Tube Topics

Section 3: The Tube Rebuilding Process

When a tube is received at the ECONCO plant to be rebuilt, it is first electrically tested and analyzed to determine what type of work must be done by our technicians to restore it to “like new” condition. After rebuilding, each tube is tested to the original manufacturer’s specifications and/or the appropriate MIL spec (or equivalent).

3.1 Device Testing

Static tests insure that the tube geometry and internal structure are as originally intended by the tube designer. Among the key static tests are filament current, *cutoff*, gas, and peak emission. Each of these imparts the following data.

- **Filament current.** Filament current continually increases during operation of a tube. The increase from the starting value on a tube is a measure of the amount of usage. In the absence of accurate recorded operating hours, it is possible to estimate the usage. By the same method, with accurate hours we can determine the operating temperature of the filament in an application. When evaluating short life difficulties, this is extremely helpful information.
- **Cutoff.** Because the emission capability of a cathode is normally many amperes and at normal bias the plate current is the result of the average fields within the tube, it is impossible to evaluate the concentricity of a structure. However, if the current is reduced to a few milliamps and the plate voltage is raised to a very high value, then only a small part of the cathode is needed to give the few milliamperes, and the degree of structure eccentricity is proportional to the bias voltage. The greater the eccentricity, the greater the bias required to reduce the plate current. Each tube type has a different range of acceptable values.
- **Gas.** A high vacuum within the tube envelope is important to proper operation and long life. All gas tests measure the quantity of electrons required to neutralize positive gas ions created by current through the tube. Positive gas ions are collected on the most negative element within the tube. The classic test is performed with sufficient plate voltage and average current to affect the rated plate dissipation while the grid remains negative. Gas currents range

from about one microamp to nearly one milliamp on large tubes. This reading includes currents from inter-element leakage or grid emission. It is almost impossible to separate the components of this test.

A more accurate gas evaluation can be obtained by the *IZ* test, which converts the tube under test to an *ion gauge*. An ion gauge has the anode operating at a negative potential. The control grid is operated positive and the current controlled by adjusting the filament voltage. Gas ions are neutralized on the anode and the neutralizing current is measured. This test is a true measure of internal gas. *IZ* currents range from hundredths of a microampere to not over one microamp.

- **Peak Emission.** In this test the saturated emission capability of the cathode is evaluated. If the emission is low, it is an indication of reduced cathode activity, and performance can be affected. Emission is evaluated with the tube connected as a diode with high voltage pulses (2500 V) applied across the tube and the resulting cathode current measured.

The previous tests define and identify a tube type. However, tube operation involves a more complex set of conditions. Fortunately, it is possible to simulate worst case conditions on all types. Constant current curves for each type are published. These curves are used by engineers to establish operating parameters during equipment design. These curves make it possible to accurately predict the power output and element currents. Using the constant current curves, it is possible to select the most demanding combination of instantaneous voltages and currents for any application. This point is normally found at the lowest anode voltage, highest anode current, and maximum drive voltage. At ECONCO, we use pulse techniques to measure the peak instantaneous values of the drive voltage and all electrode currents, and compare them to the published data. Figure 14 shows an oscilloscope presentation of the drive voltage and a current on a test console. In analyzing tube performance, it is frequently of great importance how the currents divide between the tube elements.

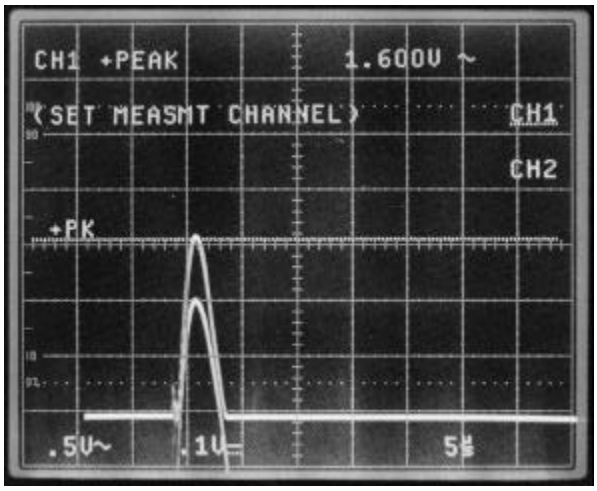


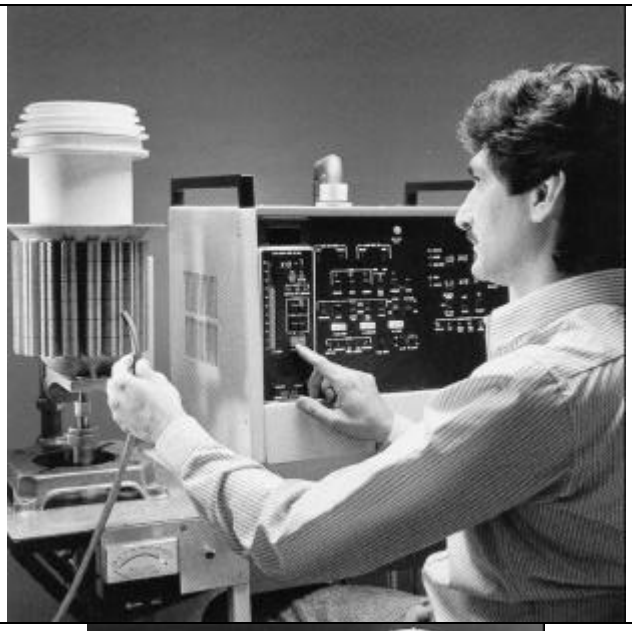
Figure 14. Oscilloscope representation of a pulse test of instantaneous drive voltage and electrode currents.

3.2 Steps in the Rebuilding Process

The following photos illustrate the process of power tube rebuilding, as practiced by ECONCO.

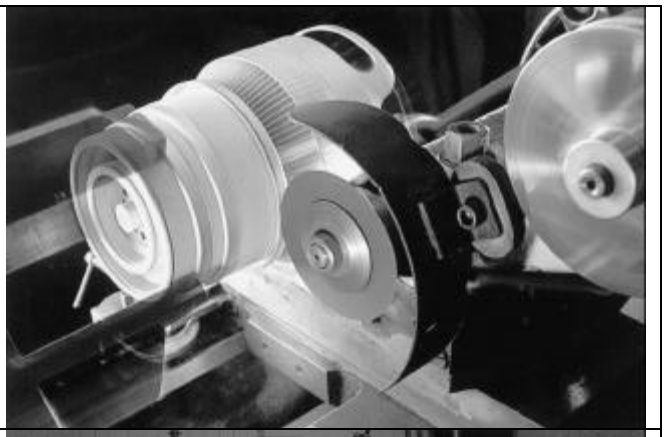
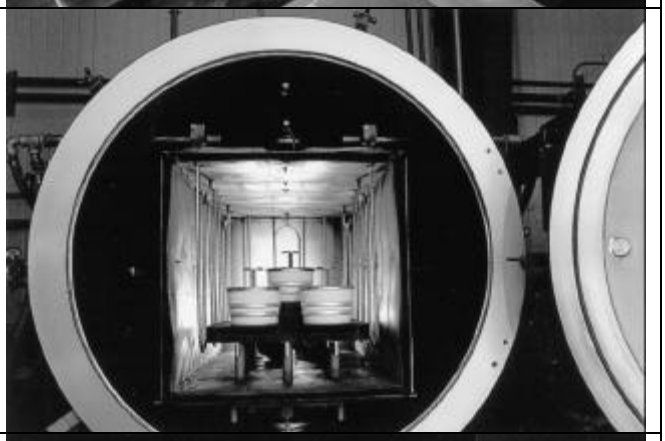
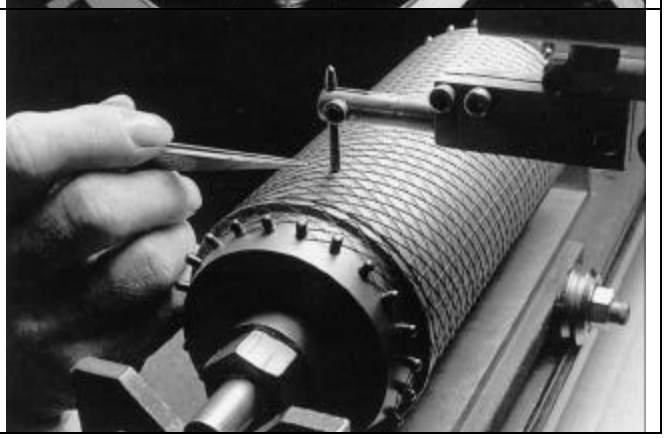
Tube Test. Incoming tubes are checked and, based on the measured results, they are routed to the proper rebuilding station. There, the vacuum envelope is opened; the internal elements are then removed as required for inspection and analysis. Experience has shown that many operational problems leave physical evidence within the structure and a thorough examination of the internal topography provides valuable information regarding the reason for failure, exceptional life, or outstanding performance.	
Carburizer. The emission of a thoriated tungsten filament depends on a complex chemical process. One of the carbides of tungsten protects the filament from ion bombardment and acts as a catalyst to lower the temperature for efficient emission. Operation to new performance specifications requires careful measurement of internal dimensions and duplication of the original component configuration when the tube is rebuilt. Through analysis of a large number of tubes that have failed in the field, ECONCO engineers are sometimes able to improve on the original design and thereby extend tube life.	

Leak Detection. Proper operation of a tube depends on a good vacuum within the envelope. The structure of the tube involves many different materials that are joined together. These joints must be vacuum tight. Here, seals are being checked on the mass spectrometer leak detector before further processing.
The operational life of a tube is highly dependent on the degree of vacuum in the envelope; the better the vacuum, the longer the life.



Materials and Components. Although ceramic has been replacing glass in power vacuum tubes, in many high voltage applications, glass is the preferred material. This tube has been opened on a glass lathe and is being prepared for rebuilding.
Vacuum tube manufacture requires special materials and close-tolerance matching of parts. In the rebuilding process, all original tube specifications are met or exceeded.

Glass sealing can be done either in a horizontal or vertical lathe. Here, a technician is sealing this 6696. With such glass lathes it is possible to manufacture new envelopes. which enable the rebuilding of tubes once considered irreparable.
After being sealed, the envelopes are annealed to relieve stress.

Tubes with cracked ceramics were previously considered unrebuildable. Here, a 4CX3500A is prepared to have the cracked output ceramic removed and replaced.	
High temperature atmosphere furnaces are used to braze new ceramic onto prepared stem assemblies. Other furnace applications include *heat-setting* of metals and processing materials.	
Grid Structures. Normal operation subjects the filament and grid structures to thermal and electrical stresses that can render them unusable in a rebuilt product. Modern tube technology requires extensive use of mesh cathodes, and special fabrication tools and jigs are used to replace the worn out cathodes. Here, a new mesh filament is being wrapped on a mandrel.	

The original tube design establishes the overall performance characteristics. Replacement parts exactly duplicate the original parts in form, fit, and function. Jigs and fixtures aid in the production and assembly, but skilled tube technicians are the brains and hands that do the job.	
Anodes. It is possible in the operation of certain industrial tubes that the anode can become damaged, and replacement with a new component is the only solution. ECONCO has the capability of manufacturing new anodes when necessary for a variety of tubes. The anode of a typical tube consists of four primary parts: the internal cup, external fins, the external anode band, and sealing rings.	
Tube Bank. ECONCO buys duds whenever possible for the purpose of having an inventory of the most commonly used types already rebuilt and in stock for delivery. The customer has the option to have a tube from stock (when available) or have a specific dud rebuilt.	

A Tradition of Excellence. The exterior finish on a tube contributes to proper operation. ECONCO believes that silver plate is the best finish for tubes unless other environmental considerations dictate another treatment.

At ECONCO, we have the technology to rebuild a wide range of power tubes. Our tubes are used in numerous applications, including radio and television broadcasting, the defense industry, specialized communications systems, wood drying, dielectric heating of plastics, vinyl sealing, and semiconductor manufacturing