

In general, this invention is directed to an oscillator acting as a tone generator that can deliver more than one frequency of useful tones. Specifically, by combining the outputs of a pair of interconnected amplifiers which share a parallel resonant circuit for double frequency output and the output from one amplifier for single frequency, applicant provides a dual frequency output oscillator.

Among many objects of the invention are the following:

To provide a novel oscillator which is adapted to provide two frequencies simultaneously, one twice the other;

To provide a novel oscillator having low cost and a minimum number of components;

To provide a novel oscillator having a tank circuit in the input which can be frequency controlled over a small musical range by altering a bias supplied to the input;

To provide a novel oscillator adapted to produce two output frequencies an octave apart with each output frequency having a full range of harmonics; and

To provide a novel oscillator having a dual frequency output which is frequency modulated by an input signal to achieve a vibrato effect for each output frequency.

Other objects and advantages will become apparent from the following description of a preferred embodiment of the invention which is illustrated in the accompanying drawings. In the drawings in which similar characters of reference refer to similar elements throughout the several views:

FIG. 1 is a schematic diagram showing an example of the prior art;

FIG. 2 is a schematic diagram illustrating one embodiment of the invention;

FIGS. 3*a*, *b*. *c*, and *d* are wave form diagrams of the voltages at points of FIG. 2;

FIG. 4 is a modification of the invention shown in FIG. 2;

FIGS. 5*a* and 5*b* are wave form diagrams showing the output voltages of FIG. 4; and

FIG. 6 is a further modification of the invention shown in FIG. 2.

In FIG. 1 is seen a frequency source of the prior art. It is an essentially conventional emitter feedback Hartley circuit. There is a single frequency output at **48**.

A parallel resonant circuit **T1** is connected at one end to the input of a transistor **10** and the emitter feeds a signal back to an intermediate point on the inductor of the tank circuit. Terminal **24** provides a forward bias and low frequency vibrato potential.

Referring to FIG. 2 which illustrates a basic embodiment of applicant's invention, it consists as shown of a pair of NPN transistors **20** and **22** connected as follows. The forward bias and low frequency vibrato signal is supplied to a terminal **24** which is connected through re-

sistances **R54**, **R50** and **R52** and leads **30** and **32**, respectively, to bases of transistors **20** and **22**, respectively. The collector of transistor **20** is connected by lead **38**, resistor **R1**, capacitor **C7** to the base of transistor **22**. Similarly, the collector of transistor **22** is connected by lead **40**, resistor **R2**, capacitor **C5** to the base of transistor **20**.

Between the junction of **R1** and **C7** and **R2** and **C5** is a tank circuit composed of inductance **L1** and tuning capacitors **C1** and **C3**. The junction of the capacitors **C1** and **C3** is grounded.

The emitters are connected together by lead **54** and grounded through resistor **R56**. The collector of transistor **20** is connected by resistor **R36**, lead **34**, and resistor **R58** to a positive supply voltage terminal **60**. The collector of transistor **22** is similarly connected through resistor **R42** to lead **34** and resistor **R58** to the positive supply terminal **60**.

An input to the oscillator is provided through terminal **24** supplying a vibrato and bias signal through resistor **R54** and resistors **R50** and **R52** to the base of transistors **20** and **22** respectively. An output signal is provided from the collector of transistor **22** through capacitor **C9** to terminal **48**. This output signal is at the LC tank frequency. A second output frequency, double the first output frequency, is taken from lead **34** which is at the junction of resistors **R36** and **R42** in the collector circuits of the transistors **20** and **22**, respectively, through capacitor **C13** and grounded resistor **R13** at terminal **50**.

FIG. 2 illustrates the simplest version of the two frequency oscillator. It uses a common untapped coil **L1** and a common emitter restor **R56**. The tank circuit formed of inductor **L1** and capacitors **C1**, **C3** is shared by the transistors. The transistor bases require some resistive isolation **R50**, **R52** relative to each other, but the common resistor **R54** is much larger and keeps substantially the same voltages supplied to the transistor bases. The collector resistors **R36** and **R42** are brought together into a common resistor **R58** to receive pulses from each transistor as each contributes current in its half cycle.

In sustaining oscillation, when the tank voltage becomes positive, for example to the base of transistor **20**, its collector supplies feedback energy to the tank by means of the resistance **R1** until limiting occurs. The feedback signals are so phased that the respective collector signals reinforce the tank voltage excursions. Relatively high loading on the tank by the feedback resistors is tolerable because of the fact that a low Q tank enhances the effect of a seven cycle vibrato voltage injected on the base bias at terminal **24**.

The operation of the circuit of FIG. 2 will now be discussed with respect to FIG. 3 which discloses wave forms at various points in the circuit of FIG. 2. FIG. 3*a* shows the voltage wave form at the double frequency output **50**, and FIG. 3*b* shows the voltage wave form at the single frequency output point **48**. FIG. 3*c* discloses the voltage wave form at the collector of transistor **20**. This voltage is fed back through resistor **R1** and capacitor **C7** to the base of transistor **22**. FIG. 3*d* discloses a double frequency voltage at a lower signal level for the voltage through capacitor **C11** at point *d* which is connected to the emitters by line **54**.

To avoid some subharmonics it is necessary to balance the complementary resistors and capacitors in the circuit. At the frequency of operation **F1** of 350 to 700 cycles in the present design the second frequency range **F2** is 700 to 1400 cycles. In this range subharmonics are easily heard and the collector outputs should be balanced to keep the subharmonics to less than 1.5%.

Because the transistors alternately saturate and cut off, they are of no particular concern in matching. Neither the

bias R50, R52 or feed back R1, R2 resistors nor the tuning capacitors C1 or C3 are significant contributors to subharmonic content. The collector resistors R36 and R42 contribute alternate signals to R58 and should be matched to each other to within 1%. The capacitor C13 can be of considerable help here if carefully chosen to offer a higher impedance to the subharmonic frequency than to the higher frequency 2F.

Representative component specifications used for the circuit of FIG. 2 are as follows:

C1	mfd..	.047
C3	mfd..	.047
C5	mfd..	.047
C7	mfd..	.047
C9	mfd..	.01
C11	mfd..	.01
C13	mfd..	.0047
L1	h..	10
F1	c.p.s..	350–700
Transistors		2N2926
R1	ohms..	47K
R2	ohms..	47K
R36	ohms..	10K
R42	ohms..	10K
R50	ohms..	47K
R52	ohms..	47K
R54	ohms..	220K
R56	ohms..	150
R58	ohms..	4700K

As noted above with respect to FIG. 3*b*, this wave form contains an additional small pulse between *t*2 and *t*3 which contributes to the even harmonics of the lower frequency wave form somewhat, but matches favorably with other full harmonic wave forms used in organ design.

Loading of the organ circuit at this point **48** must be kept low so as not to unduly unbalance the double frequency signal and induce subharmonics. The output is high, however, and large isolation resistance can be used. The embodiment of FIG. 4 eliminates the necessity for careful balancing as the transistor collector signal is fed independently to the double frequency output terminal **50**, and because the transistor saturation is very predictable, balance is assured. The extra small pulse at the output from terminal **48** is also avoided.

FIG. 4 is thus a modification of the inventive circuit of FIG. 2. It differs from the circuit of FIG. 2 in having a pair of diodes D2, D4 connected to the transistor collectors. These diodes are connected to a DC bias terminal **26** through resistor R60 so as to pass a positive voltage to the collector of transistors **20** and **22**. The double frequency output is taken from the junction of these diodes through capacitor C15 and grounded resistor R15 to terminal **50**. The single frequency output is taken as in FIG. 2 through the collector of transistor **22** and capacitor C9 at terminal **48** which is isolated from terminal **50**. Resistors R36 and R42 are in the collector circuits of transistors **20** and **22** as in FIG. 2. However, the positive voltage supply from terminal **60** is connected directly to line **34**.

FIG. 5*a* illustrates the double frequency output from terminal **50**, and FIG. 5*b* shows the single frequency output from terminal **48**. It should be noted that there is no extra pulse in the output from terminal **48** as in the circuit of FIG. 2 as seen in FIG. 3*b t*2–*t*3.

The novelty of this circuit may be seen in the unique method of connecting two transistors to one tank using a resistor feedback from opposite collectors and using either an untapped inductor or tapped inductor. The simplicity in the use of an untapped inductor is preferable from cost considerations. The use of the diodes in combining the alternate collector pulses into a double frequency signal is noteworthy. However, the double frequency signal may also be taken across the common emitter resistor R56. This circuit can deliver a balanced sine wave across the tank because of the alternate half cycle driving function. Also, this circuit can be frequency controlled, for example for vibrato, over a small musical range by altering the bias **24** supplied to the bases.

In FIG. 6 is disclosed an alternative tapped coil embodiment of the dual output oscillator of this invention. This circuit is essentially two oscillators using a single tapped tank circuit. FIG. 6 differs from the embodiment of FIG. 2 in having a tapped inductor L2 in a parallel resonant circuit. Resistors R62 and R64 connect the transistor emitters to points along the tapped coil.

The operation of this embodiment is similar to FIG. 2. A symmetrical sine wave is obtained across the tank as in the embodiment of FIG. 4.

Various modifications may be made in the invention without departing from the spirit and scope thereof and it is desired therefore that only such limitations shall be placed thereon as are imposed by the prior art and are set forth in the appended claims.

I claim:

1. A dual output musical instrument oscillator comprising a first and second amplifier each amplifier having an input and output circuit interconnected, the improvement comprising a tank circuit connected between the input of each amplifier, a bias signal input connected to each of said amplifier inputs, an impedance connected to each of said amplifier output circuits said impedances connected together and to a DC supply at their other terminal whereby a first output signal is obtained from the ouput of the first amplifier and a second output signal is obtained from the junction of said impedances whose frequency is twice the first output signal frequency.

2. In a dual output musical instrument oscillator, the combination recited in claim **1** wherein the first and second output signals have a full range of harmonics.

3. In a dual output musical instrument oscillator, the combination recited in claim **2** wherein said oscillator is a sine wave oscillator.

4. In a dual output musical instrument oscillator, the combination recited in claim **2** wherein said bias signal includes a vibrato signal to frequency modulate the output signals for vibrato effect.

5. In a musical instrument oscillator comprising a first and second transistor each having an input and output interconnected, the improvement comprising a tank circuit connected between the inputs of each transistor, a bias signal input connected to said transistor inputs, a pair of diodes reversely poled in a direction to pass unidirectional current to the output circuits of each of the transistors whereby a first output signal is obtained from said first transistor and a second output signal is obtained from the junction of the diodes whose frequency is twice the first output signal frequency.

6. An oscillator comprising a first and second transistor each transistor having an input and output interconnected, the improvement comprising a tank circuit connected between the input of each transistor, a bias signal input connected to the transistor inputs, an impedance in each of the transistor output circuits connected together and to a DC supply whereby a first output signal is obtained from the output of said first transistor and a second output signal is obtained from the junction of said impedances whose frequency is twice the first output signal frequency.

7. In a dual output musical instrument oscillator, the combination recited in claim **6** wherein the first and second output signals have a full range of harmonics.

8. In an oscillator the combination recited in claim **7** wherein said bias signal includes a low cycle AC to cause a vibrato in each output signal.

9. A musical instrument oscillator comprising a first and second transistor each transistor having an input and ouput interconnected, the improvement comprising a tank circuit connected between the bases of each transistor, an impedance in each of the transistor collector circuits said impedances connected in series, a DC supply connected to

said impedances at their junction whereby a first all harmonic output signal is obtained from the collector of said first transistor and a second all harmonic output signal is obtained from the junction of said collector transistor impedances whose frequency is twice the first output signal frequency.

10. In a musical instrument oscillator, the combination recited in claim **9** wherein said tank circuit comprises an untapped inductor.

11. In a musical instrument oscillator, the combination recited in claim **9** wherein a bias means is provided for each of said transistor inputs and a low cycle AC signal supplied to said bias means to frequency-shift each output signal.

12. An oscillator comprising a first and second transistor each having an input and output interconnected, the improvement comprising a tank circuit including the parallel connection of an inductor and a pair of capacitors in series connected to the input of each transistor, a bias signal input connected to said transistor inputs, a pair of diodes said diodes being reversely poled in the direction of the output circuit of each of the transistors and adapted to pass unidirectional current to the output circuit of each transistor whereby a first output signal is obtained from said first transistor and a second output signal whose frequency is twice the first output signal frequency is obtained from the junction of said diodes.

13. A dual output musical instrument oscillator comprising a first and second amplifier each amplifier having an input and output circuit interconnected, the improvement comprising a tank circuit connected between the input of each amplifier, an impedance connected to each of said amplifier output circuits said impedances connected together and to a DC supply at their other terminal whereby a first output signal is obtained from the output of the first amplifier and a second output signal is obtained from the junction of said impedances whose frequency is octavely related to the first output signal frequency.

14. In a musical instrument oscillator, the combination recited in claim **13** having signal means connected to each of said amplifier inputs to vary the frequency of the first and second output signals.

15. In a musical instrument oscillator, the combination recited in claim **14** wherein said signal means supplies a cyclic voltage.

No references cited.

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