

Hickok Testers- Brief Overview

Testing of vacuum tubes and conditions used by Hickok-designed testers

(Not including the Cardmatic)

Many types of receiving vacuum tubes have their transconductance performance targets, or “bogeys” stated at 250V on the elements at specific levels of bias voltage or cathode bias resistance. These test conditions and expected results appear in tube manuals published by tube manufacturers, often labeled “Design-Center Values”. During the time of vacuum tube production, the allowable variation of the parameters in production was not disclosed. Manufacturers often revealed allowable variations in documentation provided to OEM manufacturers, but this information was not widely disseminated. After the cessation of tube manufacture, much new information has been discovered – most notably from

the RCA files recovered when their tube manufacturing assets were disposed of in Harrison, NJ. In many cases, the allowable manufacturing tolerance was $\pm 10\%$ of the bogey value. In some cases, especially in older tube designs, the allowable variations were greater. Application of the exact testing conditions specified is necessary to determine if a tube is performing within the manufacturer’s design intent.

Application of the manufacturer’s stated test conditions is not a simple task; if a precision result is required, precision components and measuring devices must be used. Once the specific test conditions are applied, additional stimulus is necessary for a practical test of vacuum tube transconductance.

Additional complexity is involved if a wide variety of tube types are to be tested on a single instrument.

During the vacuum tube era, many manufacturers designed and marketed tube testing equipment, generally for use by service technicians. Some elaborate testers were marketed, but these were large, expensive and time consuming to operate. The service testers were generally termed “suitcase” units and

were portable. Keeping size and cost to a minimum were major factors. In all but a very few cases, these limitations prevented testing under manufacturer’s stated conditions. After WWII, new types of tubes

were designed for the developing mass consumer and computing markets. Introduction of the

Compactron and novar formats for color television in the 1960s greatly increased the challenge for tube tester designers.

Test equipment manufacturers devised many different shortcuts that tested tubes under conditions much

less stringent (and inexpensive to apply) than the manufacturer's stated conditions. The most notable of these was Hickok – a circuit invented by Job Barnhart was patented in 1935 which dominated the testing industry and US military tube testing until the patent's expiration in the mid-1950s. During the reign of the Hickok patent, other manufacturers' efforts to devise similarly effective arrangements that did not infringe on the Hickok patent were widespread, but did not provide the same level of credibility as did the

basic Hickok design. The only other US manufacturer that developed a superior "suitcase" tester to the Hickok was Triplett with their 3444 and 3444A testers which came close to application of the manufacturer's test conditions and actually tested for transconductance.

The Hickok patent was ingenious in its simplicity, but had its disadvantages. It applied chopped AC, not DC as specified in the classic test conditions. It applied a fixed plate voltage of 150V to the tube under test and a screen voltage (to multi-grid tubes) that was 135V maximum and which split that voltage between the bias and screen. If a pentode required adjustment of the bias control to 3V, then 132V would

be applied to the screen.

Transconductance was inferred by applying the positive and negative half cycles of the current through the tube being tested in two successive positive cycles. The signal voltage used was a full cycle, so the first half cycle applied to the plate found the grid of the tube going positive; the second half cycle was applied while the grid was going negative. If each of those half cycles was directed through a different path constituting a bridge circuit, transconductance could be inferred by measuring the difference between

the currents in each of the two legs of the bridge. This difference is generally proportional to the transconductance of a tube; however, no method for deriving a quantifiable transconductance in accordance with the published engineering requirements has been demonstrated. In addition, the Hickok

test conditions (described above) for testing a tube are much different from those specified by the manufacturers which require DC at higher voltage on the elements.

The major advantages of the Hickok circuit were simplicity and reliability; the design used no electrolytic capacitors in the power supply. The major disadvantages were the requirement for a specialized and precisely wound power transformer and the lack of any compelled relationship between the test result and

actual transconductance. This required Hickok to calibrate testers in production using “calibration” tubes.

Apparently, the company was very careful not to allow these tubes to escape from their control. Hickok published calibration procedures using 6L6 calibration tubes, but never shared information on how a calibration tube was to be selected. They also provided instructions on use of an alternate AC surrogate procedure, which does not yield the same results as using a calibration tube. Misunderstandings about the

validity of test results and calibration procedures across the different models of Hickok testers have been

compounded by Hickok’s practice of using different test conditions for the same tube types in different models of their testers.

In spite of these issues, Hickok tube testers provide test results that are related to transconductance and can provide a useful assessment as to whether a tube is fit to provide useful service in most electronic circuits. This utility, simplicity and durability allowed Hickok products to dominate the tube testing industry from the time the Barnhart patent was issued. That dominance continues to this day as do misunderstandings of how the circuit works and limitations on the validity of its results.

Because of their differing characteristics, it is necessary to break further discussion of Hickok testers into four basic branches. There were additional models and variations; the most often encountered versions today are listed below. Each of these branches is the subject of more detailed characteristic summaries in

subsequent documents:

- 1) Lower level service testers using a double shunt pot. The last of these was the 6000B; earlier versions of this circuit had the shunt pot labeled as “English”.

- 2) The dominant late and post WWII military versions, the I177, TV-3, TV-7 and TV-10 series.

Before and during WWII, the military and the Bell System generally used commercial testers.

- 3) The higher level “laboratory” testers in the 539 series. These were larger and improved versions

of the earlier testers and did reduce some of the deficiencies in the basic structure of the earlier versions. However, in spite of claims of being laboratory quality testers, they continued to employ the basic Hickok patented circuit with many of its deficiencies.

4) Special versions of the 539 series manufactured for Western Electric and used by the Bell Operating Companies in maintenance of telecommunications facilities. These testers used different bridge values and DC instead of chopped AC as bias on the tube being tested. Western Electric had their own nomenclature for these units, the last of the series being the KS-15750- L2. WeCo supplied the test values for tubes of their manufacture for distribution internally and via roll charts by Hickok. They also generated internal technical information on these testers, not

generally available to the public. Hickok marketed a version of the last of these special WECO-inspired designs as the R 1575.

Late in the tube testing era, Hickok manufactured a versatile new tester termed the "Cardmatic", all of which except the 121 were true gm measuring instruments, but also had different limitations. The Cardmatic selected available test conditions by use of cards in which holes had been punched. When inserted into a "reader" slot, the holes in the card were mechanically detected to determine the proper setup conditions for testing each specific type of tube. These were marketed commercially and to Western Electric; they are so different from the earlier Hickok designs that they require consideration as a separate subject.

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