July 11, 1967 A. DEL DUCA 3,330,941

OVEN TEMPERATURE CONTROL

Filed Feb. 12, 1960

FIG. 1.

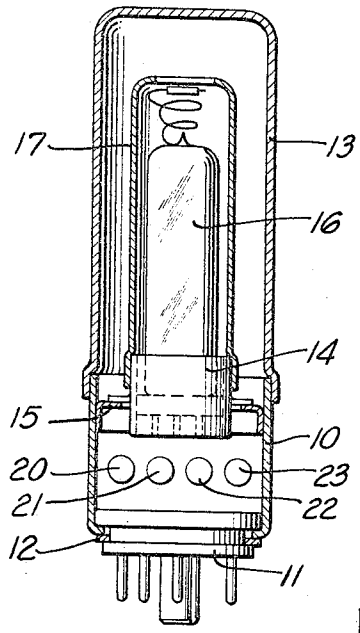


FIG. 3.

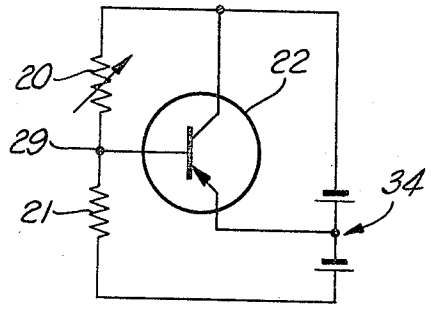
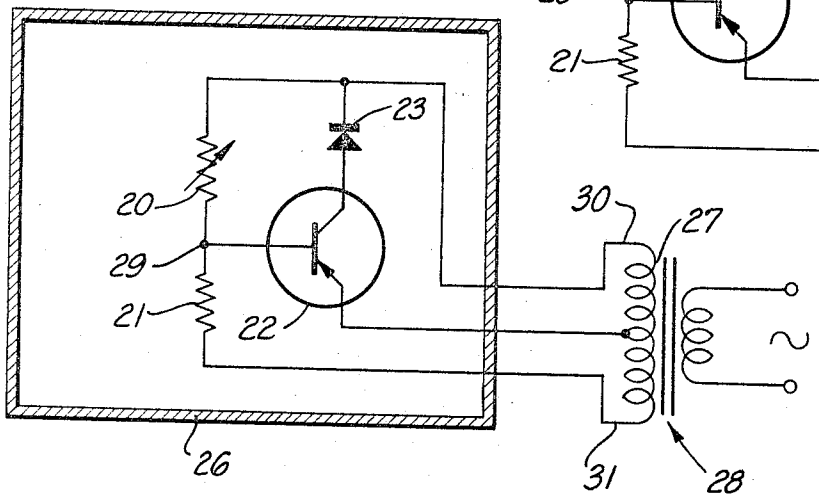


FIG. 2.



INVENTOR
ANTHONY DEL DUCA
BY HIS ATTORNEYS
HARRIS, KIECH, RUSSELL & KERN

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OVEN TEMPERATURE CONTROL

Anthony Del Duca, Garden Grove, Calif., assignor to Beckman Instruments, Inc., a corporation of California

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This invention relates to ovens for operation at substantially constant temperatures and, in particular, to an oven with a combined heat source and temperature control circuit.

Thermostats are often used in temperature control circuits but have two features which are undesirable in many applications. A thermostat requires mechanical contacts for opening and closing a circuit and provides off-on control. The mechanical contacts arc and have limited life and are subject to sticking closed. Also, the moving contacts create problems under high acceleration conditions. The on-off type control produces power and, hence, heat transients resulting in a relatively wide temperature control band.

It is an object of the invention to provide an oven that is compact and rugged and one that is easily installed and removed from associated equipment. A further object is to provide an oven adapted for use with various components the temperature of which is to be controlled and in which such components may be easily installed and replaced.

A further object is to provide such an oven that may be operated from an A.C. voltage source or a D.C. voltage source.

It is an object of the invention to provide a plug-in type temperature controlled oven having a case with a plug mounted at one end and a housing at the other end, a socket carried within the case for receiving a circuit component, and a heat source mounted in the case between the plug and socket with the heat source comprising a transistor and a voltage divider adapted for connection through the plug to a voltage source, with the voltage divider providing a current control for the transistor and with the transistor providing the heat for the oven.

The invention also comprises novel details of construction and novel combinations and arrangements of parts, which will more fully appear in the course of the following description. The drawing merely shows and the description merely describes preferred embodiments of the present invention which are given by way of illustration or example.

In the drawing:

FIG. 1 is a sectional view of a preferred form of the invention;

FIG. 2 is a schematic diagram of the circuitry of FIG. 1; and

FIG. 3 is a schematic diagram of an alternative circuit.

The oven of the present invention is particularly suitable for use in operating small electrical components at a substantially constant temperature. Typical components are a vacuum tube, a crystal, a transistor oscillator, a printed circuit board, sample and reference cells in colorimetric and spectrophotometric apparatus, and the like. The oven is illustrated herein in conjunction with a seven-pin miniature type vacuum tube, but, of course, any other component may be substituted therefor.

The oven includes a case **10** having an octal type plug **11** mounted at the lower end thereof with a retaining ring **12**. A housing **13** is a push fit over the upper end of the case **10**, with the housing, the case and the plug enclosing the oven space. A conventional seven-pin miniature socket **14** is mounted on an annular flange **15** fixed to the interior of the case **10**. The component the temperature of which is to be controlled, a vacuum tube **16**, is plugged into the socket **14** and may be retained in place by a conventional tube shield **17**.

A control circuit and heat source comprising a resistor **20**, a resistor **21**, a transistor **22** and a diode **23** is mounted within the case between the plug **11** and the socket **14**. The socket **14** and the circuit components **20–23** are wired to the plug **11**, permitting the oven to be installed and replaced at will in other electrical apparatus.

A wiring diagram for the circuitry of FIG. 1 is shown in FIG. 2. The components **20–23** are positioned within a chamber **26**, corresponding to the oven of FIG. 1. The cathode of the diode **23** is connected to one terminal of a secondary winding **27** of a transformer **28** and the anode of the diode is connected to the collector element of the transistor **22**. The emitter element of the transistor is connected to a tap on the secondary winding **27** and the base of the transistor is connected to a junction point **29** between the resistors **20, 21**. These resistors function as a voltage divider and are connected in series across the ends of the secondary winding **27**.

The resistor **20** is selected to have a resistance that varies with the temperature thereof, while the resistor **21** is selected to have a resistance that is substantially independent of its temperature. The power dissipated in the transistor provides the heat for the oven, the power and, hence, the heat being a function of the current therein. The transistor current is a function of the base-emitter potential which in turn is controlled by the relative resistances of the resistors **20, 21**. In considering the operation of the circuit, assume that the end **30** of the winding **27** is negative with respect to the end **31** and that the temperature within the oven is higher than desired. The resistor **20** is selected to have a positive temperature coefficient of resistance and, hence, its resistance will be greater than its normal value. Under these conditions, junction **29** will be more postive than normal and the transistor current will be reduced or completely cut off. Then the heat from the transistor will be reduced or eliminated and the temperature of the oven will drop. As the oven temperature falls, the resistance of the resistor **20** will also reduce to increase the heat supplied by the transistor, so as to maintain the oven at a particular operating temperature. Similary, if the temperature of the oven drops below the desired value, the resistance of the resistor **20** also drops below its normal value and the current in the transsistor is increased to increase the heat input to the oven. The diode **23** substantially limits current in the transistor to the half cycle when the collector is negative with respect to the emitter. Typically, the diode is a semiconductor device but any type of unidirectional rectifier may be used.

When the oven is operated as described above, an equilibrium point will be reached at the temperature where the power dissipated in the transistor is equal to the power lost from the oven by conduction, convection and radiation. The magnitude of the equilibrium temperature point can be controlled by controlling the value of the electrical power source and by the relative resistances of the resistors **20, 21**.

In the circuit of FIG. 2, the resistor **20** has a positive temperature coefficient while the resistor **21** preferably has a substantially zero temperature coefficient. The sensitivity of the control circuit can be increased by selecting the resistor **21** to have a negative temperature coefficient. The sensitivity can also be increased by providing amplification between the junction **29** and the transistor base. As another alternative, the resistor **20** may have a substantially zero temperature coefficient while the resistor **21** has a negative temperature coefficient. Of course, a npn transistor can be used instead of a pnp transistor, with appropriate polarity changes in the circuit.

It should be noted that in most present day transistors, the current, and consequently the heat dissipation of the transistor, increases with increasing temperature. Therefore, the sensitivity of the temperature sensing resistor or resistors must be adequate to overcome the adverse characteristic of the transistor.

In the embodiment of FIG. 1, a 2N277 transistor was operated from a 20 volts source at the secondary winding to maintain the oven temperature at 55° C. This particular transistor is rated at 55 watts at room temperature and was operated at a five to six watt level.

An alernative form suitable for operation from a D.C. source is shown in FIG. 3, wherein components identical to those of FIG. 2 are identified by the same reference numerals. The transistor collector is connected to the negative end of a D.C. power source **34** and the transistor emitter is connected to an intermediate voltage tap. The voltage divider comprising the resistors **20, 21** is connected across the source **34**. The operation of this circuit is the same as that of FIG. 2. In both FIGS. 2 and 3 it should be noted that only the transsistor and the temperature sensitive resistor need be placed within the oven, the control circuit being fully operative with the other resistor and the diode, where used, positioned exteriorly of the oven itself.

Although exemplary embodiments of the invention have been disclosed and discussed, it will be understood that other applications of the invention are possible and that the embodiments disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

I claim as my invention:

1. In an oven, the combination of: an enclosed chamber; a source of A.C. voltage having first and second end terminals and an intermediate terminal; a transistor positioned within said chamber and having a collector element, an emitter element and a base, with said elements connected across said intermediate and first terminals of said source; a rectifier unit connected in series with said collector element for unidirectional current in said transistor; a first resistor connected across said first terminal and said transistor base; and a second resistor connected across said second terminal and said transistor base, with at least one of said resistors positioned within said chamber and with the resistance of said one resistor varying as a function of the temperature thereof for controlling the current in said transistor and, hence, the heat produced thereby.

2. In an oven, the combination of: an enclosed chamber; a source of A.C. voltage having first and second end terminals and an intermediate terminal; a transistor positioned within said chamber and having a collector element, and emitter element and a base, with said elements

connected across said intermediate and first terminals of said source and with power dissipation in said transistor providing the heat within said chamber; a rectifier unit connected in series with said collector element for unidirectional current in said transistor; a first resistor positioned within said chamber and connected across said first terminal and said transistor base, with the resistance of said first resistor varying as a function of the temperature thereof; and a second resistor positioned within said chamber and connected across said second terminal and said transistor base, with the resistance of said second resistor substantially independent of the temperature thereof.

3. In a plug-in type temperature controlled oven, the combination of: a case; a plug mounted at one end of said case; a housing mounted at the other end of said case, with said housing, case and plug defining an oven space; a socket carried within said case for receiving a circuit component disposed within said oven space; and a heat source mounted in said case between said plug and socket, said heat source comprising a transistor having a collector element, an emitter element and a base, with said elements adapted for connection through said plug across the first end and intermediate terminals of a voltage source, and a voltage divider adapted for connection through said plug across the first and second end terminals of the voltage source, with a tap of said divider connected to said transistor base, and with the potential at said tap varying as a function of the temperature of said divider for controlling the current in said transistor and, hence, the heat produced thereby.

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RICHARD M. WOOD, *Primary Examiner.*

W. STOLWEIN, *Examiner.*

L. H. BENDER, *Assistant Examiner.*