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STABILIZED OSCILLATOR

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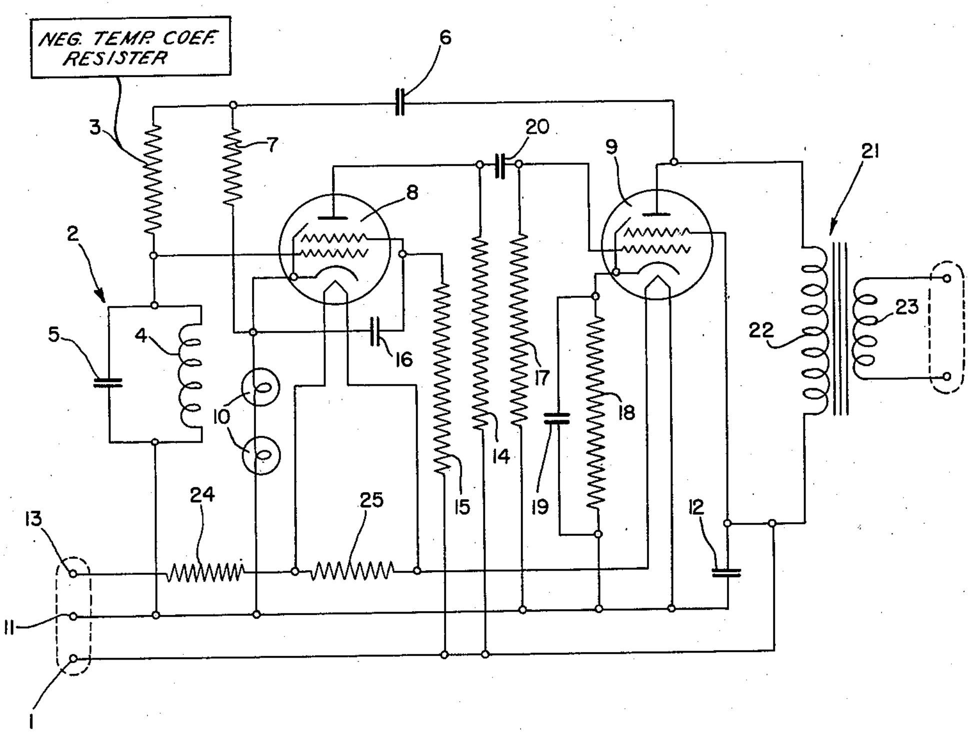

INVENTOR.
LESLIE M. HARRIS

BY George F. Goodyear
ATTORNEY

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STABILIZED OSCILLATOR

Leslie M. Harris, Williamsville, N. Y., assignor to Curtiss-Wright Corporation, a corporation of Delaware

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6 Claims. (Cl. 250—36)

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This invention relates to oscillators. More particularly, it relates to oscillators which maintain their outputs at constant frequencies and constant levels over wide ranges of temperature.

Modern developments in electronics, and its many and varied applications, make it highly desirable that electric current oscillators be available which will maintain their outputs at constant voltage and current levels and which will maintain the output frequency constant over wide ranges of temperature. It is accordingly an object of this invention to provide an oscillator arrangement which will accomplish these and other results, as will be pointed out hereinafter.

The invention will be more readily understood by reference to the accompanying drawing, in which is shown a wiring diagram of an oscillator incorporating the principles of the present invention.

The oscillator shown in the drawing is of the inductance-capacitance tuned type, the frequency being determined by means of the impedance values in a tuned circuit indicated generally at 2, this circuit including an inductor 4 and a capacitor 5. Stability of frequency is obtained by means of negative feedback through a capacitor 6 and a resistor 7 from the plate of a type 6V6 beam-power tube 9 to the cathode of a type 6SJ7 pentode 8. The capacity value of the capacitor 6 and the resistance value of resistor 7 are so adjusted as to attain a constant phase shift in the amplifier stages when the oscillator output is amplified. This is necessary in order to secure stability of frequency.

Stability of level or amplitude is assisted by means of two hot filament ballast lamps 10 coupled to the cathode of tube 8. These ballast lamps are small 3 watt S6 Mazda lamps whose resistances vary directly with variations in current. The value of the resistance 7 in combination with the lamps 10 is such as to obtain a critical current passing through the ballast lamps. The value of this critical current is such that the filaments of the lamps 10 operate at a temperature where the variation of resistance with current is large. Any tendency to increase the current through the ballast lamps as a result of increased amplitude of output oscillation will thus tend to increase the resistance of lamps 10, increase the negative feedback, and thereby counteract the tendency of the output oscillation to increase in amplitude. Any tendency of the output oscilla-

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tion to decrease in amplitude will have the opposite result.

When the oscillator is subjected to temperature changes, the impedance of tuned circuit 2 is apt to vary, principally due to change in "Q" value of the inductor 4. This in turn will cause the output level of the oscillator to vary. In order to avoid this undesirable variation in output level, there is incorporated, in a positive feedback circuit from the plate of tube 9 to the grid of tube 8, a resistor 3 having a conducting element of a material having a negative temperature coefficient of resistance, that is, its electrical resistance decreases with increase of temperature. Such materials are available commercially, and may include carbon as an ingredient, or other recently developed materials such as certain inorganic oxides. The temperature coefficient of this resistor is accurately predetermined so that the gain in feedback from the plate of tube 9 through the capacitor 6 and the resistor 3 to the control grid of tube 8, as the temperature increases, compensates for the loss due to the decreased impedance of circuit 2 with rise in temperature.

The tuned circuit 2, in combination with the positive and negative feedback circuits described above, is also an important feature in bringing about the desirable results of this invention. By this means the output frequency of the oscillator will be accurately controlled over considerable supply voltage ranges, as long as the level or amplitude is kept constant by means of ballast lamps 10.

The oscillator is supplied with a source of 250 volt direct current, which may be a battery, direct current generator, or other controlled source of direct current, through positive terminal 1 and negative terminal 11, the latter being grounded to the casing for the apparatus. Interference from outside sources is reduced by means of a capacitor 12 connected across the terminals 1 and 11. The positive terminal 1 is connected through the plate feed resistor 14 to the plate of tube 8, and through a resistor 15 to the screen grid of tube 8. The cathode and screen grid of tube 8 are coupled to each other through a capacitor 16. The positive terminal 1 is also directly connected to the screen grid of tube 9. The negative terminal 11 is connected to tuned circuit 2, the cathode of tube 8 through ballast lamps 10, the control grid of tube 9 through a resistor 17, and the cathode of tube 9 through the self-biasing resistor 18 and by-pass capacitor 19. The plate of tube 8 is coupled to the control grid of tube 9 through a capacitor 20.

The heaters of the tubes 8 and 9 are supplied with a source of low voltage (e. g. 22 volts) current through negative terminal 11 and a positive terminal 13, with a series resistor 24 to reduce the voltage drop across each heater to the proper amount. A shunt resistor 25 around the terminals of the heater for tube 8 serves to equalize the voltage drop across the heaters of the two tubes.

The output of the oscillator is passed through a primary winding 22 of a balanced iron core output transformer 21. The primary of this transformer is connected at one end to the plate of tube 9 and at the other end to the positive terminal 1. The output of the oscillator is then taken off at the two terminals of the secondary 23 of transformer 21.

In the oscillator as described above, with properly chosen values of resistance and capacitance, the frequency is highly independent of changes in both plate and heater voltages and of changes in temperature. Thus, a variation in plate voltage from 240 volts to 260 volts causes a frequency shift of less than 2 cycles in 40,000 per second. A similarly small shift results from a change in heater voltage from 5.8 volts to 6.5 volts.

The effect of temperature on frequency is controlled by the compensation applied through careful selection of the capacity of capacitor 5. Level or amplitude is controlled by the ballast lamps 10 and the temperature compensating element of the resistor 3, and the amount of variation may thus be kept as low as 0.04 per cent per degree centigrade. It may also be desired, however, to control the ambient temperature within narrow limits by means of a thermostatically controlled blower or other suitable means. The wave shapes generated by the oscillators are closely sinusoidal, with not over 0.2% distortion for an output signal of 4 volts into 120 ohms.

In the above description, it is obvious that any of the resistance, capacitance or inductance elements may be either simple or compound. It is understood that many other changes may be made without departing from the spirit and scope of the invention as defined in the appended claims.

I claim:

1. In an oscillator having a plurality of vacuum tubes each with a plate, cathode and control grid and with each cathode connected to a ground wire through an impedance, the signal output of a first vacuum tube being fed to the control grid of a second vacuum tube, the combination comprising a negative temperature coefficient resistor included in series in a positive feed-back circuit from the plate of the second vacuum tube to the control grid of the first vacuum tube, and a capacitor and an inductor connected in parallel at one set of terminals thereof to said ground wire and at the other set of terminals thereof to the control grid of said first vacuum tube.

2. In an oscillator having a plurality of vacuum tubes each with a plate, cathode and control grid and with each cathode connected to a ground wire through an impedance, the signal output of a first vacuum tube being fed to the control grid of a second vacuum tube, the combination comprising a negative temperature coefficient resistor included in series in a positive feed-back circuit from the plate of the second vacuum tube to the control grid of the first vacuum tube, a capacitor and an inductor connected in parallel at one set of terminals thereof to said ground wire and at the other set of terminals thereof to the control grid of said first vacuum tube, and a resistor whose resistance varies directly and substantially with the current passing therethrough, said last-named resistor being included in the impedance circuit between said ground wire and the cathode of said first vacuum tube.

3. In an oscillator having a plurality of vacuum tubes each with a plate, cathode and control grid and with each cathode connected to a ground wire through an impedance, the signal output of a first vacuum tube being fed to the control grid of a second vacuum tube, the combination comprising a negative temperature coefficient resistor included in series in a positive feed-back circuit from the plate of the second vacuum tube to the control grid of the first vacuum tube, a capacitor and an inductor connected in parallel at one set of terminals thereof to said ground wire and at the other set of terminals thereof to the control grid of said first vacuum tube, and a ballast lamp whose resistance varies directly and substantially with the current passing therethrough, said ballast lamp being included in the impedance circuit between said ground wire and the cathode of said first vacuum tube.

4. In an oscillator having a plurality of vacuum tubes each with a plate, cathode and control grid and with each cathode connected to a common conductor, the signal output of a first vacuum tube being fed to the control grid of a second vacuum tube, a circuit comprising a capacitor and an inductor connected in parallel between the control grid of the first vacuum tube and said common conductor, a positive feed-back circuit from the plate of the second vacuum tube to the control grid of the first vacuum tube, said positive feed-back circuit having included therein a negative temperature coefficient resistor to compensate for change in impedance in said first mentioned circuit in response to temperature changes, and a negative feed-back circuit between the plate of the second vacuum tube and the cathode of the first vacuum tube.

5. In an oscillator having a plurality of vacuum tubes each with a plate, cathode and control grid and with each cathode connected to a common conductor through an impedance, the signal output of a first vacuum tube being fed to the control grid of a second vacuum tube, a circuit comprising a capacitor and an inductor connected in parallel between the control grid of the first vacuum tube and the common conductor, a resistor whose resistance varies directly and substantially in accordance with the current passing therethrough, said resistor being included in the impedance circuit between the common conductor and the cathode of the first vacuum tube, a positive feed-back circuit from the plate of the second vacuum tube to the control grid of the first vacuum tube, said positive feed-back circuit having included therein a negative temperature coefficient resistor to compensate for change in impedance in said first mentioned circuit in response to temperature changes, and a negative feed-back circuit between the plate of the second vacuum tube and the cathode of the first vacuum tube.

6. In an oscillator having a plurality of vacuum tubes each with a plate, cathode and control grid, the signal output of a first tube being fed to the control grid of a second tube, a negative tempera-

ture coefficient resistor included in series in a positive feed-back circuit from the plate of the second tube to the control grid of the first tube, and a capacitor and an inductor connected in parallel between the control grid of the first tube and the cathodes of said tubes.

LESLIE M. HARRIS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,985,417	Koch	Dec. 25, 1934
2,186,571	Beale	Jan. 9, 1940
2,231,542	Mallinckrodt	Feb. 11, 1941
2,258,128	Black	Oct. 7, 1941
2,268,872	Hewlett	Jan. 6, 1942
2,303,862	Peterson	Dec. 1, 1942
2,394,018	Shank	Feb. 5, 1946