The Rejuvenation of Vacuum Tubes

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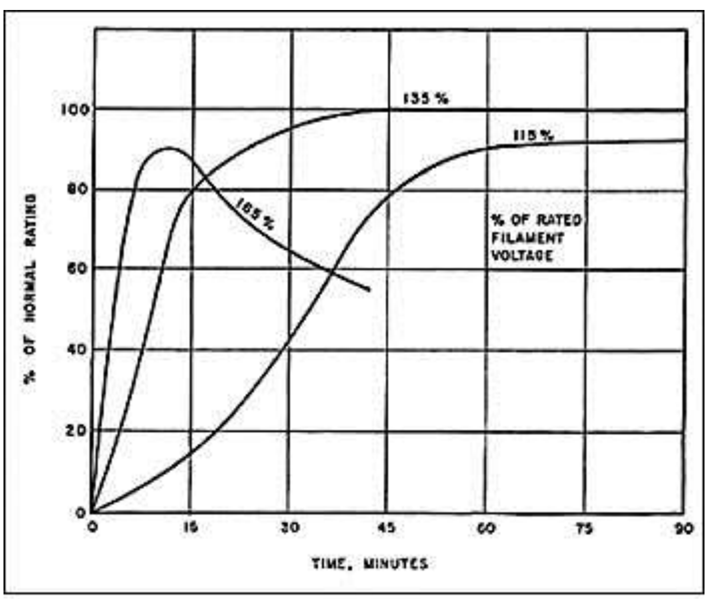
This article on tube rejuvenation originally appeared in the December, 1973 OTB. Over the years, Lane has received so many requests for copies that he suggested we reprint it. I agreed and here it is!--mfe

With the ever increasing scarcity of the old tubes, it is becoming more important that we try to save as many as possible. Over the past two years the author has been experimenting with the rejuvenation of these older tube types. This work has been based primarily on present day techniques used at Eimac and on data given in various books published during the 1920's. Using the methods described herein, the author has had approximately 85% success in returning inactive tubes back to useable transconductance. The failures have primarily been due to filaments being burned out during the application of the excessive voltages required. The tubes which failed either had filaments that had been weakened from long hours of operation, or were marginal at the weld joints. None of these failures were opened for investigation as they are still valuable for display purposes.

The main reason many of these older tube types become unusable is a loss of electron emission from the filament or cathode. With the wide inter-electrode spacings used in these tubes, a short is very rare except in the case of a broken filament or grid wire, or where the oxide has flaked from the filament or cathode and has touched the grid. The loss of electron emission typically shows up in the tube tester as a "weak" reading or even failure to raise the meter needle at all. If a tube tests normal and does not show any erratic indication on the test meter, no attempt should be made to improve it by rejuvenation.



Summary of data accumulated by author on rejuvenation of thoriated tungsten filaments. Best results are obtained at 135% of rated filament voltage. At 115%, rejuvenation time is very significantly increased; at 165%, the tube is quickly destroyed.

The equipment required for rejuvenation is relatively simple. In addition to a tube tester, a variable filament supply is required with a meter of reasonable accuracy for measuring the applied voltage. In place of a separate filament supply, a filament voltmeter may be connected to the tube tester and the filament voltage switch and "line" adjustment used for voltage control. **For the thoriated tungsten filaments it is preferable that no grid or plate voltages be applied during rejuvenation.** With an oxide emitter tube, voltages should be applied during rejuvenation. The removal of plate and grid voltages can be readily accomplished by the construction of an adaptor socket with filament connections only.

The voltage applied to the filament during rejuvenation must be carefully controlled to the values given herein. The accompanying graph shows the results of various voltages applied to a thoriated tungsten filament during rejuvenation. It shows that a voltage lower that the recommended value will eventually result in a fairly good tube, while too high a voltage will result in a tube which will remain weak.

Emission loss is generally due to contamination (poisoning) of the emitting surface. The vacuum and the original outgassing of the elements in these older tubes was not near the present day standards, therefore they contain considerable residual gases. The poor emission usually is the result of (1) the emitting surface having been poor prior to storage, or (2) the filament/cathode having been poisoned immediately on being heated by the residual gases which had condensed on the emitting surface. The function of rejuvenation is to drive off these condensed gases and to replenish the electron emitting layer on the surface of the filament/cathode.

Vacuum tubes have essentially three basic types of emitters. These are: pure tungsten, thoriated tungsten, and directly or indirectly heated oxide. The type of emitter in a given tube can be determined by its operating color at rated filament voltage. The pure tungsten filament operates bright white, the thoriated tungsten filament runs orange to yellow, while the oxide emitter operates in the dull to bright red region.

The pure tungsten filament needs little reactivation as its operating temperature makes it self cleaning. Operation at 110% of rated filament voltage for up to 30 minutes should clean up any residue. This type of filament was used in such tubes as the UV200, UV201 and in many of the early transmitting types.

The thoriated tungsten filament is probably the major one to be dealt with by the collector. This filament is a composition of tungsten and thorium, with the tungsten acting as the heat source while the thorium is the emitting source. This filament was used in tubes such as the UX200A, UX201A, UV/UX99, UX120 and in many of the later (and present day) transmitting tubes. Two methods are used for rejuvenation of these filaments. If a tube is only weak or gives erratic readings, the first of the following procedures should be tried. If a tube is completely dead (but the filament lights up) then use the second procedure.

1. Operate the filament at 135% of rated voltage for 30 minutes. Test the tube. If it has improved but is still not up to rating, continue for another hour. If, at the end of this time, the tube is still not up to specification, move on to procedure 2.

2. In this procedure the filament is run white hot to strip the emitting surface completely clean, then the surface is restored using the above procedure. Operate the filament for 15 to 20 seconds at 350% of rated voltage with no other voltages applied. (Do not attempt to test at this point as there will be no emission.) Now operate the tube under the conditions given in the first procedure. Test the tube every 30 minutes, and if the tube is not up to rating after two hours it has reached its maximum emission capability. Although a tube does not meet its full transconductance specification, it still may be useable in many applications.

Typically the oxide emitter consists of a layer of strontium and/or barium oxide deposited on a heated surface. In the directly heated type, this layer is placed directly on the surface of the filament. Typical of this type are the Western Electric tubes such a the VT-1 and VT-2 as well as the WD11, UX226, and UX280.

The indirectly heated cathode is the more modern type of emitter. It consists of a metal sleeve with the oxide layer on the exterior and the filament mounted within the interior. The indirectly heated cathodes include the a.c. heater types such as the 24, 27 and the Kellogg tubes. The oxide emitter types should initially be operated at rated filament voltage for at least one hour and then checked for quality and stability.

If they still are not satisfactory, then the following procedure should be used. With the tube in the tube tester, increase the filament voltage to 120% of rating while carefully watching the plate current or tube tester meter reading. The meter reading will slowly increase, hit a peak, then start to decrease. At the point of maximum reading, reduce the filament voltage back to rated value. Continue to operate the tube at rated filament voltage for at least four hours, then test. When two tests spaced one hour apart provide the same reading, the tube is rejuvenated as much as is possible.

The rejuvenation of old tubes can be very rewarding, especially considering that some of them would otherwise be in the junk box. It does take time for this work and there are no short cuts, but it is something that can be done without constant attendance. While not all the tubes will come up to 100% of rating, many can at least be brought up to the point of being useable. As these old tubes become more scarce, tube rejuvenation may be the only way we will have of restoring vintage sets to operation.

I'd be pleased to correspond with any readers who have questions about tube rejuvenation.