Better receiver selectivity, more transmitter output, and Magnum Six RF Speech Processor installation.

Improved Performance from the Drake R-4B and T-4XB

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The Drake R-4/T-4 line of equipment has proved to have a long, reliable life, delivering excellent performance even under adverse conditions. As with all amateur equipment, however, there are some performance areas which can benefit from change. The purpose of this article, therefore, is to describe certain changes in the R-4B receiver and T-4XB transmitter which significantly improve the operating capabilities of the rig.

Improving the R-4B Skirt Selectivity

An excellent modification appeared in January 1972 *QST* which consists of replacing the original 4-pole crystal lattice filter (5645 kHz) in the first i.f., with two 8-pole filters identical to those used in the T-4XB transmitter. A modification kit comprising the two filters (u.s.b. and l.s.b.) and matching transformers can be obtained from Drake at reasonable price.

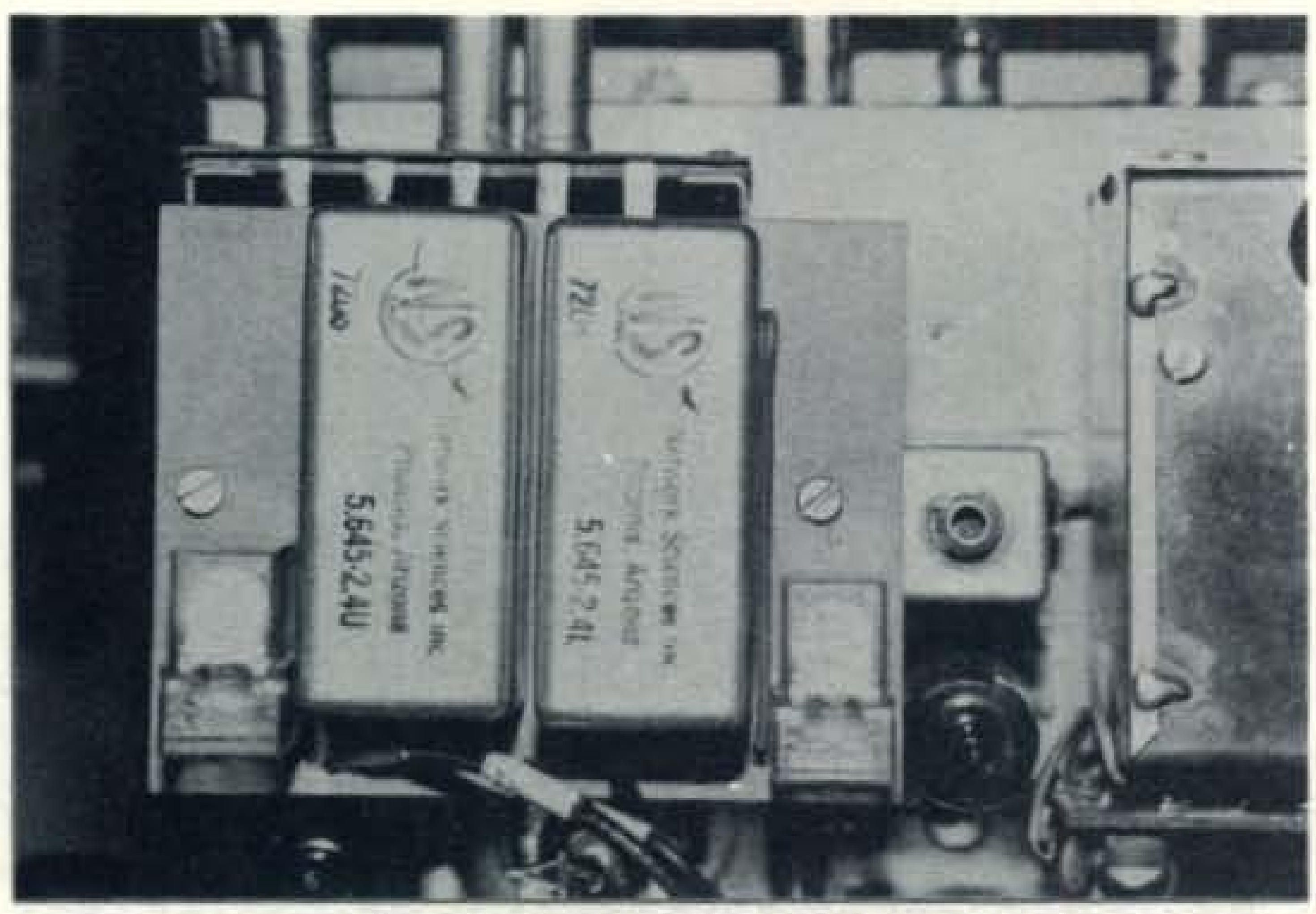
The mechanical layout described in the *QST* article, however, is very unattractive (small outboard box containing the two filters). Instead of switching the filters with a manually operated switch, one can use two low-capacitance relays, and mount the relays and the filters on a small P.C.-board inside the receiver. The author mounted the printed circuit in the left rear corner above the crystal bank (see photo). The original r.f. gain potentiometer was replaced by a pot with a push-pull switch. With this switch one can now select u.s.b. or l.s.b. Filament voltage (12 v. a.c.) can be rectified to provide the necessary d.c. voltage for relay switching. Figure 1 shows the schematic of the set-up.

The results are very impressive, and skirt selectivity identical to that in the Drake R-4C is obtained. Using the original bandpass-tuning in the second i.f. (50 kHz), one now has an i.f. system that has continuously variable bandwidth! Indeed, the two filters superimpose, and as the 50 kHz one can be shifted in frequency, the resulting "window" can be varied in width.

Increasing the T-4XB Output

Some Class B grounded grid triode linears need just a bit more drive than is originally available from the T-4XB. With the 6JB6-A's, the d.c. output varies between 100 and 140 watts on c.w. key-down (about the same PEP value on s.s.b.), depending on a.c. line voltage and tube age.

Using 6JF6-s (identical pin connections, and identical size—at least from the RCA brand) the output can be increased by more than 50%! (typically 220 watts PEP output on 20 m. s.s.b.). The Drake AC-4 power supply can easily handle the extra d.c. input as it has been designed to work



Two additional receiver i.f. filters and their associated switching relays are mounted on a piece of PC board which is then located above the crystal bank

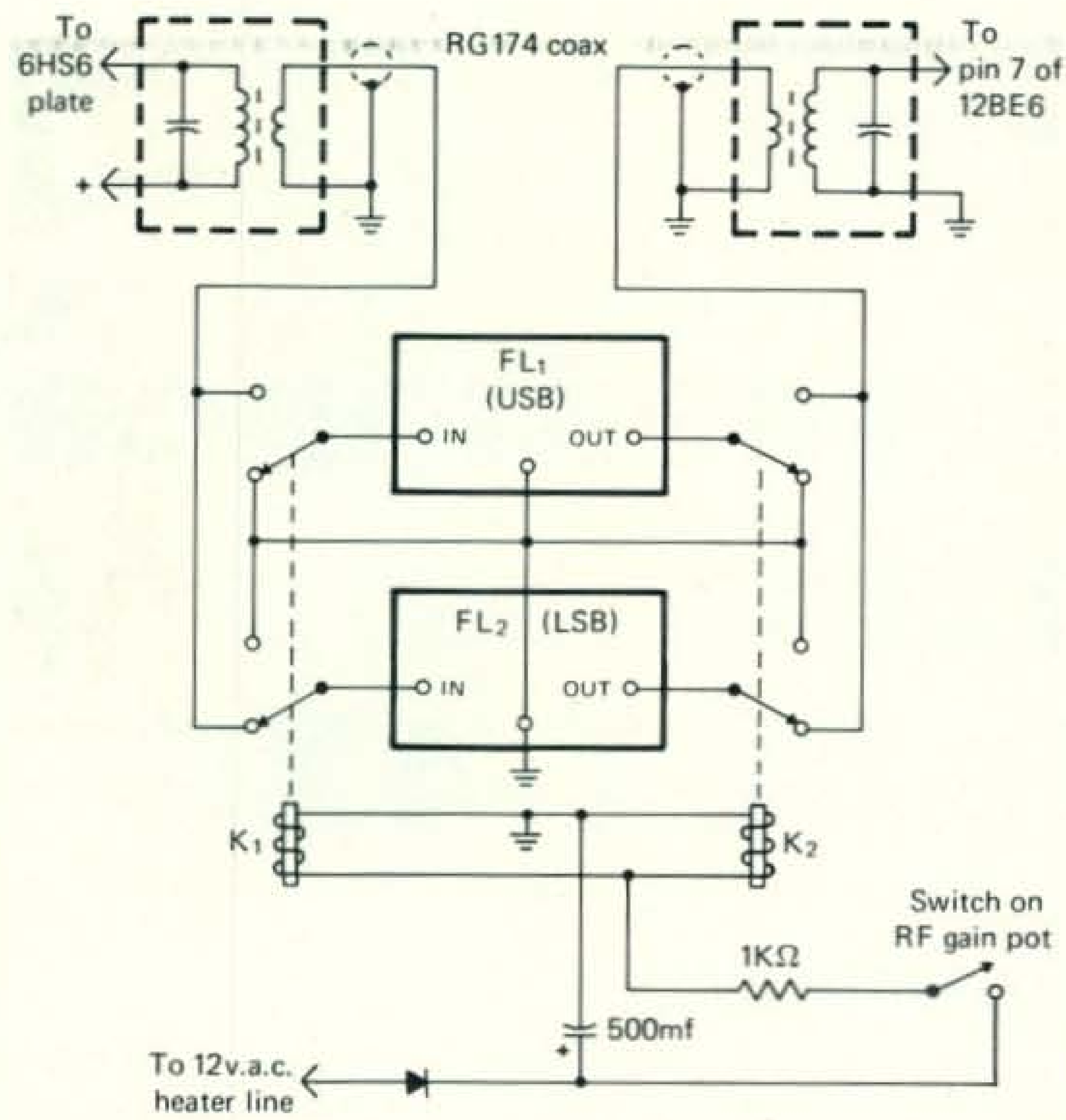


Fig. 1—Installation of two 8-pole crystal lattice filters in the Drake R-4B to improve skirt selectivity. The use of two small low-capacitance relays for filter switching enables the use of a push-pull switch on the r.f. gain control to select sidebands.

with the TR-4 as well (which uses three 6JB6's).

The author has bought 10 RCA 6JF6's and matched them up in the T-4XB. It is essential to use well-matched tubes. Just don't try it with any two tubes; it will be a catastrophic!

Matching the tubes can be done as follows:

1. Insert two 6JF6's in their sockets.
2. Adjust the bias control on the AC-4 for about 60 ma idling current.
3. Measure the voltage across R_{32} (or R_{33})—two 15 ohm resistors—in one of the cathode leads. This voltage is proportional to the tube's idling current. Note this voltage for this particular tube.
4. Switch off the T-4XB, discharge the h.v. and plug in another 6JF6.

An exciter grid current meter sits atop the Magnum Six RF Speech Processor. The muffin-type cooling fan can be seen on the T-4XB.

5. Repeat steps 3 and 4 and do so for all tubes.
6. Using the list of recorded voltages, match the tubes. A pair of matched tubes should have idling currents within 5 to 10% of each other.

Don't be surprised to find a deviation of 30 ma or even more. In my batch the idling current varied from 10 to 28 ma for one given bias value!

No changes in supply voltages have to be made to use the 6JF6's. After inserting a pair of matched tubes, the grid input circuits have to be retuned as outlined in the T-4XB manual.

The increased anode capacitance (9 pf instead of 6 pf) makes slight adjustment of the Pi-tank circuit necessary only on 10 meters. This involves reducing the 10 meter coil inductance to a value where the tank circuit can be resonated on the top end of 10 meters. To do this, locate the self-supporting 10 meter coil in the PA-compartment. Using two sets of pliers, stretch the coil slightly to reduce the inductance, until the tank circuit can be resonated. Finally the PA has to be re-neutralized. This can be done as outlined in the T-4XB manual, but a better method is as follows:

1. Connect a 50 ohm dummy load to the rig.
2. Disconnect screen and plate voltage to the 6JF6's by unsoldering two wires at the RFC's near the tube sockets.
3. Connect an r.f. probe and v.t.v.m. across the 50 ohm dummy load.
4. Switch on the rig and tune the transmitter on 10 meters. Adjust the preselector and PA tank circuit for maximum output as indicated on the v.t.v.m.
5. Now adjust the neutralizing capacitor for minimum reading (should be zero).

This completes accurate neutralizing of the rig. Reconnect screen and plate voltage. Now adjust the bias potentiometer on the AC-4 for 70 ma idling current.

It is obvious that the increased output coincides with greater heat development in the PA compartment. It therefore is essential to provide forced air cooling around the tubes to ensure longer tube life and to keep the cabinet cool altogether. The author solved this problem as follows:

1. Remove the PA shield compartment and close all sides and the top (excepted in the immediate vicinity and above the tubes) with cardboard (stick it with glue to the inside of the compartment).
2. Reinstall the screened compartment.
3. Stick self-adhesive foam tape to the top of the PA compartment so that when the cabinet is installed on the T-4XB, the foam-tape touches the inside top (this makes an air-tight joint between the PA compartment and the cover).
4. Get a 4" muffin-fan and place it on top of the T-4XB cover, so that it exhausts the air from the PA compartment. The fan can be ran at reduced

speed (use an appropriate capacitor, resistor or autotransformer) to minimize noise and still get sufficient cooling. The author's T-4XB feels cold, even after a 48 hour contest!

Although the author has not tried any other substitute tubes, it seems that 6KM6's would make a good substitute for the 6JB6A's too. Has anyone tried those?

One more word about the AC-4 power supply. If you feel it's getting too hot, remove the shielding plates, and remove it from your loudspeaker case. That should cool it down sufficiently.

Using the Magnum Six with the Drake T-4XB

The Magnum Six r.f. speech processor makes a tremendous mate for the T-4XB, when properly used and adjusted. The Magnum manual, however, does not, in the author's opinion, indicate clearly enough which points should be watched in order to get optimum results.

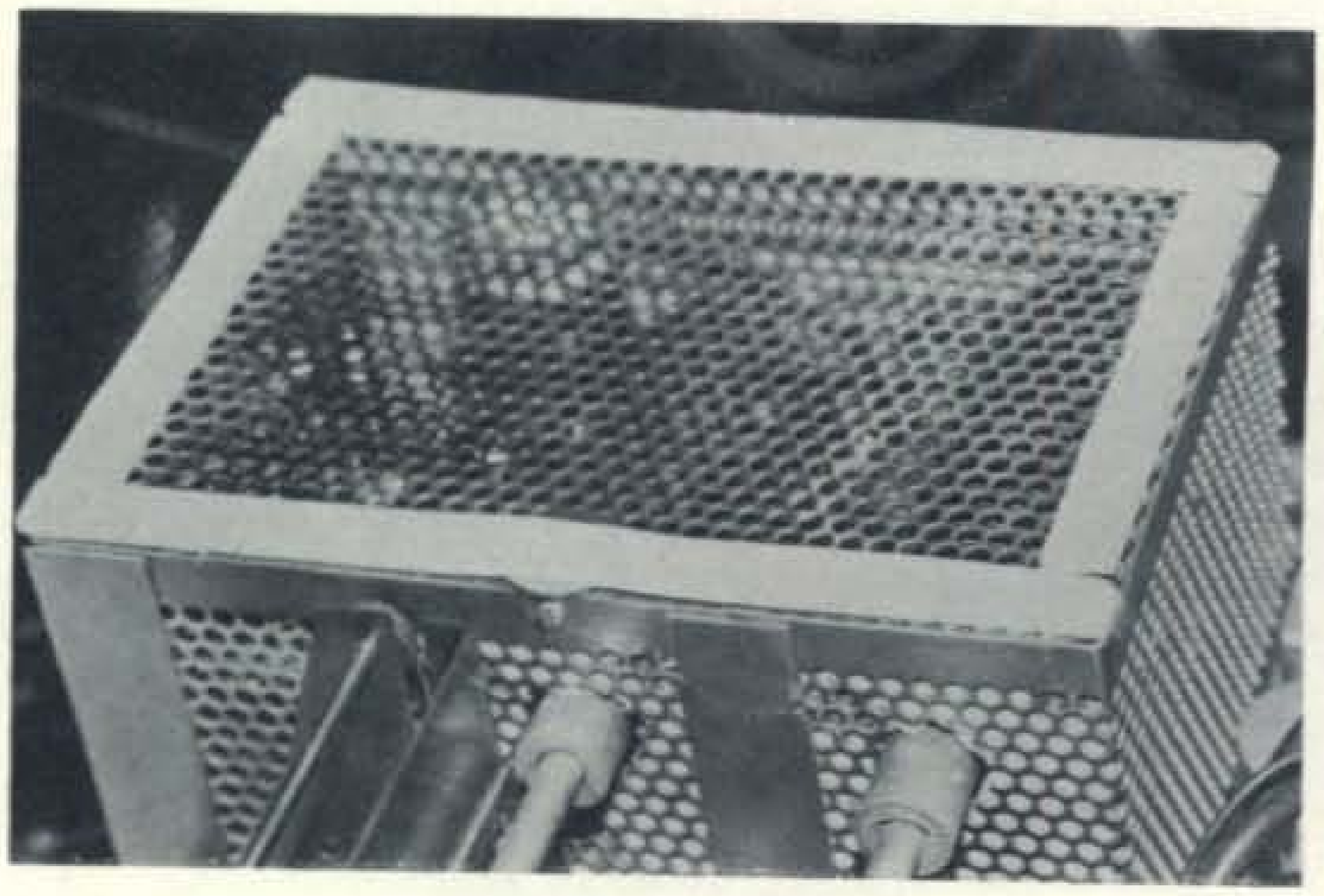
The processor is inserted between V_2 (12BA6—i.f. amplifier) and V_3 (6AU6—mixer). The original Drake a.l.c.-circuit generates a.l.c. voltage as soon as grid current starts to flow in the final tubes. The main disadvantage of such a system is that the evil has already occured before the a.l.c. can start working. That's why excessive audio gain, resulting in excessive a.l.c. action generates a lot of splatter.

Increasing the average power of the T-4XB by merely advancing the audio gain potentiometer is always done at the sacrifice of quality! Proper use of an r.f. speech processor (r.f. limiter) eliminates these problems and gives much higher average power.

The most valid reason for using a r.f. speech limiter in order to obtain increased average power is the fact that the increase can be realised with almost no sacrifice of quality. For this it is essential to keep the output level from the Magnum Six down enough as not to overdrive the final tubes. The slightest grid current results in flat topping and heavy splatter, and reduction in r.f. input to the Magnum Six, thus reducing the amount of clipping, and not reducing the drive to the final (action of the original a.l.c.-circuit).

How can we keep the output level from the Magnum Six down to the proper level? The ideal way is to use a monitor scope. The output level from the processor should be advanced to the point where flat topping just starts showing. Then back off just a bit. This point coincides with just a trace of grid current in the final tubes (on peaks).

This means that an equally effective way of adjusting the processor output level is to watch the grid current in the T-4XB. Unfortunately there is no grid current meter in the transmitter. An outboard grid current indicator can, however, easily be installed and necessitates *no* changes in the T-4XB. Figure 2 shows the schematic.



To improve PA compartment cooling, the PA shield enclosure is sealed with cardboard cemented to the inside surfaces. Self-adhesive foam tape around the outside top edge of compartment lid provides an air seal to the T-4XB cabinet.

How does it work? The original a.l.c. circuit, built around V_{1B} (a.l.c. amplifier) is a high impedance circuit (1 megohm load resistor in V_{1B} anode). If one loads the anode with a 47K resistor (plus 100 microamp meter) two things happen: 1. The meter starts flickering when grid current occurs. 2. Due to the heavy loading of the 1 megohm anode circuit, the a.l.c. circuit becomes virtually inoperative, which is to our benefit (the a.l.c. circuit had to be eliminated as it regulated V_2 which comes before the processor).

The author has found that the output level of the Magnum may be adjusted to the point where about 10 microamps flow on peaks in the indicator circuit. More current coincides with flat topping on the scope.

One phone plug, a few feet of shielded cable, a 47K resistor and a 100 microamp meter will do just as fine for adjusting the Magnum Six as will the expensive monitor scope!

Adjustment of the Microphone Gain Potentiometer

How far should the audio gain potentiometer be opened? To determine this, several situations have to be examined:

1. *Signal-to-Noise Ratio.* When there is a lot of background noise in the shack (noisy blowers, etc.) the amount of clipping in any case should be

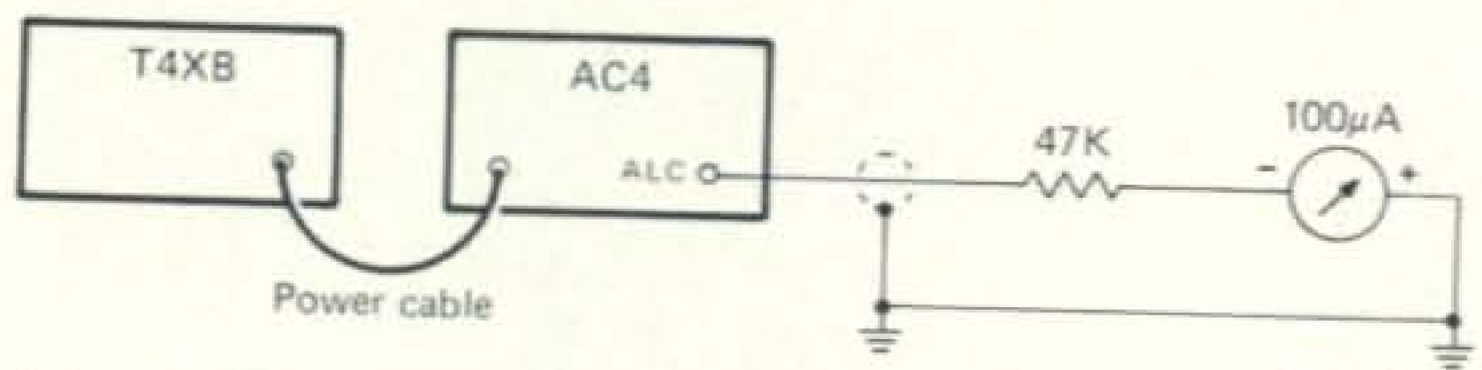
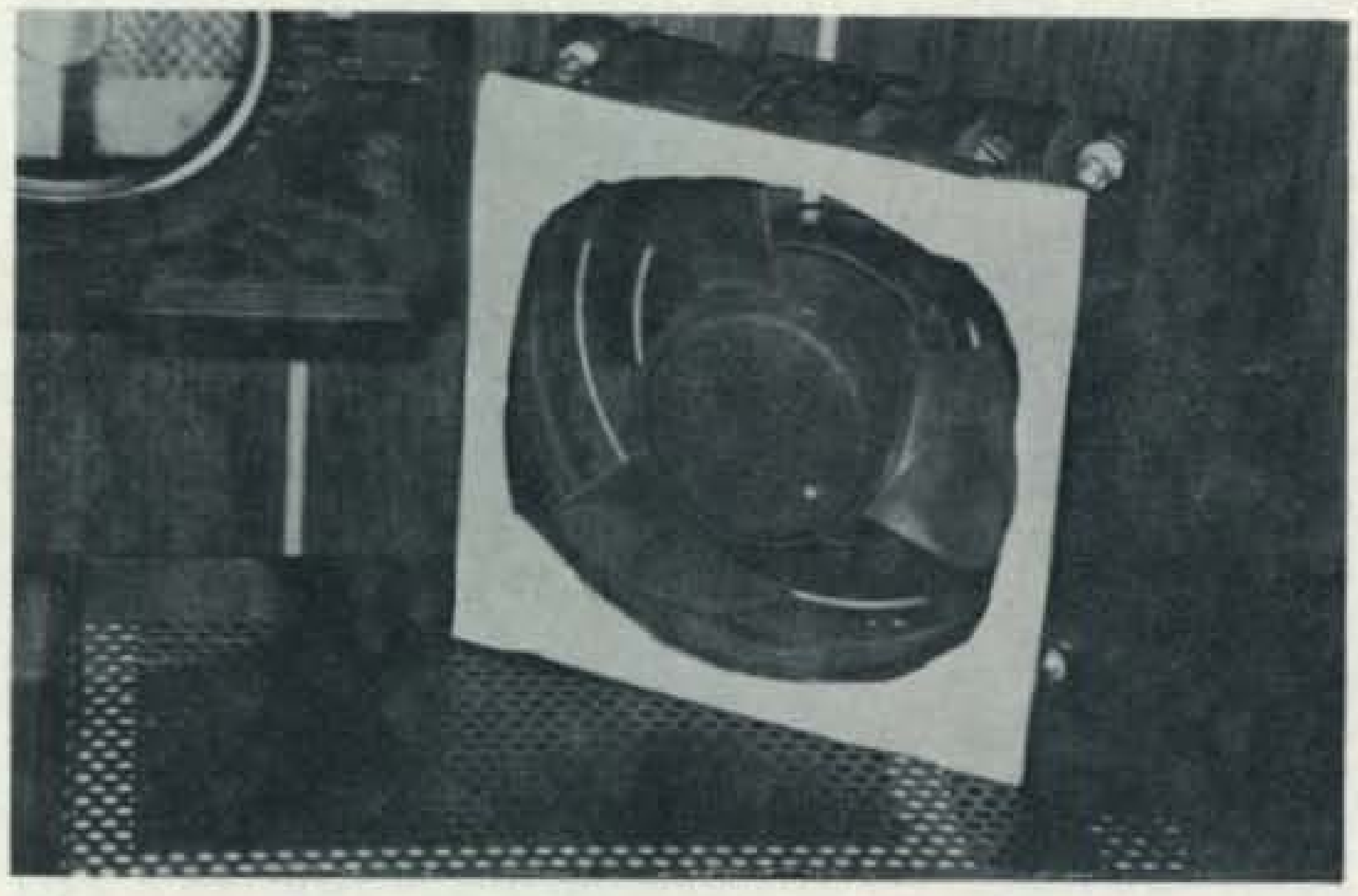


Fig. 2—The addition of an external 100 microamp meter and a 47K resistor enables monitoring the T-4XB PA grid current through the a.l.c. jack on the AC-4 power supply. About 10 microamps on the meter is a safe value; more than this generally indicates flattopping.



Self-adhesive foam applied to the rim of the muffin-type fan provides air seal.

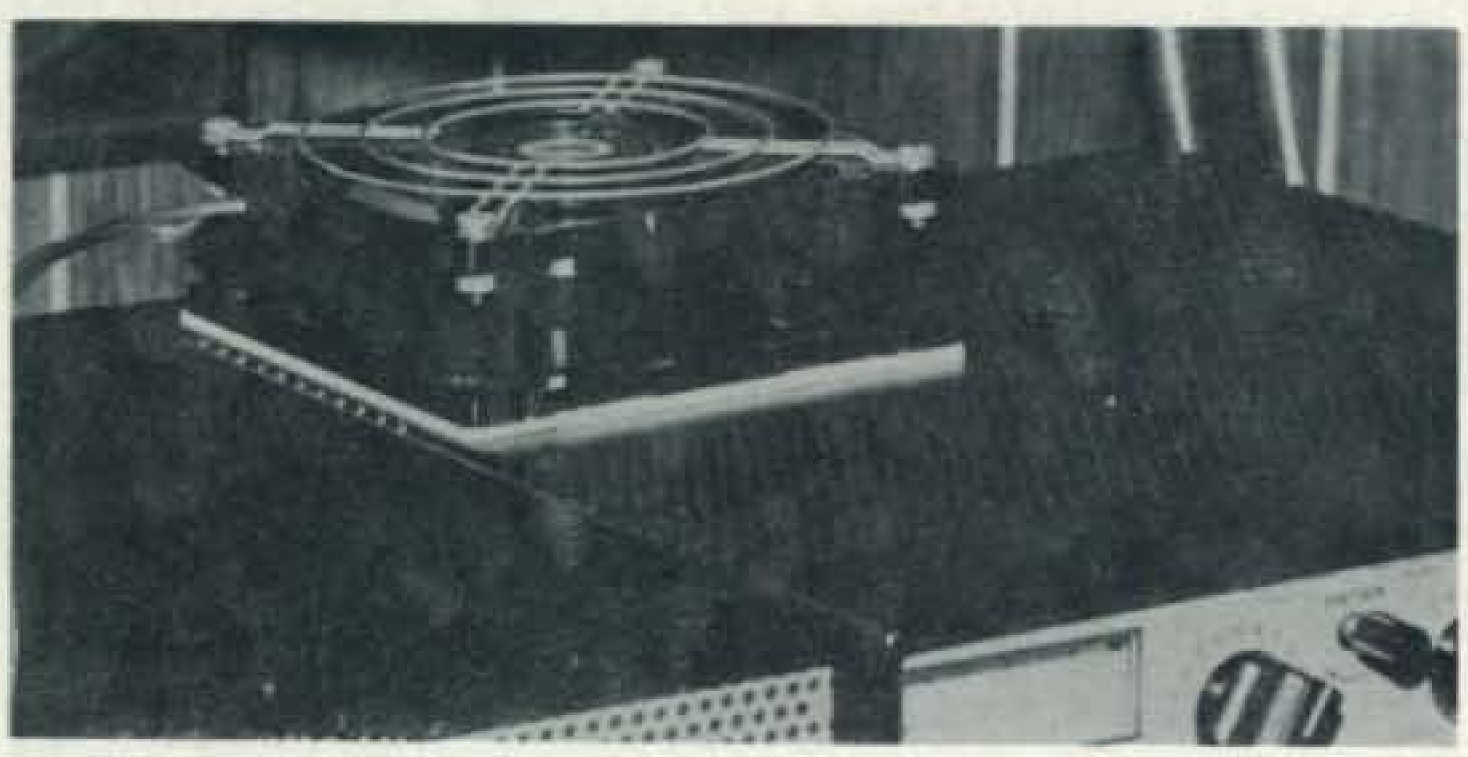
limited to the point where at least 25 db of signal-to-background-noise ratio is obtained.

How can this point be determined? If your station runs 1400 watts output on a single tone whistle, the unmodulated output (noise from blowers, etc.) should be no more than about 4 watts p.e.p. or about 2 watts indicated on your output meter.

$$\text{Max. allowable noise power} = \frac{1400}{\text{antilog}\,\frac{25}{10}} = 4.4 \text{ watts}$$

This means that in no case should the mic gain pot on the T-4XB be advanced any further than to the point where the noise indicates about 2 watts on your output meter. Otherwise, the back-ground-noise will become really objectionable. In order to keep the background noise down, a good cardioid type microphone may help. Always speak very closely to the microphone when using speech processing!

2. *Minimum Microphone Gain Level.* For a given microphone there will be a setting of the T-4XB mic gain potentiometer where clipping ceases. We determine this point by:
   a. Using the monitor scope: Set the mic level at 12 o'clock. Adjust the Magnum output level for maximum amplitude on the scope (watch out for flat topping!). Now reduce the mic gain until the peak amplitude starts falling off. That's the point where clipping ceases. This point does not change with bands. It may change with different microphones and voices, however.
   b. Using the grid current indicator: Set the mic level at 12 o'clock. Adjust the Magnum output level until the 100 microamp meter kicks up to about 10 microamps on peaks. Now reduce the mic gain until the meter shows no current. That is the point you're looking for.
3. *Optimum Microphone Gain Adjustment.* It is a waste of energy to run 20 db of r.f. clipping at all times. But how to get the feeling of how much clipping one is running? Here's a trick. 0 db is when the grid current indicator stops moving on peaks.



Fan exhausts hot air from T-4XB PA compartment.

Set the microphone gain for 0 db clipping and watch the output on the wattmeter (Drake W-4 or similar). It may peak up to 400-500 watts on peaks (for 2 kw p.e.p. input).

Now advance the mic gain slowly. The indicated output will increase slowly until a point where further increase of the mic gain will show only a marginal increase of output. The reading for a long "aaa . . ." will now be about 1200 to 1400 watts on your wattmeter. That is definitely the maximum setting you should ever use with this particular microphone. Check if for this setting the background noise is at least 25 db down from your peak output. This maximum setting (estimated at approx 20 db clipping) should only be used when fighting a pile-up or in really marginal conditions. For normal QSO's with normal signal strengths a gain setting half-way between the 0 db clipping and the maximum clipping (20 db) level is ideal.

Final Comments

A properly adjusted Magnum Six definitely gives you 4 to 6 db average power gain over a system with no limiting or compressing. One frequently hears amateurs on the bands comparing r.f.-limiting with a.l.c.-type compressing. Here, of course, the difference is much less, typically 2 db, and that's barely noticable on the S-meter, especially when signals are strong!

So why do we want to spend the money for r.f. limiting with the Magnum Six? Here's why:

1. The properly adjusted Magnum Six will give you the 4-6 db of average power gain *without broadening* the signal, because there is no grid current in the T-4XB PA at any time!
2. Because of the presence of a second 8 pole crystal filter in the i.f. strip of the transmitter, the shape factor of the system will be improved, and the signal will actually become narrower than with the T-4XB by itself!

Local on-the-air tests have revealed a substantial decrease in signal bandwidth when using the magnum at 15-20 db clipping (no grid current!) as compared to the original T-4XB configuration with a normal amount of a.l.c. compression. ■