Sept. 29, 1959 H. BODE 2,906,960

ELECTRICAL MUSICAL INSTRUMENT WITH FREQUENCY DIVIDER CIRCUIT

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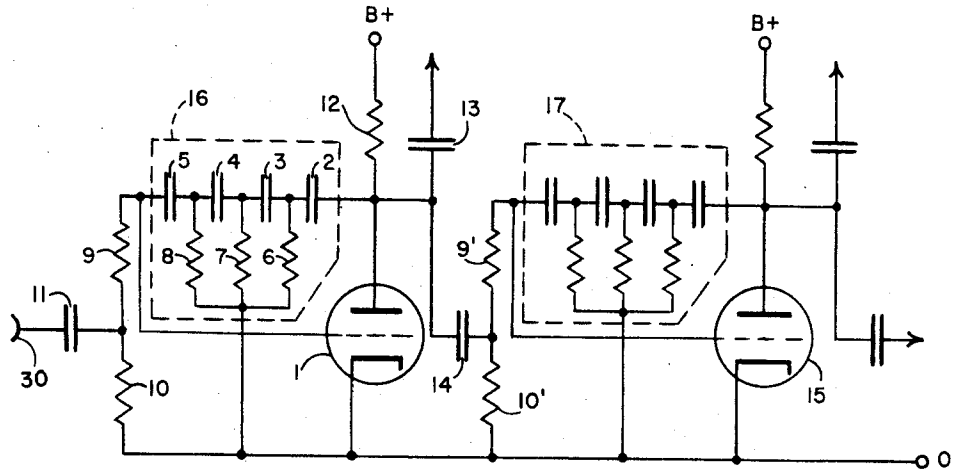


FIG. 1

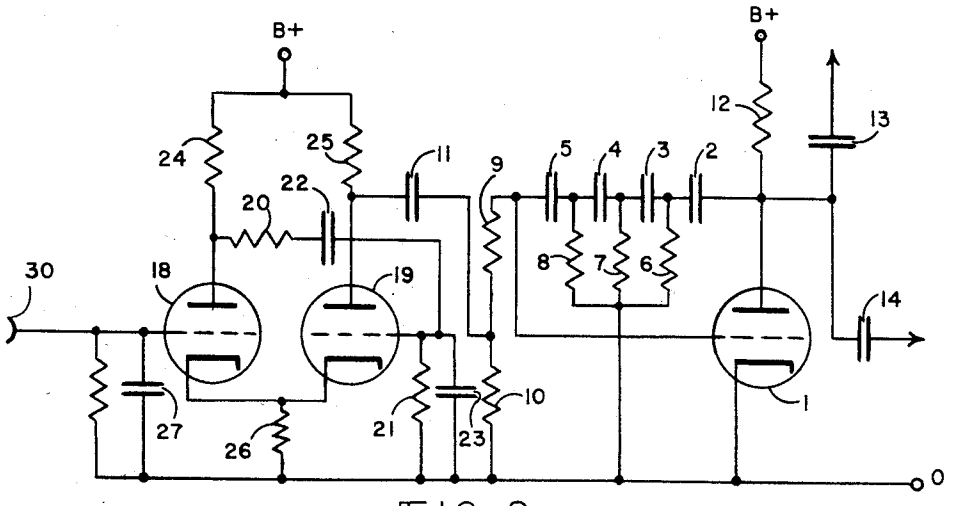


FIG. 2

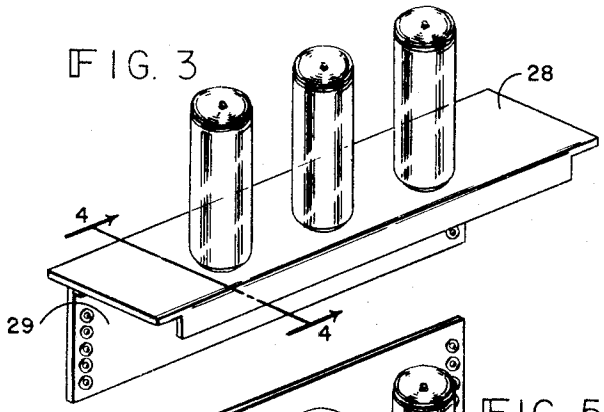
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FIG. 3



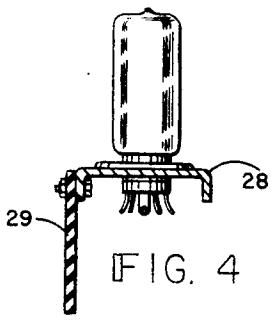
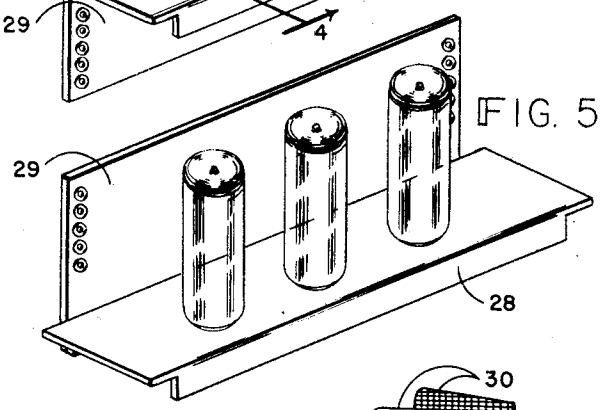


FIG. 4

FIG. 5



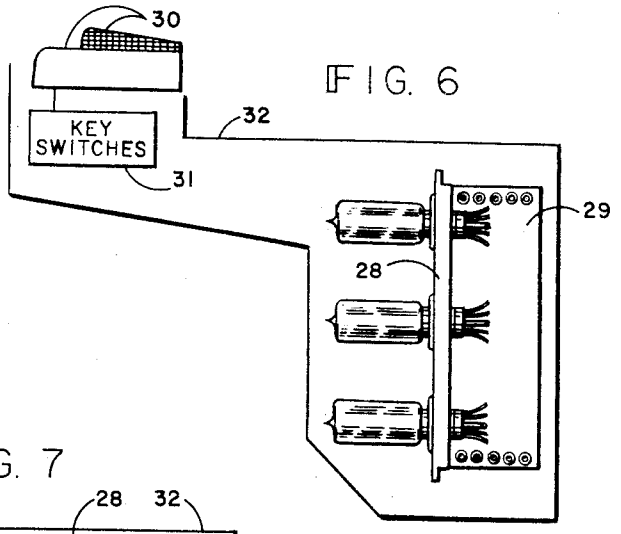


FIG. 6

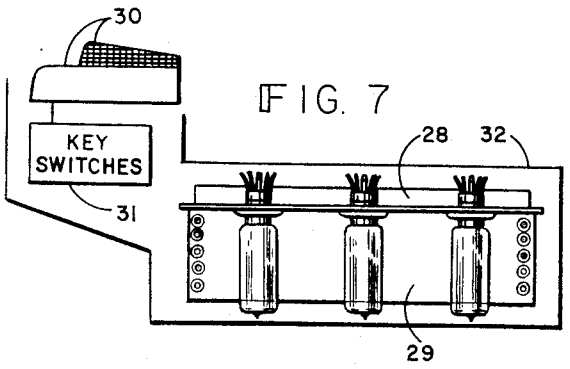


FIG. 7

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ELECTRICAL MUSICAL INSTRUMENT WITH FREQUENCY DIVIDER CIRCUIT

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Claims priority, application Germany September 5, 1953

1 Claim. (Cl. 331—51)

This invention relates to electronic musical instruments and more particularly it relates to a frequency divider adapted to generate tones in an electronic musical instrument.

It is an object of the present invention to provide a type of frequency divider which lends itself to use in an electronic organ of relatively small, light, handy and compact construction.

It is a further object of the invention to provide a miniature organ or similar musical instrument which may be housed in a portable carrying case containing in addition to the electronic circuitry necessary to produce the musical tones, the amplifier and speaker associated with the organ.

In order to provide an electronic musical instrument of the above-mentioned character, one of the most important considerations is the type of electronic tone generators to be employed owing to the fact such a larger number of these generators are necessary. Naturally, besides the requirement that the generators occupy a minimum of space and do not require an excess of power, it is also most important that they have relatively high frequency stability. To these ends, tone generators in the form of frequency dividers, synchronized in the first instance by a master oscillator, have proven effective, particularly those frequency divider circuits which employ only resistors and capacitors by virtue of the saving in space and weight which they afford. One example of such a frequency divider circuit which has been used in the past is the so-called reactance tube circuit, which is tuned by means of fixed capacitors. However, a basic failing of the reactance tube circuit in a frequency divider application is the inability of the lower divider stages to oscillate reliably. In fact, they are likely to cut off completely as the characteristics of the electronic tubes employed therein and the associated components change with age making them ill-suited for use in a musical instrument.

According to the invention, therefore, there is provided a frequency divider which embodies a phase shift oscillator having a feed-back network or phase shifting network of the ladder type with a capactive element in each series arm and a resistive element in each shunt arm. In order to couple the network to the input or control circuit of the oscillator there is provided in the last shunt arm, a voltage dividing arrangement so that the signals representing tones, generated by the frequency divider, will not be reflected in the output preceding frequency divider stage or in the master oscillator stage coupled thereto for synchronization purposes.

The novel feature of the invention, together with further objects and advantages thereof, will become more readily apparent when considered in connection with the accompanying drawings in which:

Fig. 1 is a schematic diagram of a chain of two frequency divider stages according to the invention;

Fig. 2 is a schematic diagram of a single frequency divider stage in combination with a master oscillator stage in accordance with the invention;

Fig. 3 is a perspective view illustrating a preferred mounting arrangement for a master oscillator and frequency divider chain according to the invention;

Fig. 4 is a sectional view taken on line 4, 4 of Fig. 3;

Fig. 5 is perspective view showing a modification of the mounting arrangement of Fig. 4;

Fig. 6 is a side view in elevation of a portable organ case adapted to house a plurality of the sub-assemblies of Fig. 3; and

Fig. 7 is a view in elevation of a modification of the assembly according to Fig. 5.

Referring now to the drawings, and more particularly to Fig. 1, it will be observed that a chain of two frequency divider stages according to the invention have been illustrated schematically, the first one in the chain being adapted to synchronize the second, and the first one itself being synchronized by either another frequency divider stage or a master oscillator stage (not shown), having its output circuit coupled between an input terminal **30** and ground as represented by terminal O. The first frequency divider stage in the diagram of Fig. 1 includes a triode electron discharge device **1** having an anode circuit or output circuit coupled between a source of anode potential, as represented by terminal B+, and ground; and having a control circuit or input circuit which is coupled to the output circuit in order to induce oscillation. To this end, there is provided a feedback or phase shifting network coupled to the output circuit, or more particularly coupled between the anode end of an anode resistor **12** and ground, and having a substantially 180° phase shifting characteristic at the desired operating frequency of this stage. As shown in Fig. 1, network **16** is of the ladder type and includes capacitors **2**, **3**, **4**, and **5**, respectively, in each series arm, and resistors **6**, **7** and **8**, respectively, in each shunt arm. The last shunt arm is formed with a pair of resistors **9** and **10** which serve as a voltage dividing arrangement so that only a portion of the signal voltage transmitted by the network will be impressed on the master generator. That is to say, the control electrode or grid of triode **1** is connected to the junction of resistor **9** and capacitor **5** and the cathode of the triode as well as the end of resistor **10** remote from this junction are connected to ground. To synchronize the frequency divider stage, terminal **30** is connected to the junction of resistors **9** and **10** through a capacitor **11**.

With reference to the second frequency divider stage of Fig. 1, it will be observed that the same employs a triode electron discharge device **15** in an arrangement like that of triode **1** of the first frequency divider stage. The phase shifting network in the case of the second frequency divider stage has been designated generally by the number **17** and to synchronize the second frequency divider stage at a subharmonic ordinarily the first subharmonic of the tone signals generated by the first stage, there is provided a coupling capacitor **14** connected between the anode of triode **1** and the junction of resistors **9'** and **10'** which function in the same manner as do resistors **9** and **10** discussed hereinabove.

As will be apparent to those skilled in the art, the number of arms employed in each of the phase shifting networks **16** and **17** is not necessarily limited to 4 just so long as the output tone signals developed in the anode circuits of each triode **1** and **15** are transmitted to the respective control circuits thereof with a phase shift of substantially 180° at the desired frequency of operation. As is well known, under such circumstances, the condition for oscillation will be satisfied, and owing to the synchronizing signals applied to the respective control circuits of the triodes, the frequency of the oscillations will be locked in at a different subharmonic, in each case, of the master oscillator frequency. It is preferred that

four or more series and shunt arms be employed in the phase shift network, however, since the tolerances of the resistors and capacitors which form the arms need not be so exacting. It is also desirable, in this regard, to consolidate the various resistors and capacitors which make up each phase shifting network in a single housing having external connectors arranged as a tube socket for example.

As will also be apparent to those skilled in the art, the particular type of master oscillator to be utilized in combination with a chain of frequency dividers according to the invention is more or less optional. For example, one type of oscillator which is commonly used is a Hartley oscillator because of the small inductor which it employs relative to its frequency of operation, namely the frequency of one of the tones in the highest octave. Another example of a master oscillator which is particularly well adapted for use with one or more frequency dividers according to the invention is shown in Fig. 2.

Referring now to Fig. 2, those skilled in the art will recognize that triodes 18 and 19 and their associated circuitry comprise a Wien bridge oscillator. Since the oscillator is well known, and forms no part of the present invention, it will not be described in detail. One method of producing vibrato in such an oscillator is to apply to its control circuit, that is to the control circuit of triode 18, an alternating voltage whose frequency corresponds to the rhythm of the particular vibrato desired. This will produce in the output signal of the oscillator a small amount of frequency modulation which in turn will be reflected in the output signals from the respective frequency divider stages. In a complete instrument, ordinarily 12 master oscillators are necessary to generate the 12 semitones of the highest octave and hence the control circuits of the various triodes which function as does triode 18 may be interconnected so that only a single vibrato power supply need be employed. In this event capacitor 27, which is connected across the control circuit of triode 18 in Fig. 2, prevents cross talk between the respective master oscillators.

It is proposed, as shown in Figs. 3 and 4 that the various electron discharge devices, or tubes, employed in the frequency dividers according to the invention be mounted on a U-shaped channel member 28 of metal, and that a panel 29 of insulating material be fastened to one of the shanks of the U as shown. Soldering lugs in the form of eyelets are then fastened to the panel 29 for providing input and output connections to the frequency divider and oscillator circuitry, although it will be understood that various other forms of connectors are equally suitable. Fig. 5 illustrates a mounting arrangement like that of Figs. 3 and 4 except that panel 29 extends above member 28 rather than below it.

In a complete musical instrument wherein 12 master oscillators and 12 frequency divider chains are employed, it is proposed that each of the units or sub-assemblies as shown in Fig. 3 be arranged in a Z-shaped housing or case as shown in Fig. 6. Fig. 7 illustrates a similar arrangement of the sub-assemblies of Fig. 5.

Various other modifications within the spirit and scope of the invention, particularly as regards the frequency divider itself, will occur to those skilled in the art so that the invention should be deemed to be limited only by the scope of the appended claim. What is claimed is:

In combination with a master tone generator for an electronic musical instrument, at least one frequency divider to provide subharmonically related tones, said frequency divider comprising an electron discharge device having a control circuit and an anode circuit and, a ladder type feedback network connected between said control circuit and said anode circuit, said feedback network having a capacitive element in each series arm and a resistive element in each shunt arm, and the last of said shunt arms being formed with a pair of series connected resistive elements, one of which is connected to said master generator to cause said frequency divider to oscillate in synchronism with said master generator without disturbing appreciably the tones generated by the latter.

References Cited in the file of this patent

UNITED STATES PATENTS

2,300,632	Poch	Nov. 3, 1942
2,342,286	Koch	Feb. 22, 1944
2,474,261	Leibe et al.	June 28, 1949
2,555,039	Bissonette	May 29, 1951
2,668,282	Montgomery	Feb. 2, 1954

OTHER REFERENCES

Article: "Frequency Division with Phase-Shift Oscillators" by Schmidt, pp. 111–113 of Electronics for June 1950.