OIL CAP CAUTION

The article by Bruce Brown in the April 2008 *aX*, "Upgrading a Classic Pilot Amp," was quite interesting and showed a resourceful use of older tube equipment. I just want to sound a word of caution about old oil capacitors, which are made by winding two metal foils separated by two or more sheets of kraft paper into a compact roll. The wound capacitor is vacuum impregnated with resin, wax, mineral oil, or a synthetic compound. The term "mineral oil" is loosely used to characterize any nonchlorinated liquid, including refined petroleum oils, silicones, fluorocarbons, and synthetic esters.

In the 1950s a new class of synthetic oils called polychlorinated biphenyls (PCB) was introduced by Monsanto and GE for use as dielectric fluids. Because PCBs were relatively expensive, oil capacitors were not the major use for PCBs, but they still may have accounted for 5% of the total usage. The primary use of PCBs was in large utility power transformers.

In the 1970s, PCBs were shown to cause a variety of environmental and health risks, and the manufacture and use of them was either banned or severely restricted in the major industrialized countries. The US and Canada stopped production in 1976. Large PCB-filled transformers and capacitors have mostly been decontaminated or destroyed because of the risk of fire or leakage. By federal law, all new-production non-PCB oil-filled caps must be marked as such.

However, many smaller PCB-filled oil capacitors were used in all kinds of electrical equipment, including home appliances and consumer electronics. If an oil capacitor is not marked as non-PCB, I would assume that it contains PCBs. Small PCB capacitors were still in the distribution pipeline after manufacturing ceased. It may also be possible to purchase used ones by accident (on eBay, for instance). Oils have much higher dissipation factors than more modern dielectrics, and the paper acts as a thermal insulator and holds in the heat. The maximum operating temperature for mineral oil capacitors is +85° C.

A growing number of oil-impregnated paper film caps has been in operation for 20 years or more. A recent IEEE study found that thermal stress over this time period causes deterioration, which increases the amount of dissolved CO_2 in the oil and lowers the partial discharge inception voltage. Partial discharge is a localized dielectric breakdown in the oil insulation system in the presence of high voltage. The dielectric constant of a gas void is considerably less than the surrounding oil, so the electric field voltage stress appearing across the void is significantly higher than the equivalent distance of oil. If the voltage stress across the void is increased above the inception voltage for the gas within the void, partial discharge activity could start within the void, causing progressive deterioration of the paper insulating system, ultimately leading to failure.

The oil caps in Photo 2 in the article do not have a manufacturer logo, just the 2262 date code (1962?) and FAST. LF. This does not refer to the Solen Fast Capacitors that were introduced in 1987. His caps may be 46 years old, and were manufactured during the PCB era. Sprague mineral-oil-filled caps are clearly marked Sprague and after 1976 have non-PCB markings near the date code. The late 1960s Sprague catalog I have shows that all their oil-paper capacitors used purified mineral oil. I hope this caution is useful to readers.

Charles Hansen
Ocean, N.J.

Bruce Brown responds:

I appreciate Mr. Hansen taking time to respond to my article. He is correct in his statements about the potential issues with PCBs in oil capacitors. He is also correct in pointing out the ones in my amp are quite

CORRECTION

In "The Sidewoofer Line Array" (May '08, p. 41), some of the article photos were incorrectly labeled (not the author's fault). The article, of course, makes more sense with the following corrected captions:

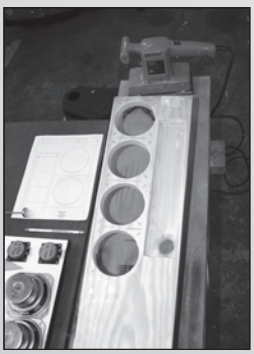


PHOTO 1: Detail of front panel tweeter slot.

PHOTO 2: Installing tweeters in slot.

PHOTO 3: Raw enclosures showing mirror image front panels.

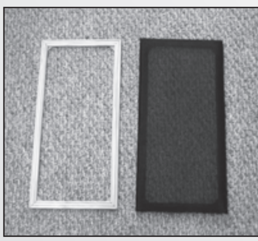


PHOTO 4: Front panel speaker grille made from screen door molding and heavy-duty pet screen material.

PHOTO 5: Crossover installed in enclosure bottom.

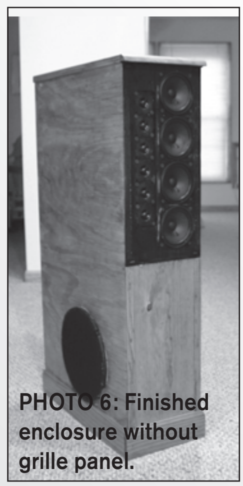


PHOTO 6: Finished enclosure without grille panel.

old. This is no surprise because they were part of the telephone amp I salvaged for the chassis—as stated in the article—which contained 4 and 5 pin tubes.

I would ask Mr. Hansen to consider writing a complete article for *audioXpress* generally on capacitors with comments on PCBs and other oil dielectrics, because I think there are still potentially thousands of sources of oil-filled caps for the consumer. I recently ordered a large number of oil-filled caps from a seller in Russia. I have not received them yet, so I don't know whether they will be marked. Some of the ones I ordered are new production, and a number of them are Russian military surplus. There are also many companies and individuals from Hong Kong, Thailand, Japan, and China selling oil caps on eBay. Given the recent issues with Chinese-made goods, and toxic substances being used, it certainly would not surprise me to find they contain toxic substances.

HYBRID AMP UPDATE

I have the following questions regarding Bill Christie's recent article, "A Hybrid High-Fidelity Power Amplifier" (*audioXpress*, January 2008, pp.30-36):

1. Figure 2 does not show any C3, C4 (15pF) or C5, C6 (33pF) caps as indicated in the Table 3 parts list. C6 and C7 are shown as 30pF in Fig. 1, but in Table 1, C7 is 470pF, C8 is 470pF and C9 is 1μF at 630V. What are the correct values? And where should C3+C4 be placed?
2. Is the chassis custom or off-the-shelf?
3. What is the P/N for U2's heatsink?
4. Subjectively speaking, what have others commented as to the sound quality?
5. Are the output tubes class A, A/B, what?
6. What changes could be made to bring the power down to, say, 25-30W?

Bill Mackenstadt
deltalight77@hotmail.com

Bill Christie responds:

1. The parts list and the schematic for the power supply are in error. The corrected versions of both are on the following page. I sincerely apologize for the confusion. I built several different versions of the amplifier using various transformers that I salvaged from amplifiers I had laying around and I got the documentation mixed up.
2. The chassis is custom built. I made it out of 1/8″ aluminum plates and fastened them together with aluminum angle.
3. The heatsink for the LM4702 is Avid Thermaloy part number 551002B00000G and is stocked in depth at Digi-Key.
4. My audiophile friends all found the sound superb, including one who is currently using Martin Logan Speakers and Bryston amplifiers and has used Magnepan Tympani speakers and Audio Research amps in the past.
5. The driver board is fairly universal and can be used with a variety of output stages. Using output transformers from the Dyna Mark IV amplifier and EL34 output tubes, the resulting amplifier should produce about 35W. And there would be considerable cost savings. At currently advertised prices:

Transformers from Triode:
Mark 4 Bundle (mk4deal) at $169.90
Mark 3 bundle (mk3-xfmrdeal) at $219.90
Tubes from Antique Electronics:
Valve Art EL34B output tubes $23.40/pair
Valve Art KT88s at $42.40/pair

The biasing voltage for the EL34s is different than for the KT88s, so resistors R15 and R16 should be changed to 47kΩ to accommodate the difference. The bias current should be set to 45mA (450mV across the cathode resistors). No other changes should be necessary. The alternates that I added to the parts list for IC U1 and transformer T3 are worth considering. The LME49710 has slightly better specs than the OPA134 and the Avel Lindberg transformer is a toroid and will generate a smaller stray magnetic field. I have used both in a conversion of the Dyna Stereo 70.

AMP DESIGN QUESTIONS

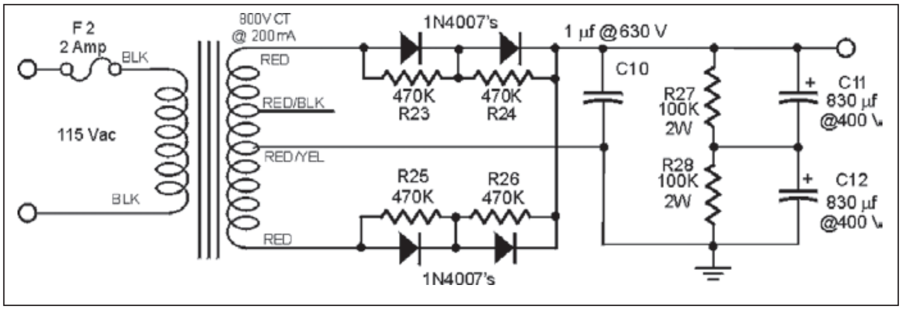
I'm in the process of building an amp using Bill Christie's ("Cascoding National's LM12 for 140W," Aug. '07) design, but I have a few questions.

1. Looking at the chassis wiring diagram pdf, I do not see where the power supply board is tied to the chassis. In fact, the chassis doesn't appear to be tied to ground anywhere. The power supply PCB doesn't have any extra pads to connect it to the chassis.
2. On the chassis wiring diagram pdf,

CORRECTED PARTS LIST FOR LM4702 HYBRID AMPLIFIER

RESISTORS	
R1	10K ½W
R2	1 Meg
R3	470 ½W
R4	15K ½W
R5	**1.8K ½W**
R6	1.5K ½W
R7	1.6K ½W
R8	10K Trim Pot
R8a	43K
R9,R10	47K ½W
R11,R12,R23-**26**	470K ½W
R13,R14	25K Panel Mount Pot
R15,R16	180K ½W
R17,R18	1K ½W
R19,R20	10 1W
R21,R22	100 1W
R27,R28	100K 2W
R29,R36	JUMPER
R30,R37	22K ½W
R31,R38	10 ½W
R32,R39	20K ½W
R33,R40	430 ½W
R34,R41	2K ½W
R35,R42	3.3K - 2W
R43	1K 1W
R44	**8.2K ½W**
CAPACITORS	
C1	2µF
C2	400pF
C3-5	not used
C6,C7	33pF
C8,C9	0.47µF
C10	1µF at 630V
C11,C12	820µF at 400V
C13	not used
C14,C18	680µF at 100V
C15,C19	10µF at 100V
C16,C20	47µF at 25V
C17,C21	47µF at 100V
C22,C23	100µF at 100V
TRANSFORMERS	
T1	Triode A-431-S
T2	Triode P-782-S
T3	Hammond 166G100 (100VCT at 0.50A)
alternate	Avel Lindberg Y236208 (110VCT at 0.45A) Toroid
DIODES	
ZD1,ZD3	1N4735 (6.2V 1W)
ZD2,ZD4	1N4744 (15V 1W)
ZD5	**1N4756 (47V 1W)**
D1,D2,...	1N4007 (1A 1000 PIV)
TRANSISTORS	
Q1	TIP122 Darlington NPN 100V, 3A, 40W)
Q2	TIP127 Darlington PNP 100V, 3A, 40W)
ICS	
U1	OPA134PA Single OP amp
alternate	LME49710
U2	LM4702C Dual HV OP amp
U3	LM317T Pos. Adj.,. 1.5A
U4	LM337T Neg. Adj., 1.5A
VACUUM TUBES	
V1,V1	KT88(6550) Power Tetrode

High Voltage section of the power supply



there is a reference to "See heatsink wiring diagram." Would it be possible to post this pdf to the *audioXpress* website?

3. And most important (to me at least) is locating an appropriate heatsink. If Mr. Christie has any suggestions about where to purchase the Aavid 79815 heatsink, I would much appreciate it, as I have been unable to locate a source.
4. More information on the chassis construction would be welcome. Were the top and bottom panels purchased or made?
5. The input signal to the amplifier appears to be shielded wire in the chassis wiring diagram pdf. I'm assuming that the shield (gnd) is connected to the input connector gnd and amplifier PCB gnd. There is also a wire with a 10Ω resistor connected to the input connectors ground. Why doesn't the last connection to ground cause a ground loop, or to ask another way, what is its function?

Thanks for the detailed drawings, PCB masks, and so on. I'm sure when I finally complete building this beast, it will have been well worth the effort.

D. Heian
St. Paul, Minn.

Bill Christie responds:

Thank you for your interest in the article.

1. The center connection of the power distribution board connects to the ground terminal of the Corcom filter that has a metal body and makes the ground connection to the chassis.
2. Here is a copy of the heatsink wiring (**Fig. 1**).
3. I bought the heatsinks at a flea market years ago. Unfortunately, the only source I know of is Aavid, and with their setup costs the price is unreasonable. I hope you can find a suitable substitute. Sorry about that.
4. I made the chassis (**Fig. 2**) from 1/8″ aluminum that I bought from a local surplus metal supplier. If you contact me, I will forward you detailed dimensioned drawings (christie.bill@gmail.com).
5. You can omit the resistors. I'm not sure what their function is. I've seen them used in other amplifiers, so for no good reason I included them in my design.

I hope these will answer your questions satisfactorily.

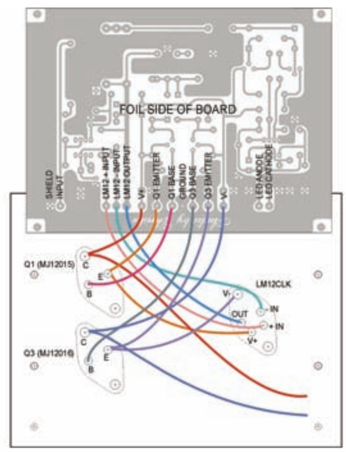


FIGURE 1: Heatsink wiring.

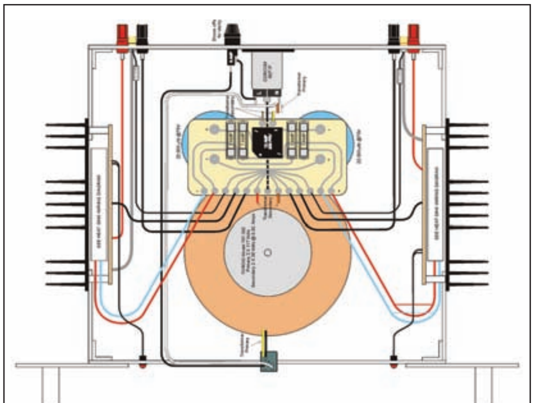


FIGURE 2: Chassis wiring.

CHANGE IN THE AIR

For those who aren't already fully up to date, here is a short rundown of what's happening and going to happen with the pending "switchover" to digital TV next February.

First, the good news: If, like most people, you are receiving your TV channels by cable (such as Comcast) or satellite (DirecTV or DISH), you don't have to do anything! In general, their boxes will receive the local digital channels and convert them to be seen on your old analog TV or new digital TV.

Cable is required to carry your local TV stations (which does *not* include stations from out of state, which you may now be able to get with an antenna).

The satellite providers are not currently delivering digital local channels in all areas, but are working toward doing that. In the meantime, they do carry the CBS, NBC, and ABC programming from East (NYC) or West (LA), but you must petition them to get those. You may need to upgrade your cable box or satellite receiver, if you want to see programs in HDTV, but they all offer deals on those.

For those who are getting their TV reception from an antenna: "Switchover" is in quotes because it is really a "switch-off." All of the local stations (those that you can receive with an antenna attached to your old TV set) are broadcasting on their digital channels already, as well as on their standard or analog channels (which can be tuned on your old TV or VCR without cable or satellite service).

So you can switch over at any time, if you have a digital tuner. You will need to do that anyway, before next February, when all the analog transmitters will be shut off.

The advantages of switching to digital reception—beyond a better and more detailed picture and up to 5.1 channel sound—are that digital can deliver an uncompromised picture with less than a tenth of the signal strength required for an acceptable picture from an analog station, and that the digitally transmitted image will have no "ghosts" or noise (snow). If the digital signal does not have enough signal strength or suffers very bad multipath problems (that would cause strong ghosting of an analog signal), there will be no image on the screen. The only exception being dynamic signal interference, during which the receiver will attempt to adapt to short-term conditions and the picture may momentarily break up.

To its credit, the FCC has mandated that all new TV sets, of any type, must have a built-in digital tuner. All older models, still in retail stock, must be labeled to inform you that they cannot receive digital broadcasts.

The government, realizing that many people can't afford an expensive digital TV receiver/tuner, is offering a $40 coupon that you can use when you buy a digital tuner, which will convert digital broadcasts to analog, so you can continue to use your old TV after next February.

Most major stores that carry TV sets are starting to get those on the shelves now. Here is the website to order coupons (limited to two per household): www.dtv2009.gov/ApplyCoupon.aspx.

There are also other kinds of video equipment, with digital tuners in them, that can receive digital broadcasts, such as DVRs (a digital version of a VCR). The ones that record and output true HDTV quality are more expensive than those that only "down res" to standard analog quality for your older TV.

However, as noted above, any new set, capable of displaying HDTV, will by law already have a digital tuner in it.

Terms and some other technical stuff: NTSC is the TV system we have all been using in the US up to now. It delivers a 480i image (a picture drawn with 480 horizontal scan lines which are produced by the visual interlacing (indicated by the i after 480) of two sequential sets of 240 scan lines. The picture format is four units wide by three units high. Among the unwelcome features of the NTSC system are the presence of a color and a tint control, which are never set just right—hence the popular translation of the acronym NTSC as never twice the same color, rather than National Television Standards Committee. Originally designed for a black and white picture and monaural sound, clever engineering subsequently managed to add color and then stereo sound, while staying within the original bandwidth limits.

ATSC, standing, of course, for Advanced Television Standards Committee, is the new digital TV system. Within these specifications are the ability to deliver many different forms of video, from the same 480i to 1080i or 720p (the p meaning progressive scan, which draws all the scan lines in the picture in a single sweep) HDTV in a wider 16 × 9 (or 1.78:1) format, versus the 4 × 3 (or 1.33:1) format of NTSC. Because it is easy to manipulate the video signal while it is in digital form, digital tuners are able to convert an incoming picture from any one of the allowable forms to any other. Thus the tuner is able to optimally match the incoming video to fit the resolution of the display it is attached to. ATSC also carries sound in the Dolby AC3 format, which allows the audio to be reproduced in mono, stereo, or 5.1 surround.

DTV, or Digital TV, encompasses all of the ATSC-permissible video standards. That can include a single channel carrying four NTSC (standard definition) programs at once, a single, fully detailed HDTV program, or a combination of one HDTV program, with a compromised image quality, along with one or two standard programs. Call the station and tell them you want your HDTV. They see the possibility of more revenue from their one channel when they can send more programs out on it. So DTV and HDTV are not synonymous.

The paranoia of content providers (owners) increases dramatically when the content is in digital form that might be easily copied or sent out (shared) via computers and the Internet. Thus HDTV content is coded with HDCP, or High-bandwidth Digital Content Protection. This mighty and complex defense system actually requires that every individual piece of electronics through which the video signal passes, from source to inside the display, must send out a query to the next piece in line and receive a satisfactory reply of authorizing identification, or the signal stops right there and never reaches your screen. These communications do not always go smoothly, especially because the specs are in their third iteration and there is a lot of first and second iteration gear in use already.

One way of simplifying the interconnection of both video and audio signals between units is the HDMI connector and cable. The HDMI specs include HDCP and have been changing up to now in their third version, including higher video bandwidth and audio signals. Much of the older HDTV equipment used the DVI (Digital Visual Interface) connector (originally created to carry digital video from a computer to its display). DVI connectors can handle the same signals as the HDMI connectors, and you can get cables with DVI at one end and HDMI at the other, as well as adaptors.

Whether you ease into it with a simple tuner/converter and your old TV set, or spring for a new flat screen, you are bound to get a better picture by next February. Happy viewing.

If you are not satisfied or just want to complain about any of this, you can e-mail me at joelco@earthlink.net. The first time you try it, Earthlink will diligently drop your e-mail into my "is this SPAM?" box, but I will fish it out in a day or so.

Joel Cohen, CTO
Crystal View Inc.

TUBE WARNING

I want to thank Charles Hansen so much for writing *A Brief History of Bendix Red Bank Tubes*. I enjoyed reading it, especially the details of the various tubes.

There is one point that may interest you. I have a Bendix tube, TD 36 "Radioactive" that is not referenced in your book. It appears to be used, although not in any obvious fashion. It was a loose tube from a science lab. I believe it to be a gas (cold) voltage rectifier.

Would you perchance have any information on this tube?

Harvey Axelrod
Williamsville, N.Y.

Charles Hansen responds:

The Bendix TD-36 (RETMA type 7416, registered on 23 March 1959) is a gas voltage rectifier as you suspected. **Photo 1** shows the similar TD-82 cold gas rectifier, which, like the TD-36, may have contained tritium gas, an isotope of hydrogen.

Photo 2 is a close-up of another tube, the TG-77 radioactive stabilized spark-gap tube, that shows the box with its radioactive warning label. This tube contains 2 microcuries (µCi) of Cesium-137 (Cs-137). I found it interesting that the label says "Caution," the symbol says, "Warning," around the box to the right, and the tube envelope says "Danger."

Cs-137 has a half-life of 30 years and emits beta and gamma radiation as it decays. Over 200,000 electron tubes containing Cs-137 were produced by all the licensed manufacturers. If you do come across one of these tubes (by way of eBay, for instance), make sure to dispose of it properly because they do contain hazardous radioactive materials. In theory, the glass envelope is thick enough to contain the beta decay particles.

As a means of comparison, the smoke detector in your home contains less than 35 kilobecquerel (kBq), or less than 1 µCi, of Americium-241 (Am-241). The SI conversion factor is 1 µCi = 37 kBq. Am-241 has a half-life of 432 years and emits alpha particles and low energy gamma rays. The alpha particles are absorbed within the detector, while most of the gamma rays escape harmlessly. *aX*

PHOTO 1: The TD-82 cold gas rectifier tube.

PHOTO 2: The Bendix TG-77 radioactive tube.

CONTRIBUTORS

Edward T. Dell, Jr. ("Editorial—"Longevity," p. 6) is editor/publisher of *audioXpress*, *Voice Coil*, and *Multi Media Manufacturer* magazines.

G.R. Koonce ("Passive Crossover Linear Phase Speakers, Part 1," p. 8) is an electrical engineer who has enjoyed the hobby of designing and building audio equipment, test gear, and speaker systems. Professionally, he worked for over 30 years producing audio frequency equipment for military use. He is a member of AES and has been a contributing writer to *Speaker Builder* since 1981.

Ron Tipton ("A Multiple Wall-Wart Power Supply," p. 20) has degrees in electrical engineering from New Mexico State University and is retired from an engineering position at White Sands Missile Range. In 1957 he started Testronic Development Laboratory (now TDL Technology, Inc.) to develop audio electronics. During the 1960s and 70s, TDL built active filters and pseudo-random noise generators for well-known companies such as Bose Corp. and Acoustic Research. He is still the TDL president and principal designer.

Gary Galo ("Is SACD Doomed?," p. 24) is Audio Engineer at The Crane School of Music, SUNY Potsdam, where he also teaches courses in music literature. A contributor to AAC since 1982, he has authored over 230 articles and reviews on audio technology, music, and recordings. He has been the Sound Recording Reviews Editor of the ARSC *Journal* (Association for Recorded Sound Collections) since 1995, was co-chair of the ARSC Technical Committee from 1996 to 2004, and has given numerous presentations at ARSC conferences (www.arsc-audio.org). Mr. Galo is also a frequent book reviewer for *Notes: Quarterly Journal of the Music Library Association*, has written for the *Newsletter of the Wilhelm Furtwängler Society of America*, and is the author of the "Loudspeaker" entry in *The Encyclopedia of Recorded Sound in the United States*, 1st edition.

Jim Dungan ("HD-2: A Single-Ended Class-A Headphone Amp," p. 31) has an AAS degree in Instrumentation, and a BS in Industrial Technology. He works for a petrochemical company as an analyzer technician. He owns a very small business repairing guitar amps, jukeboxes, tube radios, and amps.

Jan Didden ("*aX* Visits SEAS," p. 38) lives in The Netherlands and is a longtime contributor to Audio Amateur publications.

The audio hobby for **Alex Arion** ("A Greek Hybrid in Blue," p. 42) began in the magic '60s in Communist Romania in his grandmother's attic, where, together with two friends, he installed a small "illegal" laboratory. Their first attempt was a beginner's guitar amplifier and a professional guitar pickup. The tubes used included ECC40s and EF40s. The rectifier was a 5µ4, Russian equivalent. They mounted all in a hat box that they found in the attic. After finishing his studies and many years of research, Alex moved to Greece, where he continues to build different tube-based and solid-state amps.

Darcy Staggs ("Copper Tubing Capacitor Connections," p. 47) has been interested in electronics and its magic since building a crystal set in grammar school. This elementary model was later equipped with the first commonly available transistor amplifier, a GE 2N107. A college education (MS, engineering) was followed by work on the Apollo Lunar project (simulation of the electrical power system), war gaming, management software for Swedish IBM, weapons system simulation, and successfully raising two sons, who also love good music.