

Sept. 1, 1942.

A. L. NELSON

2,294,797

OSCILLATOR

Filed Sept. 26, 1940

2 Sheets-Sheet 1

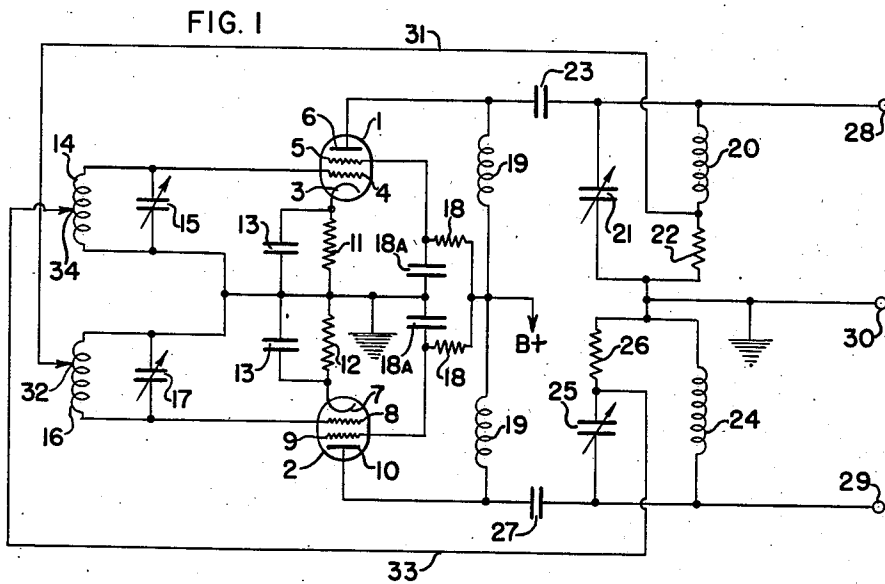
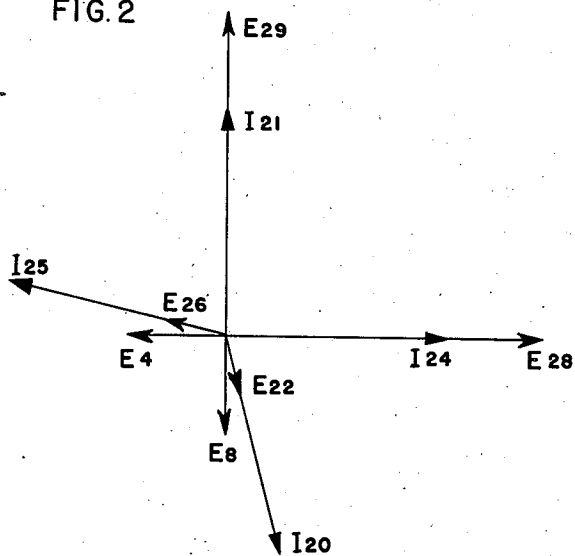


FIG. 2



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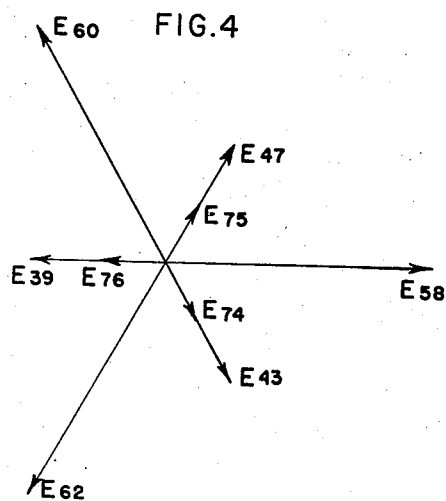
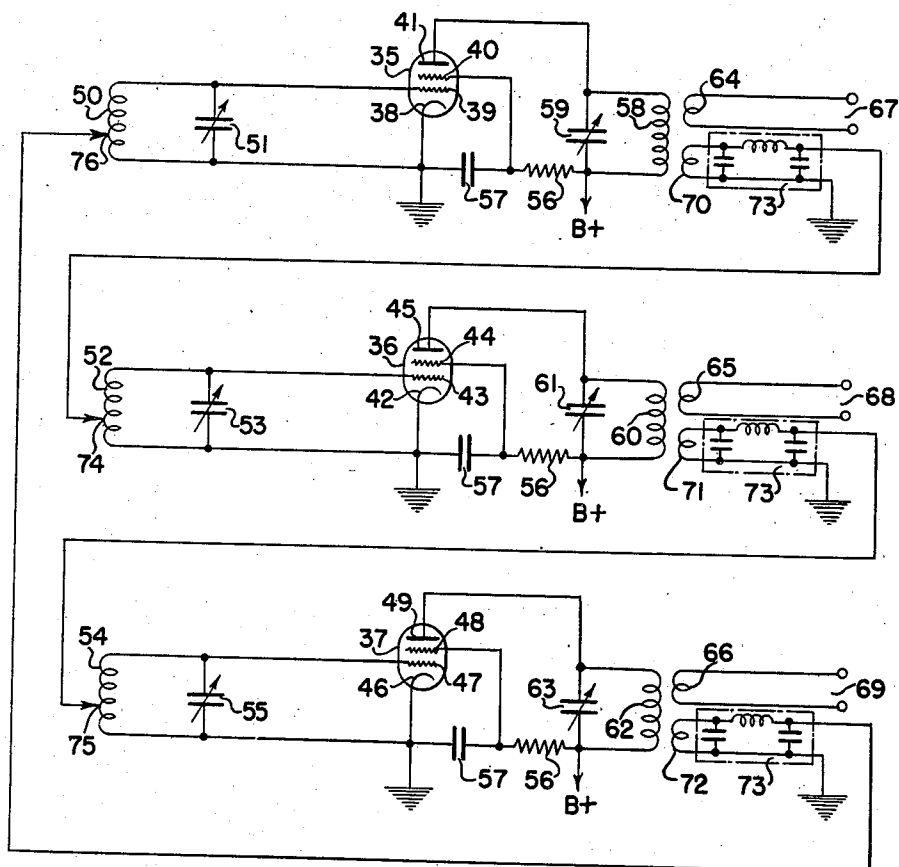
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FIG. 3



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OSCILLATOR

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Application September 26, 1940, Serial No. 358,495

3 Claims. (Cl. 250—36)

This invention relates to oscillator systems and more particularly to an oscillator system adapted to produce a plurality of signals of different phases.

Oscillator systems of the prior art are ordinarily of the type which produce a single output signal, or two output signals in phase opposition. In general, such oscillators are operated by feeding a portion of the output voltage of a signal-repeating means back into its input circuit. The feedback may take place either within the signal-repeating means itself or through an external path. Such oscillators, even those employing more than one signal-repeating means, are not adapted to supply a plurality of output voltages other than in phase opposition.

It is an object of the present invention, therefore, to provide an improved oscillator system which is capable of producing a plurality of output signals having desired phase relationships.

In accordance with the present invention, there is provided an oscillator system comprising a plurality of resonant circuits. Means including an external source of energy are also provided for translating energy from each of the resonant circuits to another of the circuits, and for energizing the latter in phase-shifted relationship to the first-mentioned one of the circuits. In this manner, signals are developed across the resonant circuits with predetermined different phases.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a circuit diagram of an oscillator system in accordance with the present invention;

Fig. 2 is a vector diagram representing certain operating characteristics of the oscillator system of Fig. 1;

Fig. 3 is a circuit diagram of a modified form of oscillator system in accordance with the present invention; and

Fig. 4 is a vector diagram representing certain operating characteristics of the oscillator system of Fig. 3.

Referring now more particularly to Fig. 1, there is shown a system comprising a pair of electron discharge tubes 1 and 2. The tube 1 is provided with a cathode 3, a control grid 4, a screen grid 5 and an anode 6; while the tube 2 includes a cathode 7, a control grid 8, a screen

grid 9 and an anode 10. The cathodes 3 and 7 are connected to ground through the resistors 11 and 12, respectively, these resistors each being shunted by a by-pass condenser 13. For the purpose of applying a signal voltage to the control grid 4 of the tube 1, there is provided a parallel resonant grid circuit comprising an inductance element 14 and a condenser 15. Likewise, a parallel resonant circuit comprising an inductance element 16 and a condenser 17 is connected between the control grid 8 of the tube 2 and ground. The screen grids 5 and 9 are provided with a suitable positive potential, from the source indicated by B+, through the resistors 18, and are by-passed to ground by the condensers 18A.

The anodes 6 and 10 of the tubes 1 and 2 are provided with a suitable positive potential, from the source indicated by B+, by way of choke coils 19. A parallel resonant circuit, comprising an inductance element 20, and a condenser 21 in series with a resistor 22, is connected, by way of the blocking condenser 23, between the anode 6 and ground. A similar parallel resonant circuit comprising an inductance element 24 and a condenser 25 in series with a resistor 26 is connected, by way of a blocking condenser 27, between the anode 10 and ground.

The high-potential terminals of the resonant circuits 20—21—22 and 24—25—26 are connected to the output terminals 28 and 29, respectively. The common output terminal 30 is grounded. The junction of the inductance element 20 and the resistor 22 is connected by means of a lead 31 to a tap 32 on the inductance element 16. The junction of the condenser 25 and the resistor 26 is connected by means of a lead 33 to a tap 34 on the inductance element 14.

The operation of the device of Fig. 1 may be understood more readily by reference to the vector diagram of Fig. 2. Let the signal voltage which appears between the output terminals 28 and 30 be represented by the vector E_{28} , and the signal voltage which appears between the terminals 29 and 30 by the vector E_{29} . The latter voltage leads the former voltage by 90° . The current which passes through the condenser 21 is represented by the vector I_{21} , and this current leads the voltage E_{28} by 90° . The current which passes through the inductance element 24 is represented by the vector I_{24} , and this current lags the voltage E_{29} by 90° . Due to the phase reversal of the tube 1, the corresponding voltage on the control grid 4 of this tube, which is represented by the vector E_4 , must be in phase op-

position with the voltage E_{23} . Likewise, the voltage on the control grid 8, represented by the vector E_8 , must be in phase opposition with the voltage E_{29} , due to the phase reversal which takes place in the tube 2.

The current through the inductance element 20 and the resistor 22, which is represented by the vector I_{20} , lags the voltage E_{23} by almost 90° . Hence the voltage developed across the resistor 22, represented by the vector E_{22} , is substantially in phase with the voltage E_8 necessary at the control grid 8 of the tube 2 to produce the desired output voltage. It is apparent, therefore, that since the voltage E_{22} is applied to the grid circuit of the tube 2 by means of the lead 31, oscillation of the tube 2 occurs, thus developing the voltage E_{29} between the output terminals 29 and 30. The current flowing through the condenser 25 and the resistor 26 is represented by the vector I_{25} , and leads the voltage E_{29} by almost 90° . Therefore, the voltage drop across the resistor 26 due to the current I_{25} , which is represented by the vector E_{26} , is substantially in phase with the voltage E_4 which must be applied to the control grid 4 of the tube 1 to produce the desired output voltage. Since the voltage E_{26} is applied to the control grid 4 by means of the lead 33, this tube oscillates, resulting in the production of the voltage E_{28} between the output terminals 28 and 30.

The inductance elements 14 and 16, in cooperation with the taps 34 and 32, function as auto-transformers to step up the relatively small feed-back voltages developed, respectively, across the resistors 26 and 22 so as to provide sufficient excitation of the control grids 4 and 8. In the absence of such means to step up the feed-back voltages, feed-back voltages of sufficient magnitude to provide oscillation could be developed only by making the resistors 22 and 26 so large that the performance of the resonant circuits including them would be seriously affected. No appreciable phase shift occurs due to the use of the taps 34 and 32, since the resonant circuits 14-15 and 16-17 are purely resistive at the frequency of oscillation to which they are tuned.

Referring now more particularly to Fig. 3, there are shown three electron discharge tubes 35, 36 and 37. The tube 35 has a cathode 38, a control grid 39, a screen grid 40, and an anode 41. The tube 36 includes a cathode 42, a control grid 43, a screen grid 44, and an anode 45. The tube 37 has a cathode 46, a control grid 47, a screen grid 48, and an anode 49. The cathodes 38, 42, and 46 are connected to ground. For the purpose of applying a signal voltage to the control grid 39 of the tube 35, there is provided in the grid circuit a parallel resonant circuit comprising an inductance element 50 and a condenser 51. Likewise, a parallel resonant circuit comprising an inductance element 52 and a condenser 53 is connected between the control grid 43 of the tube 36 and ground. Similarly, the input circuit of the tube 37 includes a parallel resonant circuit comprising an inductance element 54 and a condenser 55 connected between the control grid 47 and ground. The screen grids 40, 44 and 48 are provided with a suitable positive potential, from the source indicated by B+, through the resistors 56, and are by-passed to ground by the condensers 57.

The anodes 41, 45 and 49 of the tubes 35, 36 and 37, respectively, are provided with a suitable positive potential from the source indicated by B+. A parallel resonant circuit comprising an

inductance element 58 and a condenser 59 is connected in the anode circuit of the tube 35. The anode circuit of the tube 36 includes a parallel resonant circuit comprising the inductance element 60 and the condenser 61, while the anode circuit of the tube 37 includes a parallel resonant circuit comprising the inductance element 62 and the condenser 63. The inductance coils 64, 65, and 66 are coupled, respectively, to the inductance elements 58, 60 and 62, and are connected, respectively, to the output terminals 67, 68 and 69.

The coils 70, 71 and 72 are coupled, respectively, to the inductance elements 58, 60 and 62. The coil 70 is connected, through the phase-shifting means 73, between the tap 74 on the inductance element 52 and ground. The coil 71 is connected, through the phase-shifting means 73, between the tap 75 on the inductance element 54 and ground. The coil 72 is connected, through the phase-shifting means 73, between the tap 76 on the inductance element 50 and ground.

The operation of the device of Fig. 3 may be understood more readily by reference to the vector diagram of Fig. 4. Let the signal voltage which appears across the inductance element 58 be represented by the vector E_{58} , and the signal voltage which appears across the inductance element 60 by the vector E_{60} . The latter voltage leads the former voltage by 120° . Let the signal voltage which appears across the inductance element 62 be represented by the vector E_{62} . This voltage leads the voltage E_{60} by 120° . Due to the phase reversal occurring in the tube 35 the voltage required on the control grid 39 of this tube, which is represented by the vector E_{39} , must be in phase opposition with the voltage E_{58} . Likewise, the voltage necessary on the control grid 43, represented by the vector E_{43} , must be in phase opposition with the voltage E_{60} , due to the phase reversal which takes place in the tube 36. Similarly, the voltage necessary on the control grid 47, represented by the vector E_{47} , must be in phase opposition with the voltage E_{62} , due to the phase reversal occurring in the tube 37.

The phase-shifting means 73 are such as to produce a phase shift of 60° . Hence the voltage applied to the tap 74, represented by the vector E_{74} , lags the voltage E_{58} by 60° , but is in phase with voltage E_{43} , thus causing the tube 36 to oscillate and produce an output voltage at the terminals 68. Likewise, the voltage developed across the coil 71 has its phase shifted 60° by the phase-shifting means 73, so that the voltage at the tap 75, represented by the vector E_{75} , lags the voltage E_{60} by 60° . Since the voltage E_{75} is in phase with the voltage E_{47} , oscillation of the tube 37 occurs, thus developing an output voltage at the terminals 69. Similarly, the voltage developed across the coil 72 has its phase shifted 60° due to the phase-shifting means 73 and is applied to the tap 76, the voltage at this tap being represented by the vector E_{76} . This voltage lags the voltage E_{62} by 60° , but is in phase with the voltage E_{39} , thus causing the tube 35 to oscillate and produce an output voltage at the terminals 67. The inductance elements 50, 52, and 54, in cooperation, respectively, with the taps 76, 74, and 75, function as auto-transformers to step up the relatively small feed-back voltages produced, respectively, by the coils 70, 71, and 72, so as to provide sufficient excitation of the control grids 39, 43 and 47. Since the resonant circuits 50-51, 52-53 and 54-55 are purely resistive at the frequency of oscillation

at which they are tuned, they function effectively as a terminating resistance for each of the phase-shifting means 73.

Although the tubes are shown in Figs. 1 and 3 as tetrodes, it will be understood that triodes or pentodes may be employed with equal success. If triodes are used, neutralization means must be provided to prevent self-oscillation of the tubes due to their interelectric capacitance. Conventional means may be employed for heating the cathodes 3 and 7 of Fig. 1 and 38, 42 and 46 of Fig. 3, these means not being shown in the drawings to avoid unnecessary complication thereof.

It will be understood that the phase-shifting means 73 of Fig. 3, which are shown at π networks, may be replaced by any other suitable arrangement. By so selecting the phase shifting means as to give a phase shift other than 60° , the output voltages of the system may be made to have phase relationships different from the 120° relationship provided in the arrangement described.

Although the oscillator system here disclosed is applicable to any use where output signals of predetermined different phases are required, the arrangement in accordance with the present invention is especially suitable for use in connection with the frequency multiplier disclosed in my copending application Serial No. 314,480, filed January 18, 1940. The use of the present oscillator system to drive my earlier-disclosed frequency multiplier permits the elimination of the phase-shifting means normally employed in the latter device, thus simplifying its construction.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. An oscillator system for developing a plurality of signals having different relative phases, comprising a plurality of resonant circuits each including resistance elements in one of its arms for developing a voltage in phase-shifted rela-

5 tionship to the voltage developed across said circuit, and a plurality of signal repeating means each coupled between one of said resistance elements of said circuits and another of said circuits for translating the voltage developed across said resistance element in each one of said circuits to another of said circuits and energizing the same in phase-shifted relationship to said one of said circuits, whereby signals are developed across said circuits with predetermined different phases.

10 2. An oscillator system for developing a plurality of signals having different relative phases, comprising first and second signal-repeating means, first and second input resonant circuits connected respectively to said signal-repeating means, first and second output resonant circuits connected respectively to said signal-repeating means and each including phase-shifting means, a connection between said first phase-shifting means and said second input circuit for energizing the same in phase-shifted relationship to said first output circuit, and a connection between said second phase-shifting means and said first input circuit for energizing the same in phase-shifted relationship to said second output circuit, whereby signals are developed across said output circuits with predetermined different phases.

15 3. An oscillator system for developing a plurality of signals having different relative phases, comprising first and second signal-repeating means, first and second input resonant circuits connected respectively to said signal-repeating means, first and second output resonant circuits connected respectively to said signal-repeating means and each including a resistor in one branch, a connection between the resistor in the inductive branch of said first output circuit and said second input circuit for energizing the same in phase-shifted relationship to said first output circuit, and a connection between the resistor in the capacitive branch of said second output circuit and said first input circuit for energizing the same in phase-shifted relationship to said second output circuit, whereby signals are developed across said output circuits with predetermined different phases.

ARTHUR L. NELSON.