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V&T News

THE PERIODICAL FOR THE VALVE & TUBE INDUSTRY

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SPOTLIGHT

DTV, DVD, and Vacuum Tubes

By Lynn Olson

I recently enjoyed the PBS digital-TV rollout broadcast, "Digital TV: A Cringely Crash Course." Similar to 99.9% of the viewers, I saw it on an all-analog NTSC television—and not a particularly recent one—a 1985 NEC 25″ model. Unlike many viewers, though, I know DTV is no hype. At the 1998 CES, it was spectacular on a prototype Sony MUSE monitor. On the current generation of rear-projection sets, though, high-definition digital television (HDTV) looks as soft as line-doubled NTSC. The $10,000 flat-screen plasma sets are sort of in-between—very smooth picture, not enough pixels, and slightly dull color.

Beautiful color is the first thing many people notice about well-displayed DTV. If you've seen Photoshop on a 17″ computer monitor, just imagine the exact same quality on a 32″ monitor and in full motion! The color doesn't even look like the Eastmancolor of modern theatrical films; it's closer to the snap, depth, and realism of Kodachrome and dye-transfer prints.

Digital TV is massively overspecified for existing consumer—or even professional—video displays. When CDs came out 15 years ago, the product barely met the sonics of LPs, and fell well short of 30ips mastertapes. All of the relatively minor improvements in the 44.1/16 CD format have been nibbling at the edges—a little less jitter here, oversampling DACs there, high-speed analog circuitry, and so on.

The initial underspecification of 44.1/16 is why progress has been so slow on the CD front; if it had been more generously specified (60kHz, 20-bit, and a larger disc), the sound would have been much better at the outset, and progress would have been rapid. If you need confirmation, just compare the Chesky 96/24 DVD (CHDVD71) on a second-generation DVD player to a $5000 player with conventional 44.1/16 sources.

With HDTV, the situation is now reversed. It's much better than any display you can buy today!

struction article for a power amplifier featuring the Svetlana 3CX300A1 transmitting power triode, authored by Kobayashi Satoru, and the sound of the 3CX300A1 is reported by *MJ* to be "superb." In the same issue, the Meishinn amplifier was exhibited at the Vacuum Tube Audio Fair, in Tokyo, featuring the Svetlana SV572-3 power triode. For more information on Svetlana's 3CX300A1, SV572, SV300B, and the *MJ* articles, contact Svetlana Marketing & Engineering, 300 Alpine Valley Rd., Portola Valley, CA 94028, (650) 233-0429, FAX (650) 233-0439, Website http://www.svetlana.com.

Kinokuniya Bookstores of America is offering subscriptions to American readers of *MJ* at attractive rates: $63 for six months, and $115 for one year (plus $24 and $48 s/h, respectively). If you are interested and live in Seattle, Portland, the Bay Area, or Los Angeles, they can be reserved and picked up at the Kinokuniya bookstores in those cities, saving the cost of postage.

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In *V&T News*, Issue 6/98, the name of Michael LeFevre (Magnequest) was inadvertently left out from the newly formed Ultra-Fi Dream Team, which also includes Dan Schmalle (Audio Tonalities/VALVE); John Tucker (eXemplar); John Camille (eXemplar); Don Garber (Fi); and Winston Ma (First Impression Music, Golden String).

In *V&T* 2/99, watch for Charles Hansen's review of SpireAudio's three latest chassis that were designed to accomodate either solid-state or internal vacuum-tube designs.

TEST BENCH

THE SOFIA
By Don Jenkins

For product information on Sofia, contact Audiomatica, Via Faentina 244/g, 50133 Florence, Italy, (+39) 55-575221, FAX (+39) 55-5000402, E-mail audiomatica@mclink.it. A software demo is available at website www.mclink.it/com/audiomatica/sofiaeng.htm, and an international distributor list is found at www.mclink.it/com/audiomatica/dist.htm. In the US, contact Old Colony Sound Lab, 305 Union St., PO Box 876, Peterborough, NH 03458, 603-924-6371, FAX 603-924-9467, E-mail custserv@audioXpress.com.

The Sofia is advertised as a PC vacuum tube curve tracer. When connected to a DOS-compatible PC, the device becomes a stand-alone instrument for producing a set of vacuum-tube characteristic curves with plate current as a function of plate voltage and grid bias as the variable parameter. The other inputs to the test, such as filament voltage and current and screen voltage options, are also controlled from the computer keyboard. The unit is powered from a standard 115V AC outlet, with a 220V AC option. All fundamental interconnecting cables are also included with the hardware.

A manual is included, supplying an operational overview of how to use the device, although operation is reasonably intuitive (***cover photo***). Reading the manual, connecting the instrument, and producing the first output took me about 30 minutes. I spent several more hours becoming familiar enough with the rest of the options that I could proceed without too many references to the manual.

PHOTO 1: The front panel of Audiomatica's Sofia, constructed of aluminum.

First Impressions

The device is well made and has the overall appearance of a high-quality assembly (***Photos 2*** and ***3***). The unit is contained in a single aluminum package, the assembly is made with countersunk machine screws, and all panels are flush-fitted. The Sofia is about 17″W× 9″ D×9″H, weighing approximately 15 lbs. The tubes and connections are found on the flat top panel.

The tube sockets—one each of the 7-, 8-, 4-, and miniature 9-pin—are ceramic and flush-mounted. The interconnecting chassis sockets are of the protected "banana plug" female type and eight short male-to-male cables are provided for the external manual connections. All of these items are first-quality.

I encountered no problems while activating this unit "right out of the box." However, a DB9 to DB25 fully connected interface adapter (i.e., all pins wired) is required if your PC COM port has a DB25 socket. A "standard" mouse adapter will not work. For a unit in this price range, it seems inexcusable not to include this adapter with the rest of the hardware since most users may not have a fully connected adapter available.

Initial Operation

I produced a set of characteristic curves for a 6550 on the first try. Several options are available as to the number of and the rate at which curves are produced. With a Pentium 75 CPU, 11 curves at the slowest rate took three minutes and 35 seconds. The number of curves and the rate at which they are produced is selectable as 5, 11, or 21 curves, and slow, medium, or fast rate. The rate per curve was generally estimated to be 6.2 seconds for the fast selection, 10.2 for the medium, and 17 for the slow.

An option called "Autosettle" which the manual identifies as "wait for the parameters to be stable in this condition" is also available. I did not find much difference in the timing when selecting this option. No option is available for the serial port transfer rate, although it does not seem to matter since the unit is probably limited to the hardware rates just discussed.

I produced several sets of data for a 6550 and for a 2A3 tube. The curves are nicely presented on the CRT (*Fig. 1*). The print format is well managed in the software; a very nice curve set can be generated on a dot matrix printer. I did not try to use a laser printer due to the unavailable option of selecting the parallel port. Only LPT1 is available for output from the parallel port and only COM1 or COM2 is selectable for the serial port. Additional choices should be available for both the serial and parallel ports since an instrument of this class would likely be used in a system requiring optimal flexibility. A cable for a "plate cap" connection is also not furnished, although many tubes of interest (6146, 2E26) have this style of anode connection.

PHOTO 2: The back panel to the Sofia unit.

Detail Operation

The total value of any system is usually determined by the attention required to understand how the system operates and the amount of flexibility available to the operator. In addition, the accuracy and repeatability of the device can only be determined from a detailed evaluation. As mentioned in the first paragraph, while this instrument produces exactly the same data as advertised, some critical commentary nevertheless seems to be in order.

Method of Measurement

There are two selections for producing tube performance data. One is the "basic" format in which a set of curves is produced over a stipulated operational range. The second option is for a more or less "single-point" performance, in which only one set of inputs is specified and the unit activates measurement at this given point. This data is presented on the CRT. Although the manual suggests that a printed output can be had from "within any control panel," I was not able to generate a hard copy of this single-point data panel.

Two other measurement formats are available: Quality Control and Matching. The Quality Control mode allows you to specify a set of "acceptance" values with tolerance limits, and then to run each tube through a system sweep. The result is a CRT message with either "BAD" or "GOOD," indicating either rejection or acceptance of performance. Details of the measurements are available in printed form. This mode is discussed in greater detail in a following section.

The Match mode attempts to "match" either pairs or sets of four tubes using "reciprocal matching factors." The manual offers no explanation of how this procedure works. After running a set of tubes over a common test setup, this mode then calculates these "factors" and presents the results in a table identifying the matched pairs. I used this mode to run a series of 32 back-to-back tests with the same 6550 to determine the repeatability of the system. The results are discussed in a following section.

The manual should discuss how this matching calculation is determined and present some technical justification for using this specific approach to compare tube performance.

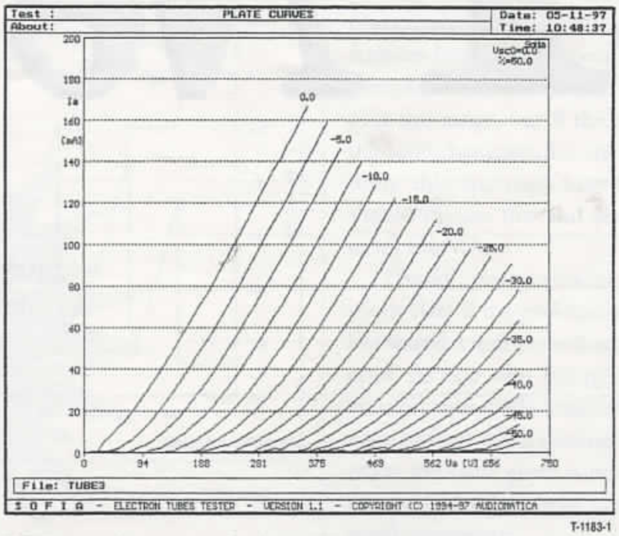
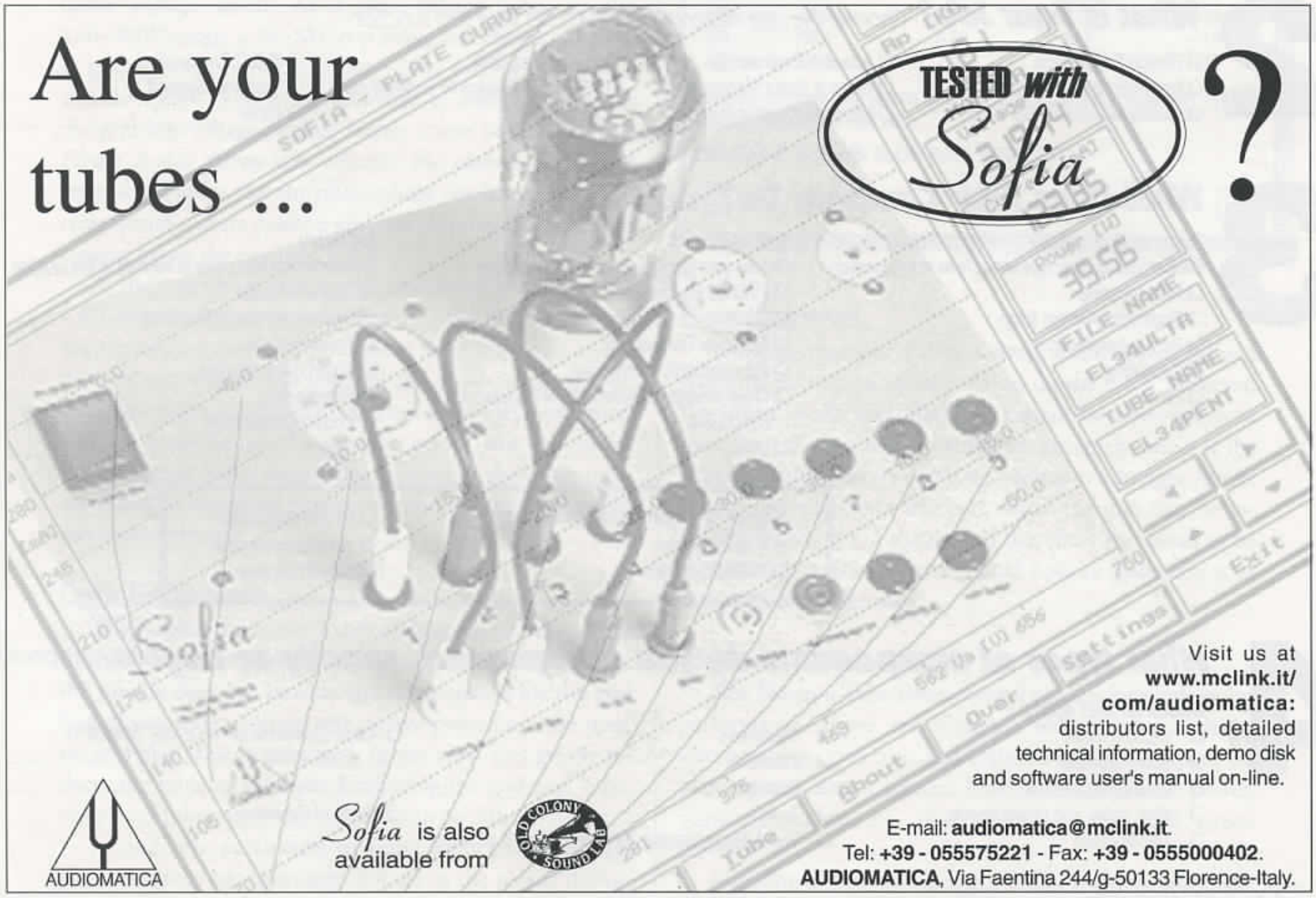

Test :
About:
PLATE CURVES
Date: 05-11-97
Time: 10:48:37
File: TUBE3
S O F I A - ELECTRON TUBES TESTER - VERSION 1.1 - COPYRIGHT (C) 1994-97 AUDIOMATICA

FIGURE 1: Plate curves for the 6550 and 2A3 tubes.

Plate Curves

The Plate Curves option is the basic format. A tube specification window opens where the tube parameters are presented. There are a number of "canned" tubes in the software database, but manual changes are both intuitive and easy to make. The options include filament voltage and current limit, plate voltage, screen voltage, and the grid bias range used to generate the characteristic curves. Plate-current limits and plate-power dissipation limits are also included. An additional option for multigrid tubes is the "ultra" selection. In this mode, the screen-grid voltage is set to a percentage of the plate voltage as the system sweeps through the measurement cycles. You can select any plate-voltage percentage from 0 to 100%.



With the initiation of the measurement cycle, the plate voltage increased in a more or less linear fashion for each grid-bias step. *Figure 2* is an oscilloscope record showing how this cycle is executed. The actual values of all parameters are determined at discrete points during these steps so that a number of data points are read for each plate-voltage sweep. Expanded time records for this sweep show that the step increment time is about 100ms.

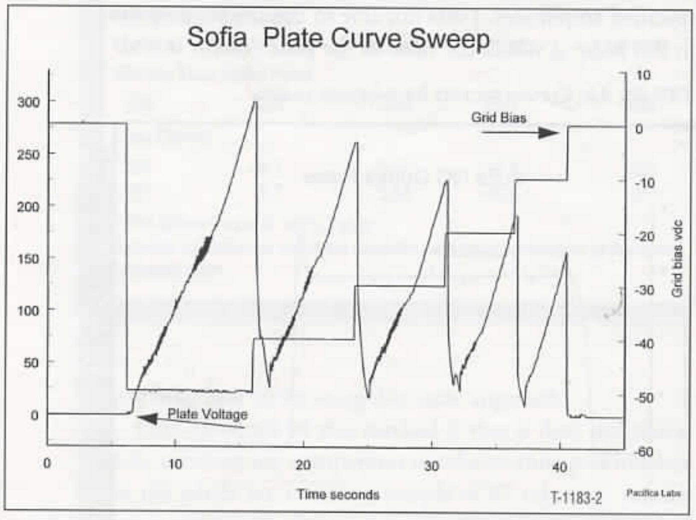


FIGURE 2: Oscilloscope record showing how the measurement cycle is executed.

This record also shows unstable plate-voltage steps at the lower voltage levels. At a plate-voltage value in the 100–300V range, a 24–38V p-p swing was always apparent at grid-bias values below about −25V, even with the Autosettle option. The swing decreased to stable levels when the grid-bias voltage reached higher (more positive) values. *Figure 2* also shows how effective the plate-current limit control is. Notice that the plate-voltage maximum value decreases with a more positive grid bias thus holding the plate current below the specified limit.

At the conclusion of this cycle, the data is plotted on the CRT (the results are shown in *Fig. 1*). After the plate curves are plotted, you may use the cursor to select any point on the performance map to read plate voltage, plate current, power, grid-plate transconductance, dynamic plate (AC) resistance, and the amplification factor. The power and mu values shown appear to be simply the product of the other measured and/or calculated parameters, and not the result of direct measurements.

Data Limitations

When using the cursor to select single-point values from the performance map, several admonitions are in order. First, the process does not provide any interpolation for the grid bias. If you pick a voltage and current point from the map, no grid-bias value is generated. In my view, this greatly reduces the value of this data. Estimating the grid bias, especially with tubes other than triodes, can be difficult.

Second, the parameters of transconductance and AC plate resistance are rigorously defined as the partial derivative of the plate current-grid bias transfer function for the former, and the partial derivative of the plate voltage-plate current transfer function for the latter. Since neither of these functions is determined directly by the Sofia measurement technique, some other method must be used. For the transconductance estimate, it appears that the measured differences between the specified grid-bias steps and the resultant plate current is used. This offers a general average value over this range, but if the grid-bias steps are too great or if the tube characteristics are not linear, the value determined using this approach may be of little utility. The manual should discuss this and alert the user to possible errors in using this value.

The AC plate-resistance value quoted may be useful for triode data if the grid-bias steps are relatively close together. For tetrodes and pentodes, the values shown can be in gross error. As one who has spent many hours trying to model vacuum tube performance, I can empathize with the software authors when dealing with this problem. Nevertheless, when the value given is not reliable, it should not be quoted. *Table 1* shows how much this value changes over very small increments.

TABLE 1
AC PLATE RESISTANCE AS DETERMINED FROM CURSOR-SELECTED POINTS

6550 MAP 11 CURVES, SLOW RATE, AUTOSETTLE

PLATE V	PLATE I MA	GM MA/V	RP KΩ	GB V DC
447	82.3	7.03	−367.6	−10
450	78.4	7.02	−99.9	−10
299	58.2	6.73	21.41	−13
321	59.2	6.82	26.7	−13
490	64.6	7.07	−78.5	−13

Using the 21 curve map seems to reduce this problem, but gross error can still exist as noted by the next entry.

6550 MAP 21 CURVES, SLOW RATE, AUTOSETTLE

571	57.4	6.41	40.8	−13.9
574	56.7	5.90	75.7	−14.1

Data Retrieval

Once the plate-curve data is saved, it can be recalled and replotted as it was originally shown on the CRT. However, the values of the measured data cannot be extracted from these "saved" data files. It would be extremely useful if the actual measured values could be written to a straight ASCII file for use with other efforts in which the user may be involved. Inspection of these saved files show the values to be there; however, the software should have an extraction routine available to the user.

Electron Tubes Tester

The Electron Tube Tester control panel is for single-point performance. Input specifications include plate voltage, screen voltage, grid bias, and filament voltage. Outputs are plate current, screen current, filament current, plate power, transconductance, AC plate resistance, mu, and screen power.

Initiation of this measurement causes the system to make a continuous chain of discrete measurements (*Fig. 3*). The top trace in *Fig. 3* shows the plate voltage, and the grid bias is displayed in the lower trace. These inputs repeat about every second. The plate voltage cycles about ±10% from the specified input voltage, and the grid bias also cycles about the same percentage. Inspection of the traces show that while the grid bias is constant at the specified input value, the plate voltage is cycled. When the plate voltage is constant at the specified input value, the grid bias is cycled. My supposition for the use of this particular sequence is to determine the transconductance and the AC plate resistance. The reliability and repeatability of this method can be judged from the results in *Table 2*.

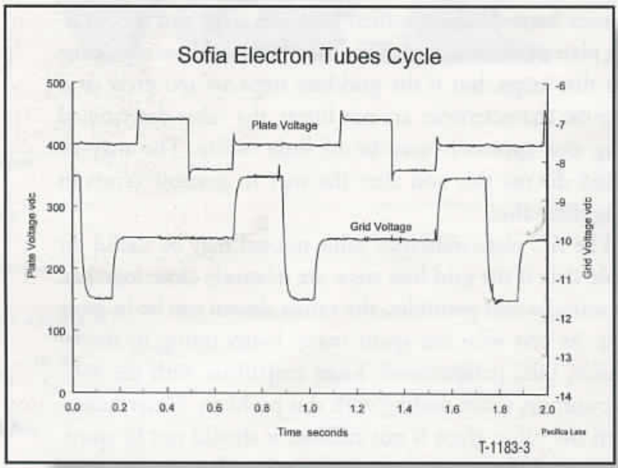


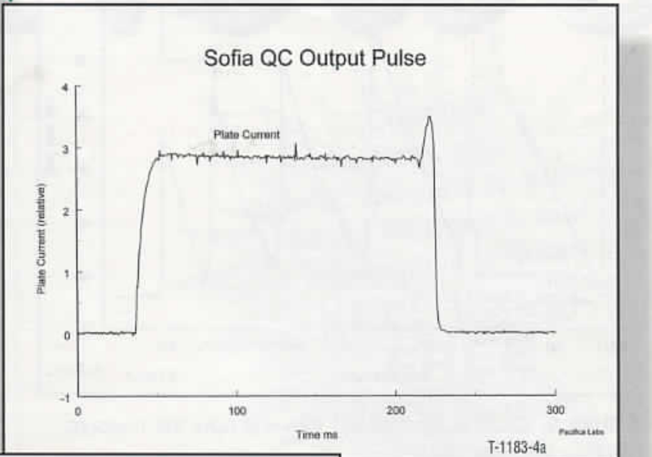
FIGURE 3: A continuous chain of discrete measurements.

QC Control Panel

The concept for the Quality Control mode is that a test specification can be written for the acceptance and/or the screening of the same type of tube. The input data has a specification for the value and tolerance of the filament, plate, and screen grid parameters. The QC test is then one of simply starting the system and seeing the result presented on the CRT as either "GOOD" or "BAD." Details of the measurements are written to a file for retention and additional analysis.

The measurements are made with a single pulse for each data point. This pulse is about 180ms in duration. *Figure 4a* shows the current record for a typical pulse in a 6550 test where the plate voltage was specified at 300, the screen voltage at 275, and the grid bias at −10. The current measured is about 140mA and the pulse form is a steady value. This pulse value was generated by a combination of plate-voltage, screen-voltage, and grid-bias pulses. *Figure 4b* is a composite record of the plate-voltage and grid-voltage inputs. The screen-voltage pulse has the same characteristics as these inputs. The voltage input pulses are stable and occur at the specified amplitudes. I was not able to determine the point in this pulse at which the value of the plate current is read.

FIGURE 4A: Current record for a typical pulse.



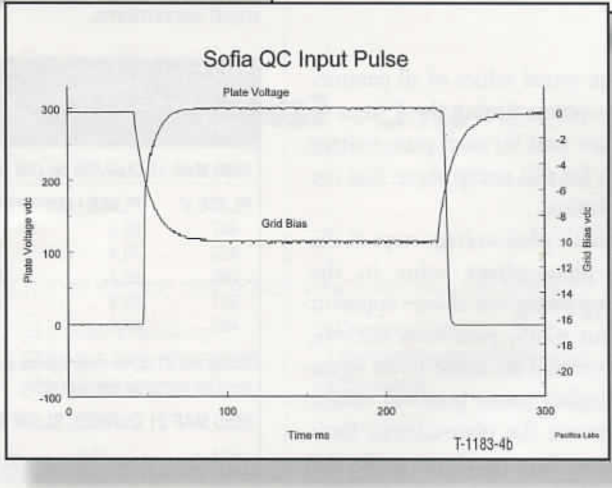


FIGURE 4B: Composite record of the plate-voltage and grid-voltage inputs.

During the QC tests, I made 20 trials with a recorded plate current in the 144mA range. Sofia made these 20 back-to-back measurements with a standard deviation, 1 sigma, value of 1.8mA or about 1.25%. For this type of instrument, that range is very acceptable for test-to-test dispersion. Remember however, that this value is for measurement repeatability, not for absolute accuracy of the measurement.

Match Mode

The Match mode uses the data produced by the plate-curve tests to "match" tube performance from a large sample of tubes. The identification is presented in tabular form with a value labeled ERR as the matching parameter. No description of what this value means, or how it is determined, is contained in the manual.

A discussion with Audiomatica revealed that this match calculation is basically a "root sum square" value. It was determined for every possible pair of tubes using the difference between the measured values of plate current and plate voltage over the range of grid-bias values for the specific test specification used. The "best match" is determined when any two tubes have the smallest RSS value (the square root of the sum of the differences squared). This value is given in the Sofia data sheet as ERR. There is also an option for

TABLE 2
COMPARISON OF ELECTRON TUBE TESTER DATA AND THAT DERIVED FROM PLATE CURVES DATA

6550 SCREEN @ 275V DC

PLATE V	PLATE I MA	GM MA/V	RP KΩ	GB V DC
Electron Tube Tester Panel				
300	71.8	7.38	29.1	–20
Plate Curves*				
297	69.7	5.67	16.8	–20
297	69.7	5.68	40.5	–20

* Two different runs @ same inputs

Significant differences are again noted for calculated parameters at the same operating point.

matching four tubes using this same approach.

One drawback of this method is that it does not necessarily produce any comparison of tube-to-tube performance for the whole lot; i.e., for a sample of 32 tubes, no specific data compares all of the tubes to each other. For instance, if tubes 1 and 2 show an ERR of 10 and tubes 3 and 4 also show an ERR of 10, in theory, tubes 2 and 4 could have any ERR. Some absolute performance criteria would also be useful as output when using this mode.

To estimate the repeatability of this screening, I ran 32 back-to-back tests on the same 6550 using both the pentode and ultra modes. Both modes seemed to have the same dispersion. From the 32 samples, 16 matched pairs were identified by the Sofia software. The ERR values for these 32 tests ranged from 9 to 67, with 11 pairs grouped below a value of 20. Since these tests were made on the same tube in a continuous series, the data should represent the specific tube test-to-test dispersion plus the measurement hardware dispersion.

The tube used was a 6550 that has been used to calibrate my instrumentation repeatability for about four years. It is in the 1–2% dispersion range. In other words, the same measurements with this tube in a day-to-day, year-to-year, back-to-back test activity produces the same performance values within 2%. In examining the individual data plots for Match Mode runs showing the maximum mismatch (value 67, for instance), the plate-current record at –10V grid bias was different by about 5mA at a 85mA absolute value. If only one value in 32 trials was "off" by less than 5%, I would consider the Sofia system to be satisfactory for its intended purpose. In use, if one finds a tube that seems to be out of the general performance range, I would suggest retesting it several times over several days to eliminate any dispersion in the system itself.

In a second series of tests to evaluate the Match mode, I used the diode selection with a resistor in place of the tube conductance path. This eliminates any variation in the tube conductance as well as dispersions in the applied grid bias when using a tube. This type of test measures the dispersion in measuring plate current, in setting the plate voltage, and in the "matching" procedure. Thirty-two tests were made with four relative resistance values of 134, 100, 80, and 66 percent.

Test:			MATCH TO	
About:				
NAME 1	NAME 2	ERR	NAME 1	
TUBE 5.PTE	TUBE 15.PTE	1	100	100
TUBE 1.PTE	TUBE 26.PTE	2	100	100
TUBE 3.PTE	TUBE 9.PTE	3	100	100
TUBE 2.PTE	TUBE 4.PTE	4	100	100
TUBE 6.PTE	TUBE 27.PTE	5	100	100
TUBE 7.PTE	TUBE 28.PTE	6	100	100
TUBE 10.PTE	TUBE 25.PTE	7	100	100
TUBE 18.PTE	TUBE 23.PTE	8	80	80
TUBE 17.PTE	TUBE 24.PTE	10	80	80
TUBE 20.PTE	TUBE 29.PTE	1485	134	100
TUBE 8.PTE	TUBE 19.PTE	1488	100	134
TUBE 14.PTE	TUBE 22.PTE	1489	100	134
TUBE 16.PTE	TUBE 21.PTE	1490	100	134
TUBE 11.PTE	TUBE 31.PTE	1971	100	66
TUBE 12.PTE	TUBE 30.PTE	1972	100	66
TUBE 13.PTE	TUBE 32.PTE	1973	100	66

TABLE 3: Two-tube match results.

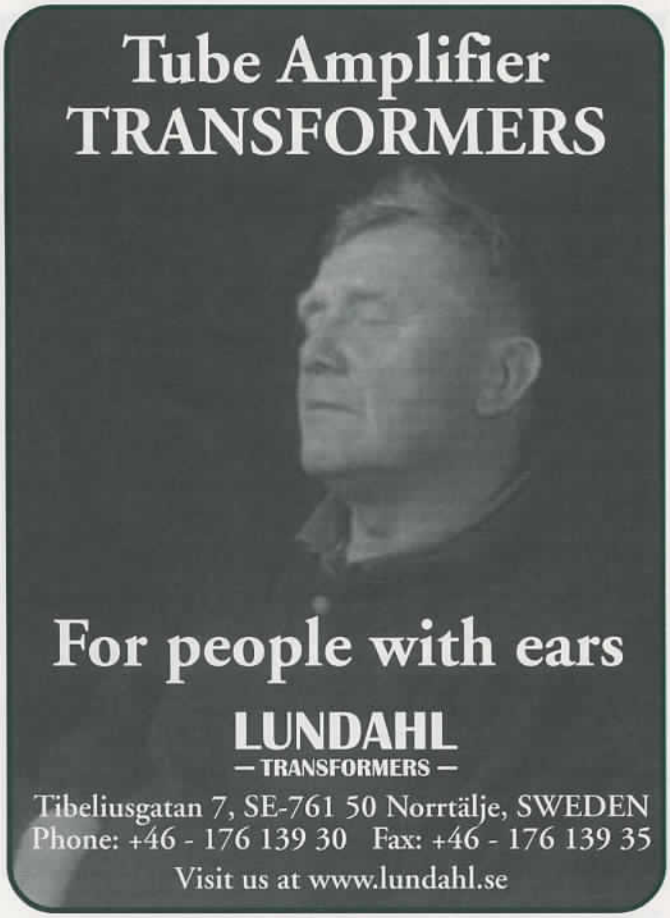
Table 3 shows the results for a two tube match. The hand-entered values in the fourth column are the relative resistance values for the tests identified in columns NAME 1 and NAME 2. (Note that the TUBEX.PTE is actually a fixed resistance.) The calculation works very well through the ninth set of comparisons, indicating almost perfect matching with ERR values of 10 or less. The calculation has problems after the ninth set. Perhaps there is a limit to the number of tubes that you should enter into the data set.

A second match option is for four tube sets. Here the Sofia does an almost perfect job in selection (*Table 4*). The 134% and 80% runs were matched with very small ERR residuals. Since there was one "odd" match, Tube 32 at 66%, the calculation identified it as noted in the last entry in *Table 4*.

System Accuracy

Data collected from any test is only as good as the accuracy of the measurement system. The accuracy of this unit was compared with the values recorded using Fluke 45 DVMs in the Sofia circuit at the same time. Calibration of the Flukes is maintained using reference standard cells. The plate-voltage and plate-current values were difficult to compare due to the cycle action described earlier. However, using an averaging technique—the measured values from the Sofia unit and the Fluke 45s—the plate voltage and current values were within 2–3% of each other.

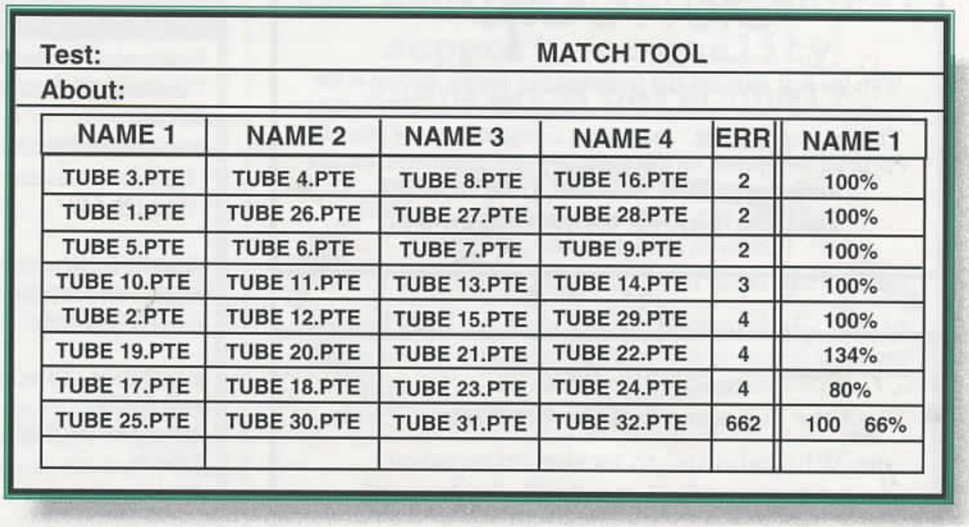
My conclusion here is that the Sofia unit's absolute accuracy for high-voltage systems is easily within 3 or 4%, certainly better than 5%. The filament parameters are not nearly as good, however, especially at a low filament voltage and high current. The 2A3 voltage was about 4% high (i.e., set to 2.5 and measured at 2.6), and the current was about 7% low (i.e., Sofia measured 1.555, Fluke measured 1.654; Sofia measured 1.984, Fluke measured 2.146).



Summary

The designers of this system deserve a lot of credit for combining a set of complicated requirements into a workable and easily used instrument. The device does precisely what it advertises: it produces a set of vacuum-tube performance curves for a wide range of vacuum tube types.

Several features could be incorporated into the Sofia software that would add significant utility to the device, including the production of transfer coefficients for selected operational points. This would eliminate the need for interpolation of the transconductance and AC plate resistance since these values would then be directly determined by differentiation of the transfer function. The need for grid-bias interpolation in the existing data format is almost a must for this class of instrument.



Test: MATCH TOOL

About:

NAME 1	NAME 2	NAME 3	NAME 4	ERR	NAME 1
TUBE 3.PTE	TUBE 4.PTE	TUBE 8.PTE	TUBE 16.PTE	2	100%
TUBE 1.PTE	TUBE 26.PTE	TUBE 27.PTE	TUBE 28.PTE	2	100%
TUBE 5.PTE	TUBE 6.PTE	TUBE 7.PTE	TUBE 9.PTE	2	100%
TUBE 10.PTE	TUBE 11.PTE	TUBE 13.PTE	TUBE 14.PTE	3	100%
TUBE 2.PTE	TUBE 12.PTE	TUBE 15.PTE	TUBE 29.PTE	4	100%
TUBE 19.PTE	TUBE 20.PTE	TUBE 21.PTE	TUBE 22.PTE	4	134%
TUBE 17.PTE	TUBE 18.PTE	TUBE 23.PTE	TUBE 24.PTE	4	80%
TUBE 25.PTE	TUBE 30.PTE	TUBE 31.PTE	TUBE 32.PTE	662	100 66%

TABLE 4: Four-tube match results.

When one considers who the potential users of this instrument may be, what the unit does not do then becomes a concern. This is an expensive device and will likely not be acquired by even the most serious hobbyist. This device seems, rather, to be directed toward the circuit designer who needs detailed tube-performance data or by a vendor who wishes to screen large numbers of vacuum tubes for a selection of specific performance parameters. The Sofia may serve the latter purpose as now configured. For the designer or evaluator requiring expanded performance data, particularly if other outputs may be needed for detailed analysis, the lack of flexibility as discussed in the previous commentary and of accuracy in certain parameters may be a restriction on the utility of the device.