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Tricking-Out the FT-901/902

—some competition mods from the Fox-Tango racing team

In the almost ten years that Milt Lowens has served as editor of the *Fox-Tango Club Newsletter*—at the beginning of which time he founded the International Fox-Tango Club for Yaesu equipment owners—literally thousands of suggestions for improving Yaesu rigs have crossed his desk. Among the best in terms of simplicity and effectiveness was one first written in abbreviated form by Harold Johnson for the November, 1980, issue of the *Newsletter.*

The first part of the following article is that 1980 piece essentially as written, but with some italicized parenthetic comments by Milton Lowens. The second part (written by Milt) gives generously illustrated instructions which should enable even a comparative neophyte to do the job. No irreversible changes are involved, no drilling or panel changes are needed, and no wiring changes are required except on one, easily unplugged, circuit board. Considering the reported effects of this modification and his own experience with it in his FT-901D, it is no wonder Milt rates it as a "winner"!

Part I: Significantly Improving the FT-901/902 Receiver

In a continuing search for a replacement for my 20-year-old KWM-2 receiver, I have either purchased or borrowed almost every "new" radio that has come down the pike. It is a sad commentary on the state of the art that, despite fringe bells, whistles, and cosmetic changes, nothing I can find on the market has measured up to the 25-year-old design, at least in the receiver department. In the final analysis, I have been forced to the conclusion that, because of deficiencies in various parameters, the present solid-state radios cannot copy signals that are still solid on the KWM-2.

Of several makes and models owned and evaluated, the Yaesu FT-901DM [*and now the 902 with all the WARC bands and other improvements, including an excellent new true-reading digital display*] came closest to measuring up to the very stringent standards I had set. Besides, its bells and whistles included the 160-meter band, all of ten meters, FM, AM, and FSK operating modes in addition to the standard SSB and CW, memories galore, RIT tuning for RX, TX, or both, built in ac and dc supplies, true rf speech processing, an automatic Curtis keyer, true variable passband and rejection notch tuning, and a very fine audio peak filter (to mention a few!).

After the first blush of ownership pride, however, one major problem with this competition grade radio (as Yaesu calls it) was a total lack of ability to compete in the receiving department. In the presence of strong signals outside the receiver passband, readability of weak signals was degraded by reciprocal mixing and agc pumping. The radio actually was in my operating position three times and each time was replaced with "old grandad." The last time, I fully intended to get rid of it as another lost cause when I decided to try to cure the shortcomings since the fringe benefits were so great. Measurements taken on the radio prior to attempting surgery revealed an ultimate rejection of only 55 dB, and I began to realize that there was a task of some magnitude ahead if I were to effect a "cure."

It was assumed initially that there must be some leakage around the existing selectivity circuits in the radio, and the search for the path was on. Since the crystal filter was diode-switched, there was the possibility of inadequate bypassing and feed-around

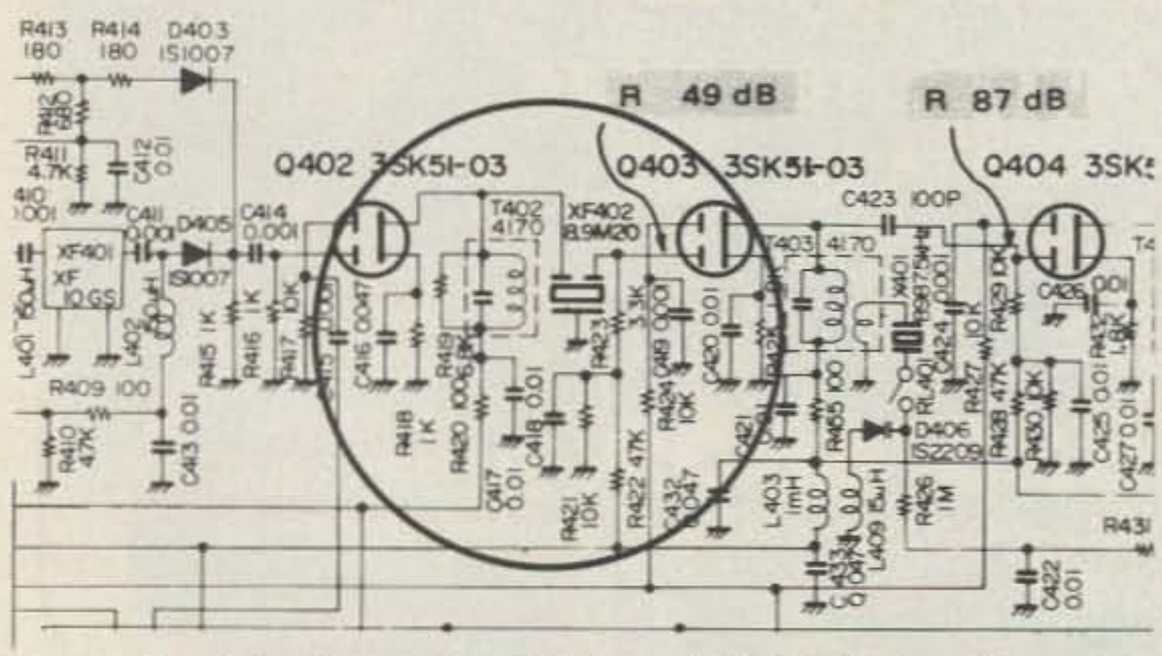

Fig. 1. Partial schematic of i-f board PB-1704 showing original connections of XF402 and related components.

occurring via the dc control lines. Twenty dollars worth of glass 0.1-μF caps at strategic spots on the filter board later, showed a total improvement of 0.

Reading of similar problems plaguing the TS-820 where the problem was in the noise-blanker circuitry, C225 on the noise-blanker board of the 901 was removed. This certainly opened the noise-blanker path but improved the ultimate rejection by not quite 1 dB. Hardly a dramatic improvement! Then noting that the i-f was passed around the filter in the FM mode, here was another possibility; diode D310 on the filter board was removed. Alas, life was not to be so easy. This simple cure netted only another 1.5 dB of improvement. Obviously, the engineers at Yaesu had cleaned up these paths right well! After all this I could see only two other possibilities: I figured I might as well tackle the cheapest one first.

That was the chance of cross-coupling in the common cabling under the pluggable board sockets. The filter board was pulled; the jumpers bypassing the optional (but not installed) CW filter were removed [*thus opening the i-f chain*]. Upon re-installation of the filter board, no difference could be determined between power on and power off in the CW mode. The radio was dead with 100,000 microvolts at the input. That experiment satisfied me that the ultimate rejection was really a function of the factory-installed filter; it just flattened out for me at −55 dB. Unfortunately, there are still lots of countries on the air that I need that are represented by signals lots weaker than 55 dB down from some of the W2s heard at the QTH.

A custom filter of at least 12 poles that would mechanically fit the filter board was a bit rich for my blood (about half the price of the radio), so an equivalent of the existing filter was ordered from the Fox-Tango Corporation for something less than $60.00. Although there was some delay at the time, this excellent filter is now available from stock. (See Parts List.) The filter was installed with diode switching at the input to the balanced modulator—after the i-f gain, as suggested by Sabin and Hayward. Skirt selectivity improvement was noticed, but since the agc amplifier is fed from a point ahead of the second filter, agc pumping from strong adjacent signals was still present and tended to mask or distort weak signal reception.

So I tried another approach (no one can accuse me of not being persistent, hi!). To obtain the bandpass-tuning feature, Yaesu up-down converts the 9-MHz i-f to 10.8 MHz with filtering at each frequency to permit a variable-width window of common passbands. This feature, first advanced by Bill Orr in the 50s, works superbly since using a common oscillator results in passband tuning with zero tracking error. After the dual-heterodyning process, a modest filter is required to rid the radio of mixing products. An extremely simple two-pole crystal monolithic filter, XF402, was utilized for this purpose (by Yaesu). See Fig. 1. While it cleans up these spurious products nicely, the filter is so elementary that it provides no help at all in enhancing the skirts of the main filter (XF302, 3, or 4).

Despite a disparity in impedance levels, filter XF402 was removed from the i-f board, the switching diodes and filtering on the added filter were removed, terminating resistors were changed, and the new filter was patched in in place of XF402. No attempt was made to add gain to the i-f amplifier to compensate for the insertion loss of the new multi-pole filter. [*Subsequently, Harold did devise a simple method for adding gain; it is described below.*]

The unconverted radio has an i-f gain such that a .7-microvolt signal gives 10-dB signal-to-signal + noise, and the MDS figure remains unchanged with the additional filter installed. I have cascaded filters in my KWM-2 and several "S" lines with spectacular results. Addition of this second filter to the FT-901DM [*and probably to the 902*] is no less startling. It turns this "competition grade" radio into a real contender.

In performing this surgery on two different radios (4 filters), the filters seem extremely well matched for center frequency with practically no effect on the "nose." The skirts, however, take a real nose dive. Ultimate rejection is beyond my ability to measure (in excess of 100 dB) and the agc system just doesn't respond to anything that isn't in the passband.

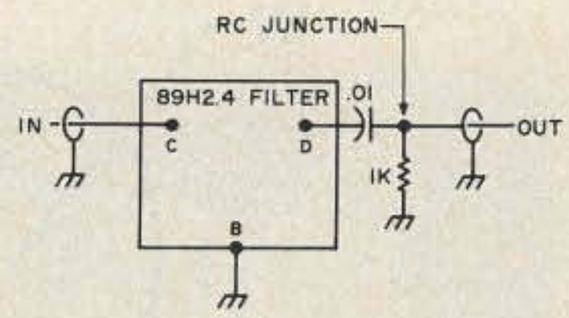

Fig. 2. Connections to new 8-pole filter YF89H2.4.

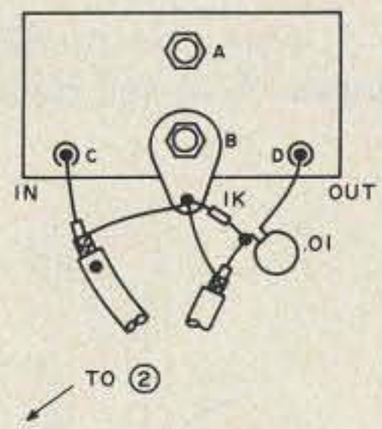

Fig. 3. Pictorial showing connections to new 8-pole filter YF89H2.4.

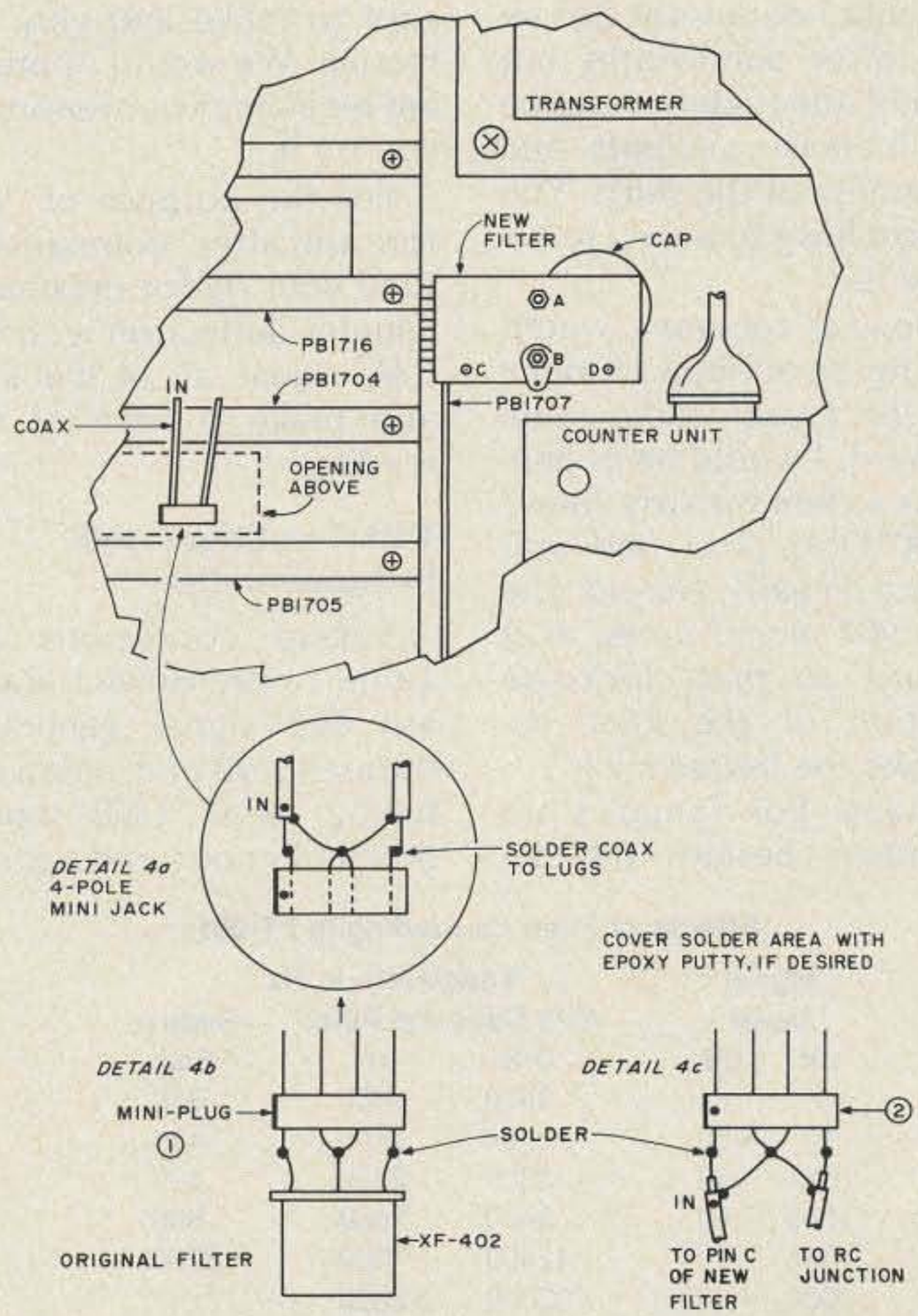

Fig. 4. Pictorial showing placement of new filter and its related connectors and cables.

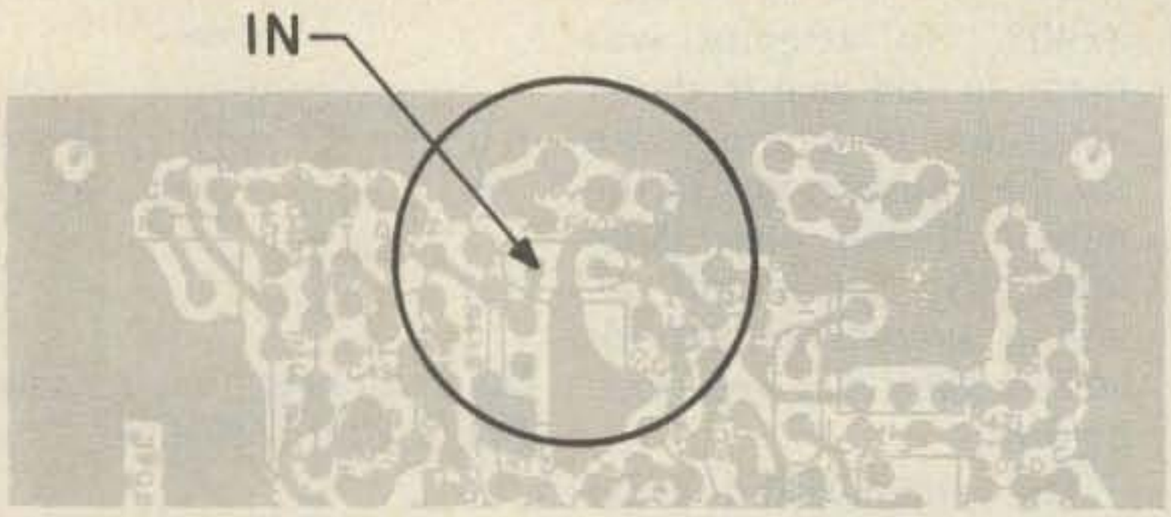

Fig. 5. Foil side of PB-1704 with detail showing required changes. Also see detail 8c.

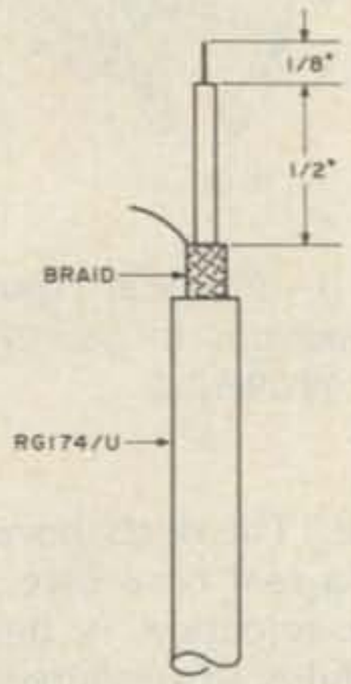

Fig. 6. Preparing the ends of RG-174/U coax for connection to PB-1704.

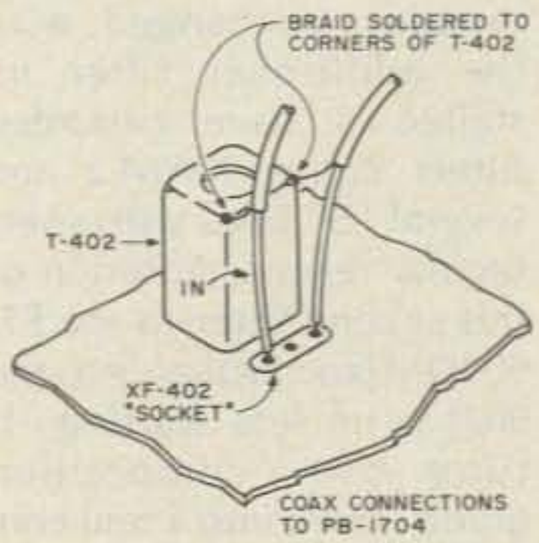

Fig. 7. Detail showing method of connecting coax to PB-1704.

Table 1 details the before and after bandwidths but cannot adequately describe the increase in depth and steepness of the skirts. You almost have to hear it to believe it.

Now, if someone would just figure out how to make the *backward* radio tune forward, I would be as happy as a clam with my "new" FT-901DM! [*Too bad you were a bit early, Harold. The new 902 model tunes, as it should, so that clockwise rotation of the knob increases the frequency.*]

Many Fox-Tango Club members besides the authors have tried this filter-cascading modification and have found it relatively easy to make and very effective. We would appreciate receiving your reports if you try it.

For the purpose of "before and after" comparison, tune your rig for maximum S-meter deflection with the CAL signal at 14,200 kHz and make a note of the reading.

Test Conditions and Instrumentation

Set-up conditions for Table 1 were Hewlett-Packard 608 signal generator through 5-dB pad, passband tuning at 0, USB mode, notch filter out, and agc off.

Effects of Filter Cascading in FT-901

Signal Level		Bandwidth in Hz With Cascade Filter		Reduction
uV	dB	Out	In	
1	−6	2400	2050	350
10	−20	2500	2100	400
100	−40	2800	2400	400
1000	−60	3400	2600	800
10k	−80	12400	4200	8200
100k	−100	33000	15800	*

*Reciprocal mixing at this signal level.

Table 1.

Part II: FT-901/902 Filter Cascading

Harold mentioned two problems in the first part of this article which troubled me a bit: the impedance mismatch when inserting the new filter and the resulting losses. Even though neither of these had a significant effect in terms of day-to-day operations because of the inherent sensitivity of the 901, I realized that some purists might be unhappy. However, before I could even write Harold about the insertion loss problem, he solved it in a simple and ingenious way by changing the location of the output coupling 1k resistor so as to load down and slightly change the bias on the next stage, Q403. This increased its gain just enough to offset the filter insertion losses almost exactly. (See Fig. 2.)

The matter of improving the impedance matching seemed like a more difficult problem until a fortunate discovery was made. Fig. 1 shows pertinent portions of the original circuitry of PB-1704C, the i-f board. The basic idea of the modification was to remove XF402 (between Q402 and Q403) and to substitute the 8-pole, 2.4-kHz bandwidth Fox-Tango filter for it. Note that the input end of the original filter is attached to the upper end of the coil in T402 which, with its shunting capacitor, looks more like a simple resonant circuit than a transformer. *If it's a transformer, where is the secondary winding?* All the other "T's" had them! Maybe T402 did too! A study of the parts list in the service manual vindicated my hunch: T402 *and* T403 had identical part numbers and a step-down secondary winding—ideal for impedance-matching the new filter! I could hardly wait to examine the back of PB-1704C in the vicinity of T402 since the parts layout diagram (Fig. 5) showed what looked like a transformer pin not connected to anything.

Eureka! I had found the solution. A few checks with the ohmmeter confirmed the presence of the winding with one end grounded, just like T403. Prior to this discovery, I had made the modification in my own FT-901D and was pleased with its results. However, upon making the simple change to utilize the newly-found secondary winding, the maximum CAL signal indication increased several dB! Talk about gilding the lily—I was delighted since the selectivity also seemed even better than before. So the following detailed instructions include the use of T402's "invisible" secondary. (See Fig. 8.)

One thing more. As originally proposed, W4ZCB's mod eliminates the possibility of AM/FM operation, a serious loss since the FM, at least, is a very desirable feature in the FT-901DM and D models (even though the DE and SD models do not have it, and for them the first design was fine—except for that secret secondary). This problem was solved by, in effect, providing a "socket" at the end of coax leads connected to the points on the board to which the original 2-pole filter was soldered.

This new socket terminated under a small removable lid in the top of the cabinet so that, by using matching miniature plugs, either the original 20-kHz filter (very small) or the new 2.4-kHz filter (at the end of another short length of coax) could readily be plugged in when desired. Further, for special purposes, *any* filter could be plugged in at this point temporarily while resting on top of the cabinet as long as a mating plug was connected to it.

They say that one picture

is worth a thousand words, and there are lots of pictures so I'll try to keep the words to a minimum. Anyway, start by comparing Figs. 1 and 8 carefully, noting the differences. Then become familiar with the others—especially the details. Next, take off the top cover of the cabinet (don't be afraid) and remove the black plastic panel at the left, over the circuit board compartments. Using the markings on this panel, locate PB-1704, remove the two screws at the ends of its hold-down strap, and using a knife blade or thin screwdriver, wedge up first one end of the strap and then the other, a bit at a time, until the board comes out of its socket. Examine the board carefully, noting the location of XF402, T402, and R419. All components have their identifications printed on the board, and the photographs in your owner's manual will help further to identify the key components.

Turn the board over and note that a portion of the foil side is covered by a metal shield which makes it difficult to see or gain access to the three soldered connections of XF402. Using long-nose or small ignition pliers, bend up the obstructing corner of the shield temporarily and you are ready to begin. Practically all the work is done right on PB-1704, no wiring is changed under the chassis, and no changes are irreversible. So heat up your light-duty, fine-tipped soldering iron, clean and tin its point, and go to work.

Detailed Procedure

A. Modifying PB-1704.

1. Clearly identify the three soldered connections of XF402. (See Fig. 5.) Unlike a crystal (which it resembles), it is not plugged into a socket—it is soldered to the board. Its three leads are thin and usually bent over before soldering. Carefully remove the solder from the three points using de-soldering wicking or suction. Straighten the leads so that when the solder is removed, XF402 can be lifted from the board without using any force.

2. Study Detail 8c and locate the short trace (foil strip) which must be cut with a hobby knife or sharp blade. Use a strong light since the trace may be hard to see under the green varnish-like solder-resist which covers all of the board except the solder points. Use your ohmmeter to be sure the trace is actually cut.

3. Locate blank pin (S) of T402 and solder a short, thin, insulated jumper wire to it. Note that it connects to the IN connection of XF402, but do not solder it there until the coax is inserted. See Fig. 7.

4. Prepare both ends of the RG-174/U coax as shown in Fig. 6. Tin the exposed ends of the center conductor and insert them as shown in Fig. 7. Solder them to the foil side (as the filter was previously). Now connect the jumper wire from pin S. Next tin the upper corners of T402 and solder the braid tails to them for grounding and strain relief. Hold the braid tail with long-nose pliers to act as a heat sink to prevent melting the plastic insulation of the coax.

5. Optional: Locate R419 adjacent to the right side of T402. Since its solder points are blocked by the shield on the foil side, cut the resistor lead as shown in Detail 8a. The cut ends can be re-soldered if ever desired.

6. This completes the work on the board. After bending the shield back to its original position, more or less, re-install it in its socket temporarily and bring the coax loop toward the front panel. Drop the black plastic panel into place after slipping the coax through the large rectangular opening in the black panel. Cut the coax at the front end of the opening. (See Fig. 4.) It is important to identify the IN lead with a bit of white tape, paint, etc. Once again, take off the plastic panel and remove PB-1704 to simplify making the connections shown in Detail 4a.

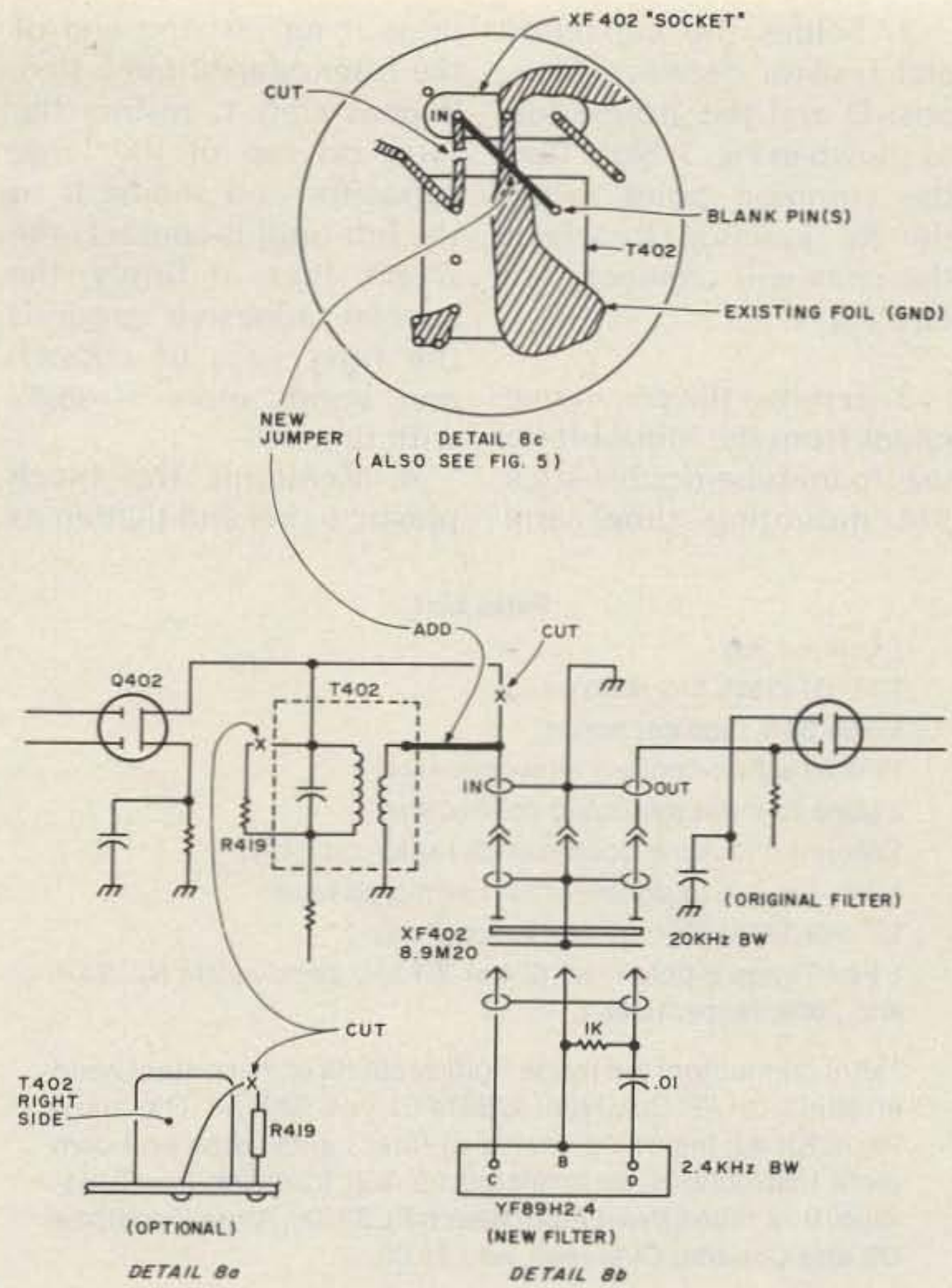

Fig. 8. Revised schematic showing essential changes involved in the modification (compare with Fig. 1).

B. Connecting the connectors.

1. Detail 4a shows a mini-jack; B and C are matching plugs. Though only three pins are needed, the four-pin type is used to make soldering of the braid tails easier and to help separate the input and output connections. The illustrations are practically self-explanatory; just expose no more of the unshielded center conductor than is necessary; tin the solder points and work carefully. The two inner lugs of the connectors are bent towards one another. A third hand to hold the connectors during soldering will make the work much easier. Use a light touch with the iron and work quickly. The leads in Detail 4c will be connected to the new eight-pole filter.

2. Re-install PB-1704, including its hold-down screws.

C. Installing the new eight-pole filter.

1. See Fig. 4. Mount the ground lug on filter stud B using the nut and star washer unless one is stamped into the lug itself. Rest the filter on top of the black cylindrical filter capacitor and slide it towards the left until it touches the metal shield of the circuit board compartment. It will be secured at this point later with special copper double-stick tape (for grounding the filter case) called a "Mount-It."

2. Solder the capacitor and resistor between filter post D and the ground lug as shown in Fig. 3. Note that the common point forms the RC junction to which the coax will connect. See also Fig. 2.

3. Remove the protective paper from the Mount-It (or use foam-type double-stick 3M mounting tape) and press it against the end of the filter nearest pin C (IN). Repeat step 1, resting the filter on top of the large capacitor and sliding it to the left until it contacts the shield. Press it firmly; the special adhesive grounds the filter case (if copper) and bonds more strongly with time.

4. Remount the black plastic panel and tighten its six hold-down screws. Bring the coax with connector 4a up through the rectangular hole. Mark the IN end with paint, brush pen, etc. Do the same for the end of the 4C connector to be chosen as IN. The two must always be connected so that the IN marks match. 4B can be connected either way. The area where the connectors and cables are joined can be covered with epoxy putty to make a neater and more secure job. Try plugging 4B into 4A. Then try 4C; its leads are longer than necessary to reach the eight-pole filter. Cut them to a suitable length with a bit of slack; bare the ends and connect as shown in Fig. 3.

5. This completes the modification. Note that the XF402 assembly (Detail 4b) can be secured to the black plastic panel at a convenient point with double-stick tape; the same is true of connector 4C. Thus, connector 4A (which is loose) can be shifted readily from one to the other. Turn on the set and test its operation. The S-meter deflection should be about the same as before or perhaps a bit greater. Adjusting the slug of T402 might improve matters a bit more, but since an extender board would be needed, it is usually not worth the expense and trouble. If desired, adjust VR401 on PB-1704 to get the original S-meter reading with the CAL signal.

6. Close the cabinet by remounting the top cover and test the connectors for accessibility by removing the small access lid. Connector A makes it possible to experiment with other filters in the future without removing the top of the cabinet. Just duplicate the 4c and Fig. 3 assembly, using clips at the filter end, if desired. ■

Parts List

1 Ground lug
1 1k 1/4-Watt, 5% resistor
1 0.01 50-V disc capacitor
1 Female four-contact mini-connector*
2 Male four-pin matching connectors*
1 Mount-It (copper double-stick tape assembly)
1 3/4" square of double-stick foam-type tape
12" RG-174/U high quality coaxial cable
1 Fox-Tango 8-pole filter (2.4 or 2.1 kHz bandwidth; No. 2110 and 2009, respectively).

*Mini-connectors are made from sections of 36-contact header strips by AP Co., Nos. 929834-01 and 929974. The above Parts Kit 4J, including choice of filter bandwidths and complete instructions, is available for $60 from the Fox-Tango Club, Box 15944, West Palm Beach FL 33406. Airmail postpaid US and Canada. Overseas, add $5.00.

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