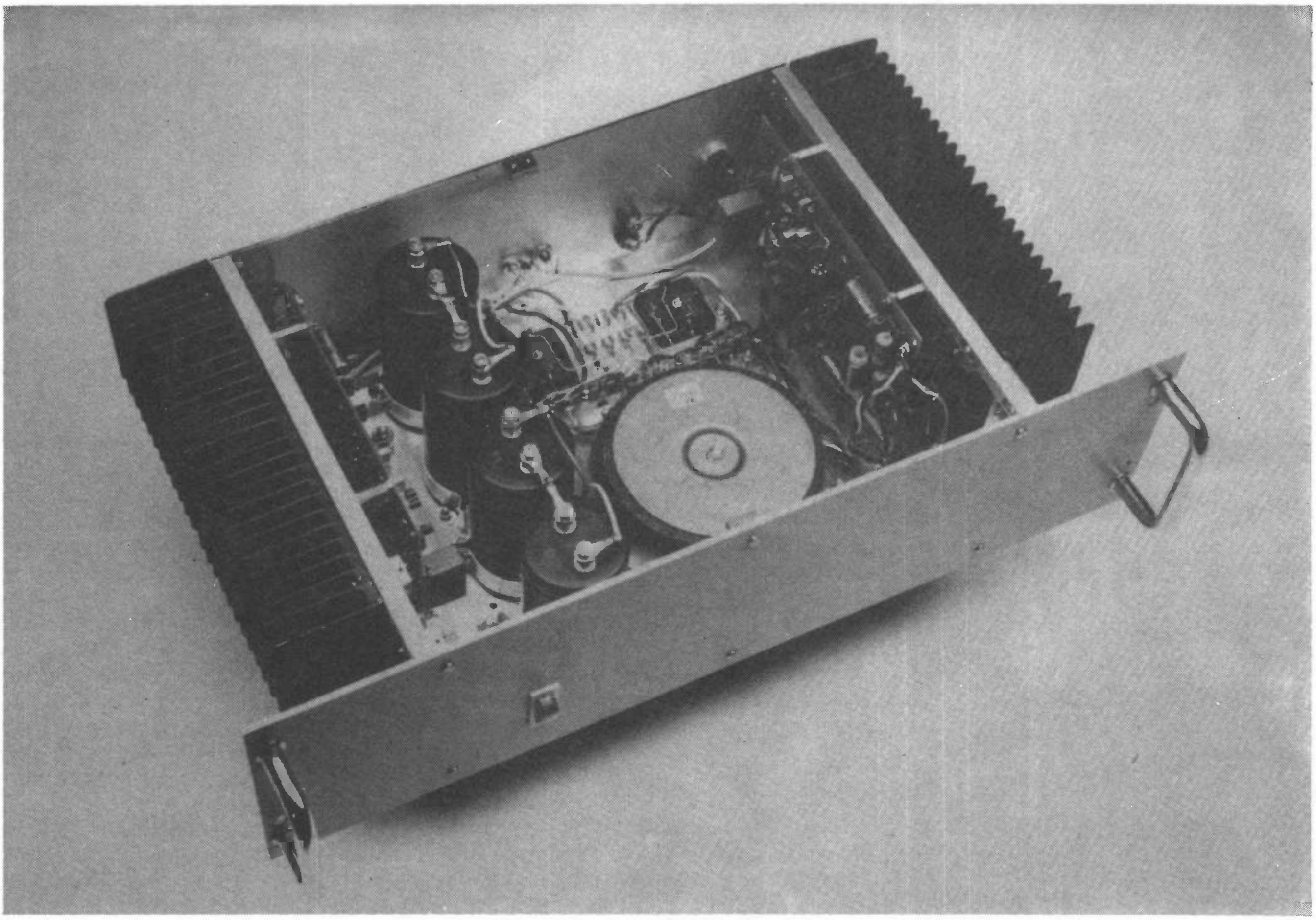
ONE-1984 $4.50

Audio Amateur

THE JOURNAL FOR AUDIOPHILE CRAFTS



Beginning in This Issue . . .

Erno Borbely's Two 100W MOSFET Amps

JUST LOOKING

If you want to keep abreast of the recording industry, perhaps you should keep **The Essentials Marketing** in mind. The Essentials stocks hundreds of items in its inventory, including albums that come under the headings of direct-to-disk, digital, half-speed mastered, high-quality analog, and Japanese and European imports.

The company also publishes a monthly *Bulletin*, which offers new releases, record-care accessories, prerecorded hi-fi cassettes and related features, plus special sales and discount values. The Essentials also distributes a quarterly catalog issue, featuring its entire inventory. A 12-month subscription to the *Bulletin* costs $3, but is free with an order of $5 or more.

If you would like more information, write to The Essentials Marketing, Dept. TA1, PO Box 7724, Eugene, OR 97401.

The Digital Domain: A Demonstration is a compact disk created "to explore the current outer limits of digital audio technology." The disk, which has been released through Elektra Records and is sold through the WEA distribution network, is a joint venture of **Warner Special Products** and **Stanford University's Center for Computer Research in Music and Acoustics**. Produced by Elliot Mazer, who is best known for his work with rock artists Neil Young, The Band and Linda Ronstadt, the disk will retail for $14.98.

Selections include several examples of digital recording, processing and synthesis. The disk also includes an extensive test section that can aid in the fine tuning of audio systems. The ten-minute test section begins with human speech segments before veering off into pink noise, square waves and sine waves, finally fading into dead digital silence.

Pioneer Electronics (USA) Inc. began marketing its new P-D70 compact disk player in January. The company has been selling a similar unit in Japan.

The P-D70 is a slim, front-loading unit, making it easy to stack with other hi-fi components. It measures less than 4 inches high and about 16½ inches across. Special optical laser technology developed by Pioneer engineers makes tracking error virtually nonexistent, and a new digital process compensates for any dropout. Harmonic distortion is an incredibly low 0.004 percent. The P-D70 also has an outstanding signal-to-noise ratio and dynamic range of 95dB. Pioneer attributes this to the electronic digital audio converter parts, which they hand select for limited tolerances and maximum high fidelity.

Using the latest in microcomputer controls, the P-D70 can be programmed to play or repeat up to ten tracks in any order. If you select a beginning and end point, it can play that section of the disk repeatedly. The unit also features four ways to search a disk—Index Search, Track Search, Minute Search and Slow Scan—while an oversized display panel shows peak channel levels on a lighted 12-dot bar graph and indicates the unit's four function modes.

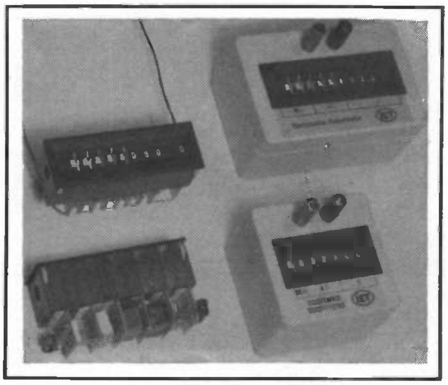
The suggested retail price is expected to be between $750 and $800. Contact Bob Thomas & Associates, 835 Hopkins Way, Redondo Beach, CA 90277.

IET Labs is now offering customized resistance, capacitance and inductance decade substitution boxes. These units use color-coded thumb-wheel switches, which allow you to dial in the desired R, C or L value, which is read as an unambiguous number. Units using rotary switches are also available for high-power and low-residual requirements.

The line includes boxes in a number of ranges, tolerances and ratings. The following values are available:

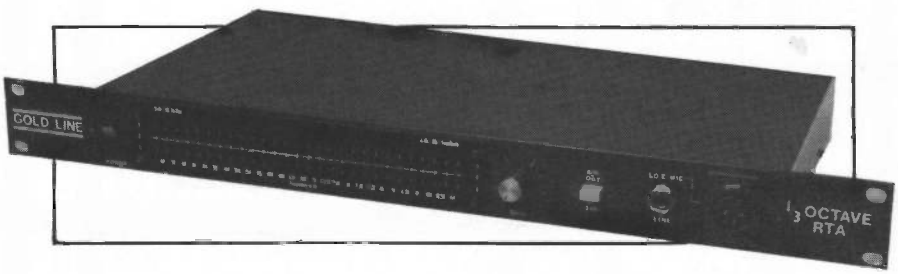
- Resistance—0.1 ohm to 900 Mohm, 0.01 to 1 percent, 0.5 to 20W;
- Capacitance—1pF to 900 microfarads, 0.5 percent to 4 percent, 100V and up;
- Inductance—10 microhenries to 90H, 1 percent, high Q.

Units come in a variety of cases or without a case for panel mounting. IET will supply any number of R, C or L substituters in one package. In addition, programmable substitution boxes



to meet users' specifications are also available. IET can accommodate any unusual or special requirements. The company also offers design advice to help users select a suitable substituter.

For descriptive literature and specifications covering the IET custom substituters, write to Mr. S. Sheena, IET Labs Inc., Dept. TA1, 534 Main St., Westbury, NY 11590.



The LM-27 is a new rack-mounted, one-third octave, real time analyzer from **Gold Line**. It has 27 bands from 40Hz to 16kHz, three rows of 27 bands each indicating either ±3dB or ±6dB, and 27 bands of three LEDs each corresponding to standard one-third octave ISO center frequencies.

The LM-27's bands correspond to the slider frequencies of most one-third octave equalizers. By patching pink noise (equal energy per octave) through a sound-reinforcement or public address system, and reading the room response on the LM-27, you can easily adjust for any variations from flat.

When unequal sound pressure levels go into a feedback loop and "howl," a spike corresponding to one of the equalizer's sliders will appear on the LM-27. A glance at the LM-27 will tell the sound engineer the correct slider to depress. Under the pressure of a live performance, the engineer can instantly make the minimum correction necessary to eliminate the feedback.

Front panel inputs and controls are a low-impedance, balanced microphone input; a high-impedance, unbalanced line input; a push-button range switch; a potentiometer-controlled reference level and a rocker-type power switch.

If you want to find out more about the LM-27 real time analyzer, contact Gold Line, Dept. TA1, PO Box 115, W. Redding, CT 06896.

The Staff

EDWARD T. DELL, JR.
Editor and Publisher

JAMES E. BOAK
ERNO BORBELY
FRED M. GLOECKLER, JR.
NELSON PASS, PETER SUTHEIM
REG WILLIAMSON
Contributing Editors

BARBARA JATKOLA
Managing Editor

RONALD H. MILLER
Book Editor

KAREN HEBERT
Office Manager

BETTE PAGE
Design/Production Director

RUTH SENECAL
Production Assistant

NANCY NUTTER
Circulation Director

WILBUR CAMPBELL
Staff Technician

TECHART ASSOCIATES
Technical Drawings

Advertising Representative
ROBERT H. TUCKER
316 St. James Place
Philadelphia PA 19106
(215) 627-5326

The Audio Amateur is published five times per year in the interests of high quality audio reproduction. Circulation and editorial correspondence should be sent to P.O. Box 576, Peterborough NH 03458. No responsibility can be assumed for unsolicited manuscripts. All MSS should include a self-addressed envelope with sufficient return postage. The staff cannot answer technical queries by telephone. Printed in the U.S.A.

SUBSCRIPTION POLICY

Subscriptions to *The Audio Amateur* are available for the whole year only. If you subscribe during the middle of the year, you will receive (upon payment) all issues for that year previously mailed, and the remaining when published. All subscriptions begin with issue No. 1 and expire with the last issue of the year's series. Back sets of 1970 and 1971 are **$6** each set. 1972, 1973, 1974, and 1975 sets are **$8** per set. 1976 and 1977 sets are **$10** per set. 1978 and 1979 sets are **$12** per set. 1980 and 1981 sets are **$14** per set. 1982 and 1983 are **$18** per set. Sample issue **$4.50** in US, **$5.50** in Canada. **1984 RATES: $18** for five issues; **$35** for ten issues. Latin America add **$2** per year. Canada and all other countries add **$4** per year for postage. Air rates on request. Note: all subscribers residing outside the Western hemisphere are served by air to Amsterdam and by surface from thence.

OVERSEAS SUBSCRIPTION OFFICES:
United Kingdom: *TAA*, Leazings, Leafield, Oxford OX8 5PG England.

THE AUDIO AMATEUR (US ISSN 0004-7546) is published five times a year (Feb., May, July, Oct. and Dec.) at $18 per year; $35 for two, by Edward T. Dell, Jr. at Old Jaffrey Rd., P.O. Box 576, Peterborough NH 03458. Second class postage paid at Peterborough NH and additional mailing offices.

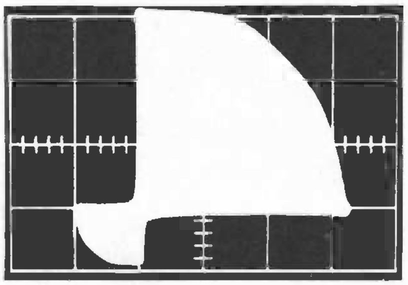
POSTMASTER: If undeliverable send PS form 3579 to P.O. Box 576, Peterborough NH 03458.

Volume 15 Number 1 March 1984

Audio Amateur

This first issue of 1984—our 59th—begins *Audio Amateur*'s 15th year. Contributing Editor **Erno Borbely** has been keeping busy, as he leads off (p. 7) with the first of two 100W power amps. The second amp and power supply information for both will appear in *TAA* 2/84. **Reggie Williamson** is back, detailing a peak reading meter for the classic ReVox A77 tape recorder. If you don't remember the difference between our American volume unit meters and the British peak reading types, Reg will explain all starting on page 19.

Chris Grupp, a newcomer to these pages, has cleverly solved a mixing board problem in his elegant constant power panning potentiometer (p. 24). **Jan Didden** finishes his series with an add-on for his 200W amp—or for any other power amp you might be using. His power switch,



which is operated by the audio signal, is an updated version of his earlier device, which appeared in *TAA* 3/78 (p. 16).

Kirk Vistain takes us to his repair bench (p. 46) for a visit to the worst of all equipment malfunctions—mysterious intermittents and secondary effects. Readers **Paul Kelly, Stephen Nitikman** and **Bob Ballard** share their helpful audio aids (p. 38), including a line filter, a delayed preamp turn-on and a turntable isolator. **Don Prock** showcases more of his handiwork in a modified Marshall Leach power amp design (p. 43), while **Don Spangler** has turned up more recorded gems in his reviews, starting on page 50.

Next time, look for Erno Borbely's second MOSFET power amp, an enhancement for a ho-hum IC power amp, how to add belt drive to a vintage rim-drive turntable, and a high-voltage regulator for tubes. □

ARTICLES

DEPARTMENTS

DOLLARS AND PUBLIC BROADCASTING SENSE

One evening last autumn, I was driving through southern New Hampshire and listening to a concert on Boston's public radio station, WGBH. When the concert was finished, the Ford Hall Forum came on, featuring Ralph Nader as one of the speakers. I was tempted to turn the dial to another music station, but left it alone when Mr. Nader began to talk about citizens' rights.

Almost in passing, he mentioned that the airwaves are often not directly accessible to the people who own them (namely, us) and that the Federal Communications Commission (FCC) assigns the right to use radio and television frequencies without charge. This is, Nader said, "virtually a license to coin money."

After the Forum program ended, I switched to another FM public radio outlet, which was in the middle of a fund drive to support the station's operation for another six months. They were asking for $50,000, offering little gifts and a big guilt trip to pique potential donors' consciences.

It occurred to me that perhaps the time had come to rent the *public's* airwaves to commercial stations. This would benefit the public in at least two ways. First, it would offset the high cost of running the agency that regulates the US airwaves, the FCC. I pay an annual fee to use the Postal Service's third-class mail communications channel. This fee, I am told, covers administrative expense. Would it be so unreasonable to ask US commercial radio and TV stations to pay $5 per watt of broadcast power annually to offset the considerable costs of the FCC's activities, as well as give them money to do better and more exhaustive research on technical questions? A $5-per-watt rental fee would amount to $5,000 a year from a thousand-watt station and only a quarter of a million dollars from a 50-kilowatt outlet, a relatively small sum representing only a few prime-time advertising spots.

The second benefit the public would derive from such a fee would be greater support of public radio and television. The money might be allocated to public stations according to the number of privately owned for-profit stations in a particular region. Of course, the money would not support public stations completely, but it would offset the amount needed from listener/viewer donations.

Such a plan was suggested back when a national public radio system was first proposed. Commercial broadcasters opposed the idea, suggesting tax support as a more equitable answer. Tax appropriations were given, but the Reagan Administration and Congress have since removed them from the budget. The presumably lower taxes that result from cutting public media out of the Federal budget make politicians look good, but now the public electronic media must raise more and more of their support money themselves.

This is achieved partly by carefully expanding the definition of "non-advertising" institutional support. It seems the announcements of who helped make each program possible get longer by the month. And annual "auctions" of commercial companies' products and services are really advertising in a not very clever disguise.

The other part of the funding comes from those who watch and listen to the public media. The argument that viewers and listeners should support public broadcasting if they think it is important has some merit. It would not be in the best interest of the public media to be entirely supported by tax monies or by a rental fee derived from the commercial stations. But the public system should be partially supported by government, preferably by some method that prevents any more bureaucratic surveillance than is absolutely necessary.

My reasons for this stance have to do with my own set of values, of course. I believe the commercial electronic media in the US do not give us a representative cross-section of what is valuable and entertaining in our culture. I think the commercial nature of their support makes that shortcoming inevitable.

On the other hand, public stations, which do not have to worry about numbers or commercial

Continued on page 58

Part I

THIRD-GENERATION MOSFETS: THE SERVO 100

BY ERNO BORBELY
Contributing Editor

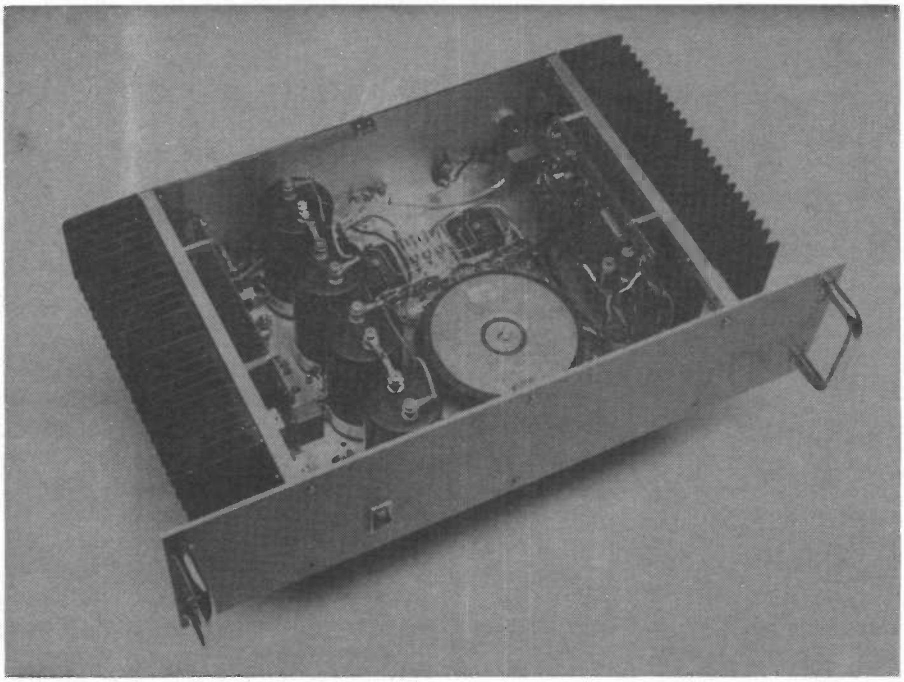


PHOTO 1: The author's prototype Servo 100 amplifier is constructed of rack panels, aluminum bar stock and large, end-mounted heatsinks. It uses a compact toroidal transformer and separate pairs of filter capacitors for each channel.

THE "SERVO 100" and "DC 100" circuits presented in Parts I and II of this article represent my third generation MOSFET power amp design philosophy. The first generation began in 1978 when I joined the David Hafler Co. and started to develop the DH-200. At that time I began using the Hitachi 2SK134/2SJ49 power MOSFETs and have used them ever since. My second generation of MOSFET amps included a 60W[1] and 120W[2] design, which led to my most recent designs. By allowing a wide choice of components, while still keeping a reasonably tight budget, this third generation provides an excellent price/performance ratio. Before describing these circuits, however, I would like to explain why I prefer MOSFETs to bipolars.

Bipolar Problems

During my 16 years of involvement with bipolar power devices, I had three problems with them. The most important is related to thermal instability,[3] which is inherent in all bipolars.

Under normal operating conditions (i.e., high current, low voltage), the transistor chip has a uniform current and temperature distribution. When the transistor is operating at high voltages, the collector current tends to concentrate in small areas, causing very high peak temperatures (200 to 300°C) in these areas. The chip's thermal instability causes these "hot spots." The average junction temperature, which you can measure on the case of the transistor, does not show the presence of the hot spots, so they can go undetected.

Internal processes in the silicon tend to reduce the current concentration and produce what we call "stable" hot spots. These usually do not cause permanent damage immediately, but they do degrade the performance of the devices by, among other things, increasing the nonlinearities of the transistor. When you increase the voltage across the transistor, the thermal instability can lead to a runaway condition, which results in secondary breakdown.

A typical "safe operating area" curve, normally published by transistor manufacturers, is shown in *Fig. 1*. It is important to note that hot spots are also produced within the safe operating area curve, especially at combinations of high voltage and high current. (See the dotted area of the curve.) If you want to avoid degradation of a bipolar device, stay clear of the area where hot spots can occur.

Over the years, a number of re-

This article is a revised version of one originally appearing in high fidelity magazine, published in Copenhagen, Denmark.

searchers have developed means to protect the bipolar transistors from secondary breakdown. RCA's Sondermeyer[4] developed the most widely known solution—a volt-amp (V-I) limiter, which gradually reduces the collector current at increasing collector-emitter voltages, thus protecting the transistors from the destructive combination of high voltage and high current. The disadvantage of the V-I limiter is that, when activated, it tends to cause unpleasant sound coloration. Nevertheless, this kind of protection, in one form or another, has been used in most power amplifiers for the past 15 years.

Unlike bipolars, power MOSFETs do not have any inherent thermal instability. The drain current is distributed uniformly across the whole chip, which prevents development of hot spots. Consequently, MOSFETs do not have secondary breakdown problems. This means that you do not need a V-I limiter in the amplifier because the power capability of the die/package combination provides the output power limit.

The second problem with bipolars is the collector current's positive temperature coefficient versus the base-emitter voltage. Increasing temperature results in increasing collector current, due to a change in the V_{BE} characteristics. This, in turn, further increases the temperature and eventually causes a runaway condition. The simplest solution is to use thermal feedback. Diodes or transistors, used for biasing the output devices, are mounted on the output heatsink, monitoring the temperature in it. This reduces the bias with increasing temperature. Unfortunately, this kind of circuit cannot react to instantaneous temperature changes in the transistor die itself, but only to the average temperature of the heatsink. A good tracking is, therefore, very difficult to achieve.

The transfer characteristic of a 2SK134 MOSFET is shown in *Fig. 2*. The characteristic is slightly positive at low values of drain current, but clearly negative at high currents. The crossover occurs at approximately 100mA, where the temperature coefficient is zero. If you bias the MOSFETs at this drain current, you have practically no temperature drift and do not have to use complicated bias-tracking circuits. A simple potentiometer can adjust the bias.

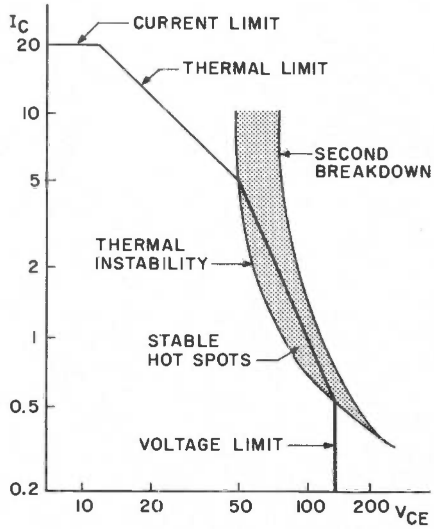


FIGURE 1: Region of thermal instability in bipolar power transistors.

The third problem with bipolars is related to the fact that they are minority carrier devices. Bipolars accumulate charge in the base region. This causes a problem in class AB operation because removing the charge takes time and effort. The charge has to be removed while one device is turning off and the other is turning on, so the amount of charge will determine the transition's duration. One consequence of this is increasing power dissipation with increasing frequency. The other is the increasing width of the crossover distortion compared to the period of the sine wave. Naturally, infinite feedback would eliminate this distortion. Unfortunately, this is not the case, especially with bipolar output stages. Using double or triple emitter followers, which is usual in medium and high-power amps, the bandwidth is limited and the accompanying phase shift is large. This means that the amount of feedback available to reduce distortion at high frequencies is limited.

MOSFET Merits

MOSFETs suffer much less from these problems. Being majority carrier devices, the charge carriers are controlled by an electric field and not by injection of minority carriers into the active region. The gate regions, therefore, contain no stored charge. Switching between the on and off state is very fast, even when the device is coming out of clipping.

In the source-follower mode, a MOSFET has a much wider bandwidth than an equivalent bipolar device used in an emitter-follower configuration (see *Fig. 3*). This allows you to realize a wider open-loop bandwidth, with more gain available for feedback at high frequencies. The combined effect of faster switching and wider bandwidth is less crossover distortion at high frequencies, a smoother-sounding amp and less fatiguing. I take advantage of these MOSFET characteristics to design low open-loop gain, wide-bandwidth amplifiers that show less high-frequency distortion than high-gain bipolar circuits.

All this does not mean, however, that MOSFETs are ideal devices. They do, indeed, have some disadvantages, although no serious ones.

The first is the relatively high "ON" resistance of the Hitachi devices I always use. Typically, this is specified at 1Ω, with a maximum value of 1.7Ω. You can easily see that this will cause a higher device dis-

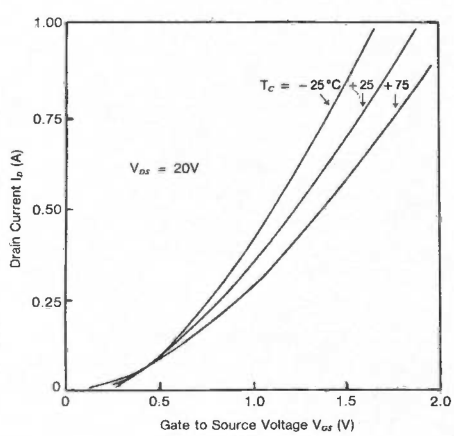


FIGURE 2: Transfer characteristics of a 2SK134 MOSFET at various temperatures. Note the negative temperature coefficient at drain currents higher than 100mA.

sipation and lower efficiency. Practically speaking, you might find that MOSFETs are running a bit warmer than equivalent bipolars on the same heatsink and that the supply voltage is slightly higher. MOSFETs with a much lower "ON" resistance are available from other manufacturers, but they do not have the same breakdown voltage or are not complementary.

The second point is the current and power capability of the Hitachi MOSFETs. The 2SK134/2SJ49s are rated at a maximum of 7A and 100W dissipation. Hitachi also offers an 8A/125W version, but even that sounds small compared to the "big" bipolars (16 to 25A). On the other hand, if you consider that the MOSFETs have no second breakdown limitation, you can use as much or more of the available power at high voltages than with bipolars.

Although usually considered an advantage, the high input impedance of the MOSFETs is not as easy to handle as it sounds. The input looks like a pure capacitor, having typical values of 600 to 900pF (N and P-channel, respectively). As you will see later, you must take this into consideration when designing the driver stage.

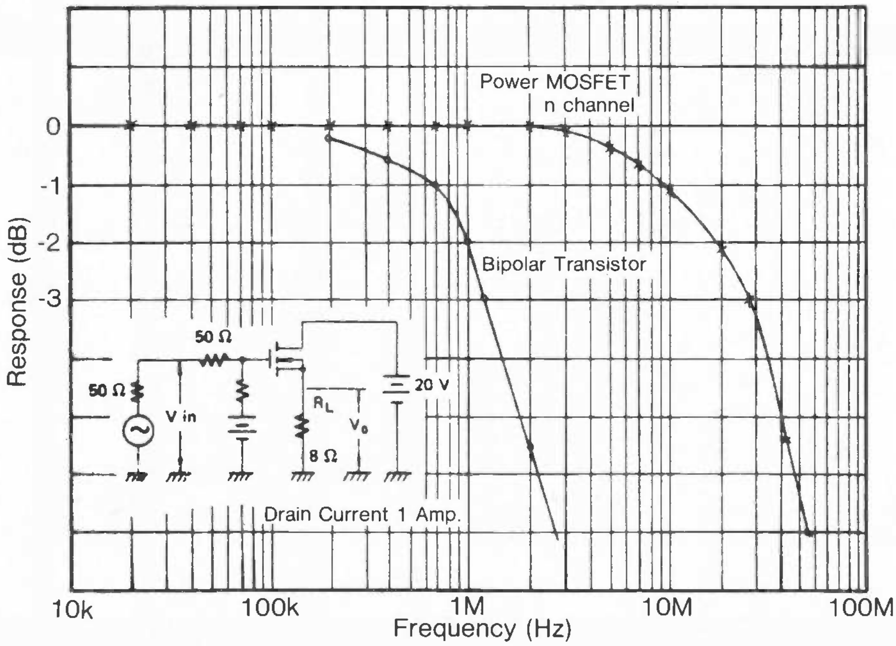


FIGURE 3: Frequency response of a MOSFET source follower. The bandwidth of the source follower is significantly wider than that of a bipolar emitter follower.

Driver Circuit Design

A power amplifier consists of two stages—the driver stage and the output stage. Output devices are usually used in a unity-gain configuration, which means that the driver stage has to supply the voltage swing needed to drive them. Selecting the driver stage topology is, therefore, the most important factor in the design. You must consider the following requirements:

- linearity;
- open-loop bandwidth;
- drive capability.

If you want to use the power amp in true DC connection, you must add DC stability to the above requirements. I will discuss this consideration in Part II.

Inherent linearity is the most important requirement in selecting the driver circuit. This means that the circuit has to have very low distortion before feedback is applied. The circuit I have been using in my 60W power amp (*Fig. 4*) satisfies this requirement. It is a two-stage, completely symmetrical circuit, consisting of a dual, complementary input stage and a differentially driven, single-ended second stage. The differential input stages are operated at 2mA (1mA in each transistor), while the second-stage transistors (Q6 and

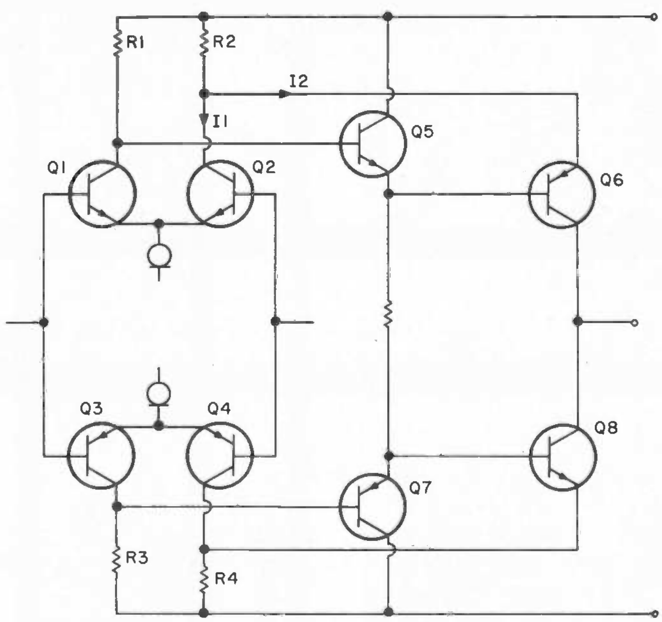


FIGURE 4: The symmetrical driver circuit originally used in the author's 60W MOSFET amplifier.

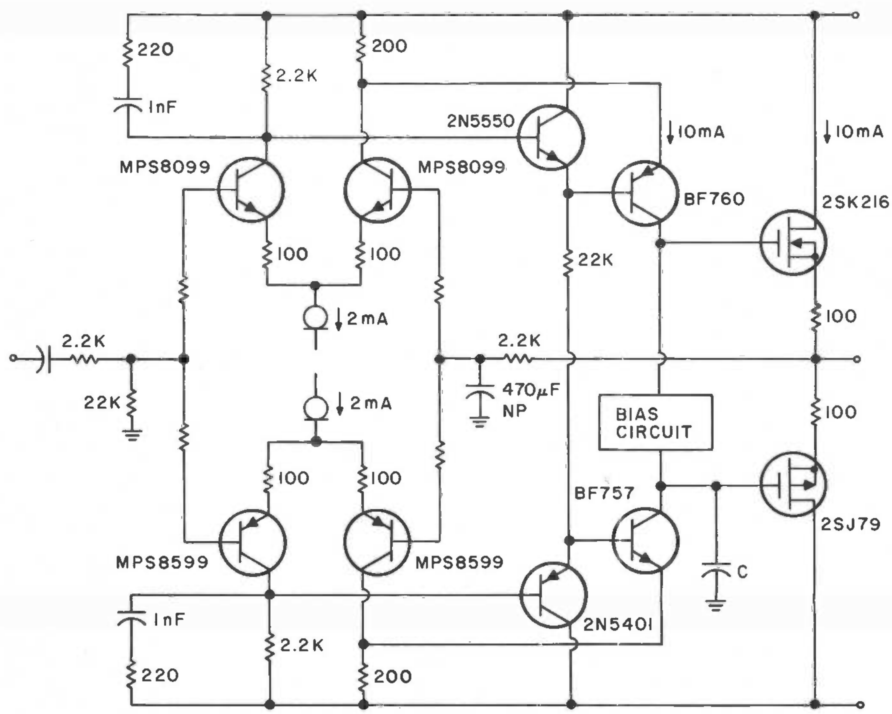


FIGURE 5: Driver circuit with source followers. The 470μF nonpolar cap removes the AC feedback at middle and high frequencies, while allowing you to make open-loop measurements.

Q8) are conducting 10mA. The current through Q6 and Q8 is controlled by the ratio of R1 to R2:

$$\frac{R1}{R2} = \frac{I2 + I1}{I1}$$

With I1 equal to 1mA, this becomes:

$$\frac{R1}{R2} = I2 + 1$$

When I2 equals 10mA, the ratio of the resistors has to be 11. Using R1 at 2.2k, R2 must be 200Ω.

In the 60W amplifier, I have been using this circuit with a current ratio of 30:1 and operating the second stage at approximately 30mA. This was the maximum ratio I could get without sacrificing linearity. Feeding a single pair of output devices, it is enough to charge and discharge the input capacitance of the MOSFETs, even at the highest frequencies. If you want 100W, however, you have to use two pairs of the Hitachi devices, and 30mA is not enough to drive the MOSFETs with low distortion at high frequencies.

I described one way of increasing the drive capability in my 120W design article.[2] In this design, the second stage of the driver circuit is operating at 50mA, which is sufficient to drive two pairs of MOSFETs with very little distortion. Operating the driver transistors at this high current requires significant heatsinking, which is rather difficult to arrange on the circuit board. Therefore, I decided to use emitter or source followers at the output of the driver circuit.

Doing so adds nonlinearity to the circuit, but it also increases the open-loop gain, which, converted to feedback, corrects the nonlinearity. More importantly, the follower can deliver extra current when needed, thus reducing the problem of driving the MOSFETs' input capacitance at high frequencies. I tried the circuit with emitter followers and source followers, but chose the latter because of the decreased phase shift they offer.

Figure 5 shows the driver circuit as it was hooked up for open-loop measurements. Capacitor C determines the roll-off of the driver circuit. With C equal to 0pF, I measured a frequency response of 1dB down at 30kHz. A realistic value for this capacitor in the final amplifier is around 50pF, which gives a 3dB bandwidth of 20kHz. This satisfies the requirements for open-loop bandwidth to avoid internal overload of a feedback amplifier under transient conditions,[5] also known as transient intermodulation distortion, or TIM.

The open-loop gain of the driver circuit is approximately 56dB. I chose 26dB for the closed-loop gain of the final amplifier, so the total feedback is around 30dB. I consider this a very good ratio between open-loop gain and closed-loop gain. The specifications of the final amplifier circuit show that you can achieve good closed-loop performance with this circuit.

Servo 100 Circuit

The complete Servo 100 circuit diagram is shown in *Fig. 6*. The diagram is divided into two parts—the circuit board and the heatsink assembly.

Components C1, C2, R1 and R2 make up the input network. Although this is a servo-controlled amplifier, I included an input capacitor for special cases. For instance, some preamps are DC coupled, but deliver some DC voltage at the output, while others might have leaky capacitors that produce an offset voltage. If you are sure that no DC comes from the preamp, you can short-circuit C1 or remove it from the board completely.

R1/C2 form a low-pass filter, which prevents out-of-band transients from reaching the amp input. It also cuts off unwanted high-frequency signals, which might cause in-band intermodulation products. For this reason, you should adjust the actual roll-off in your system to approximately two times the highest desirable audio frequency. The following table shows the recommended values for C2 as a function of the

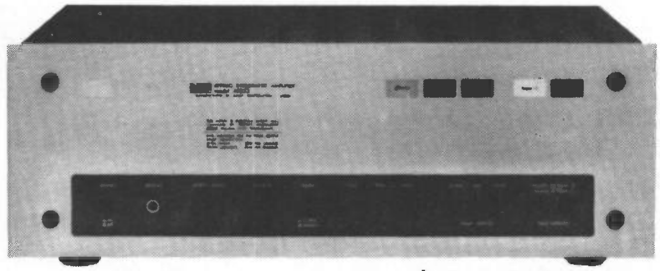
FUJITECH AUDIO KITS

MODEL A-1033

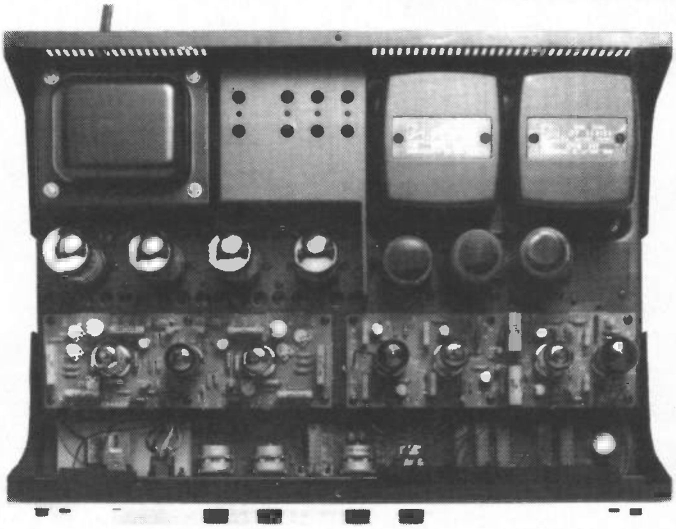
This Integrated Tube amp is winning wide acclaims from kit-building audiophiles all over Japan. Superior performance achieved by:

1. Handcrafted output transformer that is virtually distortionless within its power rating, due to special winding techniques which result in widest frequency response and minimum phase shift.
2. Latest Japanese design with choice of UL (Ultra-Linear) or Triode Output (for Class-A like performance).
3. Hum-free PCB layout for both preamp and power amp.
4. High quality components and instrument-like construction techniques.

KIT ONLY
$499.00



$499.00



SPECIFICATIONS

Tube Compliment:	6CA7(4), 12AU7(2), 6AQ8(1), 12AX7(4)
Power Output (UL Mode)	30W x 2(4Ω, 8Ω), 25W x 2 (16Ω). Both channels driven
(Triode Mode)	15W x 2(4Ω, 8Ω), 11W x 2(16Ω). Both channels driven
THD:	Below 0.4% (8Ω, 1kHz, 30W)
Intermodulation Distortion	Below 1% (8Ω, 30W, 60Hz:7kHz=4:1)
Frequency Response	30~30,000Hz (within −1dB, 8Ω, 1W)
Input Sensitivity	Phono: 2.2mV, TUNER AUX, Monitor −1, 2;190mV
SN Ratio (1HF-A weighted)	Phono: 72dB, TUNER AUX, Monitor −1, 2;92db

$299.00

MODEL A501 POWER AMP

★ Pure Class A 25W + 25W
★ Switchable to Class AB 100W + 100W
★ Switchable to Bridge Class A 100W mono
★ Switchable to Bridge Class AB 300W mono
★ Frequency Response 5-200kHz (-1dB)
★ Signal-to-Noise Ratio 120dB
★ Non-magnetic Chassis
★ "Out-board" comprehensive protection circuitry
★ DC circuitry with limited use of NFB
★ High Efficiency Fluid Convection Cooling
★ THD under 0.007%

KIT ONLY
$299.00

$349.00

MODEL A502 DC STEREO CONTROL CENTER

★ Direct DC coupling from Input to Output
★ DC servo circuitry
★ Cascade FET Input in all stages
★ Separate Moving Coil RIAA amplifier
★ Distortion below 0.005% (3V)
★ Max Output 15V
★ Frequency Response 20Hz-20kHz ± 0.2dB
★ Maximum Phono Input
MC = 16mv RMS (1kHz)
MM = 270mv RMS (1kHz)
★ Built-in Headphone amplifier
★ Relay Output Muting

KIT ONLY
$349.00

FUJITECH ALL KITS MADE IN JAPAN

Send $5.00 for each assembly manual, refundable with order

MONARCHY ENGINEERING, INC., P.O. Box 5517, 380 Swift Avenue, Unit 21, South San Francisco, CA 94080

VISA or MASTERCARD ACCEPTABLE

output impedance (calculated for a roll-off of 50kHz):

R_{out} (ohms)	C2
0	1.5nF
600	1.2nF
1k	1nF
2k	680pF
5k	470pF
10k	270pF

Consult your preamp's manual to determine its output impedance and to select the proper value of C2.

When C1 is in the circuit, R2 determines the offset voltage caused by the input transistors' bias current. Since the bias current depends on the current gain, you should use high-gain transistors for the input. Unfortunately, high gain does not usually go with high breakdown voltage, which is also a requirement for these transistors, so you must reach a compromise. My choice is the MPS8099 (NPN)/MPS8599 (PNP) complementary pair. These are rated at an 80V breakdown voltage and have a current gain of 100 to 300 at a 1mA collector current. Since 1mA is the actual current I used, I will use these values in my calculations.

First, let's look at the maximum offset you can expect. The feedback network is usually a low-impedance one, so the offset will be developed across R2. Assuming that the NPN transistor has maximum gain and that the PNP transistor has minimum gain, you get:

$$[R2 \times I_B(PNP)] - [R2 \times I_B(NPN)] = 146mV$$

where R2 equals 22k and I_B is the base current.

This value is quite high and would produce an offset of almost 3V at the output of the power amp with a gain of 20 times. With the servo circuit, however, you can compensate for this relatively easily, as you will see later. Note that the offset is directly proportional to R2, which limits the maximum value you can use.

My second choice for the input devices is the BC546B/BC556B complementary pair. These are rated at a 65V breakdown voltage and 180 to

PARTS LIST

Resistors

R1	2.2k	R24	10k
R2	22k	R25	10k, 1W, metal oxide
R2A	2.2k	R26, R27	1M
R3	220Ω	R28	10k, 1W, metal oxide
R4	2.2k	R29	22k, 2W, metal oxide
R5	200Ω	R30	22Ω
R6–R13	100Ω	R31	560Ω
R14	220Ω	R32	1k
R15	2.2k	R33	22Ω
R16	200Ω	R34	150Ω
R17	2.2k	R35	1Ω, 5W, wire-wound
R18, R19	22k, 1W, metal oxide	R36	10Ω, 4W, metal oxide
R20	2.2k	R37, R38	220Ω
R21	2.2k, 2W, metal oxide	R39–R42	0.22Ω, 5W, wire-wound, low inductance
R22	100Ω		
R23	330Ω	R43, R44	220Ω

All resistors ¼W, 5% carbon film, unless otherwise noted. The ¼W resistors can be replaced with 1% metal film. Use nearest value.

Potentiometer

P1	1k, ¼W, linear

Capacitors

C1	6.8µF, 63/100V, polypropylene, polycarbonate, Mylar
C2	330pF, 63V, polypropylene, polystyrene
C3, C4	1,000pF, 63V, polypropylene, polystyrene
C5, C6	0.1µF, 100/250V, low ind. ceramic, Mylar (stacked foil)
C7	100pF, 63V, polypropylene, polystyrene
C8	0.1µF, 100/250V, low ind. ceramic, Mylar (stacked foil)
C9, C10	0.22µF, 100V, polycarbonate, Mylar (stacked foil)
C11	0.1µF, 100/250V, low ind. ceramic, Mylar (stacked foil)
C12	47µF, 63V, electrolytic
C13	0.1µF, 100/250V, polycarbonate, Mylar (stacked foil)
C14	47µF, 63V, electrolytic
C15	0.1µF, 100/250V, polycarbonate, Mylar (stacked foil)
C16	56pF, 63V, polypropylene, polystyrene
C17	150pF, 63V, polypropylene, polystyrene
C18, C19	330pF, 63V, polypropylene, polystyrene
C20	100µF, 63V, electrolytic
C21	0.1µF, 100V, low ind. ceramic, Mylar
C22	100µF, 63V, electrolytic
C23	0.1µF, 100V, low ind. ceramic, Mylar

Transistors, ICs

Q1, Q2	MPS8099, (alt. BC546B)
Q3, Q4	MPS8599, (alt. BC556B)
Q5	MPS8599, (alt. BC556B)
Q6	MPS8099, (alt. BC546B)
Q7	LF 411ACN, (alt. LM 11CN)
Q8	2N5550
Q9	2N5401
Q10	BF 760, (alt. 2N5415)
Q11	MPS-A55
Q12	BF 757, (alt. 2N3440)
Q13	2SK216, (alt. BF 757)
Q14	2SJ79, (alt. BF 760)
Q15, Q16	2SK134
Q17, Q18	2SJ49

Diodes

D1	LM 336BZ-5V, ref. diode, National Semiconductor
D2, D3	1N5245, 15V, 0.5W zener or equiv.
D4	LM 336BZ-5V, ref. diode, National Semiconductor
D5	1N4148
D6	1N5240, 10V, 0.5W zener or equiv.
D7	1N4148
D8	1N5240, 10V, 0.5W zener or equiv.

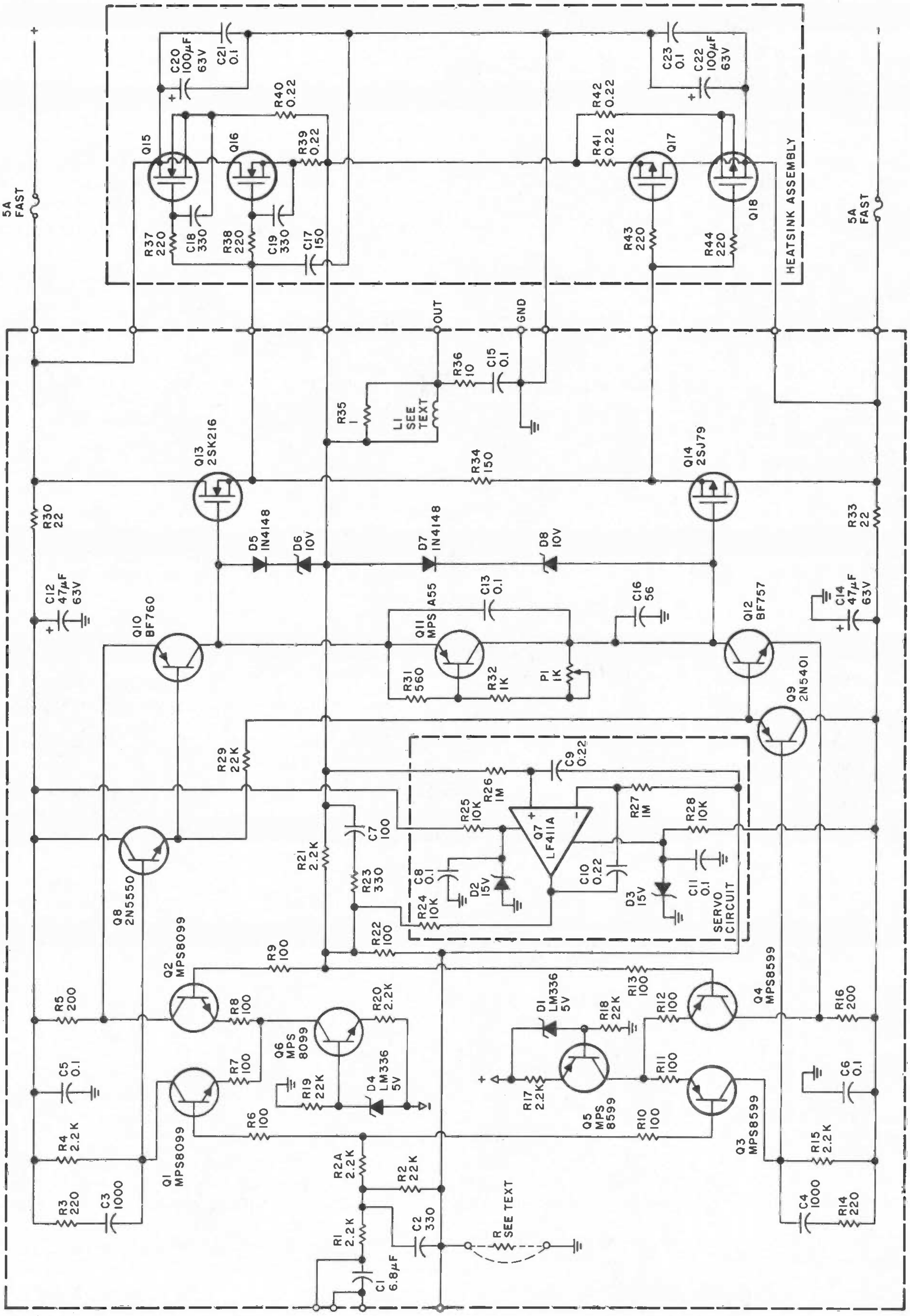


FIGURE 6: Schematic diagram of the Servo 100 MOSFET power amp.

450 current gain at 2mA. Naturally, this higher current gain will reduce the offset voltage: maximum will be around 70mV with the same value of R2. As far as the breakdown voltage is concerned, it is more than adequate for this application if the power supply does not exceed ±60V.

A third type of input device I considered was a matched pair of dual transistors. They did not improve the performance of the servo-controlled version, however, so I did not use them. I will talk more about them in the second part of this article, where they are an essential part of the true DC-coupled circuit.

The feedback network consists of R21, R22, R23 and C7. R21 and R22 determine the AC and DC gain of the amplifier. Theoretically, this is equal to:

$$\frac{R21 + R22}{R22} = 23 \text{ times}$$

or 27.2dB. You lose a bit of gain at the input because of the voltage division between R1 and R2 and the finite open-loop gain of the amplifier. The total closed-loop gain is about 20 times, or 26dB, which is standard for a 100W amplifier. R23/C7 is a phase-compensation network that you adjust for best square-wave performance.

Q5, Q6 and the components around them are constant-current sources for the input stages. To make a stable current source, you must have a stable reference voltage. Frequently, uncompensated, low-voltage zener diodes are used for this purpose. Low-voltage zeners have a high dynamic impedance, however, and require a substantial current to operate at the specified breakdown voltage. A much better solution is to use one of the excellent voltage reference diodes offered by National Semiconductor. These are active devices, operating over a very wide current range with a typical dynamic impedance of less than 1Ω. I use the LM 336, which is offered with both 2.5V and 5V reverse-breakdown voltages. I use the 5V one, which operates at 400μA to 10mA. With a trimpot, you can adjust the breakdown voltage between 4 and 6V, but I am using it unadjusted, with a tolerance of ±100mV. The type number for the inexpensive plastic package is LM 336BZ-5V.

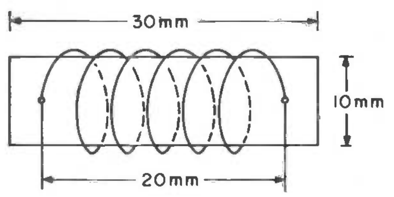


FIGURE 7: The Servo 100's L1 output coil prevents capacitive loads from shorting the output (not drawn to scale).

Q7 and associated components form the servo circuit. This is a non-inverting integrator,[6] using either an LF 411A low-offset BIFET or an LM 11C bipolar op amp. You can also use older BIFET op amps, but make sure the zener-stabilized supply can supply the necessary current. I would not recommend older bipolar units because of the high bias current they require.

Assuming that the maximum voltage swing of the op amp is ±12V, the maximum offset you can correct is:

$$\frac{12V}{R24} = 120mV$$

where R24 equals 10k. This is a bit lower than the maximum offset calculated for the MPS devices, but I used it because I do not expect to run into those worst-case conditions in making only a few amplifiers. In any case, it is necessary that you check the operation of the servo circuit when you finish building the amplifier. Do this by measuring the DC output of Q7. As long as it is not too close to 12V, everything should be okay, and the DC output of your power amp will be within a couple of millivolts of zero.

If the output of the op amp is close to the supply voltage (±15V), the servo circuit is saturated and cannot track the offset. This being the case, I recommend that you remove Q7 (it should be socketed for easy testing), measure the DC output of the power amp and go through the above calculations. You can lower the value of R24 a bit to accommodate an unusually high offset, but you should not have to go below 5k to cover the extreme case.

Emitter followers Q8 and Q9 are operating at approximately 5mA. Devices in normal TO-92 plastic packages offer sufficient dissipation. I recommend the 2N5550/2N5401 pair for this application.

Q10 and Q12 are the most important transistors in the amplifier. High breakdown voltage, low saturation voltage and linearity are the primary requirements for these devices. I have tried many transistors, but only two types—the BF 757/BF 760 and the 2N5415/2N3440 complementary pairs—work satisfactorily. The BF devices come in the TO-202 package and are capable of dissipating 2W in free air without heatsinking. The 2Ns are in a metal TO-5 package and require a small snap-on heatsink. My board layout allows you to use either without mutilating the legs.

Q11 and the voltage divider consisting of P1, R31 and R32 are used for bias adjustment. Since you do not need any temperature compensation for the MOSFETs, you could use a potentiometer for this purpose. I do not like to pass 10mA through the wiper of a small trimpot, however, so I prefer a V_{BE} multiplier.

Before you switch on the amp, set P1 to its counterclockwise position. You can adjust bias by monitoring the current through the fuses or measuring the voltage drop across the source resistors R39–R42. In the first case, the total current through the fuse should be approximately 230mA. In the second case, the voltage drop across the 0.22Ω source resistors should be approximately 22mV. In either case, the adjustment must be done with no input signal (shorted input). Both types of adjustment will result in 100mA through the MOSFETs, which is considered optimum for minimum temperature drift and crossover distortion.

Source followers Q13/Q14 are operating at the same current as Q10/Q12 (approximately 10mA). I use medium-power MOSFETs in a

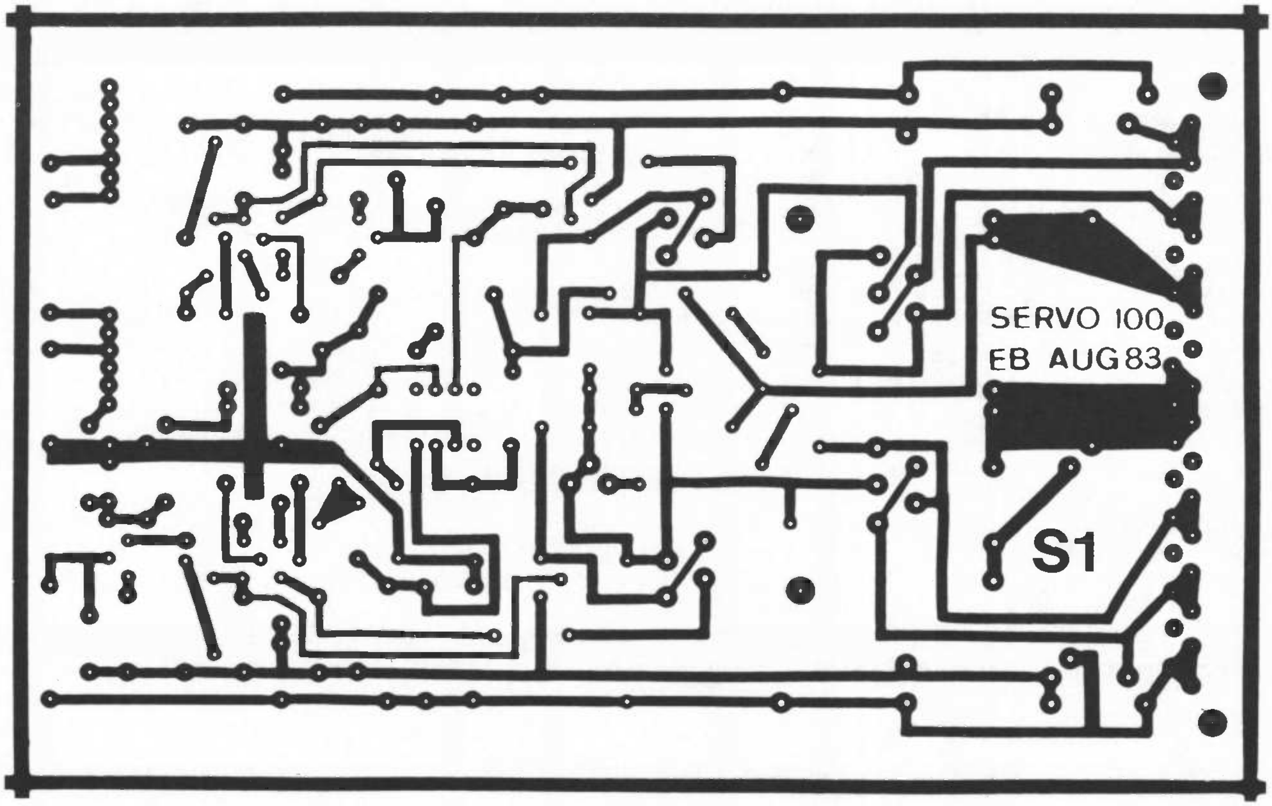


FIGURE 8a: Circuit board layout for the Servo 100, copper side.

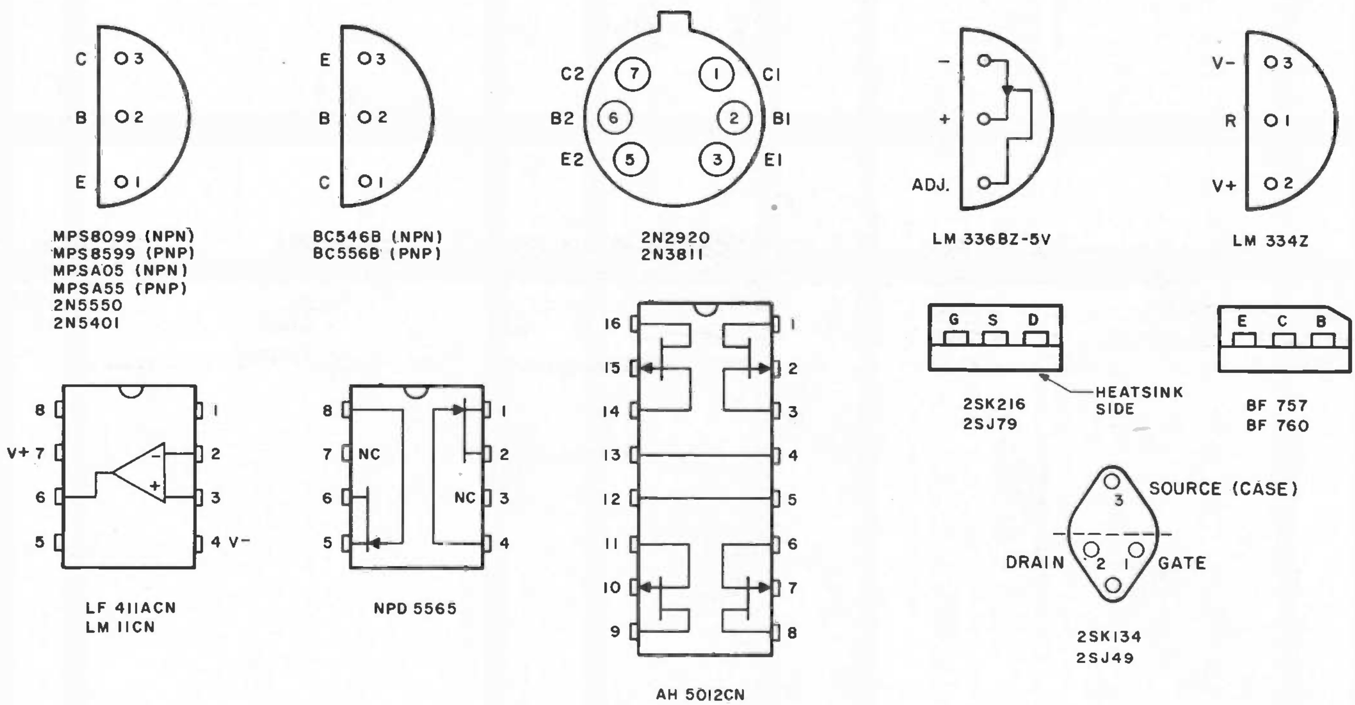


FIGURE 8b: Pin connections for the semiconductors used in the Servo 100 and DC 100 power amps. All devices are shown from the bottom view.

TO-220 package for these positions. The inherent heatsinking capability of the TO-200 package is marginal, so I recommend using a small heatsink. I use a 22-by-60-by-1.5mm aluminum heatsink (*Fig. 10*), which is bolted to the circuit board with two L-brackets. If you have problems locating these MOSFETs, you can use a BF 757 for Q13 and a BF 760 for Q14. The bipolars do not need any heatsinking.

Diodes D5/D6 and D7/D8 are protecting the MOSFETs from gate-source breakdown. The breakdown voltage is specified at ± 14V for the 2SK134/2SJ49 devices. Under normal operating conditions, you do not have this much drive at the gates. When the output is loaded with a low impedance, such as a capacitive load driven at high frequencies, the voltage swing at the output is, however, limited. The internal feedback tries to correct this by forcing the second stage to deliver more swing to the MOSFETs. Eventually, the second stage overloads, delivering high-voltage spikes to the gates, which will cause a gate-to-source breakdown.

Although I have never experienced permanent damage with these MOSFETs, I do not think you should operate them under such conditions. Hence, I limit the voltage swing at the gates to ± 10V. If you think this is too much of a cutback from 14V, use a 12V zener. This will give you a bit more current capability in low-impedance loads.

The R35/L1-R36/C15 output network is a standard in power amps. L1 has an increasing impedance at high frequencies and prevents capacitive loads from shorting the output. R35 reduces the Q of the resonant circuit, thus preventing sustained oscillations with square-wave excitation. *Figure 7* shows how to make L1 on a 10mm diameter plastic spacer. Two holes, 20mm apart, allow you to thread the ends of the coil through them. The wire's diameter should be at least 1.1mm. (*No. 17 AWG, generally unavailable, is 1.15mm. No. 16 AWG is 1.291mm and should be suitable.—Ed.*)

C15/R36 terminates the amplifier with a resistive load at very high frequencies. This ensures that the amplifier works under controlled conditions, even if your speaker has a very high impedance at these frequencies.

Finally, the circuit board has two separate grounds. One is the input ground and the other the general ground, which is referenced to the output. Whether or not these two are connected (either directly or through resistor R) depends on your amplifier's system grounding.

Figure 8a shows a 1:1 layout of the circuit board's copper side. Although not necessarily intended for plug-in systems, my layouts are usually in standard Eurocard format (100 by 160mm). For simplicity, the amp's input is on the left side and its output on the right. The right side of the layout also includes a standard 31-pin Eurocard connector. Although these are useful in large systems, I usually replace the connectors with 1mm solder pins in normal, two-channel stereo amps.

Figure 9 shows the component placement on the board. The components used are the first-choice components in the Parts List. Alternative components might have different pinouts (for example, the 2N3440/2N5415 TO-5 devices are different from the BF devices in the TO-202 package) and require careful layout analysis for correct installation. Note also the jumpers on the board. These should be 0.8 to 1mm solid wires, preferably insulated.

Heatsink Assembly

Because the MOSFETs are very fast, high-frequency devices, using them

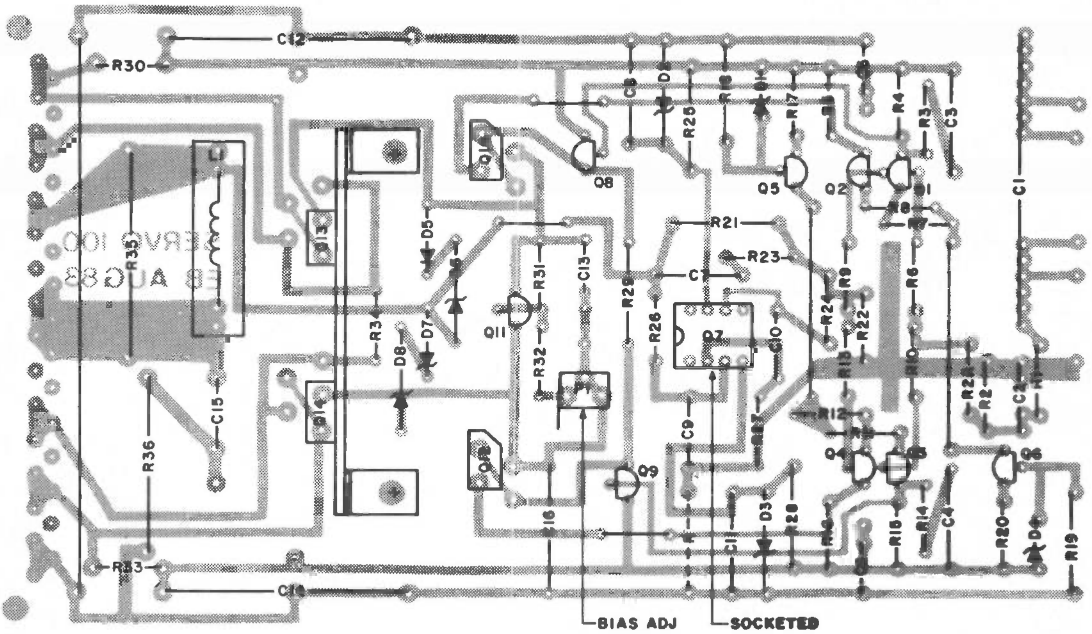


FIGURE 9: Stuffing guide for the Servo 100.

in audio amps requires caution. Like all high-frequency devices, they like to have a properly decoupled power supply line. You can accomplish this with C20/C21 on the N-channel side and C22/C23 on the P-channel side. To make the decoupling effective over a wide frequency range, parallel the 100μF electrolytics with 0.1μF capacitors. These should be low-inductance ceramics or polycarbonates. If neither type is available, use a standard Mylar capacitor.

Although the N-channel and P-channel MOSFETs are reportedly complementary devices, their internal parameters are slightly different. Most significantly, the input capacitance of the N-device is around 600pF, while the P's is approximately 900pF. This makes the rise and fall times of the amplifier different and stabilization difficult. The simplest solution is to connect an external capacitor in parallel with the input capacitance of the N-channel MOSFET. C18 and C19, which should be polypropylene or polystyrene, serve this purpose.

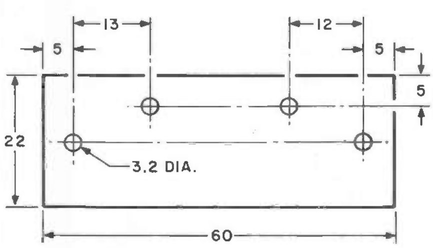


FIGURE 10: The author uses this heatsink for the 2SK216/2SJ79 source followers. No heatsink is needed if you use the bipolar BF 757/BF 760s.

In addition to equalizing the input capacitances, the source follower output stage likes to see a small capacitor from input to ground (C17). Place this, together with the 220Ω gate resistors, as close to the MOSFETs as is physically possible. I always use sockets for the output devices and solder these components directly to the sockets' pins.

One advantage of the MOSFETs is the negative temperature coefficient of the drain current. This, together with the high input impedance, enables you to parallel them without too much problem. The only parameter to watch is the gate-source voltage, required to turn on the device. The specification sheet says that you need a V_{GS} of 0.15 to 1.45V for a drain current of 100mA. My experience is that most of the devices fall in the lower range, but unless you use many of these MOSFETs and get a special selection from Hitachi, you have to live with the whole range.

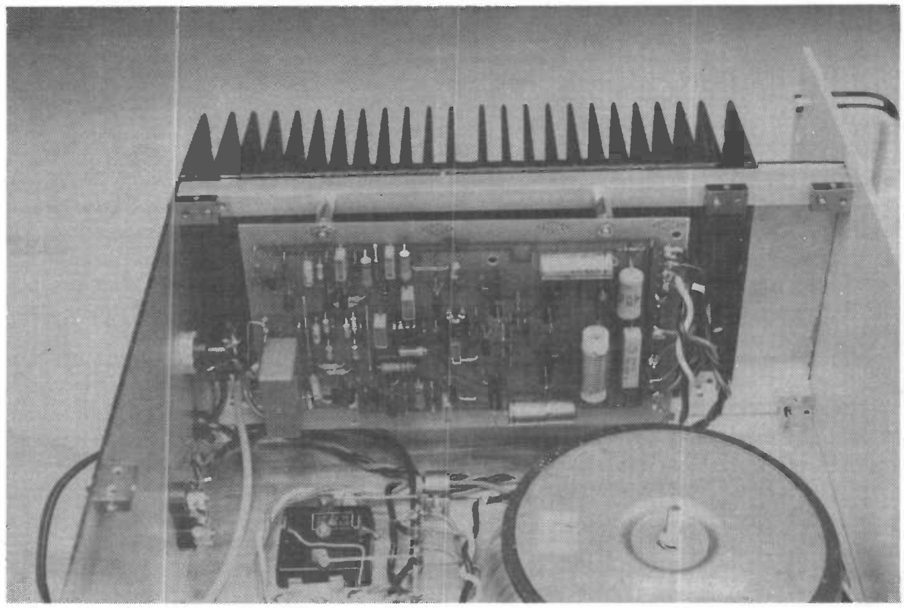


PHOTO 2: One channel of the Servo 100 as viewed from above the author's neat prototype version. Although the driver transistors in this development version are not heatsink mounted, the author believes a sink to be necessary for safe operation under all conditions. See Fig. 9.

Ideally, the output devices should be matched to ±10mA at 100mA drain current, but this is possible only when you have a large number of MOSFETs (i.e., large-scale production of the amplifier) from which to choose. For amateur applications, this approach is not suitable. Fortunately, when you buy all your devices from the same distributor and they are stamped with the same date code, chances are that they are all from the same production batch and have close V_{GS} characteristics. To reduce the dependence on the V_{GS} characteristics further, I use a small source resistor with each MOSFET (R39–R42). This has a couple of secondary advantages: it allows me to check the bias through each device individually, and, through local feedback, it helps to linearize the MOSFETs' characteristics.

Next time, Mr. Borbely will describe his DC 100 MOSFET power amp circuit.

Please note that if you are interested in building Mr. Borbely's Servo 100 power amp, Old Colony will be offering a kit (KS-1) and board. Prices and power supply options will be included in Part II of this article (*TAA* 2/84). We suggest you wait and read the DC-100 article before building the Servo 100.

References

1. Borbely, Erno, "A 60W MOSFET Power Amplifier," *TAA* 2/82, p. 7.

2. Borbely, Erno, "High Power High Quality Amplifier Using MOSFETs," *Wireless World*, March 1983.

3. Blackburn, David L., *Safe Operating Area Limits for Power Transistors*, National Bureau of Standards, Washington, DC 20234.

4. Sondermeyer, J.C., "Inexpensive Audio Amplifiers Can Be Reliable," *The Electronic Engineer*, December 1967.

5. Daugherty, D.G. and R.A. Greiner, "Some Design Objectives for Audio Power Amplifiers," *IEEE Trans. on Audio and Electroacoustics* (Vol. AU-14, No. 1), March 1966.

6. Clark, Brian, "DC Servo Loop Design for Audio Amplifiers," *TAA* 3/82, p. 14.

A PEAK METER FOR THE REVOX A77

BY REG WILLIAMSON
Contributing Editor

THE REVOX OPEN-REEL tape recorder has been around for many years and has justifiably earned its popularity among serious tape recordists. I acquired one of the first tube models back in the early '60s and have slowly worked my way up to the transistor versions. These may well be my last analog devices because it is obvious (to me, anyway) that the days of the analog audio recorder are numbered.

Nevertheless, the ReVox will be around for a few years yet. In terms of performance, the A77 is capable of professional standards, but for the real purist, there are always ways to improve it. For instance, Charles Repka explored some useful circuit changes in *TAA* (4/81, p. 28), and this article looks at what is, for the British user, a major shortcoming —the VU (Volume Unit) meters.

A Little History

Back in the '30s, when broadcasting was in its infancy and developing fast, radio in the US and the UK took divergent paths. In the US it became just another business; in the UK, under the patriarchal guidance of Lord Reith, it developed as a public service, influencing Britain's cultural life as it still does today. Because technical standards were not dictated by cost, early BBC engineers soon decided that, despite the cost advantages of the VU meter, it was far from adequate for their technical requirements. Thus was born the Peak Program Meter (PPM).

The VU meter is an AC meter with special ballistics. It comes complete with an internal rectifier and a ballast resistor and is merely shunted across the 600Ω program line whose level is to be measured. Obviously, the meter must derive all its energy from the program signal. Since these signals are intermittent, the reading will be proportional to the energy of the waveform and, therefore, to the loudness of the sound it represents. While this latter feature is reliable, its disadvantage is that it introduces a tendency to overload on short peaks with attendant distortion, which can be avoided only by reducing the depth of modulation at the transmitter.

The VU meter's advantages are, therefore, offset by an uneconomic use of the transmission system. In fact, BBC engineers realized that is was a hit-or-miss method of program-level control. Their early tests showed that in relation to a steady tone, program controlled to give actual peaks on a VU meter varied from just 2 or 3dB higher on very *legato* music to 15dB on German speech. A setting of 8 to 10dB below maximum modulation level was the best compromise—but it was a compromise, nevertheless. On the ReVox, meter movement is faster than that to broadcast standards, with a 6dB setting below maximum level for 2 percent distortion on the tape.

In 1936 BBC engineers decided to develop a very fast peak-reading meter with a logarithmic scale. Initially, they produced a circuit that was capable of registering peaks as low as 10μsec, but they soon found this speed unnecessary. Engineers performed extended tests on a prototype system in which 80 percent of the full peak value of a square wave registered in 500μsec. These tests showed that the ear does not have time to detect distortion at the transmitter by momentary overmodulation, while further tests suggested that a circuit capable of registering 80 percent of the peak value of a square wave in 4msec was the best compromise.

The final design rapidly became standard in the UK and, with variations, throughout Europe. The essential parameters were ultimately incorporated into a British Standard Specification, which was recently revised to include minor details in European practice. (This excellent document, No. BS 5428: Part 9: 1981, is available from the British Standards Institution, 2 Park St., London, England W1A 2BS, for 14 pounds plus 7½ percent for surface mail. The US agent is the American National Standard Institute, 1430 Broadway, New York, NY 10018.)

Back to the Present

As I mentioned earlier, the A77 ReVox has VU-type meters, which made me uncomfortable. My fellow worker Peter Baxandall shared my antipathy when he acquired his first A77. He first established that the mechanics of the movement used for the VU metering system were ballistically suitable for conversion to peak reading. He went on to develop a suitable PPM circuit for his ReVox, which I also used. That was back in 1971, but Peter never published the circuit. My design (*Figs. 1–3*) follows his concepts, but uses a modern IC instead of discrete transistors. It also follows the performance specifications outlined in the British Standard, with variations based on nonstandard meter movement with linear current drive, as opposed to the log law drive used by the BBC.

Essentially, I started with an op amp driver, which is required for a buffer stage with a non-loading, high-impedance input and a low output impedance. This influences the attack time. High amounts of series negative feedback not only furnish the second feature, but also provide the necessary gain adjustment. The output is coupled into a full-wave rectifier, which is essential because the negative and positive going components of program waveforms can differ as much as 8dB. The output of the rectifier bridge is integrated by a tantalum capacitor, while the time constant of the op amp's source resistance, the diodes' dynamic resistance and the capacitor determine the attack time.

The specification requires the voltage across the integrating capacitor (C2) to reach 80 percent in 4msec, so this means a time constant of 2.5msec. Using low forward resistance, junction germanium diodes allows you to meet this spec. Providing a decay time constant that allows for a decay of 8.7dB per second on the voltage across C2 requires a time constant of one second. The decay constant comes from C2, R4 and M in series. Simple arithmetic shows that my component values are for a somewhat shorter time constant and, therefore, a faster decay. The full second was a little too tardy for comfortable reading. The scale length of the ReVox meter is only 22dB against the 24dB range of the standard PPM movement with its logarithmic drive circuitry.

Construction Notes

You should encounter no construction problems with my circuit board. The only significant components are the germanium (Ge) diodes and the time constant parts of the circuit. I have specified an inexpensive twin op amp. You can use more expensive devices such as the TL082 and the 5532, but without significant improvement. The Ge diodes should be junction types. Those in the Parts List are of European origin, but if you have some small-signal Ge transis-

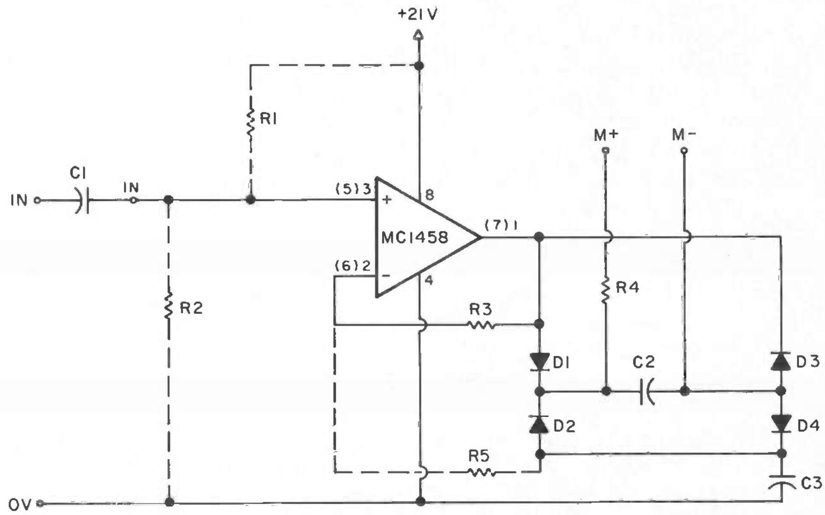


FIGURE 1: Schematic diagram of the author's Peak Program Meter (PPM) circuit modification for the ReVox A77.

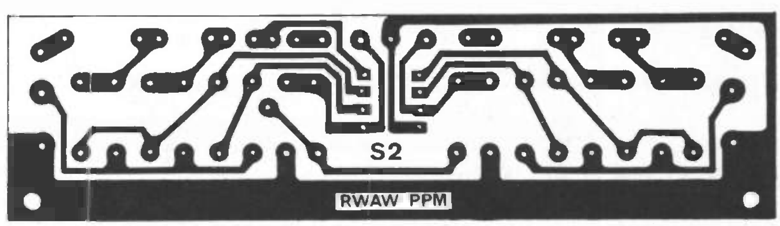


FIGURE 2: Circuit board for the PPM, designed and executed by Alan Watling.

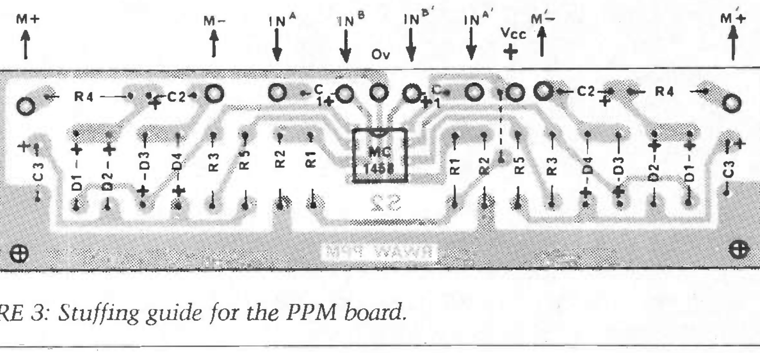


FIGURE 3: Stuffing guide for the PPM board.

PARTS LIST

ReVox Modification

IC	MC1458 or equiv.
R3	5.6k
R4	27k
R5	8.2k
C2	22μF, tantalum bead, 3V
C3	4.7μF, tantalum bead, 35V
D1-4	0A47 germanium
8DIL socket and pins	

Additional Parts for Modifications of Other Machines

R1, R2	100k
R5	alternative values as required (higher values for lower sensitivity and vice versa)
C1	1μF, tantalum bead, 35V and suitable meter movement

Note: In the UK standard broadcast practice is for line-up level to be −8dB and equal to 1mW in 600Ω (0.775V). Peak level is 0.

tors (audio, not radiofrequency), then with collector and emitter tied together, you have excellent low forward resistance diodes. All resistors should be miniature ¼W devices with a tolerance no greater than ±5 percent. All capacitors should be tantalum beads, but C2 need not be very close to the specified value.

The circuit was originally designed for the ReVox A77. To fit it in, some small changes are necessary in the tape recorder's record amplifier board. I omitted resistors R1 and R2 on the PPM board. Since op amp non-inverted input reference voltage now comes from the record amp board, I also omitted C1 and used the alternative "IN" point, which goes directly to IC pins 3 or 5. This reference is half the rail voltage of 21 in the ReVox. To alter that at the signal take-off point, I increased R510's value to 6.2kΩ, which is the E24 value closest to 6.3k. Obviously, I removed C509 and inserted a jumper. (See *Fig. 4.*)

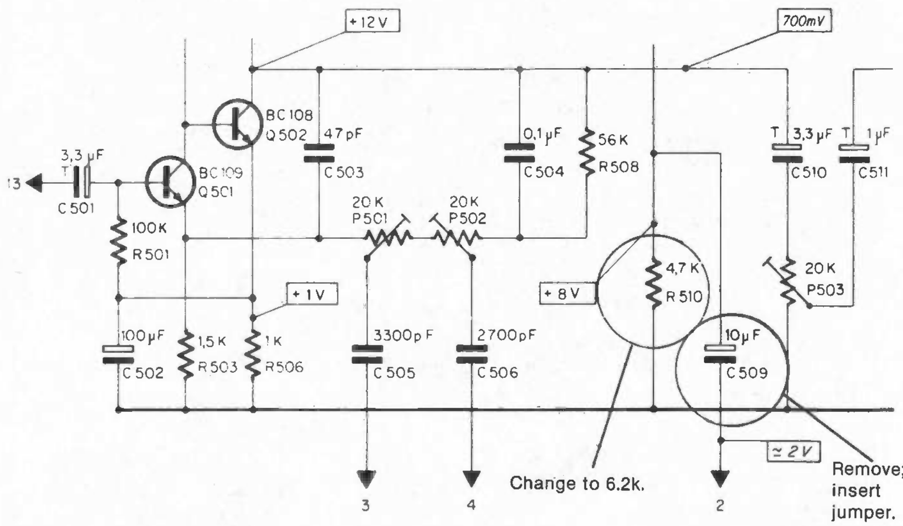


FIGURE 4: The author changed the original ReVox design by increasing R510's value to 6.2k, removing C509 and inserting a jumper.

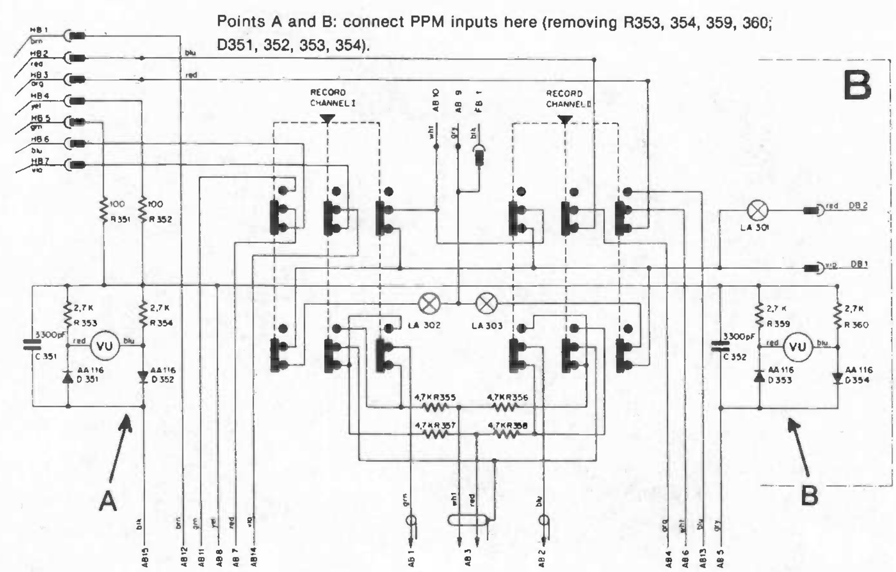


FIGURE 5: The ReVox modification includes removing the 2.7k resistors and diodes that formed the original rectifier network for the VU meter. You must also connect a wire from the "IN" point on the PPM board to the place on the VU board where the two Ge diodes are commoned.

You must also decide where to put the new board. I installed mine just below the meters, but that location might cause problems in newer models. All it requires is connection to the internal +21V and 0V rail. My installation did not require removal of the VU meter and switch board to pick up the VU meter wires for retermination on the new meter. You should remove the 2.7k resistors and diodes that formed the original rectifier network for the VU meter and connect a wire from the "IN" point on the PPM board to the appropriate spot on the VU board, where the two Ge diodes are commoned. (See *Fig. 5.*)

A fastidious user might find one more refinement desirable. Primarily because of the nonlinearity of the Ge diodes, the scale of the new PPM will not be exactly right. On pure tone, I have discovered that from 0VU, a drop of 10dB produces a fall slightly greater than this. It is not very important, but you might compensate for it by a linearizing network across the meter (*Fig. 6*). I found a series network consisting of a 2.7k resistor plus a Ge diode to be just right.

As the current through the meter increases, the network progressively shunts away part of the operate current. You can change the resistor value, since the ReVox meter scale accuracy has varied over the years. Feed in a sinusoidal tone (1kHz) and adjust the record inputs to read −10dB on the VU. Now raise the input 10dB and note whether the pointer goes above or below 0VU. If above, reduce the value of the series resistor slightly; if below, increase it.

Finally, I have chosen the op amp gain so that calibration should not be necessary. Remember that the meter is now *peak* reading, so the program level should not go above 0VU. There is no longer a "lead" of 6dB that you can take into account with VUs on some program material. The

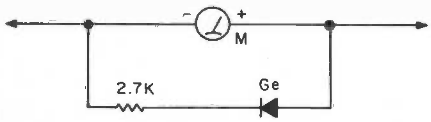


FIGURE 6: A linearizing network compensates for the non-linear effect of D1-4.

maximum level is now 0VU, the nominal 2 percent saturation point.

I am aware that purists will want to recalibrate. Just connect a THD (total harmonic distortion) meter to each replay output and feed a low-distortion tone at 1kHz into the record input. Adjust the record level to 0VU, then start to record on a standard tape. Incidentally, I am assuming that you have checked the tape for accurate bias and that all the bias traps are also adjusted correctly. Now, check the harmonic distortion on the THD meter. It ought to be around 2 percent. Check it again by replaying the tape, but *not* in the simultaneous record mode. The reason is that stray bias products can contribute to an erroneous reading on the THD meter. If it is above or below 2 percent, trim the record level pot P503 so it does give 2 percent THD. Finally, don't forget to demagnetize your heads before and after this exercise.

For those of you who might want to use this circuit in other applications, first choose your meter movement. If you can obtain the ReVox movement, so much the better. If not, find a movement with a scale sensitivity of not more than 250μA and not less than 100μA FSD (full scale deflection). Old Colony has a nice 100μA movement that fits well. The next requirement is ballistics. You can check this for yourself with a simple test rig suggested by a 30-year-old BBC internal memo that one of my friends managed to locate. Connect the test movement into the circuit as shown in *Fig. 7*.

With the "calibrate and overshoot" thrown, adjust the input voltage for FSD. Then repeatedly turn the switch on and off and observe the overshoot. It should not be greater than 5 percent. Leaving this switch off, press the "attack" key, which ideally ought to be a break-before-make push button with quality silvered contacts. Note that the meter needle reaches at least 95 percent of FSD before the capacitor starts to charge, and the needle indicates the decaying current under the one-second time constant's control.

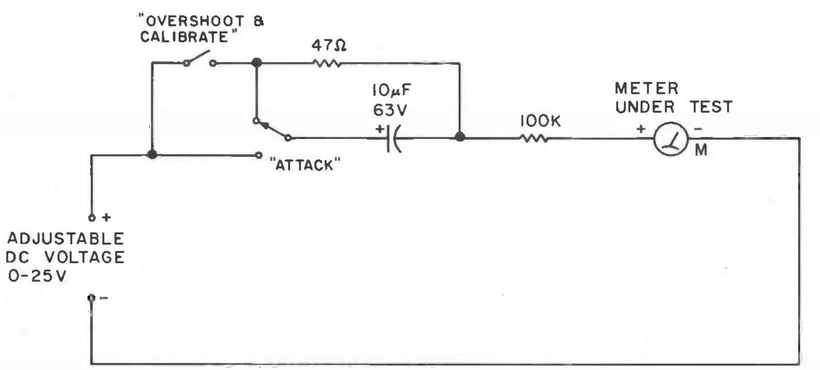


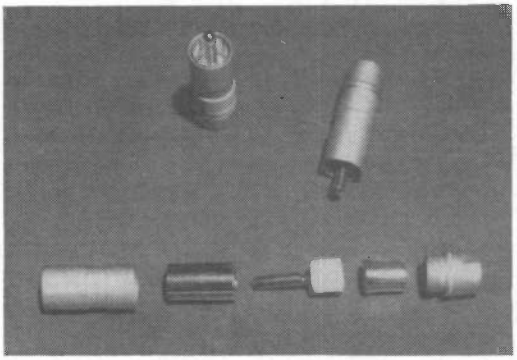
FIGURE 7: This test rig can help you to check your meter movement's ballistics.

You must, of course, adapt the circuit for different meter sensitivities and for the absence of the reference voltage on the non-inverted input. The dotted component R5 provides some adjustment to the gain. For the ReVox, it is 8.2kΩ. C1 is required to isolate the DC from the new input point, junction R1 and R2. You can also check the "attack" time if you have a sine-wave pulse generator with the ability to furnish pulses at 10kHz at 100msec, 10msec and

Continued on page 58

WINTER SPECIALS

NEW DELUXE SCXT7 ROYCE AUDIO PLUGS *Only $8.00 per pair when you buy two pairs!*



Our new ROYCE RCA-type audio plugs are custom made for Old Colony. They are fabricated from brass with heavy 14K gold plate on all working surfaces and insulated with Teflon® . The outer shell's screw-in top and bottom segments are nickel plated, dull finish. The plugs consist of five parts. The signal pin is a solid brass piece, drilled out at the solder end to accept the signal wire with a cross-drilled hole to confirm a good solder joint. The pin is knurled and force-mounted in a thick Teflon insulating sleeve, which slides into a separate gold-plated grounding skirt which in turn fits inside the threaded outer shell. A smaller flanged gold-plated crown is then inserted into the shell to compress the shield and/or ground wires down against the ground skirt. A threaded top screws into the outer shell to hold the five units together. The crown, whose inner diameter is 0.240 inch, fits over the signal wire's outer insulation. When the shield and ground wires are free, they are fanned upward around the crown and trimmed off just below the top of it. After the shielded center wire is soldered to the center pin, the top may be screwed down to form a solid, strong compression junction between the crown and the skirt. This makes a virtually unbreakable connection, which is far more rugged and dependable than the conventional soldered joint. The Royce plugs will accept Mogami Neglex 2534 audio cables and others up to 0.230 inch in diameter. The Royce plugs come in color-coded pairs (red and white) only. Pair **$9.50.** Two or more pairs **$8.00** pair.

NEGLEX 2477 SPEAKER CABLE *Only $2.00 per foot!*

For less than the price differential between standard and fancy finishes on a pair of speakers, you can make a significant improvement in the *actual sound* of your system. This high definition Neglex cable is a coaxial configuration using Mogami OFHC wire and copolymer insulation. Termination kits provide two short lengths of OFHC wire, two gold-plated, ¼" spade lugs and an insulating sleeve (one kit required for each end of cable).

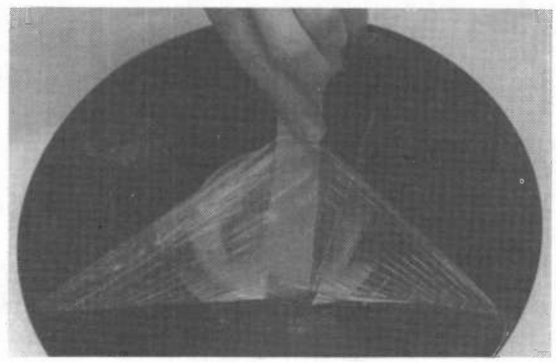
The cable has extremely low capacitance, impedance, inductance, and eddy current effects. In the audio frequency range, impedance is virtually flat (see Nelson Pass' article on speaker cables in *SB* 2/80 for a discussion of these effects). Small improvements in low bass, extreme highs, imaging, depth, distortion, and amplifier damping all add up to audibly better sound and greater listening enjoyment—just one more way to remove some of the haze which prevents your system from sounding as clear as it should.

KM-9 WILLIAMSON RECORD CLEANING SYSTEM *Only $8.50!*

Developed by Reg Williamson, this two-step system removes static charges from records virtually forever and removes deep-down dirt thoroughly and safely. Static charges (as high as several *kilovolts)* lock dirt on the record and create annoying pops as the stylus traces over charged areas. The surfactant neutralizes those charges by supplying molecules with cationic ends to capture the negative ions.

The cleaning solution dissolves the dirt and holds it in a clear film when it dries. Simply peel the film away, and the record is cleaner than when it left the pressing plant.

You supply distilled water, glycerin, isopropyl alcohol, an applicator and a buffer pad. We supply ½ ounce of de-static liquid (1000 treatments), and 4 ounces of deep cleaner (80 disks). Regrettably, due to Postal Regulations, this cannot be shipped outside the US.



ORDER FORM

Qty.		Price
______	Ft. Neglex Speaker Cable $2.00/ft.	______
______	Termination Kits $1.00 each	______
______	SCXT7 Royce Audio Plugs $9.50 pair/two pairs $8.00 per pair	______
______	KM-9 Williamson Record Care Kit $8.50 each	______
______	KM-9S Destatic Refill (½ oz) $4.50 each	______
______	KM-9R Deep Cleaner Refill (4 oz) $4.00 each	______
	Total amount enclosed:	______

Old Colony Sound Lab

Form of Payment: ☐ Check ☐ Money Order ☐ MC or Visa

Card # ______________________ Exp. Date ________

Name ______________________

Address ______________________

City ______________ State ________ Zip ________

Phone Orders: (603) 924-6371 (MC or Visa only) 9-4 EST M-F

DISCOUNT: $25-$75 = 10%, $75 and up = 15%. For full kit listing, send stamped, self-addressed envelope to: Old Colony Sound Lab, PO Box 243, Peterborough, NH 03458.

CONSTANT POWER PAN POT

BY CHRIS GRUPP

IN THE PROCESS OF BUILDING my stereo mixer, I hit upon a way to improve its performance—a constant power pan (CPP) circuit. This circuit (*Fig. 5*) will not boost or drop the level of a signal out, as it is panned from one side to the other. It works well and is fairly simple to build and use. In addition, the voltage taken from a pot, a low-frequency oscillator or some other source *controls* the panning effect.

Figure 1 shows a block diagram of the circuit, while *Fig. 2* illustrates the use of the pan circuitry. SW1 allows for manual pan control or control by an external voltage. *Figure 3* shows the wiring to make the mixer output rotate. SW2 allows you to set the right channel rotation direction in the same or opposite direction as the left channel.

Circuit Description

Constant power pan requires that the left and right channel "power" outputs (P_{LF} and P_{RT}) add up to a constant power (P_T) at all pan settings. For convenience, let's assume a 1Ω load for each channel output. This means that:

$$P_T = P_{LF} + P_{RT} = \frac{V_{LF}^2}{1\Omega} + \frac{V_{RT}^2}{1\Omega} = V_{LF}^2 + V_{RT}^2$$

If V_{audio} represents an audio signal voltage, it is easy to show that when

$$V_{LF} = V_{audio} \times \cos(\theta)$$

and

$$V_{RT} = V_{audio} \times \sin(\theta)$$

the total power (P_T) is constant for any pan position angle θ. Note that if θ equals 0°, there is output from the left channel only; if θ equals 90°, there is output from the right channel only; and if θ equals 45°, the left and right channels have equal outputs.

To see how the CPP circuit works, refer to *Fig. 1*. The pan voltage represents the pan angle θ. A pan voltage of 0V converts to 0°, while 12V translates to 90°. The wave shapers convert the left and right pan voltages into sine-wave shapes. The cosine of θ, which is equal to the sine of $(90 - \theta)$, is generated in the left channel. Note that the angle $(90 - \theta)$ corresponds to the voltage $(12V - V_{pan})$ in the circuit, so two sine-wave shapers are required.

The inverters Q1A and Q1C condition the pan voltage for the wave shapers. The wave shapers take the pan voltages (V_{PL} and V_{PR}) and shape them into sine and cosine functions. The non-inverting buffers (Q1B and Q1D) translate the sine and cosine functions into voltages that drive the voltage-controlled amplifiers (VCA) (Q2, Q3, Q102, Q103). The input voltages (V_{cos} and V_{sin}), which are cosine and sine functions, control the VCA's gain. Therefore, the actual outputs are:

$$V_{LF} = V_{audio} \times \cos(\theta)$$

$$V_{RT} = V_{audio} \times \sin(\theta)$$

Note that the VCA gain is not quite linear with the control voltage. (See *Fig. 8*.) The resulting distortion (i.e., deviation from constant power) is, however, small. Also, since the FET is in the feedback loop of the VCA, the audio distortion it contributes tends to be canceled out by the feedback action.

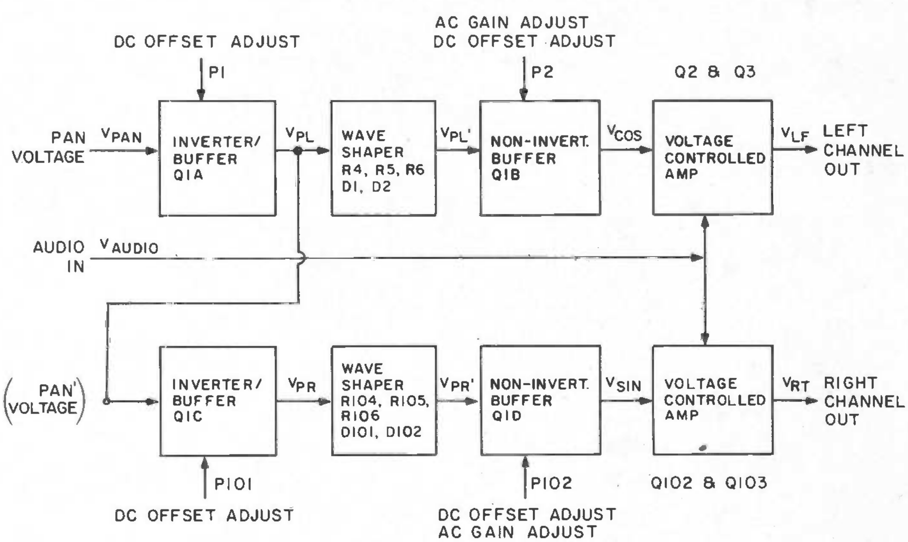


FIGURE 1: Block diagram of the constant power pan (CPP) circuit.

Each of Q1's four op amps is used as a DC amplifier. Because the DC offsets of each op amp are different, a DC offset adjustment pot (P1, P2, P101, P102) is provided for each one. These pots give enough control so that you can use almost any LM 3900 without circuit modification.

Also, the LM 3900 op amp is a Norton, or current-mirroring, type, where output voltage is proportional to the difference between the currents into the positive and negative inputs:

$$V_o = K(i_+ - i_-)$$

where V_o = output voltage, K = op amp gain (open loop), i_+ = current into positive input pin, i_- = current into negative input pin.

The positive/negative inputs to these devices are bases of transistors, which are wired in a common emitter configuration (the emitters are tied to the negative power supply rail). Be careful not to apply too much current (>120mA) to any of the inputs, or you will blow out the base-emitter junction. As shown in *Fig. 4*, the closed loop gain for these op amps is similar to the 741-type gain:

$$V_o = \frac{R_F}{R_+} V_+ - \frac{R_F}{R_-} V_-$$

V_o, V_+ and V_- are measured relative to the negative power supply input (pin 7).

Looking at the schematic (*Fig. 5*), you can see that the circuit is composed of two identical halves. Q1A, P1 and R1-R3 (Q1C, P101 and R101-R103) form the unity gain in-

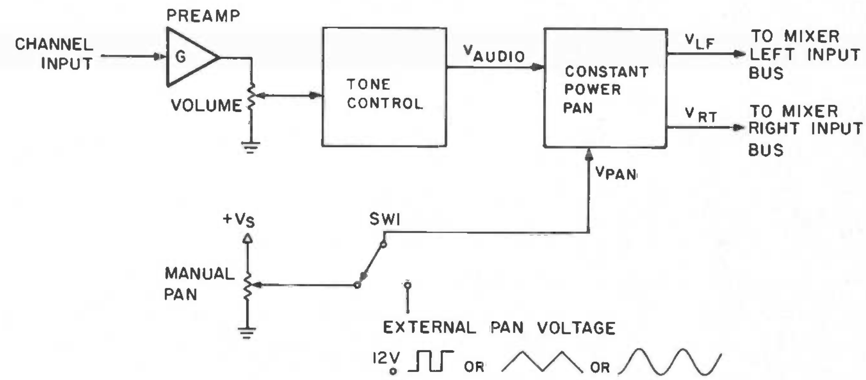


FIGURE 2: How the CPP circuit operates in the normal pan function.

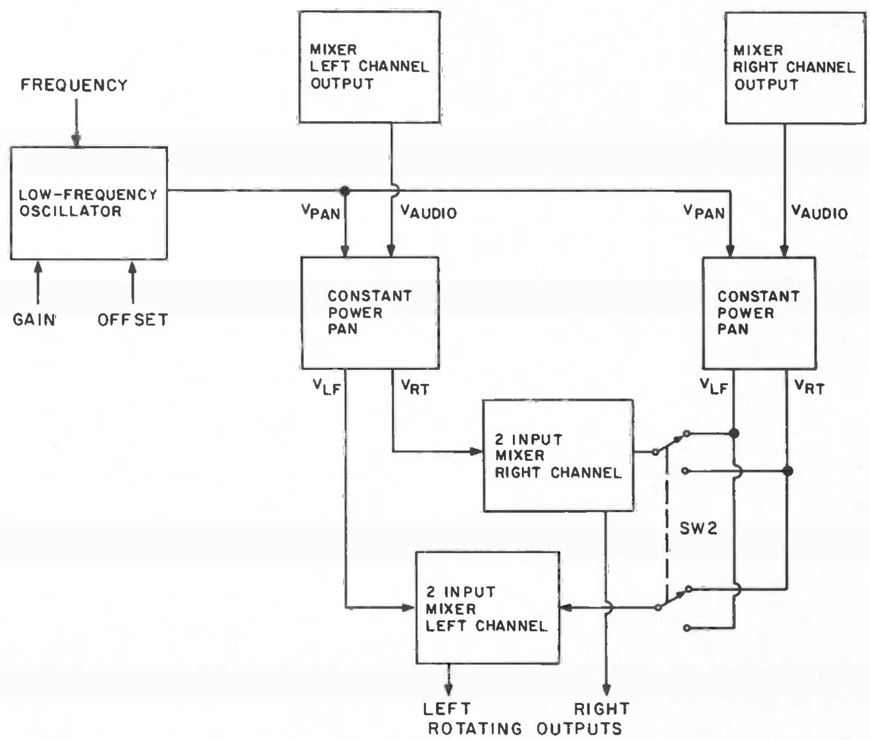


FIGURE 3: How the CPP circuit operates to rotate the mixer output.

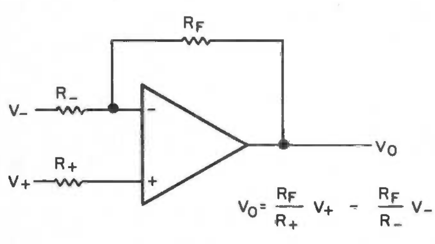


FIGURE 4: LM 3900 op amp feedback operation.

PARTS LIST

R1, R101	390k	All resistors ⅓W, ±5% MF or better.	
R2, R102	220k		
R3, R103	390k	D1, D2, D101, D102	1N3063 or equiv., 20V PIV, 100mA
R4, R104	68k		
R5, R105	22k	C1, C101	10pF
R6, R106	1.2k	C2, C102	10µF, 20V
R7, R107	3.9M	C200	see text
R8, R108	270k	Q1A, Q1B, Q1C, Q1D	LM 3900
R9, R109	330k	Q2, Q102	LM 301
R10, R110	10k	Q3, Q103	2N5458
R11, R111	1.5M	P1, P2, P101, P102	100k, 15-turn linear pot (Jameco Electronics 43P100k)
R12, R112	47k		
R200, R201	see text		

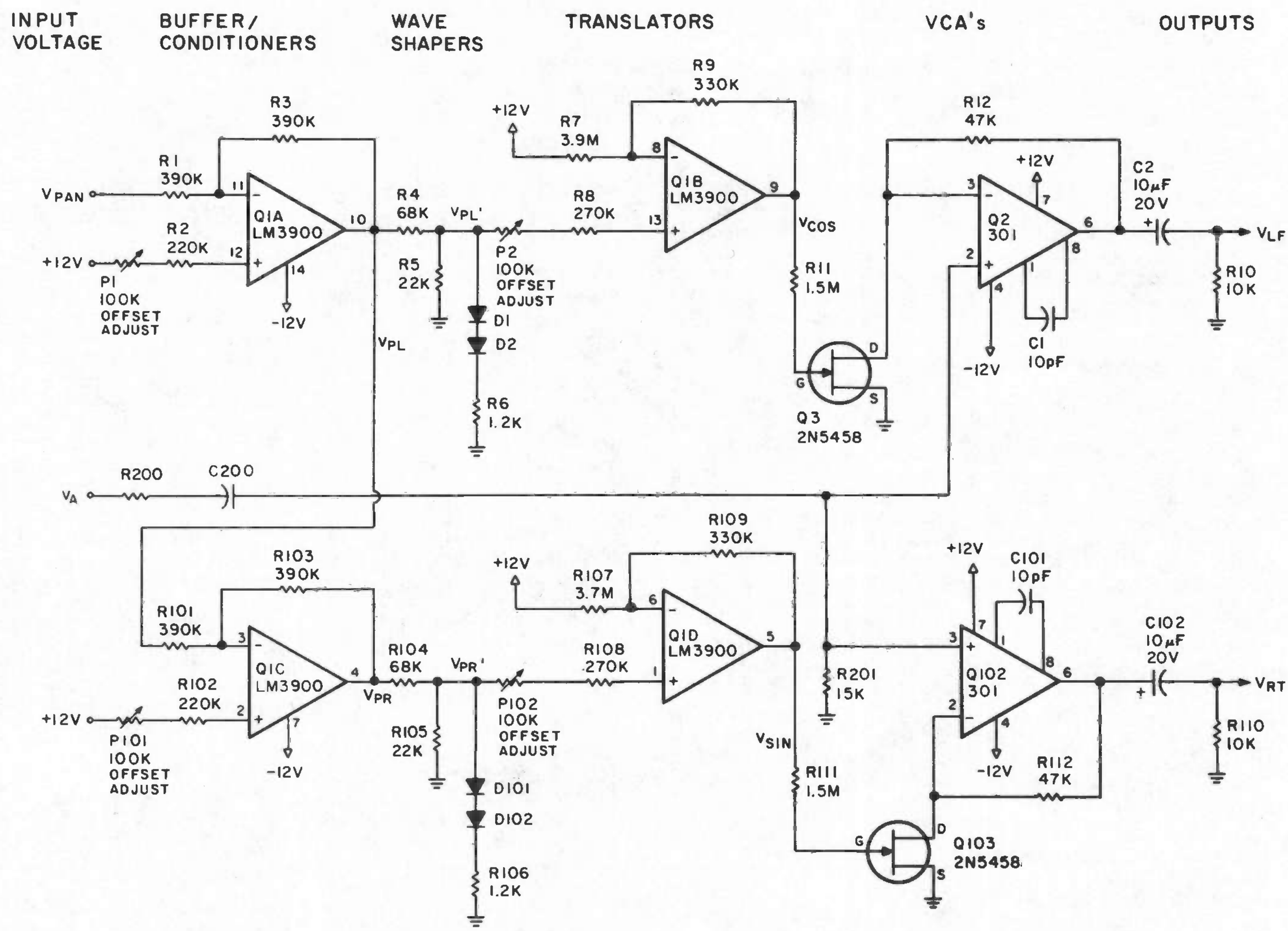


FIGURE 5: Schematic of the CPP circuit.

Old Colony Sound Lab's

BOOK SERVICE

HOWARD W. SAMS

S-4A TRANSISTOR FUNDAMENTALS: VOL. 1. BASIC SEMICONDUCTOR AND CIRCUIT PRINCIPLES *by Robert J. Brite.* Explains transistors and transistor principles; voltage, current, and resistance; the all-important Ohm's and Kirchhoff's laws; and the nature of inductance, capacitance, and resistance in AC circuits. 240 pp., softbound. Each **$7.95**

S-4B TRANSISTOR FUNDAMENTALS: VOL. 2. BASIC TRANSISTOR CIRCUITS *by Charles A. Pike.* Describes transistors and how they are used in semiconductor circuits. Uses simple circuits to illustrate the basic principles involved and more complicated ones to show how the basic operations are applied. 208pp. Each **$7.95**

S-9 REGULATED POWER SUPPLIES [3RD ED.] *by Irving M. Gottlieb.* Static and dynamic characteristics, regulation techniques, IC regulation. 424pp., softbound. Each **$19.95**

S-11 HOW TO BUILD SPEAKER ENCLOSURES *by Alexis Badmaieff and Don Davis.* The "whys" and "hows" of speaker enclosures. Drawings and instructions cover infinite baffle, bass reflex, and horn types plus combinations. 144pp., softbound. Each **$6.95**

S-12 IC OP AMP COOKBOOK [2ND ED.] *by Walter G. Jung.* The revised bestselling, authoritative, best introduction to practical op amp usage available. By *TAA's* op amp columnist and author. 480 pp., softbound. Each **$15.95**

S-13 IC CONVERTER COOKBOOK *by Walter G. Jung.* An invaluable working guide to understanding and use of IC A/D and D/A converters. Get ready for the digital age. Sections on basic principles and theory of data conversion; converter applications with working circuits plus manufacturer's data sheets. 576pp., softbound. Each **$14.95**

S-14 ACTIVE FILTER COOKBOOK *by Don Lancaster.* A practical, user-centered volume with everything you need to build your own active filters. Explains the various types and how to select the best for your circuit. 240pp., softbound. Each **$14.95**

S-16 AUDIO IC OP AMP APPLICATIONS. [2nd Ed.] *by Walter G. Jung.* A new, thoroughly updated and larger edition of Jung's earlier work on op amps for audio use. Includes a general introduction to op amps, the special factors the user must consider in using op amps for audio, building blocks, and dozens of practical and buildable circuits. 208pp., softbound. Each **$9.95**

S-17 IC TIMER COOKBOOK *by Walter G. Jung.* A full introduction to the IC timer, the types, and general usage pointers. The applications include 16 monostable timers, 14 astable types and 20 timer systems. Many surprisingly useful audio-related uses. An excellent practical and theoretical volume with lots of reference data. 287pp., softbound. Each **$10.95**

S-18 TTL COOKBOOK *by Don Lancaster.* Everything the beginner will need to know about transistor logic elements and usage. It has become a reference guide for engineers as well. Paper. Each **$12.95**

S-19 SOUND SYSTEM ENGINEERING *by Don and Carolyn Davis.* A thorough introduction to sound systems for halls, studios, outdoor locations and much else. 245pp., hardbound, 8½x11. Each **$21.95**

S-20 TV ANTENNAS AND SIGNAL DISTRIBUTION SYSTEMS *by M.J. Salvati.* Invaluable guide to servicing, selecting and installing antennas. Author tests many of the devices discussed. 256pp., softbound. Each **$11.95**

HAYDEN BOOKS

H-9 IC ARRAY COOKBOOK *by Walter G. Jung.* Putting transistors and diodes into tiny IC packaging offers the amateur high density, closely matched devices which are stable, high quality and offer high performance. Walt Jung gives us another readable, practical cookbook whose circuits work. Eight chapters cover the basics and applications followed by a survey of available devices and their manufacturers. 200pp., softbound. Each **$10.75**

The PENGUINS

P-1 THE NEW PENGUIN STEREO RECORD & CASSETTE GUIDE *by Edward Greenfield, Robert Layton, and Ivan March.* Drawing on profound technical knowledge and on vast musical and historical learning, this newly revised and updated guide to recorded classical music deals with more than 4,000 disks, giving details of title, performers, record number, label and price range. 977pp., softbound. Each **$12.95**

P-2 A NEW DICTIONARY OF ELECTRONICS *by E. C. Young.* This remarkably compact reference covers electronics from A-Battery to Z-parameters with succinct, concise definitions and illustrations. A quick reference completely revised and updated with lots of added charts and reference data. 618pp., softbound. Each **$5.95**

P-3 A NEW DICTIONARY OF MUSIC (THIRD ED., 1973; FIRST PUB. 1958) *by Arthur Jacobs.* Alphabetically arranged entries covering composers, individual musical works, orchestras, performers, conductors, musical instruments, and technical terms. 458pp., softbound. Each **$4.95**

P-8 INTRODUCING MUSIC *by Otto Karolyi.* Even if you've listened to music for years, you may be surprised at how little you know about its fundamentals. A beautifully basic and spare introduction to the grammar and vocabulary of music—enough to understand the language without speaking it. It will deepen almost any non-musician music lover's pleasure in listening. 174pp., softbound. Each **$4.95**

NEWNES CONSTRUCTOR'S GUIDES

H-7 NEWNES RADIO AND ELECTRONIC ENGINEER'S POCKET BOOK *by the staff of* ELECTRONICS TODAY INTERNATIONAL. A data bank for all the charts, equivalents tables, definitions, formulas and other information the electronics experimenter needs when trying to write, read, design, interpret, or understand. A compact 3×5" 238 pp., softbound. Each **$8.95**

NATIONAL SEMICONDUCTOR

N-1 AUDIO/RADIO HANDBOOK. Edited with occasional touches of humor, this book contains hundreds of practical, down-to-earth applications using NS products. Included are circuits for various types of preamps, variable speed motor drives, special effects (fuzz and phase), FM stereo tuners, electronic crossovers, reverb units, and ambience recovery. 210pp., softbound. Each **$5.00**

N-2 LINEAR DATABOOK. This is National's biggest, most comprehensive collection of specifi-pations and applications. Topics covered, with example circuits, include voltage regulators, references and comparators; op amps and buffers; instrumentation amps; analog switches; sample and hold; A/D and D/A; automotive, industrial, and telecommunications devices; audio, radio, TV circuits; transistor/diode arrays; and speech synthesis. 1982 Edition. 1,950pp., softbound. Each **$12.00**
Please add $1.50 for shipping.

N-3 LINEAR APPLICATIONS HANDBOOK. A wide-ranging compendium of Application Notes, this manual discusses practical circuits using their linear IC's. Softbound. Each **$16.00**

N-4 TRANSISTOR DATABOOK. This handy reference book provides data for the physical and electrical parameters of all their transistors. 559pp., softbound. Each **$6.00**
Please add $1 for shipping.

N-5 VOLTAGE REGULATOR HANDBOOK. A manual which simplifies selection of three-terminal regulators depending on your needs, and which offers information on heatsink selection and design, along with transformer and filter specifications. 312pp., softbound. Each **$7.00**

WILEY BOOKS

W-1 HIGH PERFORMANCE LOUDSPEAKERS [2ND ED.] *by Martin Colloms.* Highly praised source book on loudspeaker theory and construction by a top-notch English authority. 245pp., hardbound. Each **$29.95**

verting pan voltage buffers. P1 and P101 are adjusted so that:

$$V_{PL} = 12V - V_{pan}$$

and

$$V_{PR} = 12V - V_{PL} =$$
$$12V - 12V + V_{pan} = V_{pan}.$$

R4–R6, D1 and D2 (R104–R106, D101 and D102) convert the pan voltages (V_{PL} and V_{PR}) into approximate cosine (V_{PL}') and sine (V_{PR}') shapes. When V_{PL}' (V_{PR}') is less than two diode voltage drops ($\cong 1.2V$), the diodes provide very large resistances, and

$$V_{PL}' = \frac{R5}{R5 + R4} V_{PL}$$

$$\left(V_{PR}' = \frac{R105}{R105 + R104} V_{PR}\right)$$

When V_{PL}' (V_{PR}') is much greater than 1.2V, the diodes provide almost no resistance, and:

$$V_{PL}' \cong \frac{R6}{R6+R4} V_{PL} \; (R6 << R5)$$

$$\left(V_{PR}' \cong \frac{R106}{R106+R104} V_{PR} (R106 << R105)\right)$$

When V_{PL}' (V_{PR}') is close to 1.2V, the smooth current versus voltage characteristic of the diode curve adds resistance to R6 to produce a smooth curve. I chose R4–R6 (R104–R106) so that V_{PL}' and V_{PR}' approximate the sine and cosine curves.

Q1B (Q1D) and its associated components form a non-inverting unity gain buffer. P2 (P102) is adjusted so that V_{cos} (V_{sin}) has the proper AC gain and DC offset to drive the FET Q3 (Q103). V_{cos} (V_{sin}) should vary between 0V and approximately -1.2V.

The voltage-controlled amplifier is built around Q2 (Q102) and Q3 (Q103). Q3 (Q103) acts as a voltage-controlled resistor, which controls the gain of Q2 (Q102), a non-inverting op amp. When V_{cos} (V_{sin}) is 0V, Q3 has only about 500Ω between its drain (D) and source (S) terminals. These terminals set Q2's gain at 100. When V_{cos} (V_{sin}) is at -1.2V, the pinch-off voltage of the FET, Q3 has infinite resistance between its D and S terminals. This results in the minimum non-inverting voltage gain of 1, so the gain of this op amp ranges over 40dB. (See *Fig. 8.*) Increasing or decreasing R12 (R112) will increase or decrease the overall gain and the range of gains for Q2 (Q102).

Note that since the minimum gain for the VCA is 1, the audio input (V_A) must be on the order of 50 to 100mV so that clipping does not occur in Q2 (Q102). The values for R200, R201 and C200 depend on the type of signal being panned. If the audio input is at a low level, you can omit R200. If the signal has no DC component, you can also omit C200. If it has an appreciable DC component, then choosing C200 at 0.1μF and R201 at 100kΩ will give good bass response and block the DC. For high-level audio inputs (line outputs), using R200 at 150kΩ and R201 at 15kΩ will drop the input by a factor of ten. Again, if the audio has no DC component, omit C200; otherwise, use a 0.1μF capacitor to block it. Also, the output of the VCA has a DC component that varies with the control voltages (V_{cos} and V_{sin}). I have included C2 and R10 (C102 and R110) to remove these DC components. Finally, the FET Q103 and Q3 (2N5458s) have interchangeable D and S leads.

Construction and Adjustments

I built my prototype CPP on perforated board, but I have included an etched circuit board layout in *Fig. 6. Figure 7* shows the compo-

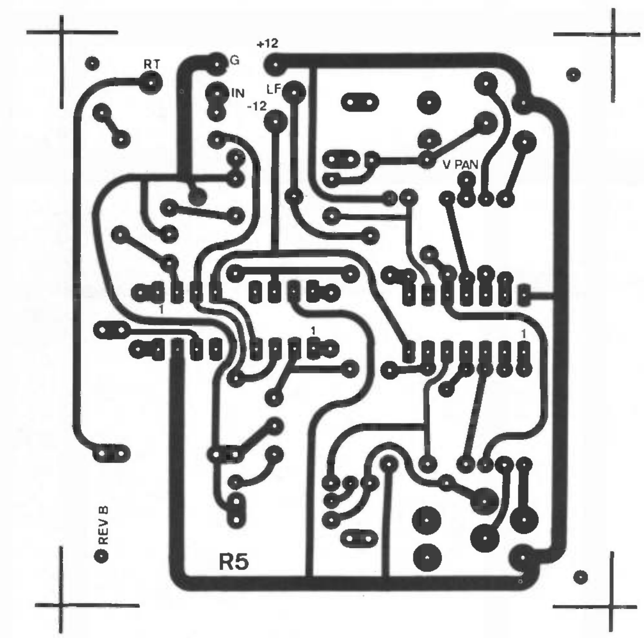


FIGURE 6: Constant power pan circuit board.

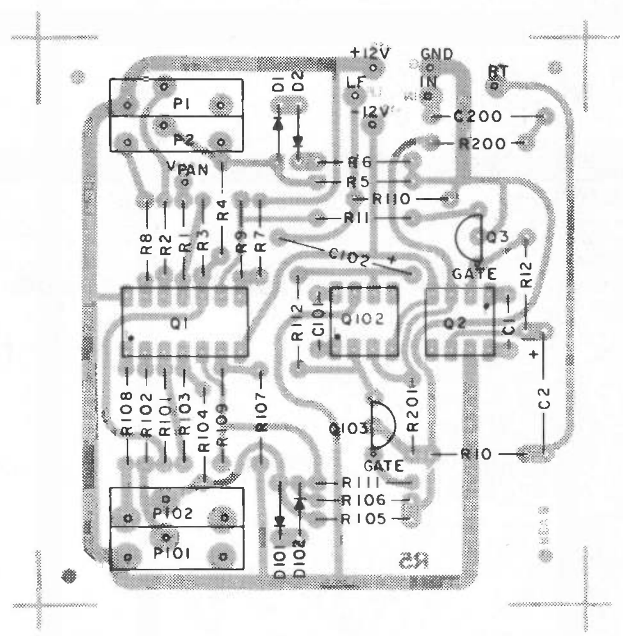


FIGURE 7: Stuffing guide for the CPP board.

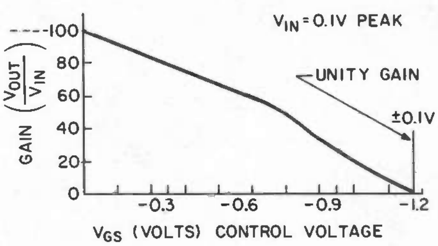


FIGURE 8: Voltage-controlled amplifier gain versus control voltage. The input voltage is a 500Hz sine wave at 0.1V peak. In the CPP circuit, V_{cos} and V_{sin} act as the control voltage V_{GS}.

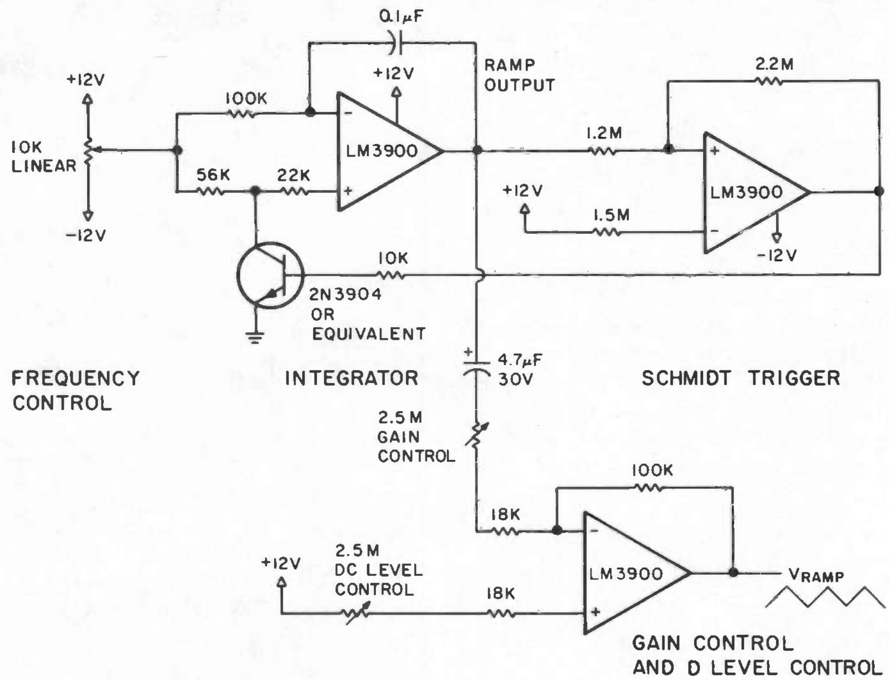


FIGURE 9: Ramp generator schematic using an LM 3900 op amp.

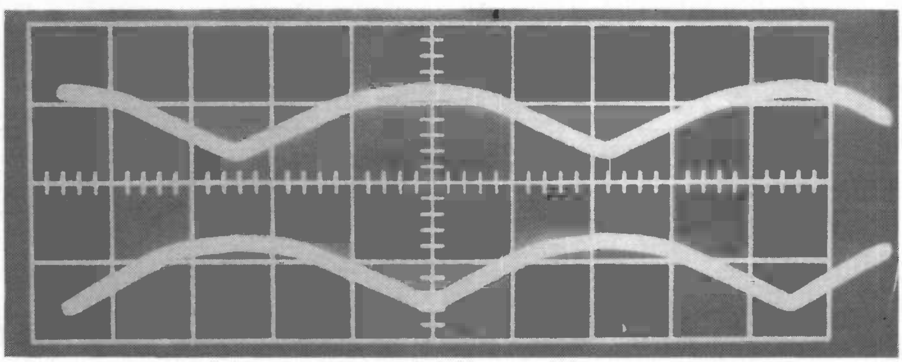


FIGURE 10: Pan voltages used for the photo sequence (0.03sec/division; 10V/division). These voltages, which control the pan function, were generated with the circuit in Fig. 9. *The top trace shows V_{pan} (V_{PR}), while the bottom trace shows V_{PL}.*

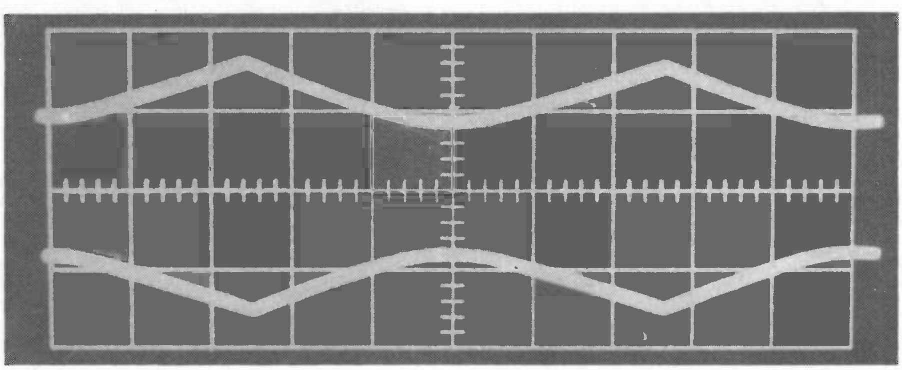


FIGURE 11: Pan voltages, after being wave shaped (0.03sec/division; 1V/division). The top trace shows V_{PL}' and the bottom trace V_{PR}'. The effect of the wave-shaping circuit is clear when you compare V_{PR}' to V_{pan}.

nent layout. Although the layout is not critical, be sure the diodes go in the proper direction and the FETs are inserted properly. The power supplies can be any value between ±15V and ±8V.

After powering up the circuit, adjust P1 first. Ground the V_{pan} side of R1 and adjust P1 until V_{PL} reaches its maximum value (saturates). Now, put V_{pan} to the positive power supply level. Ideally, V_{PL} should be at ground, but any value within ±0.6V of ground is acceptable. If V_{PL} is not within these limits, try another LM 3900 or adjust P1 for the best compromise.

Next, set P101. Again, put V_{pan} at the positive power supply and adjust P101 until V_{PR} saturates. Ground V_{pan}. V_{PR} should be within ±0.6V of ground. If it is not, try another LM 3900 or adjust P101 for the best compromise. If possible, adjust P101 so that the extreme values of V_{PL} and V_{PR} are identical.

If you have a scope or, even better, a scope with an external horizontal input, adjusting P2 and P102 is really easy. If you do not have a scope, use a headphone amplifier as follows. Hook up V_{pan} to a pot that is connected to the positive power supply and ground. (Hook up the wiper to the V_{pan} terminal.) Put some audio into the unit. Now, sweep the pan pot from one end to the other while listening to only the left output (V_{LF}). Adjust P2 until V_{LF} varies from full volume to almost inaudible over a full sweep. Repeat the procedure using V_{RT} and

P102. Now listen to both channels while sweeping the pan pot and make final adjustments to please your own ears. I have found that if the control voltage (V_{cos}/V_{sin}) exceeds the FET pinch off voltage, hiss might result. If so, back off the adjustment of P2 (P102) until the hiss just disappears.

If you have a scope and a ramp generator (or a scope with a sweep output), the adjustment of P2 and P102 is easier. If you do not have a ramp generator, get an LM 3900 and breadboard up the circuit in *Fig. 9*. You can use this circuit as the external pan voltage source in *Fig. 2*. Use the gain control and DC level control pots to generate a ramp voltage between 0V and the positive power supply voltage. *Figure 10* shows the ramp generated by the circuit in *Fig. 9*. The top trace shows the pan voltage (V_{pan}), while the bottom trace shows V_{PL}. (Note that V_{PR} is equal to V_{pan}. Also, the traces are reversed with respect to *Figs. 11–13*.) The scope is sweeping 0.03sec/division, and the gain is approximately 10V/division. *Figure 11* shows V_{PL}' (top) and V_{PR}' (bottom). The scope settings are 0.03sec/division and 1V/division. The effect of the wave shaper is evident by comparing V_{PR} in *Figs. 10* and *11*.

Put some audio into the CPP and adjust P2 and P102, using *Figs. 12* and *13* as guides. *Figure 12* shows a 100Hz audio signal being modulated by V_{PR}' and V_{PL}', while *Fig. 13* shows a 2,000Hz audio signal (0.03sec/division and 5V/division for both photos). Clearly, the sine and cosine functions have been impressed on the audio signals. When adjusting P2 and P102, make sure that you achieve minimum gain in the valleys of the sine and cosine functions.

If your scope has an external input on it, you can generate the display in *Fig. 14* to fine tune the pot adjustments. The first step is to feed the ramp signal into the horizontal and vertical inputs and adjust the gains until the trace makes a 45° angle with the vertical. This indicates that the gains in both channels are the same. Now put V_{RT} into

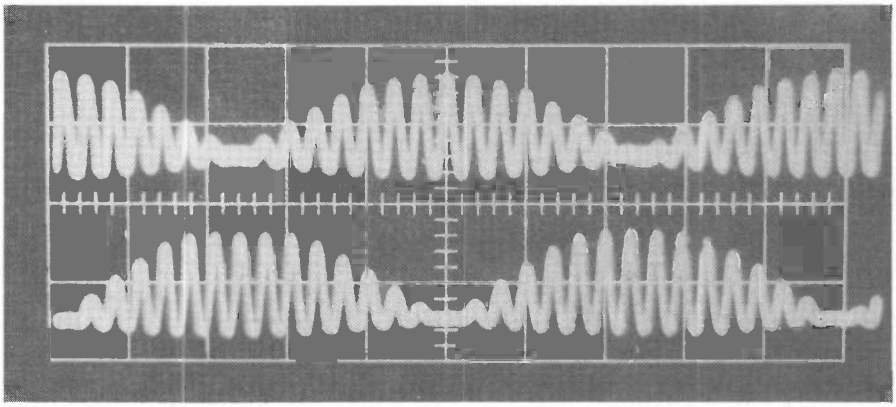


FIGURE 12: A 100Hz audio signal controlled by V_{pan} (0.03sec/division; 5V/division). The top trace is V_{LF} and the bottom V_{RT}. I used the control signals in Fig. 11 *to pan a 100Hz signal.*

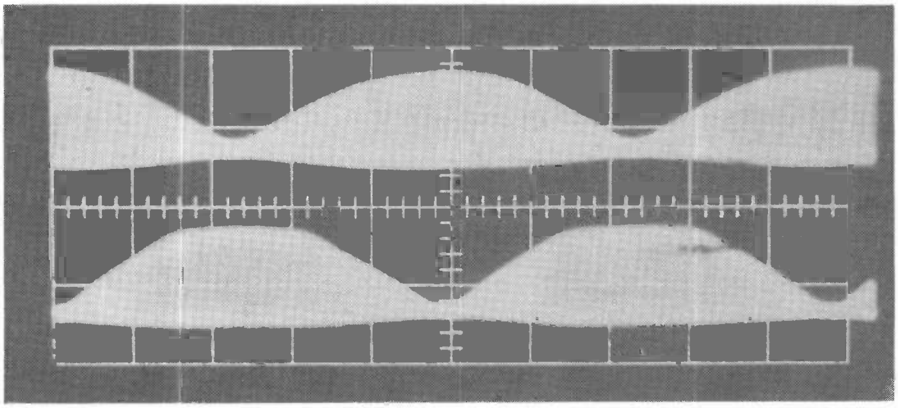


FIGURE 13: A 2,000Hz audio signal controlled by V_{pan} (0.03sec/division; 5V/division). The top trace is V_{LF} and the bottom V_{RT}. I used the control signals in Fig. 11 *to pan a 2,000Hz signal, losing all the audio signal's detail. You can use P2 and P102 to minimize the audio between the humps in the sine and cosine curves.*

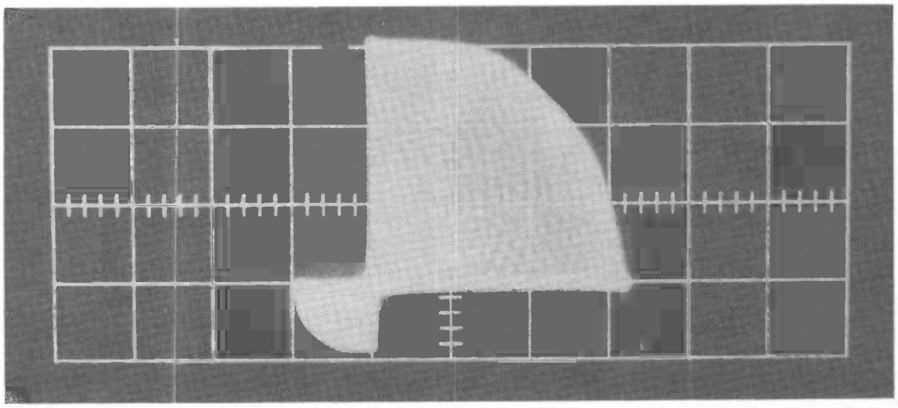


FIGURE 14: V_{LF} (vertical) traced against V_{RT} (horizontal) (both at 2V/division). If the circuit worked perfectly, quarter circles would appear on the display. To get the best circular shape, adjust P1, P2, P101 and P102, using the display as a guide.

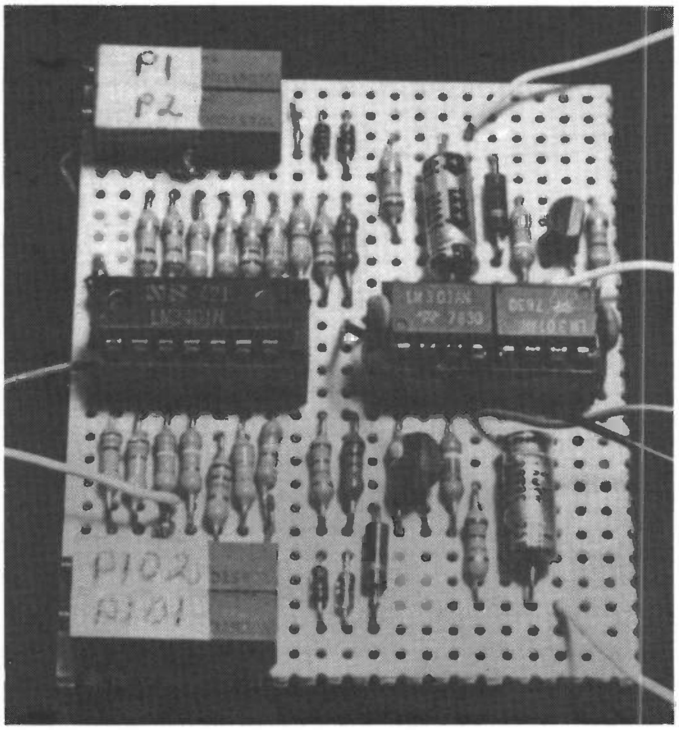


FIGURE 15a: Original perforated board prototype.

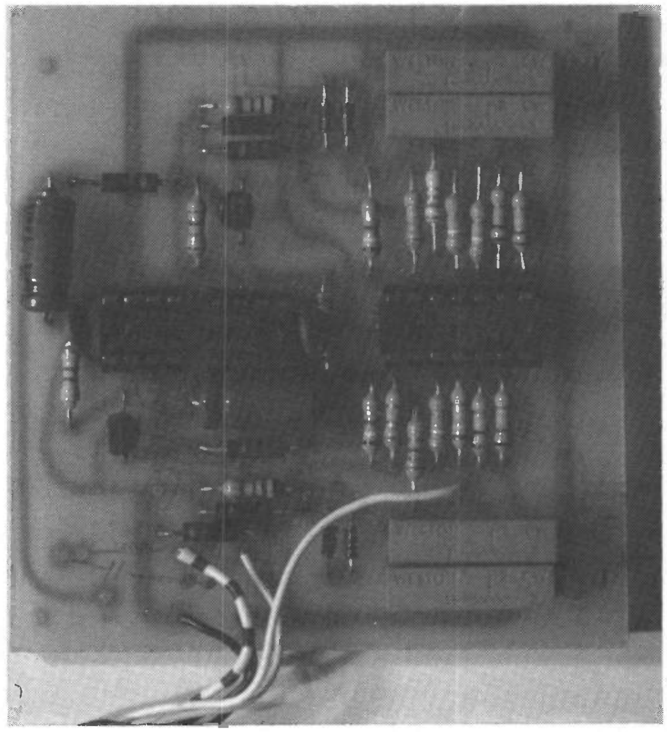


FIGURE 15b: Etched circuit board prototype.

the horizontal input and V_{LF} into the vertical. Adjust P2 and P102 to give the best circular shape. The circular shape results from the equation

$$V_{LF}^2 + V_{RT}^2 = P_T$$

which describes a circle.

I performed an error analysis graphically, using *Fig. 14.* I lined up the centers of the quarter circles on the division lines of the scope's face. I chose the reference radius for the circle at the points where θ equals 0° and 90° (which were the same because of my adjustments of P1, P2, P101 and P102). The maximum error in the quarter circles' radius was 5 percent (0.5dB), which translates into a 4 percent (0.34dB) power error. The RMS radius error was 3.4 percent (0.3dB), which translates into a 2 percent (0.14dB) power error.

That's all there is to it. My constant power pan has helped me to improve my mixer performance, thus contributing to my overall system enjoyment. □

Biographical Sketch

Mr. Grupp is an electrical/systems engineer with Calspan Corporation of Buffalo, New York. His hobbies include combining electronics and music. He is currently working on a home recording studio and a digitally controlled synthesizer.

References

1. Sherwin, James, "Program Multichannel Audio Gain," *Electronic Design*, February 1, 1975.

If enough readers express an interest in Mr. Grupp's constant power pan circuit, Old Colony will offer the board or a complete kit. Estimated cost of the board is \$8.50; estimated cost of the complete kit is \$22.50. If you would be interested in purchasing either the board or the kit, send a postcard to Old Colony, PO Box 243, Peterborough, NH 03458. Do *not* send payment. The materials will be available only if readers indicate sufficient interest.

SOCRATES WOULD APPROVE

Although we know of a number of active audio clubs, we wonder why no one has started one specifically for teenagers. Their interest in hi-fi equipment borders on the fanatical, but where are the groups to amplify and channel that interest?

Most of you have a wealth of expertise and technical skills that could be useful in leading such a group. Why keep it all to yourselves? Somebody needs to turn on the next generation to the fun and rewards of building audio equipment. This might be a good project for an existing club. Perhaps you could check with youth groups such as the Scouts, Boys or Girls Clubs, the YMCA or YWCA, schools and churches for suggestions on how to get started and where to meet. Doing so will give a few young adults a strong start in a life-long hobby. And you might find your own life enriched as well.

AN AUDIO ACTIVATED POWER SWITCH: MODEL 2

NEW POWER AMP ALTERNATIVES: PART III

BY JOHANNES M. DIDDEN

In Part II of this series, the author described the power monitor and power supply arrangements. He also offered some tips on constructing the system.

THIS NEW AUDIO activated power switch (AAPS) circuit (*Fig. 21*) has many improvements over my first design (*TAA* 3/78, p. 16). The input is now a virtual earth circuit, so high-output impedance preamps do not deteriorate channel separation.

The mechanism to detect the audio signal depends on signal frequency as well as level. If the level exceeds 1mV or so, pulses at the signal frequency will appear at the input of counter 1. The line frequency through the zero-crossing pulses from A3 will determine the interval during which the pulses will be counted. These zero-crossing pulses will periodically reset counter 1. If the input frequency is high enough, the counter will output a pulse to FF1 before the next reset. This sets FF1, and the next line zero-crossing will set FF2 and turn on the supply to the load. You can set the minimum required frequency with J1 at eight or 16 times the line frequency. I have mine set at ×8.

In theory this is a perfect "stonewall" high-pass filter, but phase shifts between the line and input signal cause the AAPS to switch on occasionally at a slightly lower frequency, which is okay. (See *Table 7*.) This takes care of the spurious signals and hum that would occasionally switch on in the first version of the AAPS.

Delayed switch-off is also related to the line frequency. Counter 2 counts the zero-voltage crossings, and when it reaches the number of pulses indicated by J2, it resets FF1. FF2 is reset at the next zero-crossing pulse. Note that this is not the ideal switch-off moment. Rather, the supply should be turned off at zero-current. This would, however, add considerable complexity to the circuit. At least the switch-off now occurs when the load current of the amplifier power supply connected to the AAPS is zero. Counter 2 is reset whenever counter 1 produces an output. This means that counter 2 can only time-out after the audio signal disappears. *Table 8* shows which delays you can select with J2.

A4 provides a convenient "protection" input and allows a manual switch-off. In my system, the protection input is wired to the amplifier protection circuits as indicated in *Fig. 11*. You can reset the system after a protection pulse by momentarily placing S in the "MAN OFF" position. You can also use this to cut off the delay manually.

The protection input sensitivity is more than 10V across 10k. D6 indicates the presence of an input signal, while D10 indicates whether the supply is activated. Note that you can realize S by using a single-pole, two-way toggle switch with a central or neutral "auto" setting.

Construction and Test

Construction is very simple if you use my circuit board layout (*Figs. 22* and *23*). *See figures on pages 36 and 37*
Text continued on page 59

TABLE 7
HIGH-PASS FILTER FREQUENCY

	Approx. High-Pass Frequency	
J1 Position	**50Hz Line**	**60Hz Line**
5	300Hz	360Hz
6	700Hz	850Hz

TABLE 8
SWITCH-OFF DELAYS

	Approx. Delay	
J2 Position	**50Hz Line**	**60Hz Line**
12	1 min., 22 sec.	1 min., 8 sec.
14	2 min., 44 sec.	2 min., 17 sec.
15	5 min., 28 sec.	4 min., 33 sec.
1	10 min., 55 sec.	9 min., 6 sec.
2	21 min., 51 sec.	18 min., 12 sec.
3	43 min., 41 sec.	36 min., 25 sec.

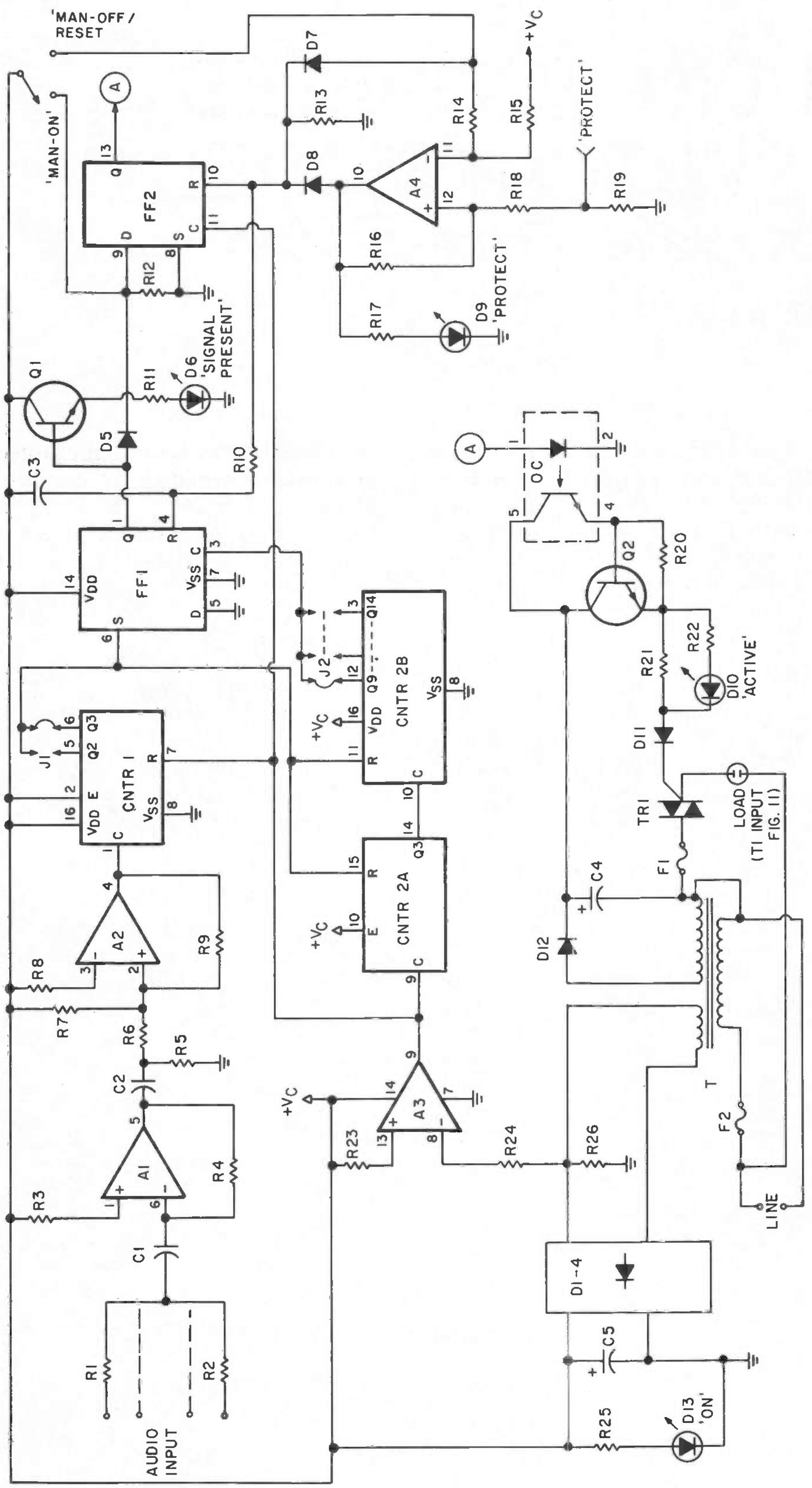


FIGURE 21: This AAPS circuit design includes many improvements on the author's original one, which appeared in TAA *several years ago.*

TABLE 9
PARTS LIST—AAPS

Resistors (¼W unless noted)

R1, R2	47KΩ
R3	10MΩ
R4	5.6MΩ
R5	100kΩ
R6	10kΩ
R7	1.5MΩ
R8	1MΩ
R9	390kΩ
R10	10kΩ
R11	560EΩ
R12, R13	1MΩ
R14	100kΩ
R15	1MΩ
R16	470kΩ
R17	560EΩ
R18	680kΩ
R19	12kΩ
R20	2.2kΩ
R21	82Ω
R22	560Ω
R23	3.9MΩ
R24	12kΩ
R25	560EΩ
R26	6.8kΩ

Capacitors

C1	0.039μF, ceramic
C2	0.01μF, ceramic
C3	0.47μF, 25V, tantalum
C4	470μF, 25V, electrolytic
C5	470μF, 25V, electrolytic

Diodes

D1–D4	1N4002
D5	1N4148
D6	LED, Yellow
D7, D8	1N4148
D9	LED, Red
D10	LED, Green
D11, D12	1N4002
D13	LED, Green

ICs

A1–A4	LM3900
CNTR1,2A	CD4520
CNTR2B	CD4020
OC	MCT2, T1L111
FF1, FF2	CD4013

Misc.

TR1	TRIAC, 400V, 8A RMS
F1 fuse	8A SLO BLO
F2 fuse	200mA SLO BLO
T	transformer, 2×10V @ 55mA (Signal ST-2-20 or equiv.)
Q1, Q2	general purpose small-signal transistor, (100mA cont.)
S	Switch SPDT with center off

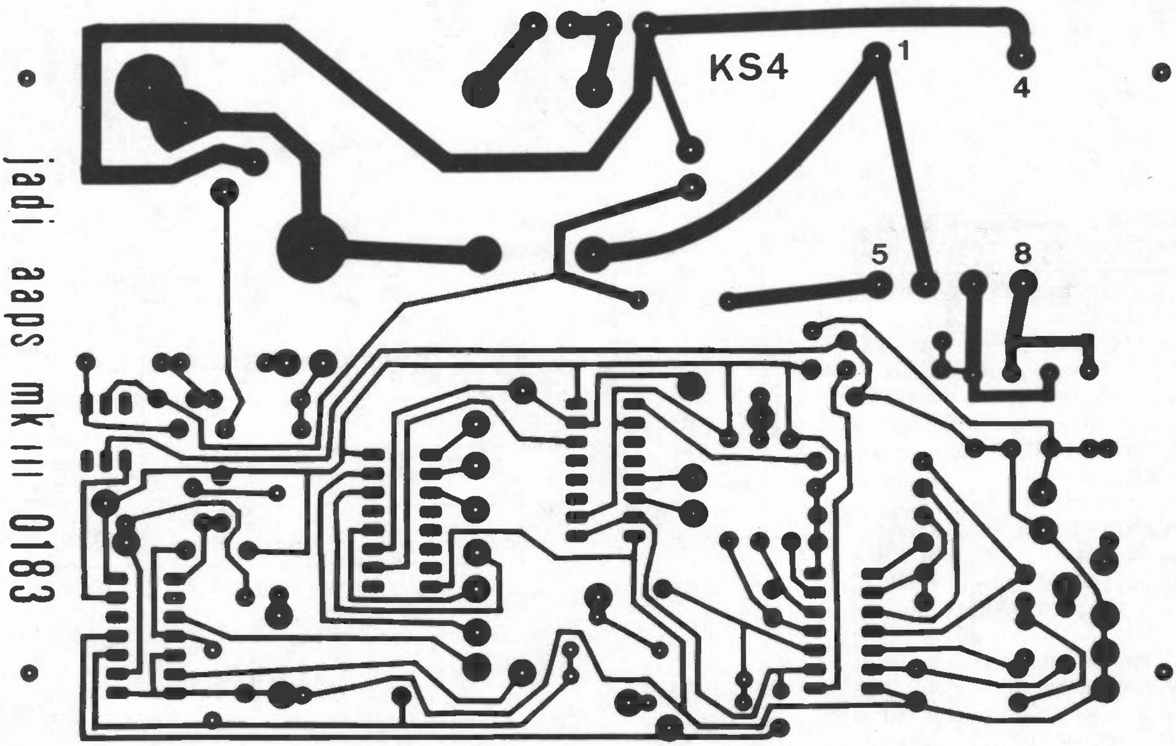


FIGURE 22: Circuit board for the AAPS, foil side.

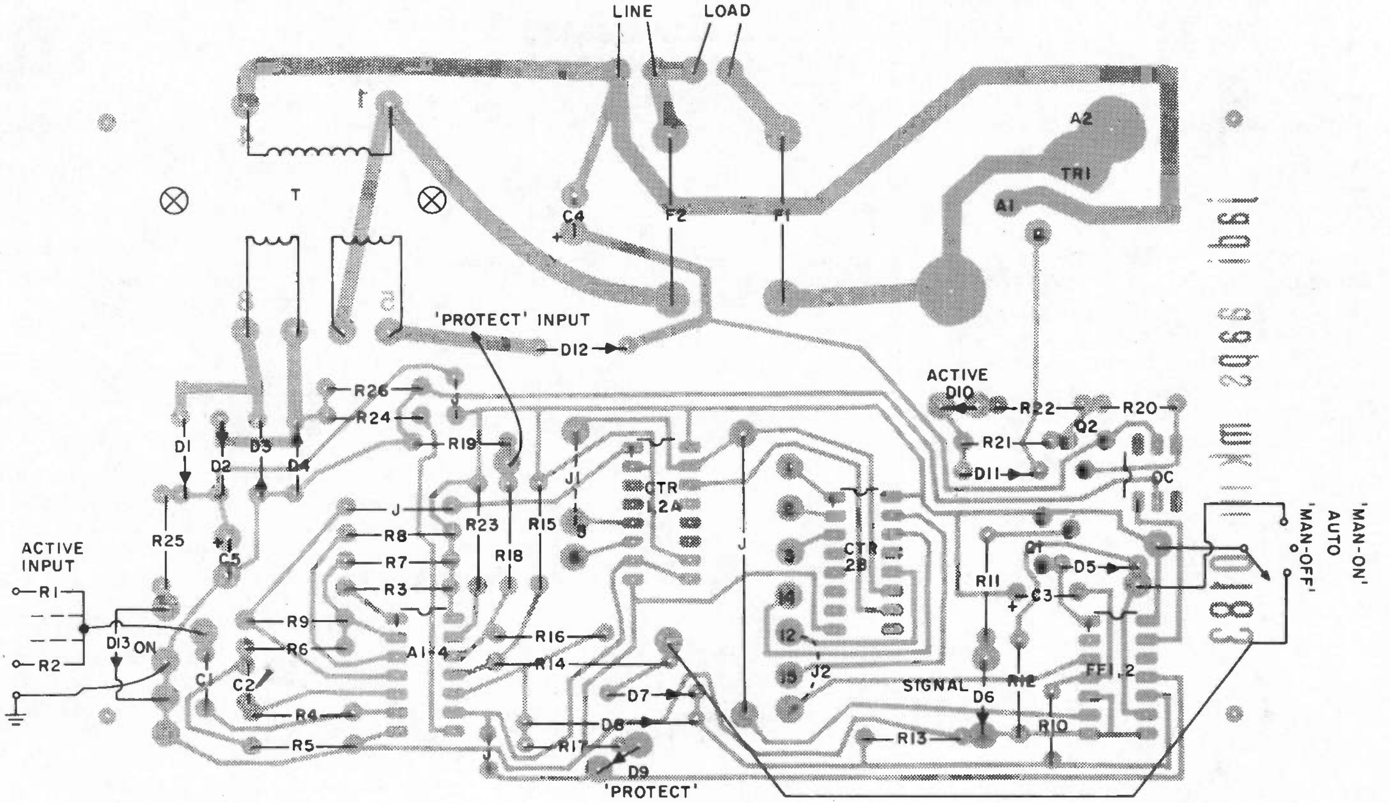


FIGURE 23: Stuffing guide for the AAPS.

AUDIO AIDS

LINE FILTER MOD

IN REFERENCE TO THE POOGE-1 and POOGE-2 articles in *TAA* 1/81 (Hollander and Jung, p. 20) and 4/81 (Jung and Marsh, p. 7), I would like to pass along a tip for additional sound improvement. Regardless of whether or not your system has been POOGEd (mine is still awaiting the completion of these mods), adding a line filter ahead of all the components can make a big difference.

I would suggest the RFI line filter, which is used in computer operations to remove hash, trash and assorted grunge from the 120V AC line voltage. This filter is available from Electronic Supermarket, PO Box 988, Lynnfield, MA 01940, Stock No. 3L0076. Each filter costs $3.50 (three for $10), but you must have at least a $10 order.

I incorporated the line filter in my system for an investment of less than $10, including an MOV (metal oxide varistor) resistor (available from Old Colony), which I wired across the line filter, and four filtered outlets. The filtered line will carry up to 10A. *Figure 1* shows a simple method of installing the filter. Make sure you solder all filter connections.

After installing the line filter, I was amazed at the dramatic improvement in the midrange and treble. My system sounded cleaner, clearer and more open. Cymbals sounded much sharper, and brushed cymbals really shimmered. My wife, who is the proud owner of a pair of registered pure stannus ears, corroborated my assessment.

PAUL T. KELLY
Fort Wayne, IN 46815

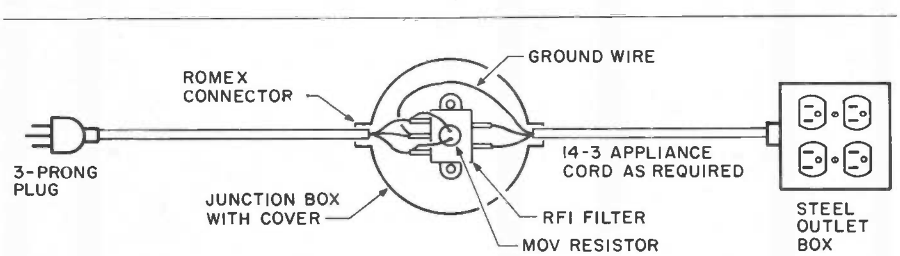


FIGURE 1: To install the RFI line filter, simply follow this easy guide.

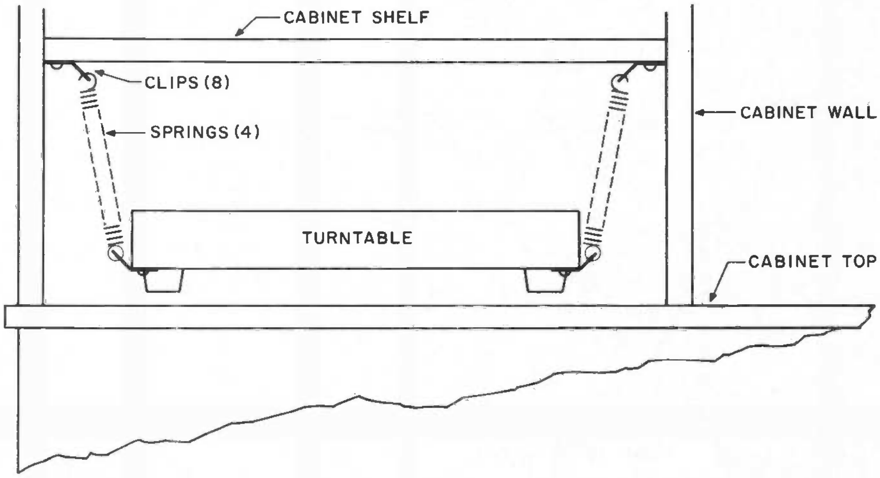


FIGURE 1: The author's seismic mounting eliminates distortion due to floor vibration and air-borne sound. The finished product should look something like this.

SEISMIC MOUNTING

TO MAKE THIS MOUNTING (*Fig. 1*), you will need eight clips, constructed as in *Fig. 2*, and two springs (normally used to close a screen door) approximately 16 inches long and ⅜ inch in diameter (*Fig. 3*). After making the clips, cut the springs in half, then form an open hook at each cut end. Put a piece of soft cotton rope, about ¼ to 5⁄16 inch in diameter and the length of the spring, inside the spring to dampen and silence it. Use a length of small wire, fastened to the rope, to pull the rope through the spring.

Attach four clips to the turntable base and four to the cabinet's "ceiling" (*Figs. 1* and *4*) or to its sides (*Fig. 4*). Attach the four springs by their open-hook ends to the cabinet clips (*Fig. 4*).

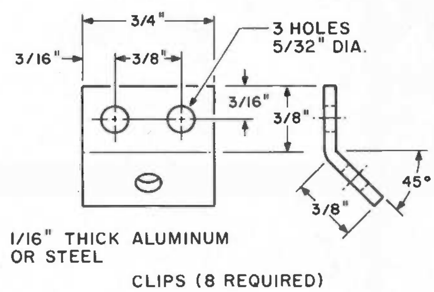


FIGURE 2: Construct eight clips to suspend the turntable from the cabinet.

To mount the turntable (*Fig. 4*), secure a length of 20-gauge aluminum wire by inserting it through the single hole in the turntable clip and twisting it on itself (*Fig. 5*). Then insert the free end of the wire through the closed-loop end of the spring, pulling out the slack in the wire until the spring supports the turntable's weight and its foot is about ⅛ inch from the cabinet top. Leave excess wire to allow for adjustment. Repeat the same procedure at the other three corners. Adjust the wires until all four feet are equidistant from the cabinet top.

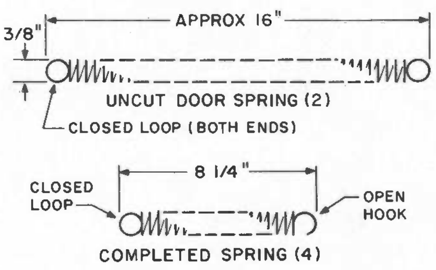


FIGURE 3: You will need four pieces of spring, approximately 8 inches long and ⅜ inch in diameter. One end of each piece should have a closed loop and the other an open hook.

For my system, the specifications are as follows:

Turntable weight—28 lbs (7 lbs/spring)
Spring constant—4 lbs/in (48 lbs/ft)
Resonant frequency (f)—2.36Hz.

I found the resonant frequency with the following formula:

$$f = \frac{1}{2\pi}\sqrt{\frac{kg}{W}}$$

where f = frequency of oscillation in hertz, k = spring constant in lbs/ft, g = gravity (32.2 ft/sec), and W = weight of turntable in pounds. Therefore,

$$f = \frac{1}{2\pi}\sqrt{\frac{48 \times 32.2}{7}} = 2.36\text{Hz}$$

A decrease in turntable weight or an increase in spring constant will increase resonant frequency. Likewise, an increase in weight or a decrease in spring constant will decrease resonant frequency.

This seismic mounting accomplishes two objectives. First, walking, dancing or jumping on the floor does not affect turntable or arm operation. Second, airborne sound, which induces vibrations in the floor and cabinet, is completely isolated from the turntable. Even my system, which has a much-touted vibration and acoustic isolation system built into the turntable, has shown a marked improvement in sound quality with this modification.

R. J. Ballard
Johnson City, TN 37601

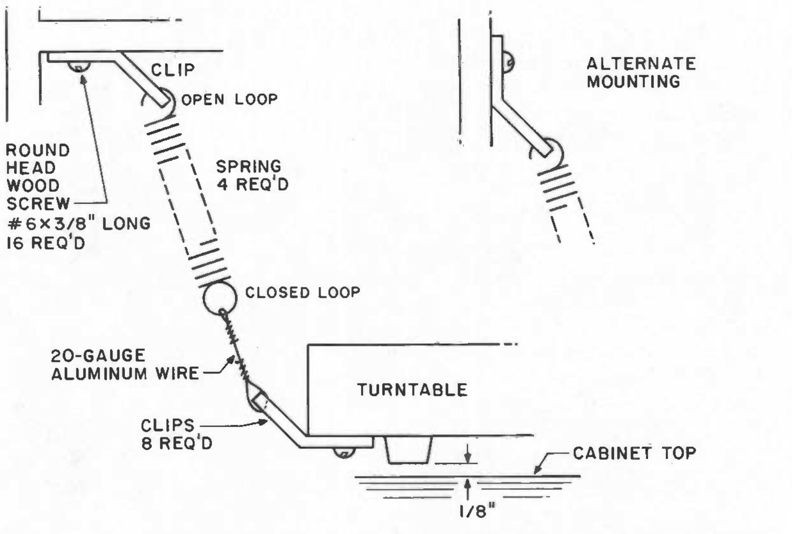


FIGURE 4: Use the spring to connect each corner of the turntable to the cabinet. Adjust the length of the spring so that each turntable foot is the same distance (approximately ⅛ inch) from the cabinet top and the turntable base is level.

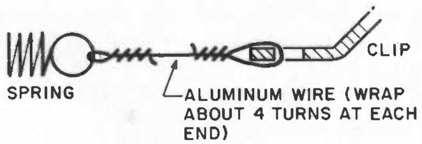


FIGURE 5: After you have adjusted each spring's length by lengthening or shortening the connecting aluminum wire, wrap the wire about four turns at each end and cut off any excess.

TUBE PREAMP TURN-ON DELAY

If a vacuum tube preamp feeds a transistorized (or worse, a FET) input, high-voltage offsets occur at the preamp outputs during warmup. These offsets can destroy a power amplifier. To solve this problem, I have adapted this simple 555 circuit to perform as a 14-second delayed turn-on for audio output.

This circuit merely shorts the outputs for 14 seconds. Note the simple, poor-regulation, high-ripple supplies that run it. This is actually an asset because the relay immediately drops when the power switch is cut off. Consequently, you can't hear any turn-on or turn-off transients in the speakers.

Stephen Nitikman
Don Mills, Ontario
Canada M3B 2P9

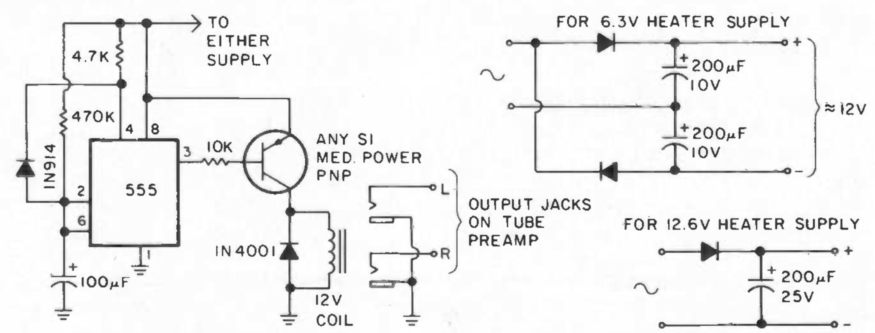


FIGURE 1: The author's turn-on delay circuit can eliminate high-voltage offsets in your tube preamp.

Old Colony Kits

What's Included? Old Colony kits include all the parts needed to make a functioning circuit, such as circuit boards, semiconductors, resistors and capacitors. Power supplies are not included in most cases. Unlike kits by Heath, Dyna and others, the enclosure, face plate, knobs, hookup wire, line cord, patch cords and similar parts are not included, and you must obtain these parts separately to complete your project. We do include article reprints with kits. Our aim is to get you started with the basic parts—some of which are often difficult to find—and let you have the satisfaction and pride of finishing your unit in your own way.

PREAMPS

REG WILLIAMSON

KB-5A: WILLIAMSON. [2:71] Stereo, all top quality parts, including alternate R_{13}, R_{14}, 200mW sensitivity resistors, all metal oxide resistors, six-pole shorting selector switch, dual 220k balance control, epoxy board. *Does not include box, panel, knobs or sockets.* Each **$60.00**

KB-5B: WILLIAMSON PREAMP POWER SUPPLY. Two stages of filtering, full-wave rectifier, transformer. All parts including schematic. Each **$16.50**

DAVE VORHIS

KP-8: VORHIS LAST PAS MOD. [5:82] Precision parts, 1% polystyrene capacitors and metal film resistors, gold plated phono jacks and B+ regulator board included. Does not include balance, volume control, or 71K capacitors. Each **$184.00**

LAMPTON/ZUKAUCKAS

KK-1: PHONO, Low Level. Two channel on single board [1:79] w/gold IC sockets. Each **$42.00**

KK-2: HIGH LEVEL, TONE CONTROLS. Two channel w/board, gold IC sockets, Bourns pots. Each **$84.00**

KK-2S: SIMPLE SWITCHING: One SPST and four DPDT. Set **$13.50**

KK-2SS: ELABORATE SWITCHING: LZ-Mk. 1. (See Fig. 1A) One 2P5T; one 2P11T; two DPDT; one SPST. Set **$19.00**

POWER AMPLIFIERS

WILLIAM Z. JOHNSON

KH-6: AUDIO RESEARCH ST-70-C3 MODIFICATION KIT. [4:77] Kit supplies ALL parts: wire, tubes, controls, assembled circuit board, and hardware to modify Dynaco's Stereo-70 stereo power amplifier to *Audio Research Corporation* levels of performance. The transformers, power switch and cord, fuse post, chassis and a few of the screws and nuts are the only parts of the Dynaco ST-70 unit used. Fully detailed construction booklet with step-by-step instructions. Each **$220.00**

KH-6B: AUDIO RESEARCH ST-70-C3. Modification kit construction booklet. Each **$4.00**

ERNO BORBELY

KP-3A: BORBELY 60W MOSFET AMPLIFIER. [2:82] All parts for one channel (except "L" choke) including board, driver and output heat sinks. Each **$72.00**

KP-3P: BORBELY 60W MOSFET AMP POWER SUPPLY. [2:82] Two channels. Transformer and all parts except chassis and large filter caps. Each **$65.00**

KP-3PC: BORBELY 60W POWER SUPPLY. [2:82] Power supply with two 10k*u*F @ 75V output filter caps. Each **$84.00**

KP-3T: BORBELY 60W MOSFET. [2:82] Transformer. 72VCT @ 200VA Each **$55.00**

KP-3S: BORBELY 60W MOSFET. [2:82] Semiconductors only. One channel. Each **$35.00**

REG WILLIAMSON

KK-13R: WILLIAMSON 40/40 [4:79] One channel. Includes all parts and board except the semiconductors. Each **$31.00**

KK-13SL: WILLIAMSON 40/40 [4:79] One channel. All semiconductors with Texas Instruments TIP-35C/TIP-36C output devices. No heatsinks. Each **$24.50**

KK-13SH: WILLIAMSON 40/40 [4:79] One channel. All semiconductors with Toshiba 2SD426/2SB556 output devices. Each **$32.00**

KK13-CH: WILLIAMSON 40/40 [4:79] Complete power amp, two channel without power supply. Toshiba outputs. Each **$115.00**

KK-13CL: WILLIAMSON 40/40 [4:79], as above with T.I. output devices. Each **$98.00**

KK-13-P WILLIAMSON 40/40 [4:79] Power supply for two channels. No sinks or transformer. Each **$28.00**

KA-2T: 20/20 or 40/40 TRANSFORMER, Toroidal with flying leads, 50V@1.8A. Each **$58.00**

JAMES BOAK

KJ-8A: DYNACO MARK III POWER SUPPLY MOD. [1:78] All parts needed to add a solid state regulated power supply to the Dynaco Mark III, including heat sink. Each **$18.00**

KJ-8B: DYNACO MARK III BALANCE AND BIAS KIT. [1:78] All parts for altering Dyna's bias system to permit DC balance of output tubes. Each **$5.00**

KL-1P: BOAK REGULATED POWER AMP POWER SUPPLY. Pass Class A version. [1:80] All parts except large, flat heatsink for either positive or negative half of Pass power supply. (Two required for one two-channel Pass amp (4:78). Board included. May be built as either (+) or (−) supply. Requires Pass DC supply components. Each **$68.00**

KL-1W: BOAK REGULATED POWER AMP POWER SUPPLY. [1:80] Williamson 40/40 or 20/20 amplifiers. All parts except large, flat heatsink. Positive supply. Use Pass 88-8 power supply (KJ-5-4) for best results and increased power output Each **$60.00**

KL-1D: BOAK REGULATOR KIT [4/81] Revised regulator for use with ST-150 MOD KM-8. All parts for regulator including new board. May be built as either positive or negative. One channel only. Includes heatsink. Each **$80.00**

NELSON PASS

A40 Class A. [4:78] 40W/channel.

KJ-5-1: Amplifier: Board and all parts including two operating and two test fuses and fuse holders, *except* semiconductors and heat sinks. One channel. Each **$25.00**

KJ-5-2: Amplifier: All Semiconductors, one channel. Each **$63.00**

KJ-5-3: Heat Sinks: Wakefield #435AAA. Four per channel needed. Each **$9.00** Eight **$60.00**

KJ-5-4: Power Supply. All parts including transformer, four 9000*u*F Sprague filter capacitors & clamps, two rectifier bridges, line cord, fuse & holder, switch, cord. Power for two channels. Each **$144.00**
West of Rockies **$147.00**

KJ-5-5: Power Supply. All parts above except four filter capacitors and transformer. Each **$18.00**

KJ-5-6: Power Supply. Power Transformer only. Signal 88-8. Two 44V CT windings @ 8A each. UPS delivery only. Each **$85.00**
West of Rockies, Each **$88.00**

KJ-5-7: COMPLETE AMPLIFIER: Stereo amplifier except for chassis and heat sinks. Two channels. Each **$311.00**
West of Rockies, Each **$316.00**

MasterCard VISA

CHARGE CARD
TELEPHONE ORDER SERVICE
MON. THROUGH FRI. 9AM–4PM
(603) 924-6371

MasterCard/Visa Cards Welcome

PASS-MOSFET

KM-7: MOSFET CITATION 12 MOD. Two channel, all parts to modify Harman-Kardon's Citation 12 except the semiconductors. [2:81] Each **$28.00**

KM-7S: MOSFET CITATION 12 MOD. One channel, all semiconductors to modify Harman-Kardon's Citation 12. [2:81] Each **$55.00**

KM-7C: MOSFET CITATION 12 MOD. Complete kit, two channel, all parts. [2:81] Each **$132.00**

BOAK-JUNG-AMER

KM-8: ST-150-BJ-1 DYNA 150 MOD. [2:81] All parts except power supply kit, two channel, all resistors and capacitors for the amplifier circuit mods. Each **$85.00**

FILTERS & SPEAKER SAVER

KF-6: 30Hz RUMBLE FILTER. [4:75] Two channel universal filter card supplied with WJ-3 (F-6) circuit board and all basic parts, 1% metal film resistors and 5% MKM capacitors for operation as an 18dB/octave 30Hz rumble filter. 30Hz, 0dB gain only. Kit may be adapted as two- or three-way single channel crossover with added capacitors and resistors. Each **$19.75**

KH-2A: SPEAKER SAVER. [3:77] This basic two-channel kit includes board and all board-mounted components for control circuitry and power supply. It features turn-on and off protection and fast optocoupler circuitry that prevents transients from damaging your system. 4PDT relay and socket included. Each **$35.00**

KH-2B: OUTPUT FAULT OPTION. Additional board mounted components for speaker protection in case of amplifier failure. Each **$6.75**

KH-2C: COMPLETE SPEAKER SAVER WITH OUTPUT FAULT OPTION. Each **$40.00**

KL-5 WILLIAMSON BANDPASS FILTER. [2:80] Two channel, plug-in board and all parts for a 24dB/octave 20Hz-15kHz with precision cap/resistor pairs. TL075 IC's. Each **$31.00**

CROSSOVERS

For KC-4A and KC-4B, choose frequency of 60, 120, 240, 480, 960, 1920, 5k or 10kHz.

KC-4A: ELECTRONIC CROSSOVER, KIT A. [2:72] Single channel, *two-way*. Values of R_1, R_2, C_1, C_2 must be specified with order. All parts and C-4 circuit board. Includes new LF351 ICs. Each **$8.00**

KC-4B: ELECTRONIC CROSSOVER, KIT B. [2:72] Single channel, three-way. Values of R_1, R_2, C_1, C_2, must be specified with order. All parts and C-4 circuit board. Includes new LF351 ICs. Each **$11.00**

KF-6: JUNG 30Hz FILTER. [4:75] With other values for the R's and C's, this becomes an excellent electronic crossover. See description under "Filters and Speaker Saver."

KF-7: CROSSOVER FOR WEBB TLS. [1:75] Passive four-way crossover, in pairs, assembled. 75W. Components are included for both STC and Celestion tweeters. Made by Falcon of England. Pair **$87.50**

KK-6L: WALDRON TUBE CROSSOVER: Low pass. Single channel, 18dB/octave, Butterworth, [3:79] includes Bourns 3-gang plastic pot, level control, Mullard tubes, board, and three frequency range determining capacitors. *Specify ONE frequency range per kit please.* (Hz.): 19-210; 43-465; 88-960; 190-2100; 430-4650; 880-9600; 1900-21,000. Single chan. Each **$43.00**

KK-6-H: WALDRON TUBE CROSSOVER: High pass. Single channel, 18dB/octave, Butterworth, [3:79] includes Bourns 3-gang plastic pot, level control, Mullard tubes and 3 frequency determining capacitors. Please specify **one** of the frequencies above. No other can be supplied. Each **$45.00**

KK-6-S SWITCH OPTION. 6-pole, 5-pos. rotary switch, shorting, for up to five frequency choices per single channel.
Each **$8.00**, When ordered with two kits above, Each **$7.00**

KK-7: WALDRON TUBE CROSSOVER POWER SUPPLY. [3:79] All parts, including board, transformer, fuse, semiconductors, line cord, capacitors. Will power four tube x-over boards (8 tubes), one stereo bi-amped circuit. Each **$88.00**

SBK-A1: LINKWITZ CROSSOVER/FILTER. *Speaker Builder's* [4:80] first kit, including all parts and board for one channel of the three-way crossover/filter/delay. 24dB/octave at 100Hz and 1.5kHz and 12dB/octave below 30Hz, with delayed woofer turn-on. Board is 5½ × 8½. Requires ±15V supply, not supplied. Use the Sulzer supply KL-4A with KL-4B or KL-4C. Per chan. **$64.00** Two chans. **$120.00**
SBK Board only Each **$14.00**

SULZER PREAMP POWER

KL-4A SULZER OP-AMP PREAMP POWER SUPPLY [2:80] ±15V regulator 30mA capacity. All parts and board. Requires a ±21V filtered DC input. No transformers, filter caps or rectifiers. Each **$27.00**

KL-4B SULZER RAW DC SUPPLY. Transformer, diodes and two 5,000*u*F @35V capacitors. Will power two KL-4A supplies. Diagram supplied for construction. Each **$18.00**

KL-4C SULZER RAW DC SUPPLY in KL-4B with AVEL/LINDBERG toroidal transformers. Each **$43.00**

KL-4D AVEL/LINDBERG ±20V Transformer only Each **$30.00**

SYSTEM ACCESSORIES

KH-8: MORREY SUPER BUFFER. [4:77] All parts & board for two channel output buffer to isolate tape outputs in your preamp from distortion originating in a turned-off tape recorder. Many uses for this versatile matchmaker. Each **$14.00**

KH-9: TONE ARM MOUNT BOARD. For the Thorens TD-124 turntable *only*. Exact fit, unpainted fine grade hardwood. Three countersunk holes drilled to fit frame. Each **$3.25**

KF-1: BILATERAL CLIPPING INDICATOR. [3:75] Single channel, all parts and board for any power amp up to 250W per channel. (Does not work well with Leach Amp). Powered by amp's single or dual polarity power supply. Each **$5.50** Two kits, as above **$8.25**

KJ-3: TV SOUND TAKEOFF. For extracting the TV set's sound to feed your audio system [2:78] Circuit board, vol. control, coils, IC, co-ax cable (1 ft.) and all parts including power transformer. Each **$21.50**

KJ-4: AUDIO ACTIVATED POWER SWITCH. Turn your power amps on and off with the sound feed from your preamp.[3/78] Includes all parts except box and input/output jacks. Each **$50.00**

KK-14A: MacARTHUR LED POWER METER. [4:79] Two channel, two sided board and all parts except switches, knobs, and Mtg, clips for LEDs. LEDs *are* included. No chassis or panel. Each **$110.00**

KK-14B: MacARTHUR LED POWER METER. [4:79] As above but complete with all parts except chassis or panel. Each **$137.50**

KL-2: WHITE DYNAMIC RANGE & CLIPPING INDICATOR. [1:80] One channel, including board, with 12 indicators for preamp or crossover output indicators. Requires ±15V power supply @ 63 mils.
Single channel. Each **$49.00** Two channels. **$95.00**
Four channels. **$180.00**

KM-10A: SWITCHBOX [2:81] (6⅜ × 4 × 2″) black with white letters with 5-position DP silver contact, steatite switch, four inputs, two outputs w/RCA jacks, nickel plated, and four ground posts.
Ppd. Each **$21.50**

KM-10B: Same as 10A but with 10 gold plated jacks. Each **$32.50**

KP-4A: BOAK HEADPHONE AMPLIFIER. [3:82] One channel includes metal film resistors, gold plated IC sockets and heatsink.
Each **$55.00**

KP-4B: BOAK HEADPHONE VOLTAGE REGULATOR. All parts for 12V or 24V regulator for one channel. Does not include transformer, rectifier, or filter capacitors. Each **$18.00**

KP-4C BOAK HEADPHONE AMP PACKAGE. Contains two KP-4A, two KP-4B. Each **$128.00**

KP-5: AUDIO SWEEP MARKER ADDER [2:82] All parts and circuit board (no power supply) for adding two adjustable markers to a swept audio signal, 20Hz-100kHz. Each **$22.00**

TONE ARM
ROD COOPER

KP-9: TANGENTIAL TRACKING TONE ARM. [4/82] Includes circuit board, matched photodiodes, alarm relay, precision-machined metal parts, nuts, bolts, bearings, pulley wheels, belts, microswitches, Litz wire, miniature connectors, and sorbothane. You provide the small 6V cassette motor, knobs and switches for the control panel, electrical parts for the board. Completed arm mounts on the turntable of your choice. Each **$160**

AMBIENT SOUND

KH-1: THE WILLIAMSON SUPER QUADPOD. [1:77] Reg Williamson's fascinating ambience decoder which may also be used for an encoder following the Blumlein system for recording. All parts for one complete four channel board. No power supply. + 18–25V DC required.
Each **$26.50**

SHOWCASE

LEACH POWER AMP UPGRADE

by Don E. Prock

My power amp is based on the Leach design (*Audio*, April/May 1980) with a few minor modifications. I replaced the 8099 and 8599 Motorola input transistors with dual matched NPN and PNP cans. This greatly reduced the DC offset at the output. I also bypassed all electrolytics and power supply capacitors with polycarbonate and polypropylene caps. This derated the heatsink requirements 75 percent, and the amp runs cool even at full output into 4Ω. The amp has a solid and dynamic bass response, an open and transparent midrange response and extremely clean and fast treble.

I am currently using three of these power amps in my system and am working on a new speaker system that will require all six channels of amplification. I am modifying one amp's power supplies and output stages for higher current drive capability to drive the Strathearn ribbon tweeters directly.

I have been very pleased with the ruggedness of the Leach design. Two of the amps have been in use for two years and at times have been inadvertently subjected to some abuse, yet neither has ever failed.

Specifications for the power amp are as follows: 125W per channel into 8Ω, 175W per channel into 4Ω ±0.5dB from 10Hz to 45kHz. Total harmonic distortion (THD) plus noise is no more than 0.2 percent from 20Hz to 20kHz. The dual power supplies with 72V center-tapped (ct) transformers at 6A each have a total power supply capacitance of 80,000mF. □

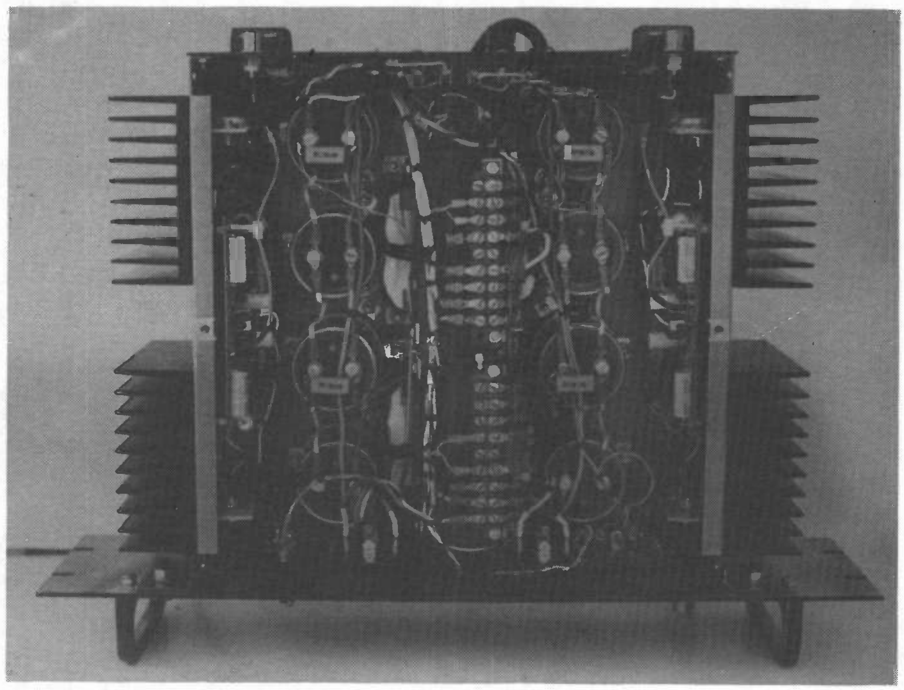


PHOTO 1: Top view of the Leach Low TIM III power amp.

PHOTO 2: Front panel of the Leach amp.

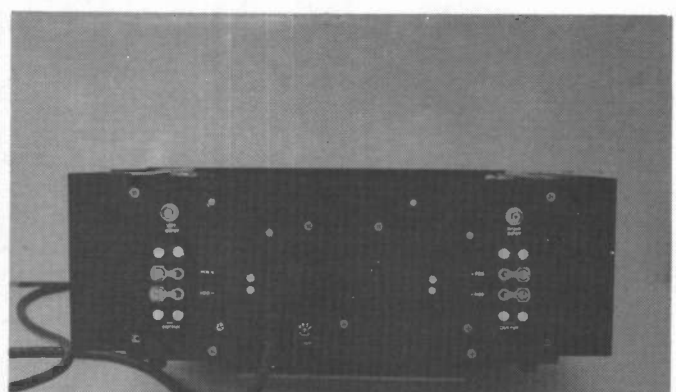
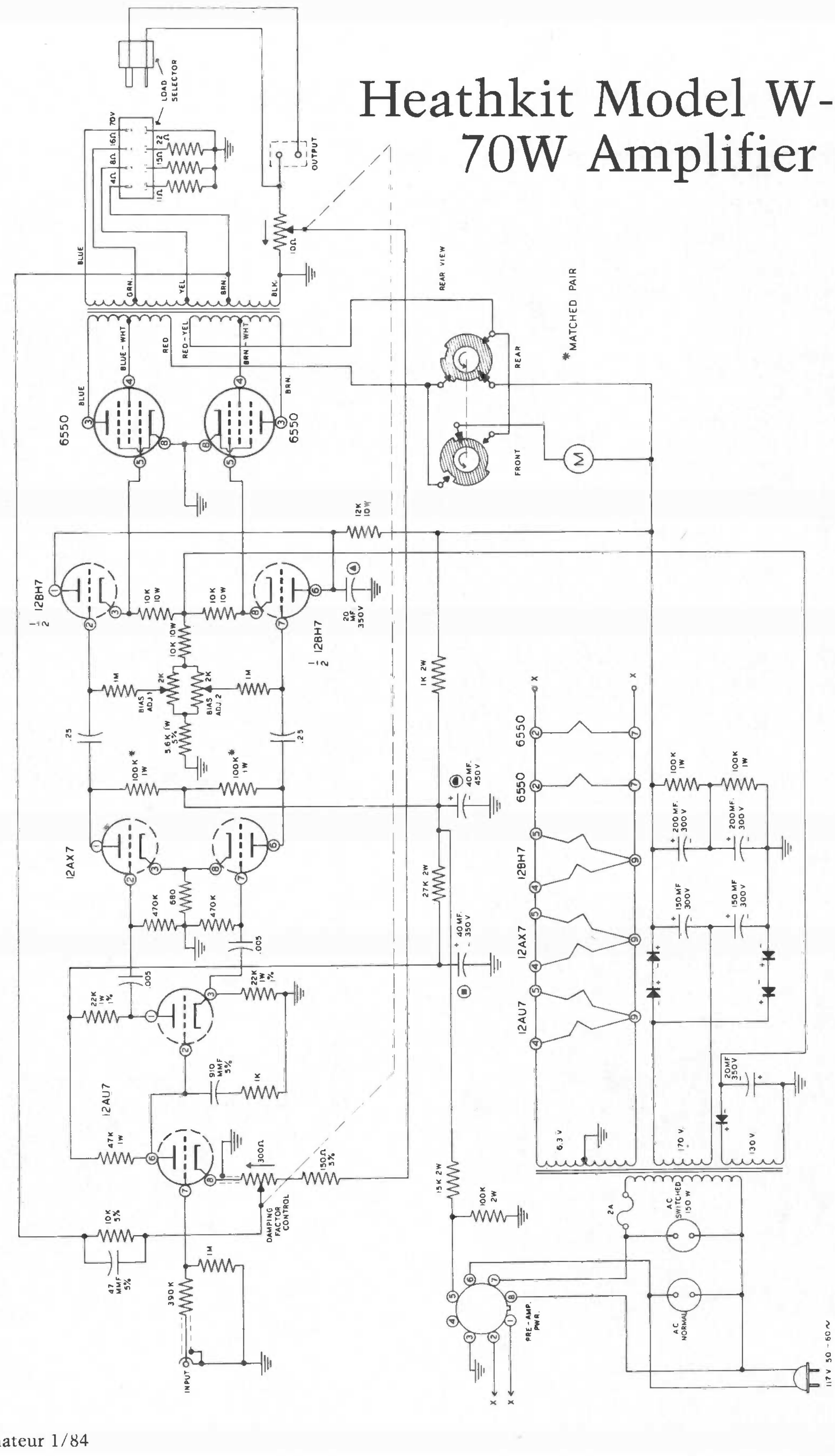


PHOTO 3: Back panel of the power amp.

Heathkit Model W-6M 70W Amplifier



KP-4C SUPER CLEAN HEADPHONE AMP

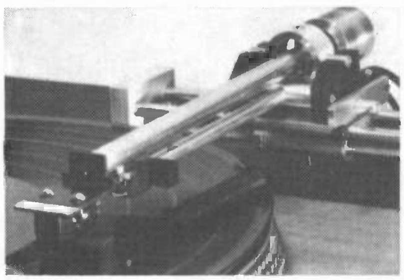
Two Channels for only $128!

- Designed by Jim Boak
- Can be optimized for either electrostatic or dynamic phones
- Direct coupled, using a 540 op amp
- Class A operation
- Low noise and distortion
- High slew rate
- Extended overload capacity gives you a clean, wide open tube-like sound
- Well regulated power supply, independent for each channel

The headphone output on most amps usually is a large resistor in series with the output to knock the level down to what is suitable for driving headphones. The resistor reduces the amp's damping ability, leaving your headphone drivers less tightly controlled. You will also suffer the distortions produced by the resistor's particular nonlinearities. To solve these problems, Jim Boak has designed a high performance amp specifically for headphones. Built around the powerful 540 op amp, it features a circuit modification, derived from Walt Jung's work, which gives the op amp a highly linear transfer characteristic. The resulting distortion curve has that gentle rise associated with good tube amps, and a clean, wide open sound quality you will enjoy thoroughly every time you listen on headphones. To top it off, Boak gave it excellent power supply regulation. Each channel has independent power supplies using three-terminal regulators to deliver stable voltages across the entire audio range. The amp may be configured for driving either electrostatic or dynamic headphones, and parts for both are included.

KP-9 TANGENTIAL TRACKING TONE ARM

Only $160!



Here's your opportunity to own a tangential tracking tone arm—and have the fun of building it yourself. Rod Cooper's ingeniously simple design elegantly achieves the benefits long attributed to tangential arms. The kit has been sold in England for several years and has been praised for its high quality. The metal parts are precision-machined for a solid, tight-fitting assembly. Mount it on your choice of turntables, and you will have an outstanding piece of equipment which you can use and enjoy every day, for many years of listening enjoyment.

- Improved tracking ability lowers distortion
- Maintains tangency ±0.2°
- Low mass (10g) tracking arm of rigid Dural
- Servo controlled, with opto-electronic feedback
- Low friction gimbal suspension

SBK-C2 PHASE-ALIGNED ELECTRONIC CROSSOVER

Two channels for only $134

One of the problems introduced by crossovers is the phase delay they cause. Over the years, many attempts to minimize this problem have been made. Bob Ballard's solution starts with a simple method of measuring the drivers' phase relationships in the air. Then he shows you how to build a crossover with phase adjusting circuits and tells you how to put your system in alignment, from the preamp outputs to the sound in the air.

- Three-way active crossover
- Phase shifting circuits to fine tune your system
- Easy method to measure actual acoustic phase relationships among drivers
- Op amp filters simplify design
- Rumble filter built in

METAL FILM RESISTORS

10¢ each in quantities less than 100, 8¢ each for 100 or more

Old Colony is closing out its entire stock of Draloric metal film resistors. Take advantage of this opportunity to stock up at bargain prices. These precision audio grade resistors are made by Telefunken to exacting standards. They have tight specs at a high level of performance with long term reliability and stability—all to assure you of high fidelity in the audio equipment you build.

- Extremely low noise:
  - less than .05 microV/V to 10k
  - less than 1 microV/V to 100k
  - less than 25 microV/V to 1 Meg
- Temperature Coefficient: 50 ppm/C°
- Tolerance: less than 1%
- Maximum Power: 0.35W @ 70°C derated linearly to OW @ 165°C
- Maximum Voltage: 250V
- Copper leads coated with eutectic solder

All standard E24 values are available except: 20, 47.5, 121, 274, 2.21k, 3.92k, 4.75k, 6.81k, 8.25k, 12.1k, 18.2k, 22.1k, 24.3k, 27.4k,39.2k, 43.2k, 47.5k, 56.2k, 82.5k, 150k, and 825k.

Minimum Order: 10 per value.

Old Colony will continue to stock metal film resistors in all standard E24 values, but take advantage of these special closeout prices on the Dralorics while supplies last.

ORDER FORM **Old Colony Sound Lab, P.O. Box 243, Peterborough, NH 03458 USA**

Qty. Price

_____ KP-4C Boak Headphone Amp Kit $128 (two channels) . . _________

_____ KP-9 Cooper Tangential Tracking Tone Arm Kit $160 ea . _________

_____ SBK-C2 Ballard Phase Correcting Crossover Kits $134 ea _________

Metal Film Resistors—Minimum Order 10 per value—10¢ each (20% off for 100 or more)

Value_____ Qty._____ || Value_____ Qty._____ || Value_____ Qty._____

Value_____ Qty._____ || Value_____ Qty._____ || Value_____ Qty._____

Total for resistors _________

Total amount enclosed: _________

Form of Payment: ☐ Check ☐ Money Order ☐ MC or Visa

Card # ______________________ Exp. Date _________

Name ______________________

Address ______________________

City ______________ State _________ Zip _________

Phone Orders: (603) 924-6371 (MC or Visa only) 9-4 EST

For full kit listing, send stamped, self-addressed envelope to: Old Colony Sound, PO Box 243, Peterborough, NH 03458

TROUBLESHOOTING

TOUGH ONES
by Kirk Vistain

After a while, most repairs seem dully routine, but just when you think you have seen it all, the gremlins mobilize, hoping to make you quit the good fight and take up accounting or some other "interesting" profession. No, I'm not talking about garden variety "tough dogs" in which you put a PNP in place of an NPN or inadvertently slop a little solder across a couple of foil lands. You can eliminate these technician-generated troubles, the most common source of frustration, by adopting good work habits.

Gremlins, on the other hand, can transmute perfectly workable assumptions, which you have used successfully on thousands of units, into time-robbing, mind-boggling, anger-producing misconceptions. This time I will examine some "tough ones," and you will see that sometimes we make our own gremlins.

Sansui Six

Here is a good example of misleading test results. This 35W receiver (*Fig. 1*) came in with a complaint of intermittent output. The customer said he could detect no pattern to the failure: every now and then the protector relay would kick out. After a minute or two, it would come back on and work normally for an indeterminate time.

I hooked it up on the back bench, connected a monitoring device to signal me

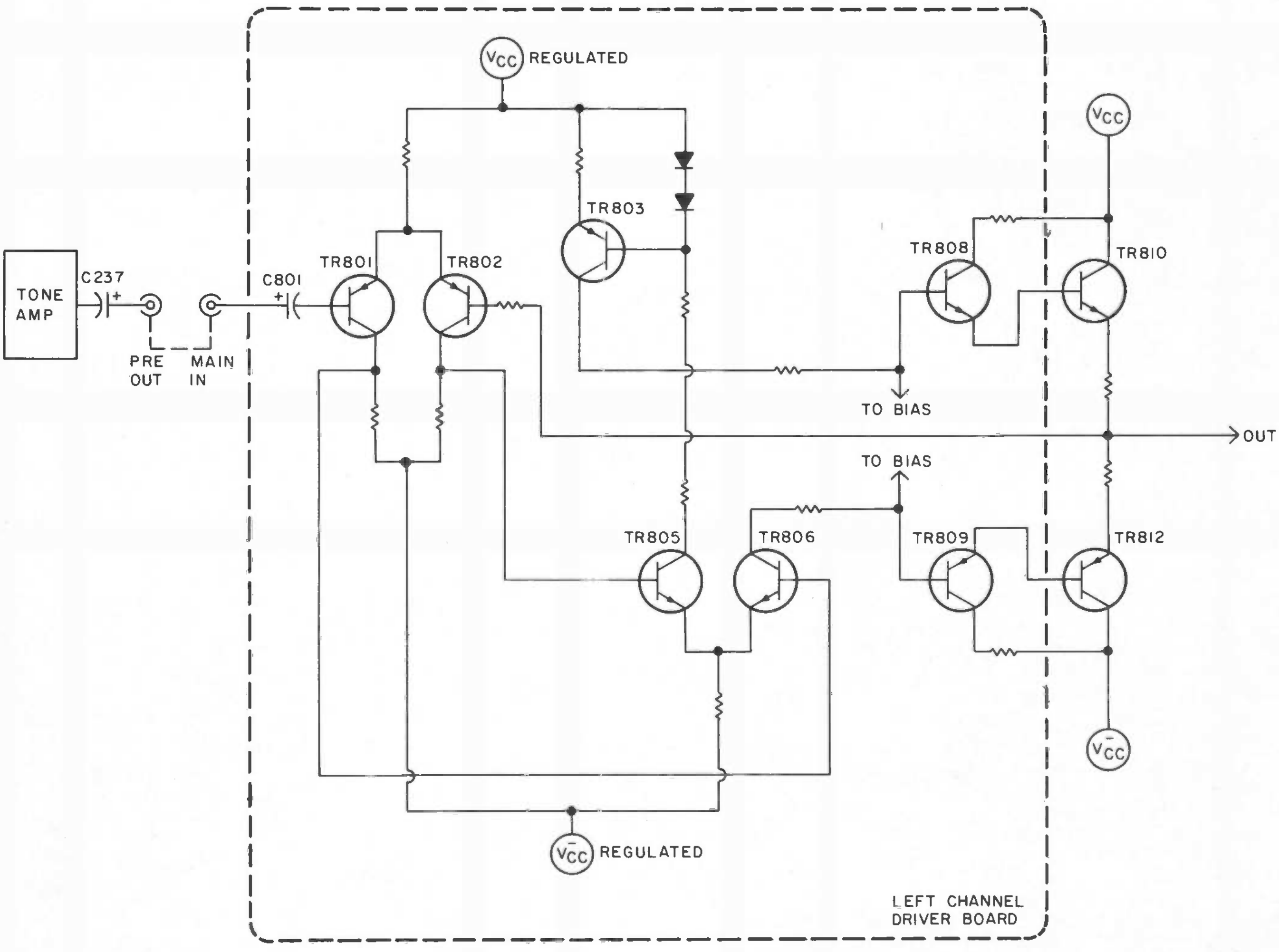


FIGURE 1: The intermittent output problem with the Sansui Six turned out to be the result of a bad capacitor in the tone amp. Shown here is the unit's simplified output subsection.

when the failure occurred, and went back up front to work on another unit. About 30 seconds later, the alarm went off. While running back to investigate, I tripped over an electrical cord and pulled the signal tracer off the bench. No time for first aid now. When I got to the bench, the unit was operating normally, so I returned to the front to clean up the mess I had made.

That Sansui ran for about 12 hours with no failure, then it quit long enough for me to put a meter on it. I was trying to discover whether the protection circuit was triggering spuriously or an amplifier defect was causing the problem. A 10V DC reading (it should have been 0V) at the emitter load tie point indicated amp failure. The offset fluctuated a bit as it slowly crept back to zero, and the relay turned on.

The handy can of freeze spray to my right made me think "thermal," so I started to cool selected transistors. A slight cooling of TR805 caused wildly fluctuating DC at the output and triggered protection. Heating the suspected transistor brought back normal operation. It acted bad, but just to be safe, I thermally cycled the same part in the good channel. No problem.

Confidently replacing the differential pair TR805 and TR806, I powered up and watched the offset go crazy again. After several minutes of testing, nearly every transistor except the outputs seemed thermally sensitive, but only in the bad channel. I did the only sane thing—shotgunned the semiconductors. Failure struck again, however, and the amp acted as flaky as ever.

I checked the offset and bias trimmers and sprayed them with contact cleaner, even though they seemed perfectly stable. After that, everything was okay. Cooking on the test set, that old Sansui happily pumped out full power for eight hours, then it quit again.

Do you still think the trouble was in the output section? Neither did I. Driver boards in this unit plug in, so checking them was a simple matter of switching left and right. The problem stayed in the same channel, a relatively sure sign that either the output transistors were bad or something ahead of the driver boards was destabilizing the power amp.

Both possibilities seemed unlikely. The TO3 cases used for the output transistors seldom become intermittent, and the tone amp fed the driver boards through two electrolytic capacitors. Having two capacitors fail at once, causing DC to appear at the differential pair of TR801 and TR802, seemed equally farfetched.

Anything is possible, though, so I switched the pre/main input cables, and the problem changed channels. The culprit was lurking in the tone amp. A leaky C237 measured a 0.3V DC at the output end. Replacement made no difference at first, but after about five minutes, the unit stabilized. Twenty hours of operation later, it was still running strong, and the owner hasn't brought it back again.

Why was the driver board in the bad channel so sensitive to thermal cycling, even though it was not defective? How come DC on C237 got past another ap-

TROUBLESHOOTING

parently good capacitor, C801, to pollute the driver board? And why did the problem take a few minutes to disappear after I replaced the leaky electrolytic? You tell me. If you have any answers, send them in, and I'll review them in a later column.

The lesson to be learned: always make several related tests before coming to any conclusions. This is especially important when you are working with intermittents. I would have saved myself an hour or so if I had just corroborated the results of the thermal-cycling test by switching the driver boards or pre/main jumpers. Sometimes a can of freeze spray and a couple of incorrect assumptions can cost you.

Sick Sony

This customer complained of poor sound when she dropped off her venerable Sony STR6045 receiver. That kind of complaint is about as useful as "It don't work," so I queried further. She simply could not articulate the symptoms, however, so the receiver went onto the bench as she watched. To me "poor sound" usually means distortion, but ten minutes of full-power operation showed no sign of it. I decided to use my ears. Lo and behold, we heard some crackling in one channel. "That's it, that's it," the owner shouted, obviously delighted that the onus of explanation was off her shoulders. I told her to come back the next day.

Figure 2 blocks out the circuit for you. During the op(eration)-check, I could kill the noise by turning down the volume control. To my simplistic way of thinking, this meant that something ahead of the control, such as the tone amp, was defective.

I sprayed the suspect transistors with

IF YOU SHOULD HAVE A TECHNICAL QUERY . . .

. . . please drop us a note explaining precisely what information you need. We will answer your question ourselves or forward your letter to someone with expertise in that area. Make sure to enclose a self-addressed, stamped envelope for our reply, and address your letter to: *Audio Amateur*, Technical Dept., PO Box 576, Peterborough, NH 03458.

Help us out by *not* calling in your question. We have neither the staff nor the time to respond to each query over the phone.

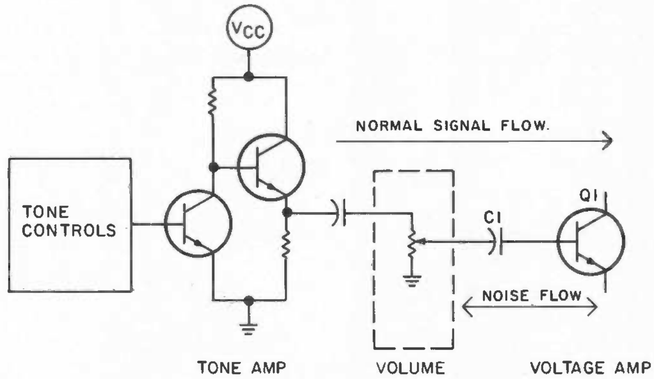


FIGURE 2: The problem with the Sony STR6045 was quite simple—a noisy transistor base. This shows the unit's simplified tone amp.

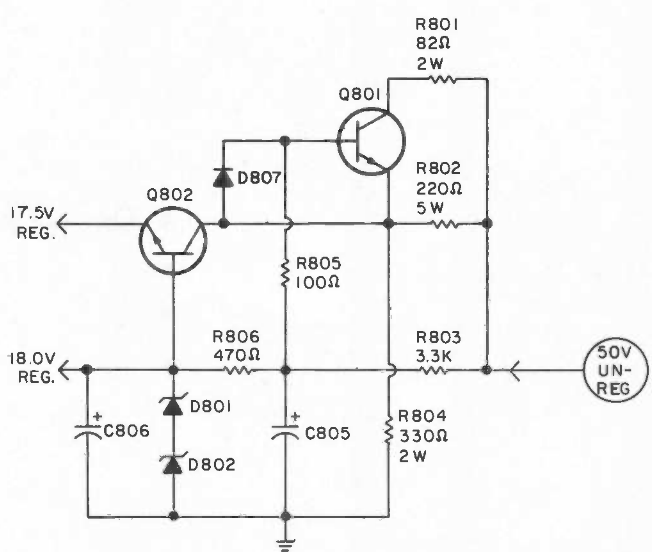


FIGURE 3: An open R803 was the perpetrator in the Sony STR7065's power supply regulator.

a can of freeze to corroborate my diagnosis. The crackling noise subsided, but did not disappear. In went two new 2SC634A devices, but the Sony still crackled.

Fortunately, the problem turned out to be quite simple. Q1, the next transistor after the volume control, had a noisy base. When the volume control was turned down all the way, it essentially shorted the crackling noise to ground through the negligible reactance of the C1 coupling capacitor.

The lesson to be learned: the supposed signal path in a circuit is the one designed by the manufacturer. When trouble occurs, unexpected alterations of this path can ensue. A designer's logic might be a repair tech's hokum.

Sicker Sony

A complaint of reduced FM sensitivity accompanied this STR7065 (*Fig. 3*). The owner told me that, among other things, the signal meter did not deflect the way it used to and the FM was weak. Bench testing resulted in a sensitivity figure of 2.5μV, which is acceptable. In the past, some of these older units with meter-adjusting trimmers had come in with similar complaints. Usually, adjustment solved the problem. Since most owners judge sensitivity by the signal strength meter, rather than background noise, I thought that was the problem here.

Several adjustments and an hour later, things were worse than ever. Sensitivity was okay, but whenever the unit received a stereo signal, the indicator light would pulse on and off, along with the MPX circuitry. Strange oscillations often signal power supply problems, so I checked that. The B+ to the FM board was 12V DC, but it should have been 17.5V DC.

As a double check, I substituted an external supply, and all worked well. Clearly, the cause of the oscillation was in the power supply. Yet all the transistors measured okay in circuit, as did all the resistors. Voltage at the cathode of D801 was 12.6V DC. I thought all the resistors were okay and the supply was not being excessively loaded, so defective zener diodes appeared to be the answer. Unfortunately, replacement helped nothing.

To shorten a sad story, an open R803 was the perpetrator. Why had it tested good in circuit? Loading effects were the cause. R803 had looked okay, and I had been fooled by all the low-value resistors into thinking that the zeners were getting plenty of current and voltage. They were not, but replacing R803 fixed it.

The lesson to be learned: ten years of experience does not the perfect thinking machine make. You cannot adequately test high-value resistors in circuit, when low-value resistors surround them.

Mailbag

Larry Sirignano has written to suggest a couple of installments on troubleshooting and adjusting tape decks. One of these days, Larry.

A defective penguin-radio prompted Ralph Petrella to write for assistance. I think this is some kind of gag, Ralph. Penguins are not exactly hi-fi. But if the bird must talk, toss out its cheap radio circuitry and insert a small speaker, which you can connect to your stereo.

Now picture this: you settle down with your favorite records for an evening's listening—some Late Romantics, perhaps. For the first five minutes, nirvana. Then you notice a slight pitch change. It must be a bad recording, since you had not noticed it before. Five minutes later, the turntable's speed is all over the place. Is it the $150 motor? Is it just a bad transistor? Maybe the belt is worn. Does it even have a belt? Next time, I will explore these possibilities and track down the real culprit. □

RECORDINGS

IN MY OPINION

Reviewed by Don Spangler

THIS IS THE SECOND and concluding batch of reviews from the summer Consumer Electronics Show in Chicago. Overall, this group of records is outstanding. Only one record I obtained at the show was not worthy of such praise. It's rewarding to know that art and science march on.

During the past few weeks, I have made a major improvement in my stereo system. I substituted a Radio Systems Research PW-200 power amplifier (*TAA* 2/83, p. 40) for my much-modified Hafler DH-200, which I used for the top end of my biamped system. I cannot believe how much more musical the PW-200 is, adding detail without excessive brilliance. It is an outstanding amplifier at any price and is the best value for the dollar I know. Unfortunately, Radio Systems has decided not to manufacture any more modules unless the demand increases.

Confessions. Steve Dobrogosz, piano; Peter Ostlund, percussion. Prophone (Proprius) PROP 9901.[2]

A recording of high merit, *Confessions* is in the quality tradition of *Jazz in a Pawnshop*, which was also recorded on the Proprius label.

Steve Dobrogosz, USA-born and now a resident of Sweden, wrote all except one of the cuts. The sensitivity of this music will wrap you in many moods—reverie, love, tension, tragedy, anguish, tenderness. The technical excellence of the album is as astounding as its passion. Piano and percussion are extremely well recorded, with close miking adding to the intimacy that the interplay of the instruments achieves. Rise time must be very fast, as the instruments on crescendos tear into you, yet much of the music is also quite delicate. Listen to the title cut, "Confessions." Have you ever heard a piano's hammer strike sound so real? This may well be the best jazz piano recording available. It is a must for any jazz collection.

In Formation. Kronos Quartet. Reference Recordings RR-9.[4]

Professor Keith Johnson has recorded the true string sound in this gem. The bite of the rosin on the strings is aggressive, the continuous tone is sonorous with no hint of harshness, and the sound stage is excellent. I cannot remember a better recording of a string quartet.

The music is quite unusual. Those who like the Fresh Aire records are likely to enjoy this recording. It is best described as contemporary chamber music. Cuts include "The Funky Chicken," "The Junk Food Blues," "Remember" and "Wind on my Back." All were written for Kronos. Using the framework of the string quartet, Kronos calls upon traditions in jazz, rock, country and folk. Although many will find the record delightful, those who prefer their string quartets a la Joseph Haydn will be aghast.

Ins and Outs. Lalo Schifrin, piano; Andy Simpkins, bass; Earl Palmer Sr., drums; Sam Most, flutes; Paulinko da Costa, percussion. Nautilus NR51 Digital.[1]

This is an excellent record from a giant in television and film music composition, Leo Schifrin. He has written music for films such as *Sting II, The Amityville Horror II, Brubaker* and *The Fox*. Some of his television successes are *Mission Impossible, Starsky and Hutch, Mannix* and *Medical Center*. In this record, Leo returned to the recording studio to play jazz himself. He also wrote about half the music on the album, which has various forms, from bebop to classical and progressive.

The piano is well recorded, but the most outstanding instrument is the bass fiddle. If your speaker system and room have any noticeable resonance, the plucked bass strings will make the resonance stand out like a sore thumb. If your bass speaker system is reasonably smooth, however, you will hear a very natural sound up and down the scale. The front-row perspective of the recording is also pleasing.

Laudate II. Uppsala (Sweden) University Chamber Choir and Drottningholms Baroque Ensemble directed by Anders Eby. Proprius PROP 7860.[2]

This is another Proprius record from the master engineer of the large church sound, Bertil Alving. I always marvel at how he achieves such space and ambience without much loss of detail and without smearing. Typically, he uses two microphones to capture the sound listeners at the live concert hear—including reflections and reverberations. This record will transform your listening room into the interior of Johannes Church in Stockholm.

The music is from the library of the University of Uppsala and is sure to delight baroque lovers. The choir, soloists and ensemble—playing original baroque instruments—perform devotional music as it was heard in the mid-1600s. They, in addition to the organ, are well separated in depth and breadth. The performance is peerless.

Romantic Music for Violin and Piano. Richard Strauss: *Sonata in E-Flat Major;* **Antonin Dvorak:** *Romantic Pieces, Op. 75.* Arnold Steinhardt, violin; Lincoln Mayorga, piano. Sheffield Lab 18 Direct Disc.[3]

Doug Sax has again engineered an outstanding record. Natural is the best way to describe the sound. The perspective is just right for the music—not too close to make it sound theatrical and not too far away to cause excessive ambience and smearing. If you closed your eyes during this record, you would swear a piano and violin were giving a concert in your listening room. It is that good.

The performers are competent. The music, while romantic and sensitive, has energy and spirit. The music might not be every person's cup of tea, but the recorded sound is worth experiencing.

Schubert: *Sonata in A Major (Posthumous).* Jerome Rose, piano. Sheffield Lab 19 Direct Disc.[3]

The Morning Glory has done it again. Sheffield Lab's direct-disk mastering of Schubert's A Major Sonata is, as always, accurate and well defined. Slight surface noise in one section (side), unexpected in a Sheffield production, detracts only slightly from the excellence of the recording.

Jerome Rose interprets the sonata beautifully, recreating the compulsion and magic with which Schubert wrote, yet disguising Schubert's struggle for correctness. Rose's fluent fingers and mastering of the pedal produce a resonance at times reminiscent of a Bosendorfer. He plays a Steinway to sparkling perfection for this recording.

Sheffield's engineering shines: the lively Scherzo and Rhondo especially are real tests of control and transient response. Doug Sax and company capture each note as though no vinyl were involved. The production is an excellent combination of art and technical mastery.

Ragtime Razzmatazz (Vol. II). Mark P.

Wetch, rag piano. Wilson Audio W-8212.[5]

This one is even better than Volume I ("In My Opinion," *TAA* 4/82, p. 51), offering the high quality that you expect from Wilson Audio. The sound stage is fantastic when your tonearm and cartridge are adjusted properly. Play "Alexander's Ragtime Band." When all is well (especially the vertical tracking angle), you can hear every hammer at the proper location as it strikes the strings, and the leading-edge attack sounds natural.

Mark Wetch certainly is at home with ragtime. The piano is a Kroeger modified with "hardened" hammers and purposely detuned, while Wetch's playing is dynamic and authentic. This is a very entertaining record.

Sources

1. Nautilus Recordings, Nautilus Plaza, Box C, San Luis Obispo, CA 93406.
2. AudioSource, 1185 Chess Drive, Foster City, CA 94404.
3. Sheffield Lab Inc., PO Box 5332, Santa Barbara, CA 93108.
4. Reference Recordings, Box 77225X, San Francisco, CA 94107.
5. Wilson Audio, 655 Louise Ave., Novato, CA 94947.

LETTERS

CORRECTION: FUJITECH PHOTO

Photo 2 *in our review of the Fujitech A-502 preamp (*TAA *4/83, p. 38) was flopped upside down in relation to the information in its caption. We apologize for any confusion or inconvenience this might have caused.—Ed.*

RAVE REVIEWS

I AM WRITING to praise you for the quality of *TAA* and to suggest an item of interest to your readers. Your magazine has increased my understanding of, and appreciation for, my audio equipment. Perhaps more importantly, it has helped me to have a better-sounding system. Specifically, the Hafler DH-200 mods have really opened my eyes to how much difference some wires and capacitors can make. I also modified my Dahlquist DQ10s by adding a ribbon tweeter and replacing the internal wiring with Monster Cable. I was surprised to find that rewiring made such a big difference.

My suggestion concerns a small company called Musical Concepts, which makes modification kits for Hafler amps and preamps. I installed the 200B mods in my Hafler DH-200 and am very pleased with the results. Basically, these mods follow those suggested in *TAA* by Walt Jung and others—better caps, new wiring, an improved feedback loop, and so on. The point is, the instructions are clear, the parts are all in one place, and John Hillig, who runs the company, is as helpful as anyone could be.

I know many readers probably have not tried to build or modify their equipment yet, but I can't think of a better way to get started. The cost is modest, anyone who built the kit in the first place can do the mods, and making your own equipment sound better is gratifying. Readers can write to Musical Concepts at 1060 Fifth Plaza, Florissant, MO 63031.

Again, thanks for doing such a wonderful job with your magazine. You folks are the best buy I get for my money.

TED KASTELIC
Washington, DC 20002

SURROUND SOUND

FIRST I'D LIKE to tell you I'm one of your *very* satisfied customers. *TAA* is the most helpful and informative magazine I read. You have managed to be on the leading edge in a technical area and still retain accuracy, which is no easy task.

Considering your quality contributors and progressive editorial policies, offering suggestions for future articles is difficult. One topic that most magazines ignore, however, is still a favorite of mine—Surround Sound. Notice that I did not say "quad," which is only one part of Surround Sound. Mainly I am referring to Ambisonics and other psycho-acoustics that enhance the listening area. I'd like to see more on this topic in future issues of *TAA*.

R. SCOTT VARNER
Roeland Park, KS 66205

An article on Ambisonics is being prepared for publication.—Ed.

EDITORIAL COMMENTS

I WOULD LIKE to comment on "A Modest Proposal: Abolish Disks," by Steve Birchall (*TAA* 2/83, p. 6). First, National Public Radio uses an *analog* satellite distribution system. It also includes a 3:1 compander (like dbx, only more), which does not always expand exactly what was compressed. The 3:1 companding gets acceptable dynamic range at acceptable costs.

The Sony PCM-1 needs a video-quality transmission or storage medium. While I do not know what WGBH used to get encoded signals from the Boston Symphony Orchestra to the studio, it probably was a video telephone line, which has response to 6MHz. (*The studio is in Symphony Hall.—Ed.*) These telephone lines are extremely expensive and are not very common. If it did not use a video telephone line, WGBH must have used a video microwave link, which is also rather expensive.

While it is technically feasible to transmit data on an FM subcarrier, this is done at relatively slow data rates. It is not possible to transmit digitally encoded stereo using the Sony PCM F-1 system on either a subcarrier or even the main FM carrier: the necessary bandwidth simply is not there. It would be possible to transmit the F-1 signal on a television carrier, but it would be very boring viewing.

I certainly agree that the capability of receiving digitally encoded music from some great data base would be fantastic, but even today's technology does not have the storage capacity to make an entire record catalog available in real time. It might come, and probably a two-way cable system (fiber optics, anyone?) would be the link between your home and the digital "record collection," but it isn't going to happen in the near future.

WILLIAM F. RUCK JR.
San Francisco, CA 94122

dbx-DIGITAL DISPUTE

I'M WRITING IN response to Steve Birchall's editorial in *TAA* 2/83 (p. 6). Contrary to what Mr. Birchall says, National Public Radio (NPR) uses an analog Single Channel Per Carrier (SCPC) distribution system on Westar IV with 3:1 companding by dbx, *not* a digital system. One advantage of SCPC over digital is that you can operate multiple linkups simultaneously without having to back-haul your feed to the common linkup for digital multiplexing. For this reason, the lower cost and good quality, Mutual also chose the SCPC system. ABC, CBS, NBC and RKO decided to go digital and are just now putting the system on-line.

PBS does offer a digital audio system—DATE (Digital Audio for Television)—as an option to its affiliates, with selected fine arts program audio being simulcast on this and the regular audio channel. Stations usually use the DATE audio for a stereo simulcast. For those NPR stations sharing facilities with a PBS affiliate, NPR did use the DATE system briefly for selected feeds before its satellite system was in place.

Concerning Mr. Birchall's suggestion of digital transmission on FM subcarriers, by the Nyquist theorem, to get even 15kHz response, you need to sample at more than 30kHz. That immediately gives you a bandwidth problem that would be hard to meet on a subcarrier, although the recent FCC change in the maximum subcarrier limit from 67kHz to 99kHz helps. Present digital subcarrier use is for data and slow-scan video. (Bandwidth is why the compact disk (CD) spins so fast, and recent home digital recorders make use of a video tape recorder with its spinning head.) I would suspect that WGBH is using a coax or radio link to get its PCM (pulse code modulation) signal back to the studios.

I agree that digital is the way to go, but Gary Hardesty makes an interesting point in his *Broadcast Engineering* article ("Digital Audio for Radio Networking," July 1983, pp. 20–28). As he says, just being digital does not necessarily mean everything is wonderful. I recently heard a CD of Miles Davis and marveled at the tape hiss from the analog master. I also heard an Eagles album and marveled at the waste of dynamic range. When good program material becomes available, however, watch out!

On a practical scale, when you consider cost, a dbx-encoded tape or disk comes awfully close to digital quality. The ultimate question is, do enough people care enough about excellent sound to pay that much extra for digital?

TOM MCGRANE
Raven Radio
Sitka, AK 99835

Mr. Birchall replies:

Thanks for your interesting letter. I am glad to know others are following the fascinating developments in digital audio broadcasting. The system I referred to is, of course, the DATE system. I have heard several broadcasts over DATE—not all of them simulcasts—but I was not aware that NPR had let it slip into disuse, which is a real shame.

As for the Boston Symphony broadcasts, you will be interested to know that Peter Swanson and his associates at WGBH have used both the Sony PCM-F1 and the dbx 700 on the microwave link from Symphony Hall, with great success. Unfortunately, this was not a permanent arrangement. Swanson is pleased with both systems, but prefers the sound of the dbx 700, which he says lacks the slight edginess of the Sony. From my own experience, I agree with that evaluation.

Last September, he used the dbx 700 via the Westar satellite linkup for a live broadcast from Munich. The occasion was a festival of electronic and computer music, including a performance of Paul Earls' opera Icarus. *An Apple computer took its place in the orchestra with the other instruments and was also used to drive the laser images, which were projected on Otto Piene's large inflatable sculptures in the air. During the festival, audio and video were transmitted in both directions, permitting some interactive performances.*

My suggestion for selling recordings through facilities such as The Source is still quite valid. Real-time transmission is not necessary if, as I suggested, you store the data for later playback. The problem is that at 300 or 1,200 baud, the on-line charges would be prohibitive, so an accommodation on rates would be necessary for this to be practical.

A digital signal could be sent through a cable system quite easily. Swanson pointed out that such a signal would be simpler than the PCM-F1 output, since it would not need all the videotape formatting signals. Many cable systems already provide a premium music service with a special decoder, so putting a digital *decoder in place would be no particular problem. The only thing standing in the way is lack of imagination in getting started.*

Is a dbx-encoded analog recording just as good? Not really—nor is Beta Hi-Fi—because they are still subject to all the cloudiness and inability to resolve fine detail that characterize even the best analog recordings. Just because the signal-to-noise figures are similar does not mean all other parameters are equal, too. We learned that lesson with frequency response long ago: one measurement alone does not guarantee high fidelity. Digital might have its problems, but they are insignificant compared to its advantages. Among those advantages are new methods of distribution that can deliver extremely high quality sound to every home inexpensively. That in itself is worth working for.

MULTIPLIER ERROR

FRANCIS DRAKE HAS written to inform me of an error in my capacitance multiplier ("Audio Aids," *TAA* 4/82, p. 40). Contrary to the information in that piece, you must run C4 in parallel with R3. I have also found one other snag. When you connect the output of two units for a positive and negative supply, some direct-coupled amplifiers tend to hang up—blowing up a speaker in the process. You must, therefore, use a speaker-saver circuit.

I deeply regret that I could have committed such an elementary error.

HO YU TOR
Kuala Lumpur 23-08
Malaysia

RE-GREENING OF THE REVOX

I ENJOYED Charles Repka's article "The Greening of the ReVox A-77" (*TAA* 4/81, p. 28). I have been itching to perform some modifications on my A-77 II, which I have biased for TDK Audua tape. My unit has Dolby B noise-reduction circuits and sel-sync incorporated. My microphones are Sony C-500s, which have an output impedance of 250Ω, so I do not have to use the mediocre mike input amp on the A-77.

A couple of things in Mr. Repka's article are not clear to me. First, on page 28 (third column, second paragraph), one sentence reads, "Then reposition tape to the 10kHz test tone and adjust the *new trimpot* until the VTVM reads the same as during the 1k portion." Is the "new trimpot" the 10k pot shown in *Figs. 2a* and *2b*? If Mr. Repka is replacing R809 with an optimum value of resistance, wouldn't it be better to use a 10k pot temporarily, then remove it, measure its resistance and substitute one or two fixed, metal film resistors having the optimum value?

Second, on page 30 (first column, second paragraph), Mr. Repka discusses replacing resistors on the VU meter board. I am not sure how he arrived at the optimum values for mike input impedance. I can see replacing R314 and R319 with something around 2kΩ, but if you use R318 and R323, this leaves an open or infinite resistance where they were. Would this situation and the 3.3k values for R317 and R322 be optimum for my mike's 250Ω impedance? I suspect that I have had a problem with too much gain in the mike input amp because on tape I usually get a ringing noise or distortion when I am recording live piano. I have not heard the noise with the selector set on input.

I would appreciate any suggestions Mr. Repka or anyone else might have.

AL HALSTEAD
Waverly, NY 14892

Mr. Repka replies:

In response to your first question, the purpose of the 10k trimpot is to allow you to adjust the playback equalization (EQ) to match tapes recorded on other tape machines that might not have had their record EQ properly adjusted to the NAB standard. Another possible use is to correct for wear in the playback head, although I must admit that one of my unmodified machines has been very stable in this respect and needed no EQ adjustments even though it is more than ten years old. If all you intend to do is play back tapes recorded on your own machine, you need not change R809 at all. Instead, adjust the record electronics (bias and EQ) for the flattest response using TDK Audua tape.

As for your second question, I arrived at the values for the resistor changes by calculation. These are the values necessary to produce a 10dB reduction in gain in the mike amp. A general rule of thumb is that the mike amp input impedance should be approximately ten times the microphone output impedance. For instance, 2.2k is just fine for a 250Ω mike such as the Sony 500. Removing R318 and R323 does make the "mike low" switch position inoperative, so you must use the "mike high" position instead. If you prefer, you can leave R318 and R323 in place and use other 2.2k resistors. This will give you two low-impedance mike inputs on the machine—one with high sensitivity and the other with 10dB lower sensitivity. An alternative solution is to use your mikes into the high-impedance input via a 1:1 transformer.

In reviewing the schematics for the article, I discovered that ReVox changed its R and C designations in its manuals. I used the R designations (e.g., R323) from a MK-II manual, and unfortunately they do not apply to a

LETTERS

TABLE 1

EQUIVALENT R DESIGNATIONS

MK-II		MK-0
R317	=	R329
R323	=	R330
R320	=	R324
R319	=	R323
R322	=	R326
R318	=	R327
R315	=	R322
R314	=	R321

MK-0 machine. See Table 1 *for a list of equivalent values. Before changing any resistors, be sure to find the equivalent resistor for your machine. I do not own all versions of the service manual and cannot say when the changes took place.*

TRANSFORMER TROUBLE

John Sloan's Showcase item on his DH-200 (*TAA* 1/83, p. 45) is an absolute marvel—congratulations. I have resorted to an outboard power supply using a Hafler universal transformer, putting approximately 115V into the 100V input taps to get regulator headroom, but this is barely enough (±72V no load). Where did Mr. Sloan get those 110V center-tapped (ct) toroidal transformers and at what cost? Is he using stock Hafler 10,000μF, 75V capacitors? I am working on a full POOGE-2, but the power supply, for lack of a transformer, has been my biggest problem.

Charles A. Calcara
Oceanside, CA 92054

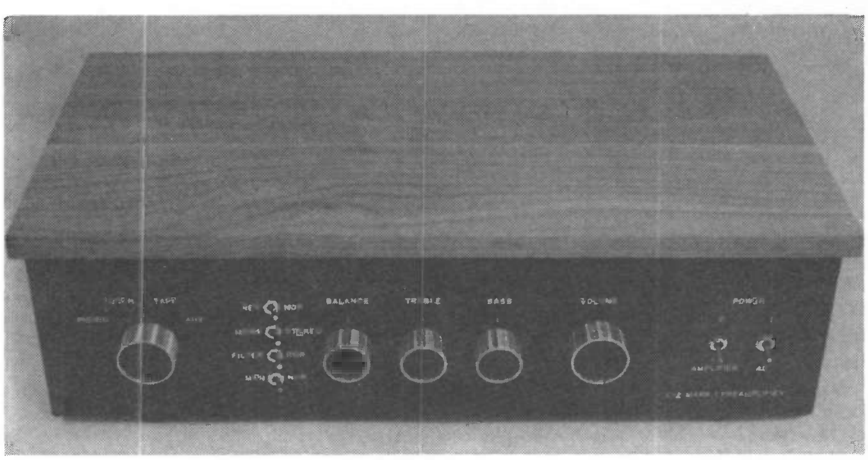
Mr. Sloan replies:

Thank you for your kind words regarding my amplifier. The transformers in the photo are manufactured by Hammond, but ILP Electronics (Graham Bell House, Roper Close, Canterbury, Kent, England CT2 7EP) produces toroidals at a better price. You would want transformer No. 80033, which, for a 110V AC input, produces 100V ct at 5A (a 500VA rating). The size is 140mm by 60mm, 8.8 pounds, with 4 percent regulation. With 117V AC in,

Are You My Maker?

Just as Dr. Seuss's baby bird searches tirelessly for its mother in the children's classic *Are You My Mother?*, this preamp is searching for its creator. Recently, we found a series of excellent photos in our "Showcase" file, but could not seem to locate the text. If you recognize this impressive piece of equipment, please drop us a line. We will return the photos to you so that you can try to re-create the text. Such a beautiful preamp shouldn't be without a home.

Let this be a reminder to all *TAA* contributors: always include your name and address on each page of your submission, including all artwork and photos. We don't want any more orphans floating around our files.



[redacted]

you can expect about ± 75V DC across your filter capacitors under moderate load. At last check, these cost 14.38 pounds or about $24 US, each.

The 75V, 10,000μF capacitors are low-ESR, Mallory computer-grade units. They are not cheap, but are worth the price. I would not, however, hesitate to use standard computer caps. I would also highly recommend the Boak regulators.

I hope I have been able to help you somewhat with your project and wish you the best of luck with it. Happy listening!

LETTER WRITERS AHOY . . .

We need your cooperation in the matter of your welcome letters to authors and other readers. Please enclose a stamped and addressed envelope if you expect a reply. If the author/reader lives outside the USA, please include two International Postage Reply coupons (available at your post office) instead of stamps on your envelope.

Please leave room in your letter for replies. Your questions should relate to the article, be framed clearly, and written legibly. Please do not ask for design advice or for equipment evaluations.

Letters to authors or other readers cannot be acknowledged, unfortunately. Any letter which does not comply with the requests above will not be answered.

COLOR ORGAN MODS

THIS LETTER IS for those of you who have one or more cheap Radio Shack-type color organs. My two biggest complaints with these devices are the following:

- Every time you adjust the volume, you have to adjust the lights as well.
- They have a limited dynamic range.

You can overcome the first problem with a cheap op amp buffer and a small audio amp. The second problem is trickier, particularly because we see color intensity linearly (approximately, anyway) and hear logarithmically.

When I saw "Paul Bunyan" in *TAA* (3/81, p. 14), I found the buffered logger I needed. I started my circuit at VRI from my tape number 2 output and cut it before R13 and D3, leaving a buffer, a logger and an amplifier. My local supply house had an op amp-based audio amplifier for about $15. I feed it directly from the output of IC2-1, which in turn drives the color organ. The whole works runs off a ±15V, 5A regulator that I built from 7815, 7915 and pass transistors. Also, if you have that starred plastic, try using clouded plexi instead.

Although I don't use the lights very often, they do work. Most important, it was rewarding to build something you can't buy.

MIKE EDWARDS
Port Coquitlam, B.C. V3C 2R2

DEFEAT DIELECTRIC ABSORPTION

I HAVE JUST finished re-reading R. N. Marsh's article "Dielectric Absorption in Capacitors" (*TAA* 4/80, p. 31) and would like to present my theory as to why dielectric absorption (DA) might have an influence on audible distortion in subjective listening tests. The answer is in popular design philosophies (op-amp related) and their related circuit topologies (a combination of split power supplies, differential inputs and push-pull outputs). The key lies in the absence of polar potential at the inputs and outputs of these designs. Of course, slight variations around 0V are due to offset currents.

Walt Jung and Dick Marsh point out that capacitor biasing can be helpful. Their example was for circuits where the crossover is close to R, but I think this application also helps remove audible DA-influenced signals. If you inject an asymmetrical "audio" signal into such an amplifier with an input capacitor connected, the signal develops a DA voltage potential across the input capacitor. Since the duration of the DA potential is approximately 10 to 20 times longer than the original input signal, it seems obvious that it could not be musically related to the original signal. The amplifier, however, responds to the DA potential by shifting its bias point around zero in proportion to the DA potential level and frequency.

I think what is happening is that, due to the ever-present DA potential, the amplifier's DC quiescent point is never stable. The subjective listening test reveals an effect called "grunge" following or enveloping the original input signal. This obscures the intended decay of the original input signal and the oncoming rise of the following signal. In my opinion, the grunge is not the capacitor itself, but the "breathing" of the various amplifier bypass and feedback bootstrap caps, along with other voltage-sensitive areas of the circuit that are never stabilized because of DA potential in the amplifier input. You can eliminate DA-induced distortions by using two capacitors, connected back-to-back and biased at the center point with a potential greater than any signal levels that may be applied.

I am not sure how to evaluate my theory scientifically, but I would appreciate feedback on this matter.

KEVIN A. BARRETT
Plainfield, NJ 07062

Editorial

Continued from page 6

interests, are much more likely to give us a representative sample of our cultural riches. By cultural riches, I do not mean strictly intellectual or "high-brow" items for an educated elite. In the past five years, public broadcasting has done a remarkable job of rebalancing its coverage of the world's cultural range. However much I might wish for an exclusive diet of classical music on my local public radio station, I think it is important that all types of music and programming be aired in the public media. The range of material now available on public radio and television justifies some sort of substantial government-sponsored support. The best source of that support is a rental fee.

Surely, a fee for commercial use of broadcast frequencies will not be popular with local radio and TV stations or with the networks. Yet if we step back and look at the US communications scene, it is disheartening to see that our system benefits those who have the *privilege* of using it far more than it does the citizens who provide that privilege free of charge. I realize that the money will come out of our pockets, as the higher ad rates will certainly be passed along in the costs of those products advertised. But current support from corporations that provide grants for public broadcasting projects also comes out of our pockets.

Perhaps we can start a crusade here. Although this is an unlikely forum for launching so large an undertaking, I would welcome your comments as individuals and would urge clubs to put the issue on their agendas for an upcoming meeting. Perhaps your local public station manager would like to receive a copy of this proposal, along with a cover letter from you asking for his or her response. In any case, my little balloon is up. Let me hear what you think.—E.T.D.

Meter For Revox A77

Continued from page 22

5msec. After lining up on steady tone at 0VU, a 100msec pulse should just reach 0VU, a 10msec pulse 2dB lower and a 5msec pulse 4dB lower. The tolerance in each case is ±0.5dB, ±0.5dB and ±0.75dB, respectively. With the removal of tone at 0VU, the needle should decay to −20dB in 2 seconds, ±0.5sec. This parameter, as I indicated earlier, is not that important. You can adjust it slightly for subjective comfort, as I have done for the ReVox movement. It might be different for others.

The movements recommended in the British Standard Specification are made by Ernest Turner in the UK. They have special black scales, with arbitrary markings of 1 to 7, and require a special logarithmic-shaped drive current. They are very expensive, and for that reason I would not recommend them. □

Activated Power Switch

Continued from page 35

Note that the input summing network (R1,R2) is mounted off-board. To limit hum induction, I mounted them directly at the input terminals, with a screened cable connection to the board. The board has enough space for a small heat-sink for the triac, should that become necessary.

After completion, you can test the AAPS without a load. Be careful, though: some parts of the board carry line voltage. Activating the MAN ON switch should illuminate D10, while activating MAN OFF should turn it off. Connecting the protect input to the $+V_c$ line should turn D10 off and D9 on. MAN OFF should reset the circuit. Next check whether the circuit reacts correctly on audio inputs of various levels and frequencies. Do not forget R1 or R2, or you might damage A1. If you have a scope, connect a small light bulb and check whether the triac conducts for the full line period. If not, you can raise the trigger current by decreasing the value of R21 to 47Ω. If it still does not work, get a real triac.

I hope you have enjoyed reading this series as much as I enjoyed writing it. Good luck with this or your next project. □

Further Reading

1. Bauer, Anton, "Control of the Operating Point of Push-Pull Class B Amplifiers by Direct Sensing of Quiescent Current," *Funkschau*, nr 12, 1978 (in German).
2. Dodson, George, "Quasi Class A/Improved Class AB Bias Loop," AES *Preprint 1683*, October/November 1980.
3. Feldman, Leonard, "Super Class A Amplifiers," *Radio Electronics*, March, May 1980.
4. Johnson, Jeffrey H., "Power Amplifiers and the Loudspeaker Load," *Audio*, August 1977.
5. Leach, W. Marshall, "Build a Double Barreled Amplifier," *Audio*, April/May 1980.
6. Martikainen, Ilpo, Ari Varla and Matti Otala, "Input Requirements of High-Quality Loudspeaker Systems," AES *Preprint 1987 (D7)*, March 1983.
7. Nakagaki, Harushige, Nabutaka Amada and Shiegeki Inouse, "A High Efficiency Audio Power Amplifier," AES *Preprint 1804*, October/November 1981.
8. Pass, Nelson, "Cascode Amplifier Design" *Audio*, March 1978.
9. Roehr, Bill, "The Autobias Amplifier," *Journal of the AES*, April 1981.
10. Tanaka, Susumi, "New Biasing Circuit for Class B Operation," *Journal of the AES*, March 1981.

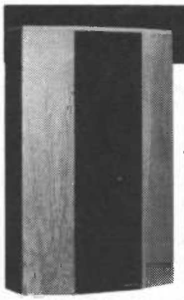
CLASSIFIED

TRADE

PRIVATE CLASSIFIED ADVERTISING SPACE *up to 50 words in length* *is open to* The Audio Amateur's *subscribers without charge for personal, non-commercial sales and for seeking information or assistance. The publishers reserve the right to omit any ad. Any words beyond 50 are* ***20 cents per word.*** *Please type or neatly print ad copy on a separate sheet or card with your full name and address.*

TRADE CLASSIFIED ADVERTISING RATES: *55 cents per word* *including name, address, and zip code—prepaid only. 10% discount for four insertions. Minimum charge $10.* The Audio Amateur *cannot accept responsibility for the claims of either the buyer or the seller.*

CLASSIFIED



The NEW Speakerlab K.

16' of exponential bass horn folded into a 4' high enclosure for awesome impact and dynamic range, high efficiency and power handling. We updated a time-honored design with a 15" woofer, 7" midrange, and horn tweeter for a digital-ready speaker for the 80's. Learn more in our FREE 32-page catalog. (Allow 4 - 6 weeks for delivery. Send $1.25 for faster, 1st. class.)

speakerlab

Dept. AA41 *735 N. Northlake Way Seattle, Washington 98103*

"IN PHASE" 24dB/octave electronic crossover minimizes irregularity in radiation pattern through crossover region. 0.0008% distortion, 5 year warranty. Single frequency (specify) $445.00. Standard version 100Hz $370.00. Power supply required: $78.00. ***DB SYSTEMS,*** Main St., Rindge Ctr., NH 03461. TTF

WE'RE BACK BETTER THAN EVER with quality electronic components at sensible prices. Stamp brings flyer. ***MIDNIGHT ENGINEERING GROUP,*** RR, Maquon, IL 61458. T1/84

NEW EXPANDED 1984 CATALOG. Audax, Becker, Dynaudio, Eclipse, Focal, JVC, Peerless, Morel, SEAS, Vifa, SIARE, more. Send 25¢ to ***MENISCUS SYSTEMS,*** 3275 Gladiola, Dept. AA, Wyoming, MI 49509. T4/84

SENSIBLE SOUND RATES MEGACABLE as least colored, most neutral, most widely compatible cables available! Our interconnects and speaker cables, designed for high-tech microwave systems, are SOTA for high resolution audio systems. POWER TO THE PEOPLE—Most comprehensive publication available on regulated power supply construction. Includes everything you should know for $16.50. 37¢ SASE brings regulator/cable information. ***MIDWEST AUDIOPHILE SUPPLY,*** Box 3, Emerson, NE 68733, (402) 695-2509. T5/84

GOLD LION, "INDIA," TELEFUNKEN tubes. Cramolin. Furman Sound. Hartley. Kimber Kable. Precision Fidelity. Sheffield. Sonex. V.P.I. Visa, MasterCard, American Express. ***VECTOR ELECTRONICS,*** 2030 NW Marshall St., # 104, Portland, OR 97209, (503) 227-5641. T5/84

CIRCUIT BOARD AS LOW as 15¢ sq. in. Free drilling. ***INTERNATIONAL ENTERPRISE,*** 6452 Hazel Circle, Simi Valley, CA 93063. T3/84

PROFESSIONAL RECORDING MIKES. Knowles BT-1759 condenser capsules, original PZM production mike, excellent for flush mount or conventional mike, $25.00 each. Custom Jensen transformers available $28.50. Miniature Ultra Flexible cable, three conductors with shield, .076 OD, $0.60/ft. Stock distributor for all Cramolin products: 2 oz. bottle - red or blue $10.50 each. 6-oz. can spray—red or blue $8.50 each. 1 oz. can red paste—plain or copper particles $5.50 each. ***JES AUDIO DESIGN,*** Box 11015, Eugene, OR 97440, (503) 687-0336. T1/84

FM TUNER FANS: Custom PLL Stereo Demodulator modification of ANY tuner. Only $44.95 complete with return shipping. Specs: THD 0.04%, separation 45dB. Free alignment for Dynaco FM-1 and FM-3 with modification. Also, specific kits for all Dynaco tuners with step-by-step instructions. ***VSM AUDIO,*** PO Box 114, Maspeth, NY 11378. T3/84

DELIVERANCE! For new systems or to upgrade present systems. Jordan 50mm modules and subsystems deliver! Send $5 for the 46-page Jordan Manual of Theory, applications and speaker plans. Write for free specifications and pricing. ***OPUS RAGER CO.,*** PO Drawer H, Foresthill, CA 95631, (916) 367-2292. T1/84

AUDIO CONCEPTS continues with the finest esoteric loudspeaker kits in the world. Dynaudio, Morel, Strathearn, WonderCap®, Peerless, Shadow. Electronic crossovers, audio grade caps, coils, cabinets, etc. Best products, service for the builder. Trade discounts available. New 1984 catalog $2.00 refundable. 1631 Caledonia St., LaCrosse, WI 54601, (608) 781-2110. T3/84

LOFTECH AUDIO TEST SET TS-1. Digital decibel/frequency meter plus audio signal generator. $253.00 shipped UPS. ***DIRECT-TO-TAPE RECORDING COMPANY,*** 14 Station Avenue, Haddon Heights, NJ 08035. T4/84

WONDERCAP®, REL-CAP & SIEMENS audio grade capacitors, OFHC wire and silver solder for the discriminating audiophile. Available from ***PRECISION AUDIO SUPPLY,*** PO Box 96, Downey, CA 90241. T5/84

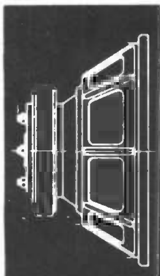
AUDIO CLUBS

Space in this section is available to audio clubs and societies everywhere free of charge to aid the work of the organization. Copy must be provided by a designated officer of the club or society who will be responsible for keeping it current. Send notices to Audio Clubs in care of the magazine.

SAINT LOUIS AUDIO SOCIETY meets monthly for discussion and equipment audition. For information sheet send a stamped, self-addressed envelope to SLAS, 7435 Cornell, Saint Louis, MO 63130.

SERIOUS AUDIOPHILES interested in a central Colorado group (Denver, Boulder, Ft. Collins, Greeley area) contact James S. Upton, 2631 17th Ave., Greeley, CO 80631.

THE BOSTON AUDIO SOCIETY INVITES YOU to join and receive the monthly B.A.S. SPEAKER with reviews, debates, scientific analyses, summaries of lectures by major engineers. The BAS was the first to publish info on TIM, effects of capacitors, tonearm damping, tuner IM distortion, Holman's and Carver's designs, etc. Sample issue $1., subscription $16/yr. P.O. Box 7, Boston, MA 02215.



Madisound Speaker Components

8982 Table Bluff Road
Box 4283
Madison, Wisconsin 53711
(608) 767-2673

Audax, Dynaudio, KEF, Philips Loudspeakers

FT. WORTH AREA AUDIO SOCIETY being formed. Would like a diversified group (women welcome), for information send a stamped, self-addressed envelope to Richard P. Machos, 6201 Onyx Drive North, Ft. Worth, TX 76118.

A CLUB FOR FM AND TV DXERS, offering antenna, equipment, and technique discussions, plus updates from FCC on new station data. Monthly publication "VHF-UHF Digest;" annual convention in August. For more info: Worldwide TV-FM DX Association, P.O. Box 97, Calumet City, IL 60409.

PACIFIC NORTHWEST AUDIO SOCIETY (PAS) consists of 50 audio enthusiasts meeting monthly, second Wednesdays, 7:30 to 9:30 pm at 4545 Island Crest Way, Mercer Island, Washington. Be our guest, write Box 435, Mercer Island, WA 98040 or call Bob McDonald, (206) 232-8130.

NEW JERSEY AREA AUDIOPHILES: A new audio club will be forming in the Colonia, New Jersey area. The emphasis will be on construction of electronics and speakers. For more information please contact Bob Young, 116 Cleveland Ave., Colonia, NJ 07067, (201) 381-6269. Staten Islanders are also welcome.

LOW-NOISE TUBES

Largest suppliers of audio output tubes. The best European and American quality. Includes KT88, KT66, KT77, 12AX7/ECC83, EL34/6CA7, 6L6GC and many others. Free price brochure.

Temtron Electronics Ltd.

15 Main St., East Rockaway, NY 11518.

Toll free: 800-645-2300 NY: 516-599-6400

CONNECTICUT AUDIO SOCIETY. Now recruiting additional members from throughout the state. We are a small but active and growing club interested in many facets of audio. Contact John J. McBride, 33 Perry Drive, New Milford, CT 06776, (203) 355-2032.

THE VANCOUVER AUDIO SOCIETY publishes a monthly newsletter with technical articles, humor, and news of interest to those who share our disease. We have 50 members and meet twice every month. Dues are $15/year which includes 12 newsletters ($15 US outside Canada). Call (604) 874-3225 or write Dave Mann, VAS, Box 4265, Vancouver, BC, Canada V6B 3Z7. We would like to be put on your mailing list.

MINNESOTA AUDIO SOCIETY. Monthly programs, newsletter, special events include tours and annual equipment sale. Write: Audio Society of Minnesota, P.O. Box 3341, Traffic Station, Minneapolis, MN 55402.

THE NORTHERN CALIFORNIA AUDIO SOCIETY invites you to join the country's most active group of audio hobbyists and professionals. Hear what the leading experts have to say, learn about the latest equipment, kits and mods, read about the results of our listening panels and more. Members receive our information-packed monthly newsletter and our quarterly journal with in-depth articles. $22 per year. Sample issue $2. Free info. N.C.A.S., P.O. Box 14156, San Francisco, CA 94114.

SAN FRANCISCO BAY AREA AUDIOPHILES, Audio Constructors society for the active, serious music lover. We are dedicated, inventive and competent. Join us in sharing energy, interest, expertise, and resources. Send self-addressed stamped envelope to S. Marovich, 300 E. O'Keefe St., Palo Alto, CA 94303 for newsletter.

THE AUDIO SOCIETY OF HONOLULU cordially invites you to attend one of our monthly meetings and meet others like yourself who are interested in the how's and why's of audio. Each meeting consists of a lively discussion topic and equipment demonstrations. For information on meeting dates and location, contact Bob Keaulani at 1902 South King St., Honolulu, HI 96826. Phone (808) 941-1060.

THE COLORADO AUDIO SOCIETY is a group of audio enthusiasts dedicated to the pursuit of music and audiophile arts in the Rocky Mountain region. We offer a comprehensive quarterly journal plus participation in meetings and lectures. Membership fee is $10 per year. For more information, send SASE to: CAS, 4506 Osceola St., Denver, CO 80212.

THE NEW YORK AUDIO SOCIETY meets monthly with prominent guest speakers, discussions and demonstrations of the latest equipment. Its $20 annual membership dues includes a subscription to S/N, the society's quarterly publication. For a free invitation to our next meeting, call (212) 544-1222, (212) 289-2788 or (201) 647-2788 or write us at PO Box 125, Whitestone, NY 11357.

NORTHWESTERN NEW JERSEY audio society wanted. Serious audiophile-music lovers contact Kevin Carter, 14 Irving Place, Summit, NJ 07901, (201) 277-3231.

WOULD LIKE TO CONTACT experienced home builders of audio equipment in the southern Ontario area. I have built Marsh preamp and head amp . . . they sound great. T. B. Palmer-Benson, R. R. 1, Ariss, Ontario, NOB 1BO, (519) 837-3964.

CENTRAL FLORIDA AUDIO SOCIETY meets monthly in Orlando. Come and meet others who share your interest in music reproduction as we audition equipment and recordings or discuss audio related topics. Contact Ron Deak, 2404 S. Conway Rd., #162, Orlando, FL 32806, (305) 894-6784.

SOUTHEASTERN MICHIGAN WOOFER AND TWEETER MARCHING SOCIETY (SMWTMS). Detroit area audio construction club. Meetings every two months featuring serious lectures, recording studio visits, design analyses, digital audio, AB listening tests, equipment clinics, annual picnic, and audio fun. Club publication, *LC, The SMWTMS Network* journals the club's activities and members' thoughts on audio. To join or subscribe call (313) 544-8453 or write SMWTMS, PO Box 1464, Berkley, MI 48072-0464.

AUDIOPHILES in the Riverside-San Bernadino areas to form an audio club. Contact Frank Manrique, 1219 Fulbright Ave., Redlands, CA 92373, (714) 793-9209.

AUDIOPHILES interested in starting Yugoslavian audio society contact JAS, Likob Matjaz, Stefanovaga, 61000 Ljubljana, Yugoslavia.

AUDIO SOCIETY WANTED. Toronto-Mississauga-Oakville-Burlington area. Serious audiophiles contact Neelam Makhija, 212 Kerr St., Suite 902, Oakville, Ontario L6K 3B1, (416) 842-2606.

ORGAN MUSIC ENTHUSIASTS: If live recordings of fine Theatre Organ Music are your thing, SFORZANDO has room for a few new members. We lend you the music on reels or cassettes. All operation is via the mail. SFORZANDO, c/o E. A. Rawlings, 5411 Bocage St., Montreal, Canada H4J 1A2.

FOR SALE

HP 333-A distortion analyzer with auto null, just calibrated, with manual. Same 334-A but no AM section, $875; Simpson 360-2 DMM with analog scale, AC/adapter leads, $375 retail, $185 boxed; Heathkit audio analyzer, I.M., power output, 4, 8, 16, 600 & high Z loads, VTVM, oscillator, more. Call or write. N. Palladino, 33 Village Road North, Brooklyn, NY 11223, (212) 996-2252.

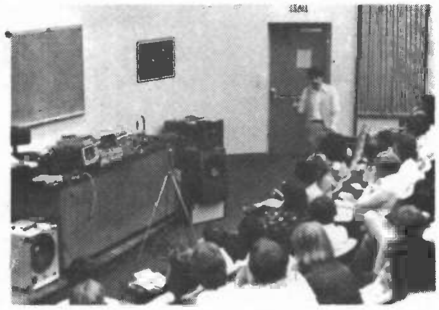
Mayware Formula IV with lightened headshell, damped arm tube, excellent cond., $70; Connoisseur BD1-K turntable in custom base, like new $45; Heathkit IO-4540 oscilloscope, DC-5MHz, triggered sweep, with cables, manuals and 10X probe, like new, $150; 1 pr. KEF B200 SP1014 mid-woofers, excellent cond., $75. Ronald A. Howanel, 518 14th St., Virginia Beach, VA 23451, (804) 491-2731.

ReVox A77, late model, low hours, 3¾-7½ ¼-track, mint, $400; SAE 2400, 280W/channel at 8Ω, clean, $500; AR amplifier, $100; Dyna SCA 35, new tubes, $80; Ortofon STM72Q MC transformer 2Ω/50kΩ, $30; Sonus Silver P cartridge, new, $50 (cost $100); Sonus Black A cartridge, new, $40 (cost $80); Dyna PAS 3/FM3/Stereo 70, mint, $225. E. Benary, (914) 679-9237.

Three Dynaco ST-70s, three PAS 3Xs, ST-120, PAT-4, SCA 80Q, FM 5, MK III. Also Dual changer, Technics tuner, Klipschorns pair, preamp deck and amp. Other items. Moving to Florida. Call (203) 848-3770. Write B. Ilson, 57 Cottonwood Lane, Uncasville, CT 06382 to make offer.

MXR 132 expander, factory sealed with warranty, $180; Dyna 70 with P.P. cap mod., mint, $125; Dyna 70, stock, $80; Heathkit 0-6 oscilloscope with manual, $60; Sony XL 33 cartridge (MC) with HA-T10 transformers, Stylast treated, $65; Heathkit W-5M amp, not working, $20; three Gold Lion KT 88 tubes, good, used, $15. Roger Artman, 14048 Idaho-Maryland Rd., Nevada City, CA 95959, (916) 272-6427.

JOIN AN AUDIO CLUB



Expand your horizons. Improve your system. Learn about the latest equipment and techniques. Share viewpoints and experiences. Don't miss out on the fun and value of belonging to an audio society.

Typical activities include:

- ***Guest Speakers.*** Here's your chance to listen to and meet "superstars" of circuit design, prominent manufacturers, acoustical consultants, and recording engineers.
- ***Tours.*** Get a behind the scenes look at the equipment and talk with the people who operate it at local TV and radio stations, universities, research labs, recording studios, and factories.
- ***Newsletters.*** These publications are often of high technical quality and are full of worthwhile information even if you don't attend many meetings. Ads and reviews help you find the right equipment, the latest records, and the dealers who carry them.
- ***Evaluation and Testing.*** Frequently clubs sponsor clinics so you can bring in your equipment for checkups on test equipment most individuals don't own.
- ***Group Buying.*** This can be an effective way to obtain obscure items from abroad, including audiophile disks.

No club in your area?

Start one—with a **free classified ad** in *Audio Amateur* or *Speaker Builder.*

For more information, see the club listings in the Classified Ads of this issue.

CLASSIFIED

Symmetric Sound Systems SSS EQ-1 equalizer kit (similar to EQ-2), $60; Audio Control 520 equalizer (with subsonic filter), excellent, $50; 10.5 inch metal tape reel, as new, $7 or trade for 7-inch; Heath IM-17 multimeter broken, meter ok, $20. Prices plus shipping. Want: basic sweep generator (trade?). A. Keller, 1455 Twin Sisters Drive, Longmont, CO 80501.

Braun TG-1000/4 studio tape deck, all mil-spec tantalum capacitors, ultra low noise, very little use, $800; Sony condenser mikes, one ECM 22P, one stereo, both for $100; Shure V-15 III with two new factory matched styli, $50; Concord 881 reel-to-reel, $100. Johan Granfeldt, 1184 14th St., Los Osos, CA 93402, (805) 528-3273.

Eico HF92A FM/AM tuner, $29; Eico HFT-90 FM tuner, manual, $26; Heathkit AA-14 stereo, 15W amplifier, home-built walnut enclosure, $43; Knight 8″ KN839 three-way speaker in 10x13x24 enclosure, $49. Plus UPS shipping costs. David DuPuy, Box 869, Lexington, VA 24450.

Jung/White PAT-5/WJ-1A with full mods, mint condition, $200; Linsley-Hood 75W/channel amp, *Hi-Fi News* design, $150. Willard Ramsay, 456 Hillside Dr., Newcastle, N.B., Canada E1V 2P1, (506) 622-3273.

A complete set of speakers, crossovers and L-pads for a pair of Klipsch-type folded horn speakers (Speakerlab). These are new and in the original boxes. W1508 15-inch woofers, HD-350 midrange drivers with exponential horns, HT 3500 tweeter with horns. All for $500. Call Joel Seidenberg, (201) 257-5189 evenings.

Sixty signal transformers, PC-24-450, 24V, 450mA, center tapped, $2 each or $100 for all. Send SASE to William Wagaman, RD 1, Box 470, Mertztown, PA 19539.

Carver C-9 Sonic Hologram Generator for superb imaging, $150 (cost $279); Heath AJ-15 FM tuner, identical to the famous AR-15 receiver that was state of the art in its day, $95 (was $200 kit). Joe Gorin, 856 Lynn Rose Ct., Santa Rosa, CA 95404, (707) 525-8335.

Sony PCM701ES digital audio processor, 14/16 bit, $950; 1954 EV Patrician, blonde with 18wk and EV Stereon, $1,000; 4 KLH-4 speakers, $50 each; two Dyna 120s, one channel out, $60 each; Super Tiger, $40 dead; Dyna PAS-2, $35; PAT-4, $50; dbx 119, $100. Marshall Buck, 3221 Provon Lane, Los Angeles, CA 90034, (213) 559-3947.

Hafler DH-101 preamp. Electrolytic capacitors bypassed by metal film, switchable RIAA (tight tolerances) or IEC equalization, $95. Headphone-speaker switchbox by Berning, $35; Magnecord 748 tube reel-to-reel, restored, electrolytics replaced by metal film caps, magnificent. Will sell for right offer. Ron Cohen, 12204 Nutmeg Lane, Reston, VA 22091, (703) 476-9521.

Dynaco Stereo 70, VG, $75; Dynaco Stereo 70, VG (no cage), $55; AR-3 original tweeters, $45 pair; JVC ribbon tweeters, $30 pair; Peerless polypropylene woofers, 12″, $70 pair; Shure V15-1VG stylus in excellent shape, $45. All plus shipping. Tom Fonte, 23940 Los Codona #16, Torrance, CA 90505, (213) 378-2341.

Hewlett Packard 241A push-button oscillator, 10Hz to 1MHz, $150; H/P 130C oscilloscope, 500kHz, 200μV, $100; General Radio 1553A vibration meter with P52 pickup, $300; Bruel & Kjaer 2203 precision sound level meter, $225; Thorens TD-124 with Ortofon RMS-212 arm and SPE cartridge, $150. Everything excellent to mint condition with manuals supplied. Call (214) 495-0039 evenings.

Two Heil AMT tweeters, $75 pair; two MXR 119 tape companders, $45 each. Reed Hurley, 1121 25th Ave. North, Texas City, TX 77590, (409) 948-8451 days 8-5.

Bruel & Kjaer 2304 graphic level recorder, 50dB pot, $350; 2605 microphone amplifier, $100. Both in fine condition with manuals. Harry Norris, RFD 3, Burt Hill Rd., Winchester, NH 03470, (603) 239-4840.

Linn Ittok LV-II tonearm, $300; Dynavector 17D cartridge, $250; cartridge is brand new, tonearm rarely used and is in absolutely new condition. Will sell LV-II and 17D together for $525. Also Advent 101 Dolby B outboard noise reduction unit, encode/decode, $75. R.E. Kalil, 2629 Arboretum Lane, Madison, WI 53713, (608) 262-4903 evenings.

WANTED

Back issues of *TAA* '70 to '78. Call (313) 934-2443 or write A. Gerkman, PO Box 28251, Detroit, MI 48228.

Schematic or service manual for Spencer-Kennedy Labs variable electronic filter Model 302; also for TEAC Model A-4010S recorder & RA-40S recording amplifier. Also need a mechanical exploded diagram for Crown 700 or 800 series tape transports. Will pay. John Stein, 4502 Hickory Lane, Mt. Airy, MD 21771, (301) 831-7781 evenings and weekends.

Fisher 125 power amps, Janzen electrostatic tweeters, Ionovac tweeters. Robert C. Bartok, 8296 Stoneham Dr., Ypsilanti, MI 48197.

MacIntosh C22, MX110 or Luxman CL 35 II or III tube preamps. James D. Jeffrey, 17 Thorncliffe Dr., Belleville, Ontario, Canada K8P 4L3, (613) 967-1944.

Will pay for schematic or photofact for Pedersen W-30 tube amp. Call Dave, (415) 752-6420 or (415) 387-6706.

Cartridge slide-in mount for PE 3012 turntable/arm. Call Sherm collect, (801) 363-1049 evenings MST.

ABC's of Vacuum Tubes by Donald A. Smith, published by Sams, *Vacuum Tube Amplifiers* by Valley and Wallman, *Electronic Organs*, a Sams book. Rick Bergman, 2108 Stuart #3, Berkeley, CA 94705, (415) 841-2564.

Any information/experience with the Contrabombarde conical slot loaded horn subwoofer, originated by Hegeman, now produced by Shahinian Appreciated. A rough sketch of the design and driver used would suffice. Peter Bandurian, 6495 Kalua Rd., #103, Boulder, CO 80301, (303) 530-3051.

Schematic for Pioneer SF850 electronic crossover. Roger Artman, Box 185, Cotati, CA 94928.

Multiplex adapter for my HH Scott, 330-B, AM/FM tuner. I am interested in collecting old hi-fi tube equipment if price is right. Allan Hibsch, 4 LaFolet Ct., Oraville, CA 95965, (916) 589-0138.

Info and/or issues of *Listener's Review Finder, Hi-Fi and Video Dealer News* (British), *Stereonotes* (Canadian), *Leisure Time Electronics, Critical Record Review, Engineering Research, Records & Reviews,* and *B-C Reel News #64*. G. Mileon, 14 Border St., Lynn, MA 01905.

Marantz 7 preamp suitable for Pooge 1 modification. Brian Krown, 2420 N. Creasy Lane, Lafayette, TN 47905.

AD INDEX