

April 15, 1947.

B. J. KINSBURG

2,418,842

SCANNING OSCILLATOR

Filed March 4, 1943

2 Sheets-Sheet 1

FIG. 1

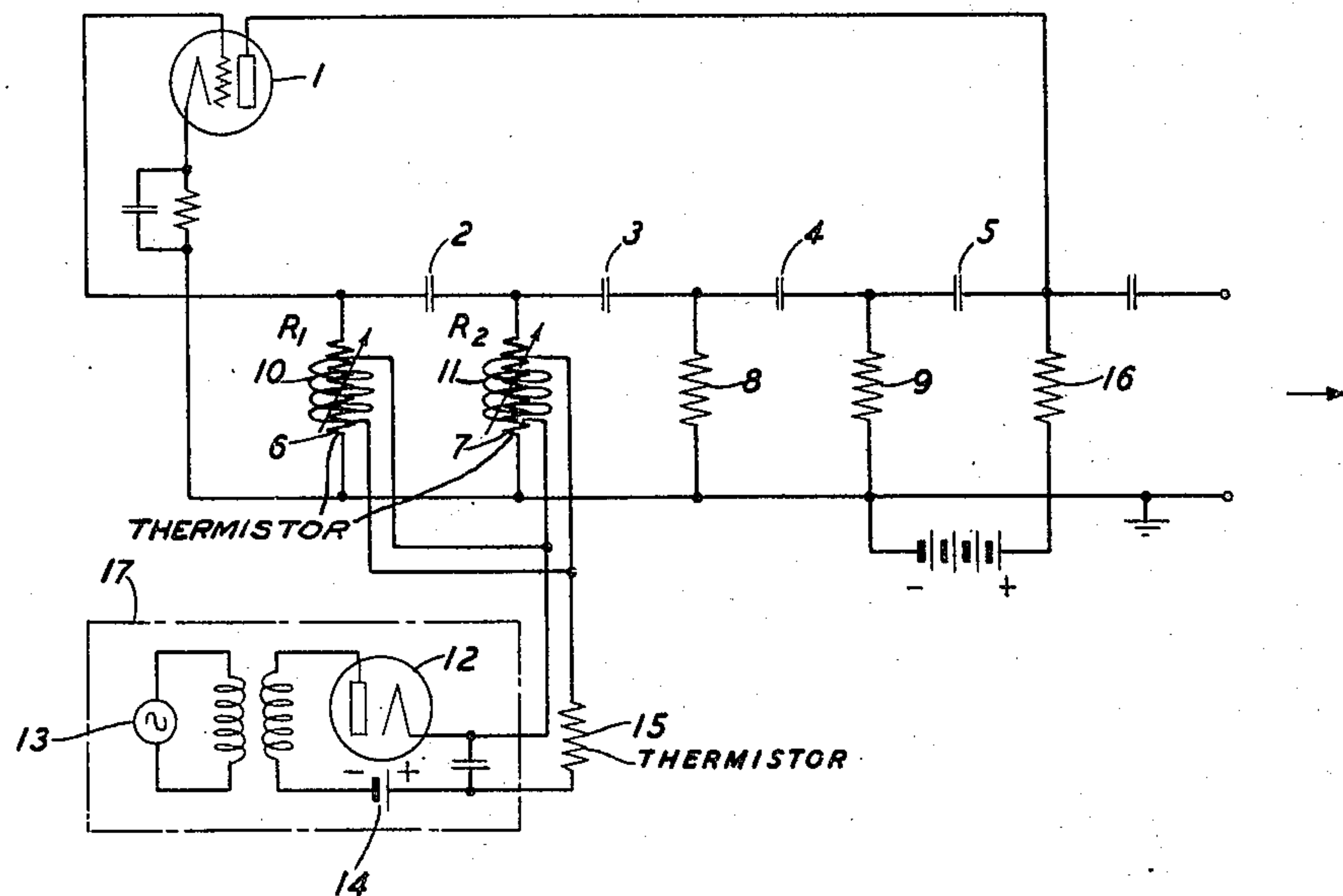
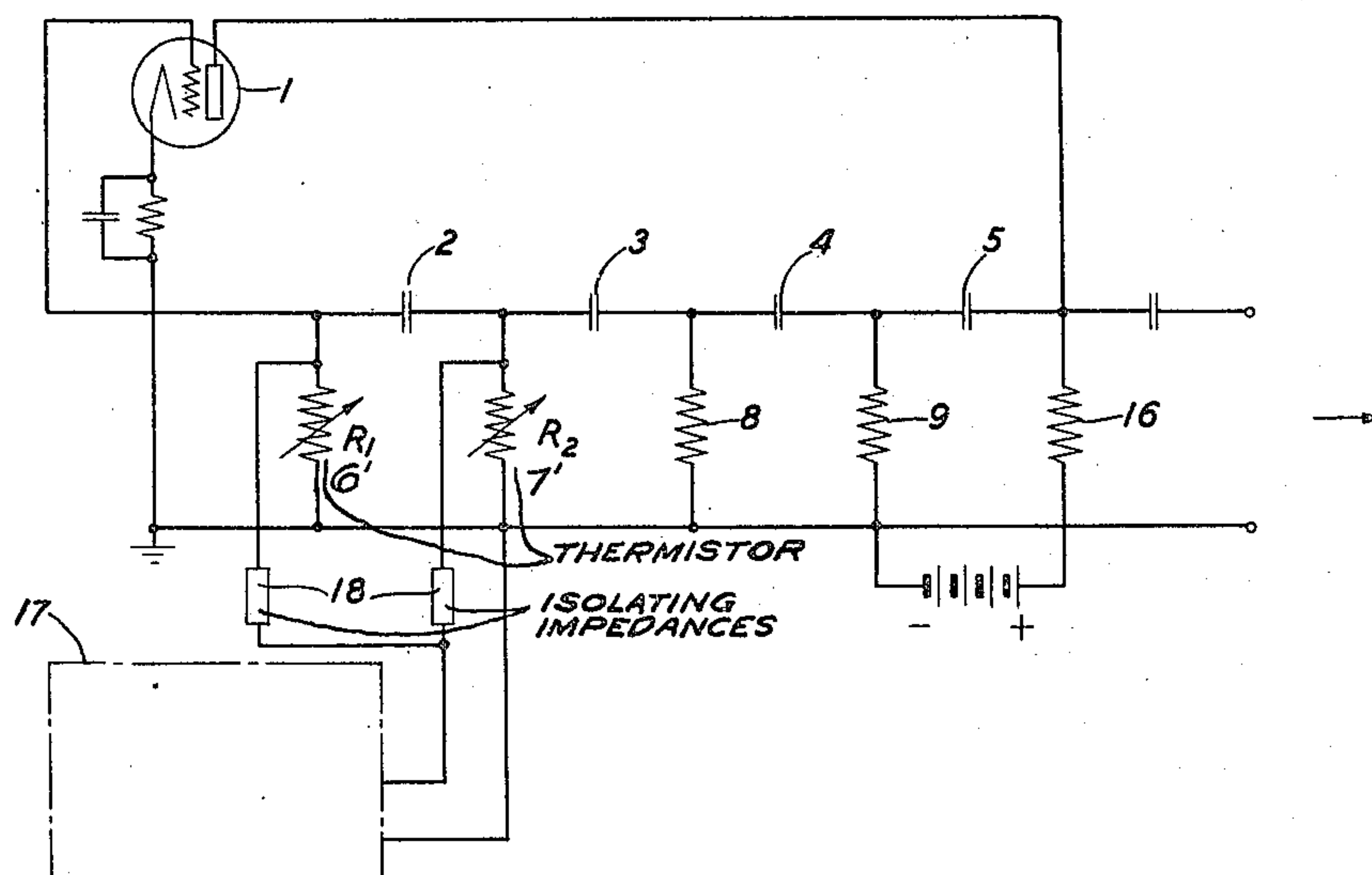


FIG. 2



INVENTOR
B. J. KINSBURG
BY
W.C. Farnell
ATTORNEY

April 15, 1947.

B. J. KINSBURG

2,418,842

SCANNING OSCILLATOR

Filed March 4, 1943

2 Sheets-Sheet 2

FIG. 3

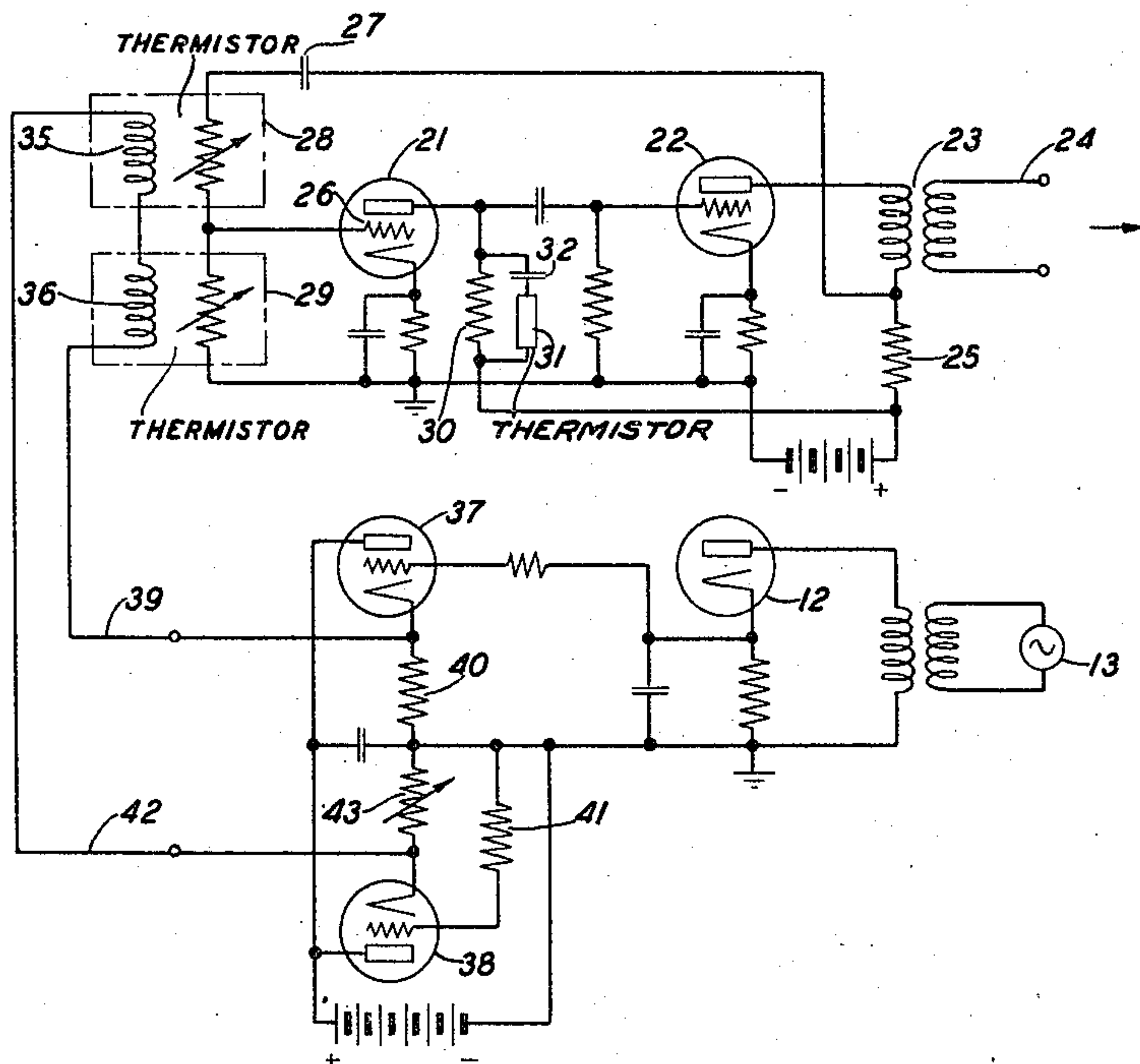
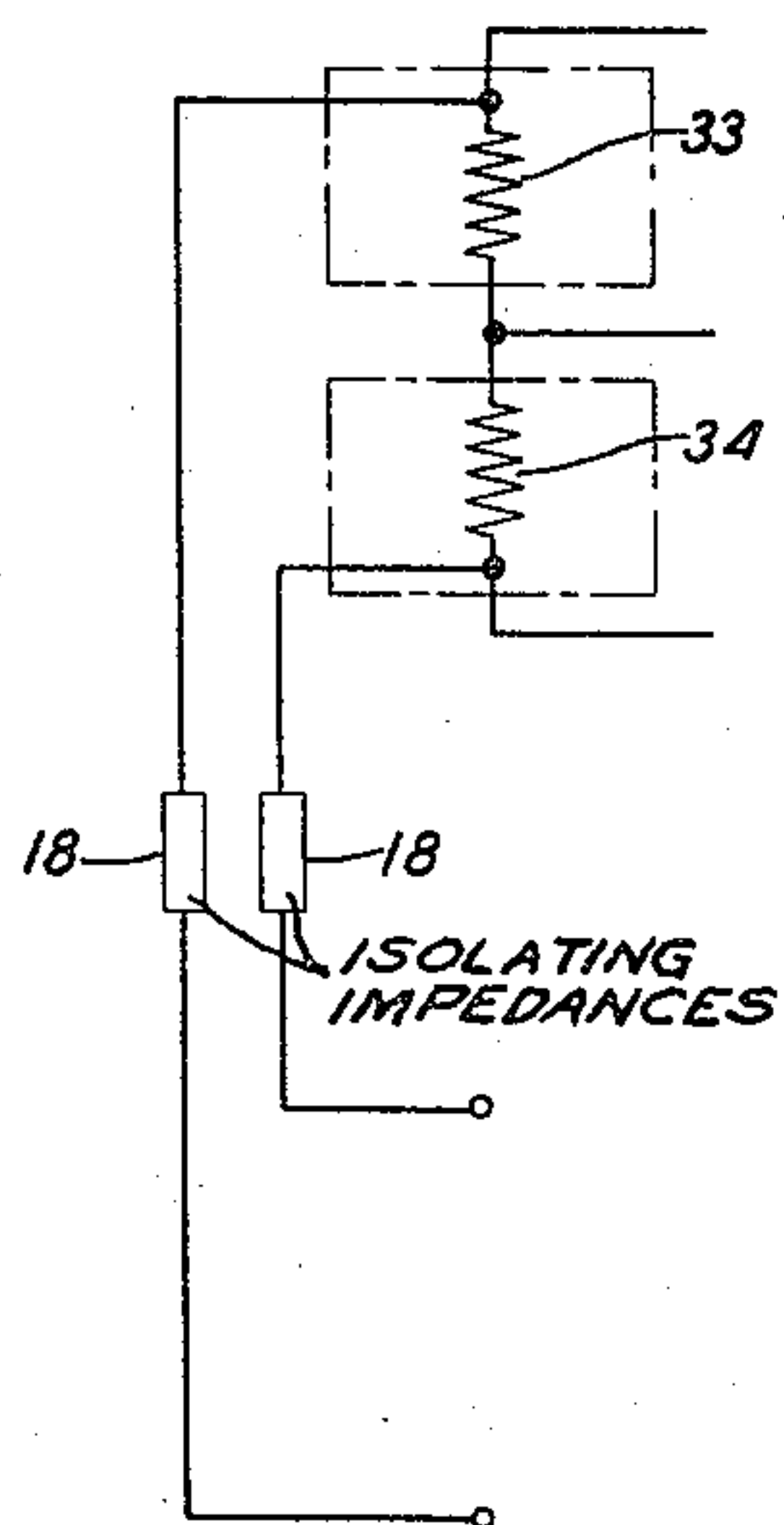


FIG. 4



INVENTOR
B. J. KINSBURG
BY W.C. Parnell
ATTORNEY

UNITED STATES PATENT OFFICE

2,418,842

SCANNING OSCILLATOR

Boris J. Kinsburg, New York, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application March 4, 1943, Serial No. 477,985

6 Claims. (Cl. 250—36)

1

This invention relates to oscillation circuits and particularly to vacuum tube oscillators of the so-called RC type in which the frequency determining circuit consists solely of resistance and capacity elements.

RC oscillators are commonly used as scanning oscillators for testing purposes particularly where the sweep frequency range is such that oscillators having tuned circuits are too expensive or impracticable. In such prior scanning oscillators the output frequency is caused to vary over a desired frequency band by cyclically varying the impedance of one of the elements in the frequency determining network. This cyclic variation involves the use of some mechanical means, such as a motor-driven condenser or potentiometer which gives rise to objectionable noise components in the output of the oscillator. Although some of these noise components, such as those due to eccentricities of the condenser plates, are synchronous with the sweep frequency they produce a displacement in the return trace so that it is not directly superimposed on the forward trace and therefore must be suppressed or blanked out. This blanking out is usually accomplished by contacts on the condenser or potentiometer shaft but such contacts introduce peaks of noise which are also very objectionable.

Other noise components, such as those due to deformations on the condenser plates during rotation, often are not synchronous with the sweep frequency and therefore produce on the oscilloscope screen moving patterns which make accurate observations very difficult or impossible.

For these and similar reasons all known forms of mechanical drive are often found unsatisfactory for scanning oscillators in testing systems.

The object of this invention is an improved RC type oscillator in which the frequency is varied without the use of any form of mechanical drive.

According to the invention one or more of the resistance elements in the frequency determining circuit of such an oscillator are of the thermally sensitive type and the resistance of these elements is periodically varied over the range necessary to produce the required variation in frequency by heating current applied from an external source of current of the desired sweep frequency. Thermally sensitive resistors suitable for this purpose are now called thermistors and are well known as evidenced by U. S. Patents 2,184,847, 2,276,864 and 2,280,257 to G. L. Pearson.

As shown by these patents, the resistance of these devices may be varied directly by the heat-

2

ing effect of the current in the thermistor or indirectly by means of a heating element in an electrically separate circuit. The indirectly heated type is preferred for the purposes of this invention particularly for oscillators of very low scanning frequency. In cases where the scanning period is so short that the resistance of indirectly heated thermistors does not vary sufficiently to cause the oscillator to sweep over the required frequency range, the heating current circuit may be connected directly to the thermistor. However, when two or more thermistors in a frequency determining network are to be controlled simultaneously they must be decoupled from each other by suitable impedances in the heating circuit.

In the drawing,

Fig. 1 is a single tube scanning oscillator according to the invention in which the thermistors are indirectly heated;

Fig. 2 is a similar oscillator with directly heated thermistors;

Fig. 3 is a two-stage oscillator; and

Fig. 4 shows the connections for directly heating the thermistors in the circuit of Fig. 3.

In Fig. 1 the vacuum tube 1 is an RC oscillator of the general type disclosed in such patents as 1,442,781 to Nichols and 2,236,985 to Bartelink in which an iterative network comprising series condensers and shunt resistors is connected between the plate and grid circuits. As pointed out in the Bartelink patent, the frequency of such an oscillator can be varied over a wide range by varying one or more of the shunt resistors. In the circuit of this invention the network comprises four condensers 2, 3, 4 and 5 and four resistors 6, 7, 8 and 9 of which one or more such as 6 and 7 are thermistors with heating elements 10 and 11 connected in parallel to a pulse generator 17 which may comprise a diode rectifier 12 which passes to the elements pulses of heating current at the frequency of the alternating source 13. While the rectifier circuit shown is preferred as a simple and inexpensive device for obtaining a suitable scanning frequency, it will be understood that it may be replaced by any other known device such as a relaxation oscillator, for producing the required low frequency heating pulses.

The rectifier may be biased, as by a battery 14, to limit the duration of the rectified pulse to a desirable fraction of the positive half cycle at the plate of the diode. In this way the temperature range of the thermistor between successive pulses may be varied to produce the desired variation in the frequency range of the oscillator. The

3

thermal inertia of the thermistors 10 and 11 will ordinarily produce a sufficiently gradual change in their resistance but if necessary the wave form of the heater current pulses may be modified by one or more auxiliary thermistors such as 15 in series or parallel with the heater circuit and the effect of these auxiliary thermistors may be varied as required by the addition of series or shunt connected resistors.

While the thermal inertia of thermistors is sufficient to produce a gradual change in resistance over the heating period they are nevertheless so sensitive as to undergo large variations in resistance between successive pulses of relatively low frequency and hence the output voltage of the oscillator across the resistor 13 will vary over a wide band of frequencies at the frequency of the source 13.

In some cases particularly where the scanning frequency is relatively high, that is, 60 cycles per second or higher, and the oscillator must scan a wide frequency band, the indirectly heated thermistors may not be sufficiently sensitive. In such cases the thermistors 6 and 7 may be replaced by thermistors 6' and 7' of the directly heated type as shown in Fig. 2. If the frequency of the oscillator is varied by means of two or more of such thermistors, suitable resistors or retard coils 18, 18 must be used in the heating circuits to prevent the heating circuit from forming a low impedance by-pass in shunt with the thermistors. If resistors are used they should be of a value greater than the maximum resistance of the thermistor and if retard coils are used their impedance at the lowest frequency of the oscillation should be much greater than the maximum resistance of the thermistor in order to obtain the maximum range of frequencies from the oscillators.

In Fig. 3 the principles of the invention are applied to a two-stage RC type oscillator comprising two conventionally coupled tubes 21, 22 with a coil 23 for conducting the output to the work circuit 24. Due to the addition of the second tube very little phase shift in the feedback path is required. The signal voltage across the resistor 25 in the plate circuit of the output tube is impressed on the grid 26 of the tube 21 through a small blocking condenser 27 and an indirectly heated thermistor 28. The grid circuit of this tube is shunted by a second thermistor 29 and by simultaneously varying these series and shunt thermistors a very wide range of frequencies may be obtained.

When such oscillators are used to scan a wide frequency band the amplitude of the output current may vary considerably with frequency. This may be corrected by conventional automatic volume control circuits but in most cases sufficiently close regulation can be obtained by connecting a third thermistor 31 or its equivalent in series with a small condenser 32 across the resistor 30 in the plate circuit of the tube 21. The variations in the resistance of this thermistor with the variations in the output of the tube 21 will tend to keep the alternating potentials applied to the grid of tube 22, and hence the output of the oscillator, constant over the scanning frequency range.

As in the circuit of Fig. 1, the indirectly heated thermistors 28, 29 may if required be replaced by directly heated thermistors 33, 34 as shown in Fig. 4. When the thermistors are directly heated neither heating lead can be at ground potential but both must be at the same potential

4

with respect to ground to prevent the heating current from affecting the bias on the grid 26. Regardless of the type of thermistor used the heating circuit should be balanced in order to stabilize the oscillator against fluctuations in the voltage of the source 13 and other variations such as those due to aging of the tubes in the pulse generating circuit.

To obtain this balanced relation the pulse generating diode 12 is connected to the heater windings 35, 36 of Fig. 3 or to the directly heated thermistors 33, 34 of Fig. 4 through a direct current amplifying stage comprising two tubes 37 and 38. The tube 37 is a conventional amplifier with one heating lead 39 connected to the cathode end of the cathode load resistor 40. The tube 38 is of the same type as 37 but has its grid connected to ground through a high resistor 41 and does not function as an amplifier but merely as a means of bringing the lead 42 to the same potential as the lead 39 by adjusting the cathode resistor 43 to balance the quiescent plate currents of the tubes 37 and 38. Under this condition the pulses from the diode 12 will be amplified in tube 37 and will vary the resistance of the thermistors as described above. The amplitude of the current pulses in the heating circuit will be relatively small compared with the steady plate currents of the tubes 37 and 38 so that the potential drop in resistor 43 will vary with the amplitude of the current pulses and keep the conductors 39 and 42 at substantially the same potential with respect to ground.

Obviously the required balance can be obtained in a very simple manner by using a full wave rectifier in place of the diode 12 but this would double the scanning frequency. Very often, however, a frequency of about 60 cycles is desired and the circuit just described gives this frequency directly from the usual commercial supply line.

What is claimed is:

1. In combination a vacuum tube oscillator having a frequency determining network consisting of resistance and capacity elements at least one of the resistance elements being a thermistor and means for automatically varying the resistance of the thermistor comprising a source of alternating current, a circuit including a rectifier between the source and the thermistor and means for biasing the rectifier to control the variation in the resistance of the thermistor between successive alternations of the source.

2. The combination of claim 1 in which the circuit includes an auxiliary thermistor for controlling the rate of change of the resistance of the thermistor in the frequency determining network.

3. The combination of claim 1 in which at least two of the resistance elements are thermistors and the circuit is connected to each thermistor through an isolating impedance.

4. A vacuum tube oscillator comprising two vacuum tube stages having input and output circuits connected in tandem, a thermistor connected in shunt to the input of the first stage, a feedback connection including a second thermistor from the output of the second stage to the input of the first stage and a heating circuit balanced with respect to ground for cyclically varying the resistance of both thermistors.

5. An oscillator according to claim 4 having a resistor in the output circuit of one of the tubes and a condenser and a third thermistor con-

nected in series across the resistor for regulating the amplitude of the oscillations.

6. An oscillator according to claim 4 in which the heating circuit includes two similar vacuum tubes having output circuits connected in balanced relation to the thermistors, grid electrodes connected to ground, an impedance in one of the grid connections, a source of alternating current and a rectifier connected to the source in series with the impedance.

BORIS J. KINSBURG.

REFERENCES CITED

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

UNITED STATES PATENTS

	Number	Name	Date
5	1,934,322	Osbon -----	Nov. 7, 1933
	2,321,269	Artzt -----	June 8, 1943
10	2,258,128	Black -----	Oct. 7, 1941
	2,319,965	Wise -----	May 25, 1943
	2,300,632	Poch -----	Nov. 3, 1942