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METHOD OF TREATING ELECTRONIC-EMISSION DEVICES.

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This invention relates to devices of the type utilizing electronic emission from heated cathodes, of which class of devices the audion tube is an example; and comprises a novel method for improving the emissive characteristics of such devices. In its preferred embodiment my method improves the emissivity of the heated cathode element of such tubes in two important respects; first, by increasing the emissivity under normal or even abnormal operating conditions; and second, by rendering the emissive element or cathode less sensitive to conditions destructive of or injurious to its emissivity. I will describe my invention with specific reference to the treatment of a filament mounted in audion tubes of types commonly used for radio reception, but it is to be understood that these examples are illustrative only, and that the method is applicable with appropriate modification of its conditions to a wide variety of devices depending upon electronic emissivity from heated cathodes.

The filaments of such tubes are commonly made of tungsten, which is either admixed with a relatively small proportion of thorium oxid (thoria) or alloyed with metallic thorium. Either of these additions improves the emissivity of the filament, although the characteristics of the two types of filament are quite different in certain respects. My method, now to be described, is applicable to both the alloy and oxid types of filament, tending in either case to increase the emissivity, and markedly improving the stability of the filament, that is, reducing its sensitiveness to otherwise destructive conditions.

It is well known that the emissivity of thoriated filaments is rapidly reduced when they are subjected at an abnormally high temperature (that is to say, at a filament voltage substantially above the normal operating voltage) to a high plate voltage: and my experiments have demonstrated that thorium alloy filaments act under these conditions in

a somewhat similar manner although to a lesser extent. It is a characteristic feature of my invention that it utilizes as the first or preliminary step in the improvement of the filament, this supposedly destructive action of high plate voltage at high temperature, preferably continuing this action until the emissivity has fallen to half or less of its initial value. Thereafter, as a second operating step, the plate voltage is discontinued and the high filament voltage continued for a further period, and until the emissivity of the filament is restored to the desired degree, which is usually but not necessarily higher than the initial emissivity.

It will readily be understood that the numerical value of the filament and plate (or grid) voltages, as well as the duration of the treatments, may vary somewhat widely according to the size and type of the audion tube or other electron emissive device. Accordingly the following examples are to be regarded as illustrative only. In these examples the tube designated "thoriated filament" was of the type commercially known as "U. V. 201 A", having in addition to plate and grid, a filament of tungsten containing a small admixture of thoria, and designed for operation at 5 volts and 0.25 amperes. The tube designated "alloy filament" was similar in size and construction, but contained a tungsten filament having alloyed therewith approximately one % of metallic thorium. In both cases, the negative terminal of a 100 volt battery was connected to a filament terminal, the positive terminal of the same battery being connected through a milliammeter to both plate and grid. Under these conditions the milliammeter indicated the total emission, and it was possible to note the decrease in emission under the "stripping" action of the ionic bombardment. In order to observe the effect of the drop in emission on the behavior of the tube, measurements of the mutual conductance were likewise made. In each case

the test was continued until the emission fell to or below 14 milliamperes.

Thoriated filament.

Elapsed time	Emission (milliamperes)			Mutual conductance (micro-mhos)		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
Start.....	43	25	20	860	620	680
1 minute.....	22	10	13	780	340	570
3 ".....	16			660		
5 ".....	12			560		
10 ".....	9			420		
15 ".....	9			420		

Alloy filament.

Elapsed time	Emission (milliamperes)		Mutual conductance (micro-mhos)	
	No. 4	No. 5	No. 4	No. 5
Start.....	30	35	860	840
1 minute.....	25	32	860	840
3 ".....	21	26	860	840
5 ".....	18	24	820	840
10 ".....	15	21	760	840
15 ".....	14	19	710	820

Thereafter these several tubes were subjected to a stripping and aging treatment according to my invention, and as below described: and upon re-testing under precisely the same conditions as before, it was found that their initial emissivity had been restored or even increased, and that they were distinctly less sensitive to the bombardment. The tubes, after treatment, gave results as follows:

Thoriated filament.

Elapsed time	Emission (milliamperes)			Mutual conductance (micro-mhos)		
	No. 1	No. 2	No. 3	No. 1	No. 2	No. 3
Start.....	41	37	45	840	620	860
1 minute.....	40	32	43	840	620	860
3 ".....	37	29	37	840	620	860
5 ".....	34	24	35	840	620	860
10 ".....	29	20	32	840	610	840
15 ".....	27	18	29	820	580	840

Alloy filament.

Elapsed time	Emission (milliamperes)		Mutual conductance (micro-mhos)	
	No. 4	No. 5	No. 4	No. 5
Start.....	37	40	850	840
1 minute.....	36	39	850	840
3 ".....	35	37	850	840
5 ".....	35	35	850	840
10 ".....	34	32	850	840
15 ".....	33	29	850	820

By comparing the behavior of these tubes before and after treatment it will be observed that the rate of drop of emission is in all cases much less after treatment: in other words the filaments have been rendered far less sensitive to the ionic bombardment to which they are subjected either in nor-

mal operation or under the extreme conditions recited above. Also their initial emissivity is in general higher after than before the treatment.

The specific beneficiating treatment to which these particular tubes were subjected consisted in superheating the filaments by subjecting them to a supernormal filament voltage, in this case 6.7 volts, for a period of fifteen minutes, the filament terminal being at the same time connected to the negative pole of a 125 volt battery, the positive pole of which was connected to both plate and grid, whereby the filament was subjected to a very intensive stripping action. Following this stripping step the plate voltage was discontinued and the superheating of the filament under the 6.7 volt filament current was continued for one hour.

As already explained these specific values apply only to particular types of tubes, and it is to be understood that the optimum treating conditions may vary rather widely with differing types of tubes or even with tubes of the same type made by different manufacturers. But so far as my observation has extended the optimum conditions in all cases involve superheating the cathode (filament) in presence of a high anode potential; followed by a further or "ageing" process in which the superheating is continued, preferably for a much longer period, and either in the absence of anode potential or with so low a potential as will not interfere with the ageing operation. It is to be understood that the expression "absence of anode potential" as used herein means absence of anode potentials of sufficient magnitude to amount to a continuance of the first or stripping operation. While I prefer to continue the heating of the cathode in absence of anode potential under supernormal filament voltages, that is to say under superheat conditions, I may with less advantage substitute a more prolonged ageing treatment at temperatures equal to or even somewhat below normal operating temperatures; but I regard such procedure as both less effective and less desirable than the continuance of the superheat conditions during this ageing step.

I claim:

1. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a high anode potential to reduce the emissivity, and thereafter further heating the cathode in absence of anode potential.

2. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a high anode potential until the emissivity under normal operating conditions has fallen to less than one-half its

initial value, and thereafter further heating the cathode in absence of anode potential.

3. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a super-normal anode potential to reduce the emissivity, and thereafter further heating the cathode in absence of anode potential.

4. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a super-normal anode potential until the emissivity under normal operating conditions has fallen to less than one-half its initial value, and thereafter further heating the cathode in absence of anode potential.

5. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a high anode potential to reduce the emissivity, and thereafter further superheating the cathode in absence of anode potential.

6. Method of treating electronic emission

devices to improve their emissive characteristics, comprising superheating the cathode in presence of a high anode potential until the emissivity under normal operating conditions has fallen to less than one-half its initial value, and thereafter further superheating the cathode in absence of anode potential.

7. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a super-normal anode potential to reduce the emissivity, and thereafter further superheating the cathode in absence of anode potential.

8. Method of treating electronic emission devices to improve their emissive characteristics, comprising superheating the cathode in presence of a super-normal anode potential until the emissivity under normal operating conditions has fallen to less than one-half its initial value, and thereafter further superheating the cathode in absence of anode potential.

In testimony whereof, I affix my signature.
MAURICE D. SARBEY.