PB 151393

NBS

Technical Note 34

RESISTANCE DIODE BRIDGE CIRCUIT FOR TEMPERATURE CONTROL

U. S. DEPARTMENT OF COMMERCE
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OCTOBER 1959

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Resistance Diode Bridge Circuit for Temperature Control

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The conventional ac bridge gives irregular performance including loss of temperature control when the temperature error exceeds a certain critical value. The present note describes a simple method of achieving stable temperature control over a large range of temperatures.

A common type of temperature controller[1,2] uses a platinum resistance thermometer as one arm of an ac resistance bridge. The output of the bridge is amplified and fed to a thyratron, which in turn controls a relay. One of the shortcomings of this instrument is loss of temperature control when the temperature error exceeds a certain critical value. When the bridge is unbalanced beyond this critical value, the temperature controller continues to supply heat to an oven when the temperature is already too high. Large temperature errors which give rise to this type of faulty performance may occur during initial warm-up of the oven, or during a change of operating temperature, or in the event of an open circuit in the platinum resistor. The last circumstance can be most serious, since it frequently occurs when there is no one present to monitor the performance of the oven. The faulty performance of the controller is due to the failure of the thyratron to properly recognize the phase of a large error signal and due to distortion and phase shift in overloaded amplifier stages. It is not practical to increase the critical value of the temperature error substantially by appropriate biasing of the thyratron because of the accompanying severe reduction in sensivity and stability of the circuit. Satisfactory performance of a thermistor temperature controller from 20 to 300°C was achieved by symmetrical limitation of the signal at each amplifier stage with the help of silicon diodes and by use of an average responding phase detector.[3/] The present note describes a simpler circuit which provides stable control over a very large range of temperature.

The circuit shown in Fig. 1 has been tested in control of an oven from room temperature to 900°C without loss of temperature control. The bridge is driven by an ac voltage. The use of the two diodes in the bridge provides an error signal which is pulsating dc, the polarity being determined by the direction of unbalance. When the error signal is <u>of the proper polarity</u> and magnitude at the output of the bridge, the thyratron will fire and heat will be supplied to the oven.

If the oven is at a high temperature and it is desired to control at a much lower temperature, the rheostat may be adjusted to the lower control point without first cooling the oven. The error signal from the resistance diode bridge will be of positive polarity and after a phase inversion in the amplifier stage, will not be able to fire the thyratron. The limitation of the thyratron as a phase detector for high signals is avoided in this case, as well as the effect of any distortion or phase shift of the error signal by the amplifier.

The characteristic behavior of the thyratron provides some proportioning control when the error signal is small.[2/] Further proportioning has been obtained by placing the resistance thermometer in close proximity to the heater coils and isolating the specimen region of the oven from the heater coils by means of a large cylindrical metal tube. With this arrangement, a control of $\pm 1^{\circ}C$ has been achieved. Control to within a smaller temperature interval should be possible with an improved furnace design.[2]

Very stable operation of the controller was noted using semi-conductor power diodes in the bridge circuit. The forward resistance of either diode is not critical as long as it is small compared with the 100 ohm resistor in the same arm of the bridge. Similarly, any mismatch between the pair of diodes is not critical. The balance point of the bridge is, of course, unaffected by the nonlinearity of the resistance of the diodes. Another arrangement of the bridge which is essentially equivalent to that shown in Fig. 1 places the diodes in opposite rather than adjacent arms of the bridge.

The authors wish to thank Dr. J. R. Manning for calling their attention to this temperature controller and for several informative discussions relating to its construction and improvement. In addition, the authors are indebted to Dr. Forest K. Harris for valuable comments on the manuscript.

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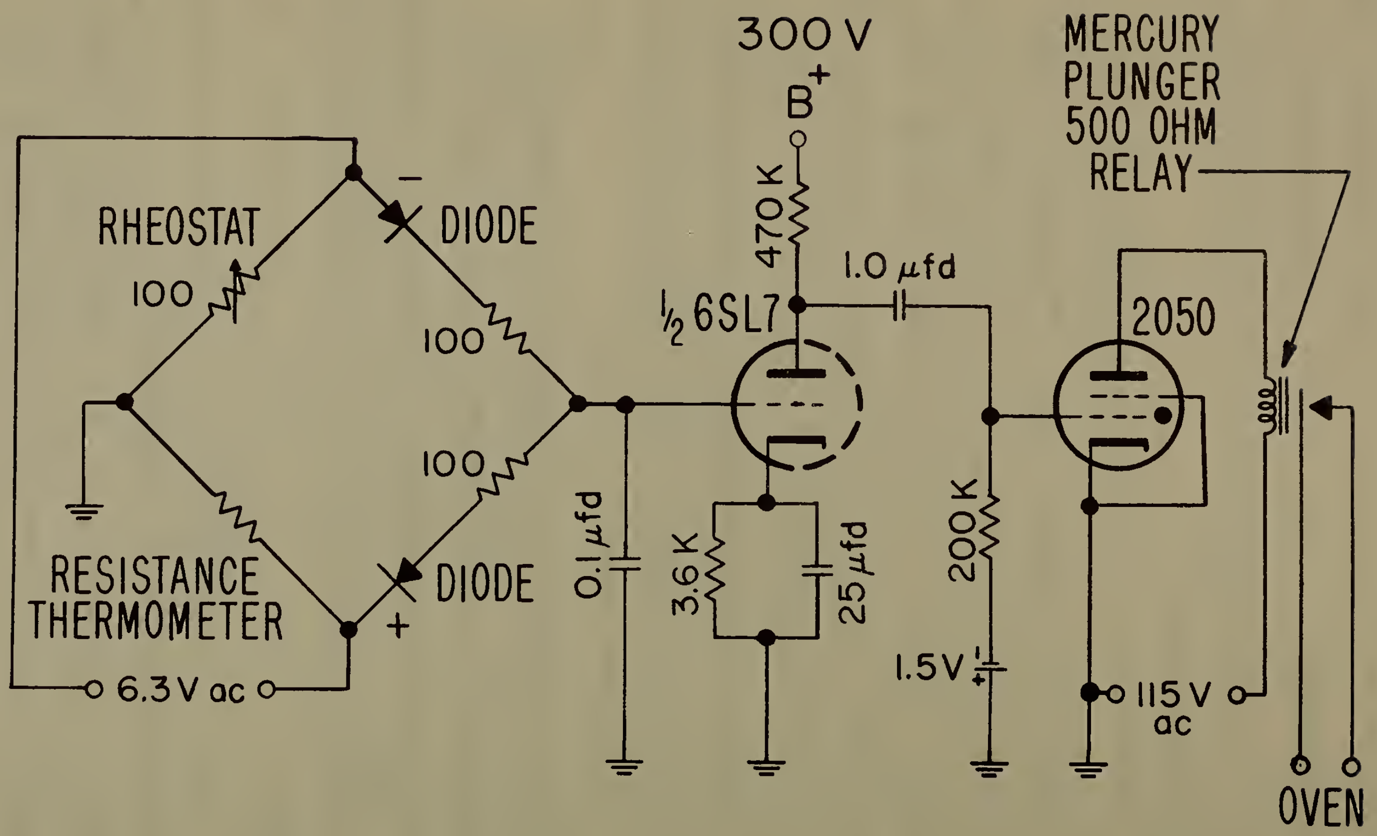

Figure 1. Resistance diode bridge circuit

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