United States Patent Office

2,915,355

Patented Dec. 1, 1959

2,915,355

INSULATING HEATER WITHIN CATHODE SLEEVES

Ture H. Carlstrom, Shippen Township, Cameron County, Pa., assignor, by mesne assignments, to Sylvania Electric Products Inc., Wilmington, Del., a corporation of Delaware

No Drawing. Application September 9, 1957
Serial No. 682,610

5 Claims. (Cl. 316—1)

My invention relates to a method for improving the operating characteristics of vacuum tubes. More particularly it deals with a method for reducing the hum level of said tubes which is due to heater-cathode leakage while not disturbing the other electrical characteristics of the tubes.

An object of my invention is to provide a method for reducing the hum level of vacuum tubes to levels below those encountered in the tubes manufactured by prior art methods.

A further object of my invention is to provide a method for reducing the time required to age vacuum tubes.

Another object of my invention is to provide a method for satisfactorily reaging tubes which, having been aged by previously known methods, had been rejected because they showed an unacceptable hum level due to heater-cathode leakage current.

Still another object of my invention is to provide a method for producing tubes which are more resistant to change in leakage due to drop tests or to rough handling during transportation.

The present method of aging vacuum tubes which have an alumina insulated indirectly heated cathode, as is widely practiced, comprises what is known as "burn-in," i.e., operating the completed tube for a period of several hours with an applied steady filament voltage 30% to 50% in excess of the rated voltage. Broadly, my invention consists of cycling the applied filament voltage from a value approximately 50% of the rated filament voltage to approximately 200% of the rated filament heater voltage, while applying a direct current potential between the cathode and heater of an otherwise fully processed tube.

To demonstrate the efficacy of this method in comparison to the prior art standard ageing technique, tests were made on tubes taken directly from the production line. The tube in this case was a type 12AT7 which is a duotriode having separate heaters and cathodes. Each section is treated as a separate unit in the following tabulations showing the distribution of the results obtained. In these tabulations Table I sets forth the measurement of hum voltage (in millivolts) and Table II sets forth the measurement of heater-cathode leakage current (in microamperes, D.C.). In both tables column (*a*) is the distribution of unaged tubes taken directly from the production line; column (*b*) is the distribution of tubes aged by the new method which in this exemplification of the invention consists in varying the normal 6.3 volt heater voltage, stepwise, both heaters being in parallel, between 4 volts and 16 volts with a 10 second dwell at each voltage, for a total period of five minutes, while a direct current voltage of the order of 100 volts is applied between the cathode and heater, with the cathode positive; column (*c*) is the distribution obtained from measurements of tubes aged in production by a prior standard method and column (*d*) is the distribution of the tubes of column (*c*) after being again aged by the new method.

Table I—Measurement of Hum Voltage 12AT7

Millivolts	(*a*) Initial Unaged Condition	(*b*) Aged by New Method	(*c*) Aged by Prior Method	(*d*) Prior Method Aged Tubes Re-Aged by New Method
0–5				1
5–10	3	23	1	22
10–20	7	4	6	5
20–40	1		4	
40–80	6	2	10	1
80–160	5		3	
160–320	4	1	2	
320–640	2		3	1
640–1280	1			
1280–2560	1			

Table II—Measurement of Heater-Cathode Leakage Current 12AT7

Micro Amperes, D.C.	(*a*) Initial Unaged Condition		(*b*) Aged by New Method		(*c*) Aged by Prior Method		(*d*) Prior Method Aged Tubes Re-Aged by New Method	
	+	−	+	−	+	−	+	−
.01–.02	4		3		5		7	
.02–.04		1	8	1	1	2	10	5
.04–.08		11	3	10	1	5	5	14
.08–.16	1	14	6	15		18	2	6
.16–.32	4	4	5	4		2	2	3
.32–.64	2		3		4		1	
.64–1.28	4		1		8	2		
1.28–2.56	9		1		2	1	1	
2.56–5.12	5				6			
5.12–10.24	1				3			
10.24–20.48								

(+, −, indicate heater polarity with respect to the cathode.)

From the tables may be seen the wide distribution of values of hum voltage and heater-cathode leakage current which is present in the unaged tube and in those aged by prior methods. This results in uneven performance from tube to tube and is a cause for rejection for some uses. The new method results in a concentration of the distribution at low values which of course is extremely beneficial. This concentration also occurs in tubes which have been re-aged by the new method after being aged by the prior art methods.

Tests on other tube types have shown that the heater time cycle may be varied from a ratio of 1 to 1 to a ratio of 1 to 3, the first term of the ratio being the duration of high voltage and the second term of the ratio being the duration of low voltage, without adversely affecting the reduction of hum level. The D.C. potential applied between the cathode and heater during the processing in the new method is dependent upon the spacing between them. In tube types such as the 12AT7, which have close spacing, 100 volts is sufficient; while in tubes such as the 6W4 or 6AX4, which have a widely separated heater and cathode, higher voltages may be required to realize this benefit. Further tests with the cathode negative and the heater positive have disclosed that the hum level was reduced but not to the extent obtained when the heater is maintained negative relative to the cathode. In some instances an increase in hum level has been found to occur by this last method, possibly due to insulation breakdown.

As can also be ascertained from the above tables and in conjunction with the previous discussion, a considerable reduction in the time required to age vacuum tubes has been obtained with the new method. With prior art ageing techniques a period of several hours is required as compared to the short time required by the new method.

While the actual mechanics of what occurs is not fully understood, it is believed that periodic cycling of the filament voltage aids the migration of some of the aluminum oxide coating from the heater to the interior of the cathode, thus creating a higher resistance between the heater and cathode and causing a reduction in heater-cathode leakage currents. Periodic cycling reduces the damage done to the tube parameters as the heater must attain a very high temperature to release any aluminum oxide for transfer under influence of the temperature and the imposed electric field. If the cathode were continuously operated at this temperature it would ruin the performance of the tube. The transference of the aluminum oxide apparently results in a more adherent coating on the interior of the cathode sleeve which reduces the susceptibility of the tube to change in heater-cathode current leakage due to drop testing or rough handling during transportation.

What is claimed is:

1. A method for reducing heater-cathode leakage currents in a fabricated vacuum tube having an indirectly heated cathode comprising the steps of applying to the heater a stepped heater voltage varying between 50% and 200% of the rated heater voltage with a ratio of dwell at high voltage to dwell at low voltage within the range from one to one third, and applying a positive potential to said cathode with respect to said heater.

2. A method for reducing heater-cathode leakage currents in a fabricated vacuum tube having an indirectly heated cathode comprising the steps of applying to the heater a stepped heater voltage varying between 50% and 200% of the rated heater voltage with a ratio of dwell at high voltage to dwell at low voltage within the range from one to one third, and applying a direct current potential of the order of 100 volts between said heater and said cathode, with said cathode positive with respect to said heater.

3. A method for reducing heater-cathode leakage currents in a fabricated vacuum tube having an indirectly heated cathode comprising the steps of applying to the heater a heater voltage varying between 50% and 200% of the rated heater voltage and applying a direct current potential between said heater and said cathode with said cathode positive with respect to said heater.

4. A method for reducing heater-cathode leakage currents in a fabricated vacuum tube having an indirectly heated cathode comprising the steps of applying to the heater a heater voltage varying between 50% and 200% of the rated heater voltage and applying a direct current potential of the order of 100 volts between said heater and said cathode with said cathode positive with respect to said heater.

5. A method for reducing heater-cathode leakage currents in a fabricated vacuum tube having an indirectly heated cathode comprising the steps of applying to the heater a stepped heater voltage varying between 50% to 200% of the rated heater voltage with a dwell at each voltage of 10 seconds for a period of five minutes and applying a direct current potential of the order of 100 volts between said heater and said cathode with said cathode positive with respect to said heater.

References Cited in the file of this patent

UNITED STATES PATENTS

2,413,707	Helliar	Jan. 7, 1947
2,435,475	Stromeyer	Feb. 3, 1948
2,774,645	Batchelor	Dec. 18, 1956