

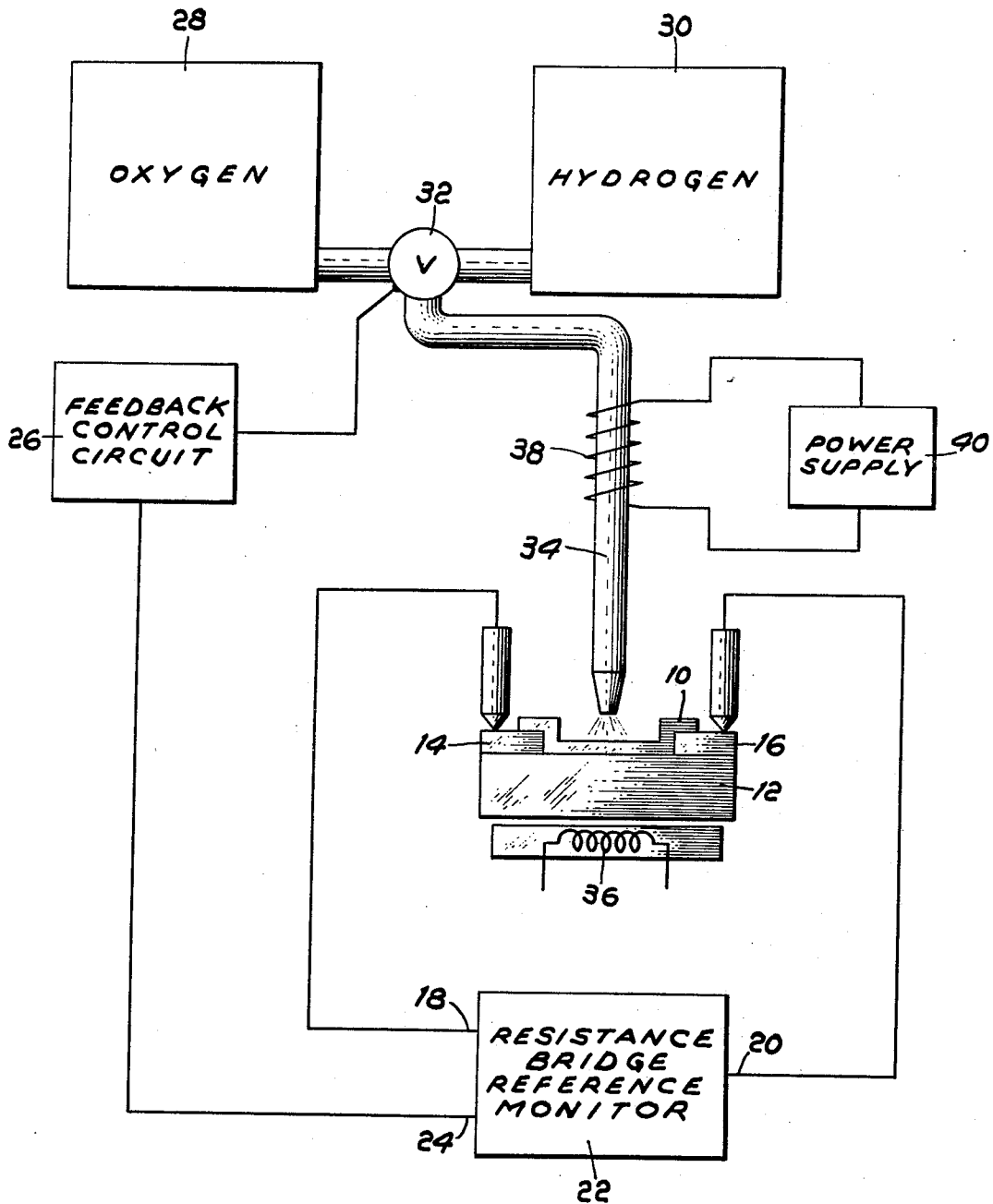
Dec. 2, 1969

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3,481,306

APPARATUS FOR CHEMICAL ADJUSTMENT OF FILM COMPONENTS

Filed April 27, 1967



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1

2

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APPARATUS FOR CHEMICAL ADJUSTMENT OF FILM COMPONENTS

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Filed Apr. 27, 1967, Ser. No. 634,360
Int. Cl. H01c 17/00

U.S. Cl. 118—8

6 Claims

ABSTRACT OF THE DISCLOSURE

Vitreous enamel film resistors are adjusted to highly accurate tolerances utilizing reversible gaseous oxidation and reduction reactions which permit bi-directional trimming of resistance values.

BACKGROUND OF THE INVENTION

Field of the invention

The present invention relates to the manufacture of film resistors and particularly to a gaseous reaction method and apparatus for bi-directional chemical adjustment of film resistors to predetermined resistance values.

Description of the prior art

Vitreous enamel film resistors are generally prepared by a screen printing process wherein viscous pastes or inks are deposited through a patterned fine mesh metal screen onto suitable ceramic substrates. Resistor characteristics are then established by air firing the components at elevated temperatures. A known composition of such a resistor includes a mixture of palladium and silver imbedded in a glass matrix, as described in U.S. Patent No. 2,924,540 issued Feb. 9, 1960. Accuracy of present techniques for obtaining predetermined resistance values is limited by many variables such as the change of viscosity of resistor inks, screen wear and varying conditions during firing, and tolerances of only 5 to 10% are possible. More accurate tolerances must be obtained by special trimming after firing.

Two general methods of adjusting or trimming resistors to exact values have been employed; the electric probe method and air abrasion or sand blasting. Both methods are destructive, in that they increase resistance by mechanically removing resistor material and also damage the protective glaze surface which causes the resistor to be exposed to environmental conditions.

These methods have allowed adjustment of resistance in only one direction, which was usually that of increasing the resistance. As a result, it has become standard to produce resistors on the low side of the desired resistance value and then to trim them up to a more accurate value if necessary. Difficulties occur, however, in forming more complex microcircuits utilizing different resistor links where trimming of the entire circuit arrangement is required. It is thus desirable to have a more flexible, simplified, non-destructive process which permits trimming in a bi-directional manner to increase or decrease the value of a resistor.

Other methods for producing different types of resistors have employed heated atmospheres of particular gases. An example of the use of a reducing gas followed by reoxidation to improve the stability of resistors, is described in U.S. Patent No. 2,717,946 issued Sept. 13, 1955. It has now been found that such reducing an oxidizing gases may be employed in a novel arrangement to trim vitreous enamel film resistors.

SUMMARY OF THE INVENTION

It is therefore the primary object of the present invention to provide an improved method and apparatus for bi-directional chemical trimming of resistance values in a non-destructive highly accurate manner.

These results are achieved by a novel reversible gaseous reaction wherein selectively applied oxidizing and reducing atmospheres are directed at one portion of a vitreous enamel film resistor to cause an oxidation reaction which increases the resistance or a reduction reaction which decreases the resistance. The details of the invention may be more fully understood and other objects and advantages become more apparent by reference to the following description and accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The figure is a schematic diagram illustrating the apparatus employed in the novel resistor trimming method of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in the figure, a vitreous enamel resistor body 10 of a thick film type preferably formed of palladium and silver imbedded in a glass matrix, is fired onto a suitable high melting point ceramic substrate 12 such as alumina (Al_2O_3) which is the standard material, beryllium oxide, porcelain, glass or steatite. Other elements such as indium, platinum or tungsten may be used to form other vitreous enamel resistor compositions. Two terminals 14, 16 are positioned at opposite ends of the resistor and are respectively connected to two terminals 18 and 20 of a resistance bridge reference monitor 22 which provides intermittent or continuous measurement of the resistor value and establishes a predetermined reference resistance for the processed resistor to meet. A third terminal 24 is connected from the bridge to a suitable feedback control circuit 26. This circuit can selectively control the type and quantity of gas supplied by tanks 28 and 30, respectively containing oxidizing and reducing gases, through a valve 32 and can shut the valve when the desired resistor value is obtained. Gas tubing 34 of a suitable material, having a narrow orifice over the resistor, directs a stream of gas at the surface. The substrate and gas are preferably heated by electrically energized heating coils 36, 38 positioned respectively below the substrate and around the tubing, to increase the speed of the reactions. The coils are connected to a suitable alternating current power supply 40.

In operation, upon application of a reducing gas such as a mixture of 85% nitrogen and 15% hydrogen, a hydrogen reduction reaction takes place at the surface of resistor body 10 and in a known manner releases oxygen from the body to reduce the resistance of the metal layer. The addition of nitrogen minimizes the volatility of the reducing gas. On the other hand, by reversing valve 32, pure oxygen is applied to the resistor surface to cause an oxidation reaction which forms an oxide layer on the surface and increases the resistance. The type of gas and quantity are thus selectively controlled to permit variable adjustment of resistor values.

Test results have been obtained with resistive inks of the DuPont 8000 series which provide typical resistance values of from 3000–5000 ohms per square unit of a predetermined length, width and thickness. A plurality of such units available in different sizes and ratings may be connected in series to obtain a desired range of resistance. Trimming rates of from 16 to 120 ohms per minute have been obtained with a gas pressure of 10 p.s.i. supplied at a rate of 4 cubic feet per hour. Under these conditions, the reduction mode can provide a decrease of up to –66% and the oxidation mode an increase of up to +25% of

3

the nominal resistance after about 5 and 15 minutes respectively. The substrate was heated to 350° F. and the gas between 105 and 155° C.

Close monitoring has achieved resistance trimming to 0.1% of the design value. The bi-directional operation permits simplification of the process, while the nature of the chemical reaction preserves the hermeticity of the resistor glaze and retains the geometrical configuration and power handling capability. Instrumentation and control are easily implemented since trimming can be performed in either direction, any number of times, in any sequence and at any rate, with little power consumption.

It is thus apparent that the present invention provides a novel, fast efficient and accurate method and apparatus for bidirectional adjustment of vitreous enamel film resistors. While only a single embodiment has been illustrated, it is to be understood that the invention is not limited to the exact form or use shown and that many other variations may be made in the particular design and configuration without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. Apparatus for adjusting vitreous enamel film resistors comprising,
a pair of terminals connected to spaced portions of said vitreous enamel resistor,
means for selectively applying a reactive gas from said sources to a surface of said resistor a source of an oxidizing gas, a source of a reducing gas, between said terminals to cause reversible oxidation and reduction reactions on said surface to respectively increase and decrease the resistance of said resistor, means for measuring the resistance between said terminals, and

4

means for removing said gas upon reaching a predetermined value of resistance.

2. The apparatus of claim 1 wherein said oxidizing gas is oxygen and said reducing gas is a mixture of nitrogen and hydrogen.

3. The apparatus of claim 1 wherein said resistor is a thick film resistor of palladium and silver imbedded in a glass matrix.

4. The apparatus of claim 1 including means sensing the difference in resistance between said predetermined value and measured value and automatically controlling the application of said gases to obtain said predetermined value.

5. The apparatus of claim 3 wherein said gas means comprises tubing having a narrow orifice positioned over said resistor surface.

6. The apparatus of claim 3 including means for heating said gas and substrate.

References Cited

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U.S. Cl. X.R.

29—620; 117—106

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,481,306

December 2, 1969

James A. O'Connell et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, lines 28 and 29, after "resistor" cancel "a source of an oxidizing gas, a source of a reducing gas," and insert same after "resistor," in line 26, same column 3.

Signed and sealed this 29th day of December 1970.

(SEAL)

Attest:

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Commissioner of Patents