

[54] **APPARATUS FOR RECHARGING A TR TUBE**

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[22] Filed: **Feb. 1, 1973**
[21] Appl. No.: **328,828**

[52] **U.S. Cl.**..... **316/28, 313/175, 316/2**
[51] **Int. Cl.**..... **H01j 9/50**
[58] **Field of Search**..... **316/28, 1, 2, 27, 30; 313/174, 175, 180, 223; 417/48; 55/158**

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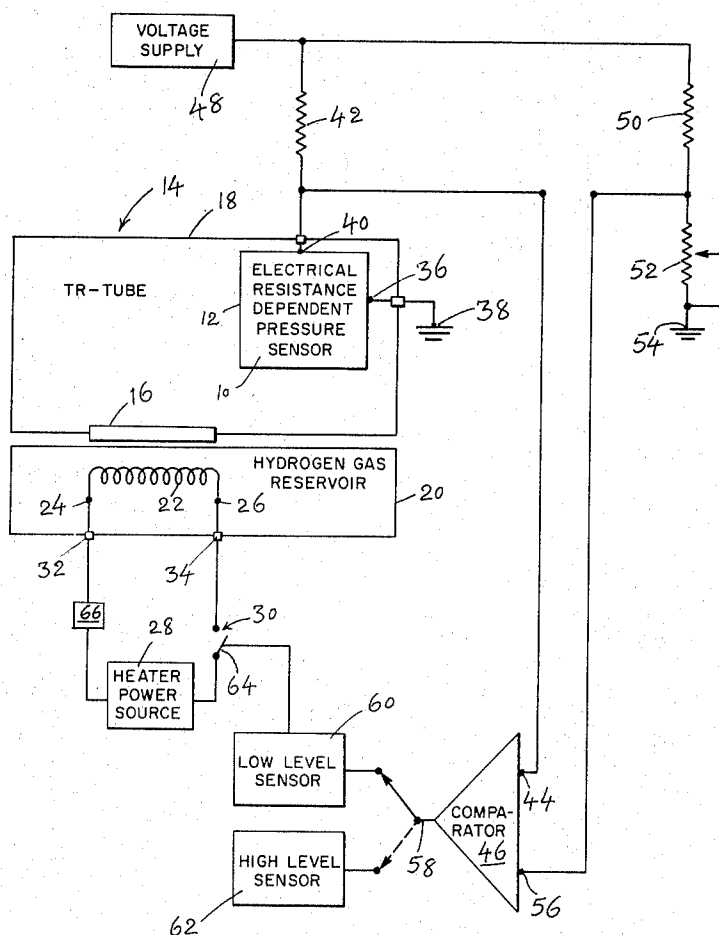
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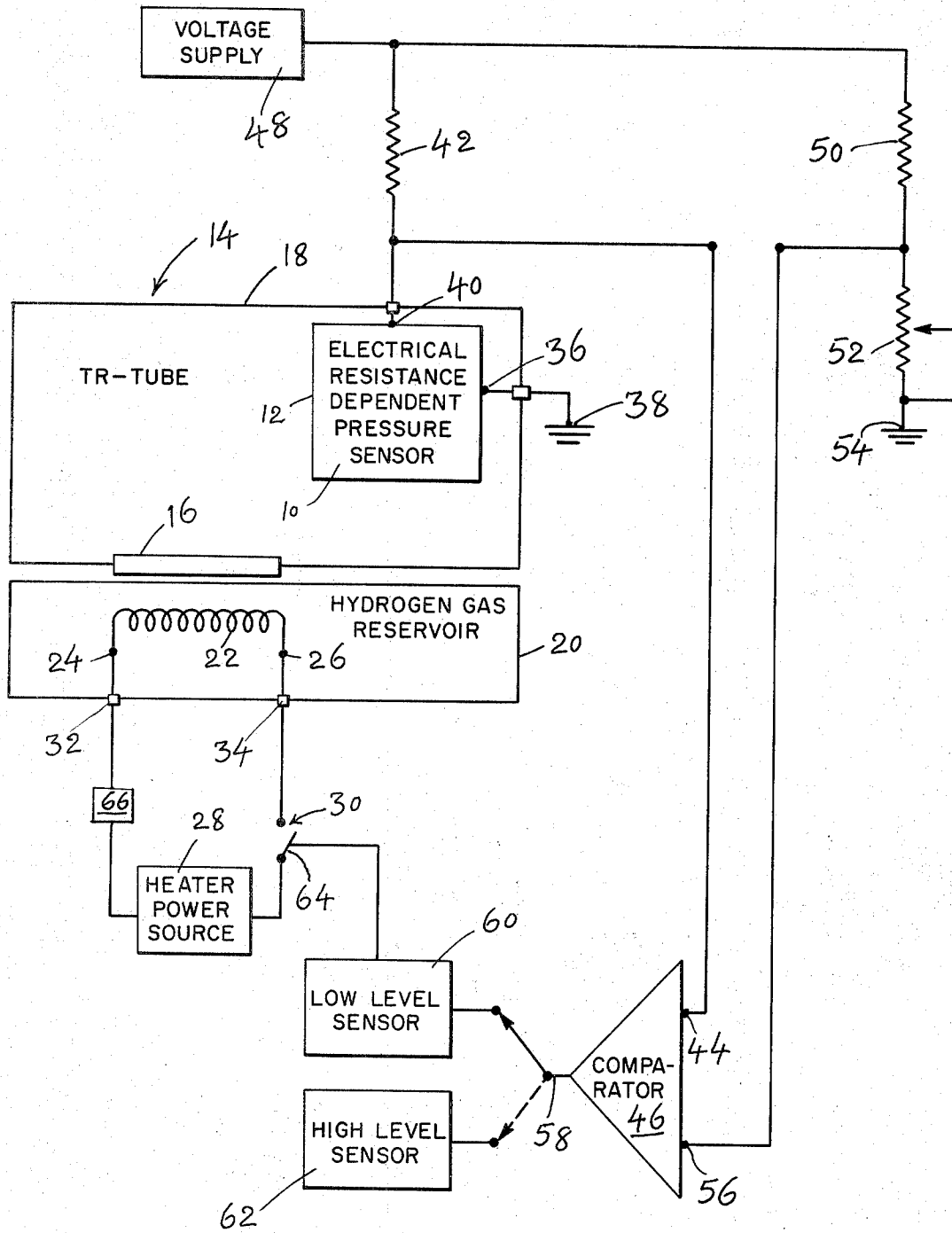
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[57] **ABSTRACT**

A hydrogen gas reservoir outside main discharging chamber of a transmitter-receiver tube is allowed to leak hydrogen at a controlled rate through a palladium window in the envelope of the TR tube. An automatic pressure controlling unit is provided which comprises an electrical bridge circuit with a pressure sensing element in one arm of the bridge. An imbalance in the bridge circuit turns on a heater which raises the temperature of the palladium window which in turn lets hydrogen from the reservoir pass through it to re-charge the TR tube.

7 Claims, 1 Drawing Figure





APPARATUS FOR RECHARGING A TR TUBE

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to an apparatus for controlling hydrogen pressure in a tube and more particularly to an apparatus for recharging a transmitter-receiver tube, hereinafter called a TR tube, to allow the TR tube to meet recovery time specifications and thus increase its useful life.

Complex clean-up behavior has been studied in gas discharges not of microwave nature. It has been found that clean-up, and subsequent thermal recovery of the sorbed gas following the discharge varies with discharge intensity, ambient temperature, wall materials, and type of gas. In microwave gas-discharge switching devices, clean-up is one of the major factors limiting operating life. Various studies have shown that a predominant life limiting process of a TR tube, is loss of hydrogen resulting from activated diffusion. The principal mode of failure which can be attributed to the hydrogen loss is that the TR tubes fail to meet the recovery specification. Once a TR tube loses its hydrogen due to activated diffusion, it becomes unfit for use. No satisfactory means has been used in the past to recharge such TR tubes once they fail to meet the recovery time specifications.

SUMMARY OF THE INVENTION

The apparatus of the present invention for recharging a TR tube comprises an electrical bridge circuit which uses an electrical resistance dependent pressure sensor as one of the arms of a wheatstone bridge type circuit. A variable resistance is used in one of the other arms of the bridge circuit. The pressure sensor is installed inside the TR tube. Any change in hydrogen pressure inside the TR tube changes the electrical resistance of the pressure sensor, thereby disturbing the balance of the bridge circuit. The imbalance in the bridge circuit turns on a heater element which is located outside the TR tube near a window installed in the envelope of the TR tube. The window is made of a hydrogen absorbing material such as palladium. As the temperature of the window is raised, hydrogen passes through the window into the TR tube to attain a desired hydrogen pressure inside the TR tube.

One object of this invention is to recharge a TR tube and thereby increase the useful life thereof.

Another object of this invention is to control the pressure of hydrogen in a TR tube.

Still another object of this invention is to meet the recovery time specification of a TR tube.

Another object of this invention is to avoid frequent failures of TR tubes resulting from loss of hydrogen pressure due to activated diffusion.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanied drawings, the single FIGURE of which illustrates an apparatus for recharg-

ing a TR tube constructed in accordance with the teachings of the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

An apparatus for recharging a TR tube is shown diagrammatically in the drawing. The apparatus comprises an electrical resistance dependent pressure sensor 10 shown by block 12 inside a TR tube 14 having a window 16 which forms a part of the envelope 18 of the TR tube. Window 16 of the TR tube 14 is made of a hydrogen absorbing material, preferably palladium. A hydrogen gas reservoir 20 is fitted with a heater element 22, which has its terminals 24 and 26 connected to a heater power source 28 through a switch 30. The heater element 22 is insulated from the hydrogen reservoir 20 at points 32 and 34. The heater 22 is located inside reservoir 20 so that it is adjacent window 16 of the TR tube 14. The pressure sensor 10 is preferably a thermister element with its electrical resistance varying with its temperature. Terminal 36 of the pressure sensor 10 is connected to a ground terminal 38. Terminal 40 of the pressure sensor is connected to one end of the resistor 42 and is also connected to terminal 44 of a comparator 46. The other end of resistor 42 is connected to a voltage supply 48 and is also connected to one end of resistor 50. The second end of resistor 50 is connected to one end of a variable resistor 52 which has its other end connected to a ground terminal 54. The second end of resistor 50 is also connected to terminal 56 of comparator 46. The output terminal 58 of comparator 46 can be connected either to a low level sensor 60 or to a high level sensor 62. Low level sensor 60 is connected to the movable arm 64 of switch 30. The comparator 46 is preferably a high gain D.C. amplifier which is used to compare voltage inputs at terminals 44 and 56 of comparator 46. Voltage supply 48 is a regulated D.C. power supply, preferably supplying 9 volts. Heater power source 28 can be any A.C. or D.C. power source. Switch 30 is preferably a conventional magnetic relay. Numeral 66 represents a charging indicator light in the heater circuit which is energized when the heater circuit is on upon closing of switch 30. Pressure sensor 10, resistors 22, 50, and 52 form a wheatstone bridge type circuit. Pressure sensor is a part of the TR tube with terminals 36 and 40 insulated from the TR tube.

OPERATION OF THE CIRCUIT

An electrical bridge circuit comprising pressure sensor 10, resistor 42, resistor 50 and resistor 52 is provided with a D.C. voltage, preferably 9 volts D.C. and variable resistor 52 is changed in such a way that comparator 46 gives a null reading at its output terminal 58. This makes the circuit ready for use. As the pressure of hydrogen gas inside the TR tube 14 decreases because of activated diffusion, the temperature of pressure sensor 10 increases because of less transfer of heat by convection around pressure sensor 10. This results in an increase of electrical resistance of the pressure sensor 10 which in turn disturbs the balance in the electrical bridge circuit. The imbalance in the electrical bridge circuit disturbs the null setting at the output terminal 58 of the comparator 46. The output terminal 58 is first connected to high level sensor 62 to ascertain whether the loss of hydrogen pressure in the TR tube is too high to recharge the TR tube. If the high level sensor 62 is

energized as a result of the signal at terminal 58, the TR tube is considered to be so low in its hydrogen pressure inside that it is beyond any recharging state. The level in the high level sensor 62 can be set at a predetermined level; as desired. However, if the signal at output terminal 58 does not energize high level sensor 62, terminal 58 is then connected to the low level sensor 60. Low level sensor 60 is set to be energized for all signals below the predetermined level set in the high level sensor 62. Once low level sensor 60 is energized because of the signal from terminal 58 of comparator 46, switch 30 in the heater circuit is closed and heater power source 28 heats heater element 22 and at the same time activates light 60 to indicate that the TR tube is being recharged. An increase in temperature of heater element 22 heats up window 16 of TR tube 14 and thereby makes window 16 porous to hydrogen. Hydrogen gas from reservoir 20 then passes through window 16 to increase hydrogen pressure inside TR tube 14. This increase in hydrogen pressure increases heat transfer by convection around pressure sensor 10 inside the TR tube 14 and results in a decrease of electrical resistance of the pressure sensor 10. This process continues until the electrical bridge circuit reaches a balanced condition again and a null position is reached at the output terminal 58 of comparator 46 and low level sensor 60 is de-energized and heater circuit is opened.

Thus, the apparatus of this invention for recharging a TR tube comprises a pressure sensor housed inside the TR tube which acts as one arm of an electrical bridge circuit. The electrical bridge circuit is balanced by using a variable resistor as one of the other arms of the bridge circuit. Any change in hydrogen pressure inside the TR tube due to activated diffusion changes the electrical resistance of the pressure sensor and thus disturbs the balanced condition of the bridge circuit. The unbalanced condition of the bridge circuit provides power to a heater element housed in a hydrogen gas reservoir, the heater element being located near a hydrogen absorbing window of the TR tube. An increase in temperature of heater element raises the temperature of a hydrogen absorbing window which then allows a hydrogen gas from reservoir until a balanced condition of the bridge circuit is attained.

Obviously many modifications and variations of the

present invention are possible in the light of the above teachings. As an example, a different bridge arrangement may be used. Furthermore, different setup other than a high gain D.C. amplifier can be used in order to sense the condition of the bridge circuit. It is therefore understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. An apparatus for recharging a TR tube having an envelope, comprising:

a pressure sensor housed inside the TR tube envelope;

a hydrogen-absorbing window forming a part of the wall of said TR tube;

a hydrogen gas reservoir located external of said TR tube envelope and in communication with said window;

a heater element mounted in said reservoir adjacent said hydrogen-absorbing window of said TR tube; and

means for energizing said heater element in response to loss of hydrogen gas pressure inside said TR tube as indicated by said pressure sensor.

2. The apparatus of claim 1 wherein said pressure sensor is an electrical resistance dependent pressure sensor.

3. The apparatus of claim 2 wherein means for energizing said heater element comprises an electrical bridge circuit having said electrical resistance dependent pressure sensor as one of the arms of the bridge.

4. The apparatus of claim 3 wherein said electrical bridge further comprises a high gain D.C. amplifier for sensing the null condition of said electrical bridge.

5. The apparatus of claim 2 wherein said electrical resistance dependent pressure sensor is a thermistor.

6. The apparatus of claim 3 wherein said electrical bridge further comprises a low level sensor and a high level sensor.

7. The apparatus of claim 1 wherein said hydrogen-absorbing window mounted in the envelope of said TR tube is a palladium window.

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