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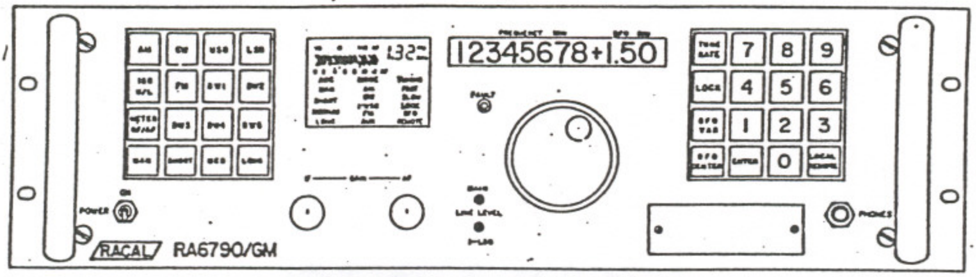
RA6790/GM: A Brief Review

Dallas Lankford, 13 XII 93



About six months ago the U.S. military disposed of several hundred RACAL RA6790/GM (R-2174(P)/URR) receivers through surplus bids, and subsequently several surplus equipment sellers have offered them for about $1500 (with filters, checked for operation). The R-2174(P)/URR is identical to the RA6790/GM except that the R-2174(P)/URR was equipped with plug-in crystal filters instead of mechanical filters. There was some variation in filter line-up from one to another of these surplus 6790's, apparently because some of these receivers released for surplus bids were missing one or more filters; see, for example, Fair Radio's Fall 1993 Catalog Supplement. Evidently many also required repair amd/or replacement of some parts.

The 6790 I received contained five filters, 0.4, 3.24, and 6.8 KHz nominal symmetric bandpass filters, and 2.7 KHz USB and 2.7 KHz LSB filters, all of them the large plug-in crystal filter type. Apparently 1.2 KHz and 16 KHz BW filters were also installed in some 6790s. The bandwidths mentioned above are nominal. For example, the measured bandwidths for the 3.24 KHz and 6.8 KHz filters in the 6790 I tested were 3.48/5.00 KHz and 8.01/13.5 KHz at -6/-60 dB respectively. The 3.24 filter is excellent for DXing, but the 6.8 filter is a bit wide even for SW pleasure listening.

A detailed review of the RA6790/GM (R-2174(P)/URR) is contained in the 1982 WRTH, so this review will necessarily be brief. The 6790 tunes 0.500000 to 29.999999 MHz with resolution and readout to the nearest Hz in the finest (slowest) tuning rate. Tuning rate resolutions are 1 Hz, 30 Hz, and 1 KHz, selectable by a front panel push button. The 6790 does not tune below 0.500000 MHz contrary to a statement in the 82 WRTH. There is a "trick" you can use to tune below 0.500000 MHz. For example, in the 1 KHz tuning rate, press ENTER then 01310, then press ENTER again and 00. The receiver will be tuned to 310 KHz, but if you move the main tuning knob ever so slightly, the 6790 returns to the 0.5-30 MHz range.

The 6790 is still in production, and spare parts and the manual are available from RACAL. You should phone or write for prices and parts availability: RACAL Communications, Inc., 5 Research Place, Rockville, MD 20850, (301)948-4420.

These surplus 6790s did not include the optional independent sideband module (ISB PC board, assembly A5), or the remote control module (serial asynchronous remote interface PC board, assembly A6A1). The 6790 manual also mentions other options which are available: improved internal frequency standard ±3 parts in 1,000,000,000, an RF amplifier for greater receiver sensitivity, extended low frequency tuning range to 10 KHz, and a broadband IF output.

The following performance parameters were measured for the 6790 I tested. AM sensitivity for the 3.24 filter for a 10 dB S+N/N using 400 Hz modulation at 50% modulation varied between 0.7 and 1.7 microvolts. The 3rd order intercept at 100 KHz or greater spacing was +30.5 dBm. The 2nd order intercept was +56.5 dBm. Both of these values are, of course, outstanding for a receiver with no front end preselection. The 3rd order intercept was phase noise limited at 20 KHz spacing. The weak point of the 6790 is eight reciprocal mixing spurs within ±30 KHz of the tuning frequency. A graph of the 6790 reciprocal mixing characteristics is given below together with reciprocal mixing characteristics of an R-390A, NRD-525, and WJ-8711. The four close-in reciprocal mixing spurs at about ±6.66 KHz and ±13.32 KHz can be heard on-the-air if a nearby signal is strong enough. For example, I have one super-local MW station, KRUS on 1490 KHz, which puts about 20,000 microvolts per meter field intensity into my location about one mile away from the KRUS antenna. This causes KRUS to appear not only at its normal 1490 KHz, but also at 1477 KHz, 1484 KHz, 1496 KHz, and 1503 KHz. This is not exactly what one would anticipate from a $20,000 professional grade receiver. Neither my venerable boat-anchor R-390A nor my lightweight NRD-525 produce any such spurious responses.

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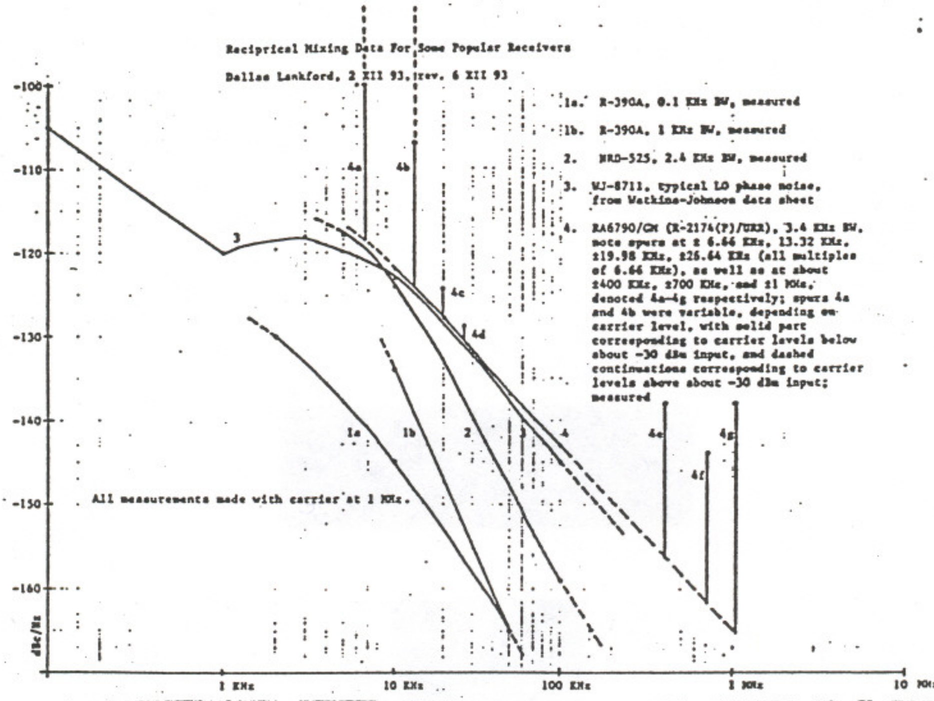
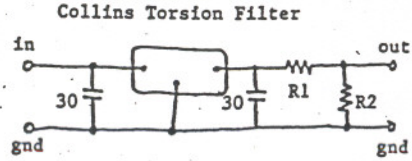


While KRUS 1490 is the only station received at my location to produce multiple spurious receptions of a signal, urban listeners with multiple super-locals would likely observe multiple occurrences of this phenomena. The close-in reciprocal mixing spurs at ±6.66 KHz (approximately) produce two other unusual phenomena. When a strong signal is tuned in a wide bandwidth (say, 12 KHz or greater), a weak but noticeable 6660 Hz het is heard. And when tuning splits at night (when signal strenths are stronger) in the MW band, this same 6660 Hz het is often heard (in narrow bandwidths). Again, this is not exactly what one would expect for a $20,000 professional grade receiver, and neither my R-390A nor my NRD-525, nor any other receiver I have ever used, has produced any such spurious responses. The 6660 Hz (approximately) hets due to the ±6.66 KHz spurs are not strong (except in the case of KRUS 1490), and might not be noticed by many listeners. It is very unlikely that they would cause any serious problems when DXing splits. Also, the KRUS 1490 spurs can be completely eliminated by inserting a 5:1 (14 dB) attenuator between the 6790 and the antenna.

The 6790 is dual conversion, with 40.455 MHz 1st IF, and 455 KHz 2nd IF. There are two crystal filters, separated by an amplifier, in the 1st IF, one marked 20 KHz BW, and the other marked 25 KHz BW. The measured combined BW of these two filters in the 6790 I tested was 32 KHz at -6dB and 70 KHz at -60 dB. This exteremely wide BW of the 40.455 MHz IF filters is easily made available by jumping the input and output of the next vacant filter position (if one is available) and running the BITE program (which automatically identifies the filters, measures their 3 dB BWs, and assigns them in increasing BW order to the front panel buttons B1-B5).

It is straightforward to add additional or optional 455 KHz filters to a 6790, though time consuming to fabricate the required homebrewed PC board plug-in adapter. At present I am using 2.5 KHz and 6.0 KHz BW Collins torsion mechanical filters in addition to the regular filters in the 6790 I have tested. The torsion filters have somewhat less loss than the standard plug-in crystal filters, so to equalize signal throughput I used a resistor divider network; see the schematic below. These filters, the 6.0 BW (Collins part # 526-8636-010), and the 2.5 BW (Collins part # 526-8635-010), are speced at 5.5 KHz min/ 11 KHz max and 2.5 KHz ± 0.1 KHz/ 5.5 KHz max for -6/-60 dB respectively, and measured 5.88/10.19 and 2.55/5.24 respectively. They are available for $76.81 each from Rockwell International, Filter Products, 2990 Airway Avenue, Costa Mesa, CA 92626, (714)641-5311; contact

Collins Torsion Filter



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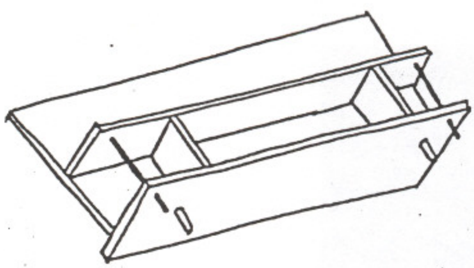
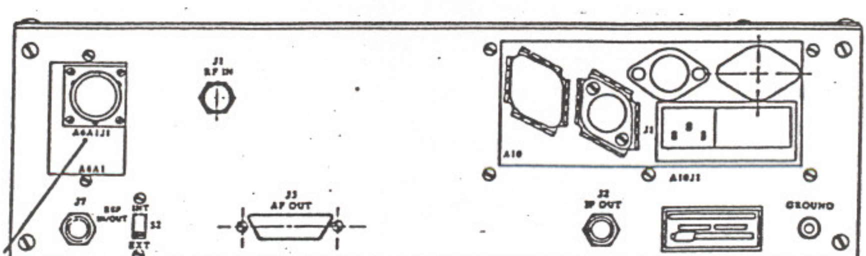
Bob Johnson, Principal Engineer for current price, availability, and ordering information. These are wonderful little filters, about 1.24 inch long by 0.47 inch wide by 0.23 inch high with pins about 0.17 inch long. They are much smaller, much higher performance, and less costly than previous Collins filters. For example, their ultimate rejection, not counting spurs, is typically in excess of 100 dB. The closest spurs to 455 KHz are typically at about 480 KHz and are about 82 dB down, and so all of the torsion filter spurs would be reduced to below 100 dB down by the 40.455 MHz crystal filters of the 6790. For the two Collins torsion filters discussed above, I used R1 = 820 ohms and R2 = 1200 ohms to equalize signal throughput (and to terminate the filters in the required 2000 ohm load resistance). The general rule is to select R1 and R2 so that R1 + R2 = 2000 ohms (approximately) and signal throughput is about equal to the other 6790 filters.

Similarly, Collins FD type filters can also be used. Of course, the resonating capacitors will not be 30 pF as used for the torsion filters. And various kinds of ceramic filters can be used; no resonating capacitors are required for ceramic filters, and R1 + R2 should equal the load resistance of the ceramic filter used (2000 ohms for some, 1500 ohms for others, and perhaps still other values for still others). For example, I tried an FD455FD58 filter with 1100 pF resonating capacitors which worked fine, except the bandwidth was a bit wider than the 6.0 torsion filter. And as a wideband option I made an adapter using a Murata CFL455G3 which had a measured BW of 13/19 at -6/-60 dB.



The general features of the plug-in filter adapter PC boards I fabricated are shown at left. The lenght is 3 inches, height 2 inches, and width 15/16 inches. The bottom of the bottom PC board is the fiberglass side. The small pins are #22 tinned (with the rough cut ends tinned with solder and smoothed with fine steel wool). The large pins were octal plug pins, obtained by breaking apart octal plugs (like the plugs used to plug in old tube type Q-multipliers). The large vertical PC board, and the two small PC boards are not etched, and the upper side of the base PC board is etched only at the corners where the two smaller "pins" pass up to the upper PC board (which holds the filter, resonating capacitors, if any, and resistors). The positions of the small and large pins on the base PC board are obtained by careful measurement of the 6790 plug-in filter sockets. The individual PC boards were soldered together along their seams.

As mentioned above, when new or alternate filters are plugged into the 6790, the BITE program is run, and it automatically sorts the filters into increasing BW and assigns them to the B1-B5 buttons on the front panel. In addition, the measured 3 dB BW is displayed in the square LCD when any of B1-B5 are selected. The choice of 5 filters, independent of mode, plus USB and LSB filters, is one of the nice features of the 6790. There are 3 AGC release times selectable from the front panel, SHORT (fast) MED, and LONG (slow), with release times of about 30 msecs, 200 msecs, and 3.75 secs respectively. The MED and LONG AGC positions are "hang" AGC, which seems superior to other AGCs I have used. In MAN mode the AGC release times are still operable, but the AGC threshold is set by the front panel (manual) IF gain control. All of the 5 non-SSB filters (B1-B5) can be used for SSB by using CW mode and the VAR BFO control, which permits the BFO to be set ±8 KHz from center frequency. The detector in AM mode is a synchronous detector, which perhaps accounts for the very good audio quality of the 6790 in AM mode. As with other solid state receivers, there is some noticeable hiss on weak signals in the narrower bandwidths. The AM synchronous detector does not lose lock in fades, or become confused (as with some other well-known receivers). Its operation is completely transparent to the user. The only anomaly I can attribute to the AM synchronous detector is that it makes the -60 dB filter BWs seem wider than they actually are when filter BWs are measured using AM mode (or else some filter leakage is caused by AM mode, which seems unlikely).



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The rear panel contains a 455 KHz IF output (BNC connector, 50 ohms impedance, -10 dBm level nominal). Also on the rear panel is a 25 pin D type connector for local audio output (1 watt into 8 ohms, distortion less than 3% at 500 mW, frequency response 100 Hz to 16 KHz at 3 dB points), two line audio outputs (operable only with ISB option), and AGC diversity connections. The antenna input is type N female. I use a UG-201A/U connector adapter (N male to BNC female) to convert to BNC for quicker antenna connection and disconnection. The RA6790/GM has no front end protection diodes or other type of front end protection. You should use some kind of front end protection device for the 6790, such as the LA-1B with BNC connectors which can be mounted inside the 6790 between the BNC female output of the antenna input conector and the BNC male connector with miniature coax which connects to the 30 MHz low pass filter.

The 6790 maintenance manual, RACAL part # 84249, is about 250 pages plus about 35 pages of large fold-out schematics. Unfortunately, the schematics are incomplete, missing the first mixer circuit (said to be quad passive FETs, Siliconix SD215DE). And there is little information in the manual about aligning transformers and trimmer capacitors, or about adjusting various potientiometers. If you are familiar with the thoroughness and completeness of the R-390A maintenance manuals, you will find the 6790 manual disappointing. Similarly, the NRD-525 maintenance manual, though not as good as the R-390A manuals, is much better than the 6790 manual.

At first I considered the 6790 close-in reciprocal mixing spurs to be an indication of a problem with the 6790 LOs or other circuits. But another 6790 user I contacted has similar, if not identical, reciprocal mixing spurs. And one of my sources told me that an FCC monitoring station in Florida had similar spurs in their RACAL receivers. So the present evidence indicates that the close-in spurs at multiples of 6.66 KHz (approximately) are normal for the 6790. One problem did develop with the 6790 I tested. After being left turned off for several months, the 6790 came up into the BITE routine and then locked up when turned on. This problem was cured by replacing the nickel cadmium volatile memory back-up battery. Curiously, the 6790 manual does not discuss this potential fault, or replacement of the battery. The battery requires about 72 hours to reach a full charge, and will keep volatile memory alive for several months after the 6790 is turned off. Replacement of this battery should be a regular maintenance item (about one replacement every four years). If/when you replace the battery, resistor R9 270 ohms should be checked (in case the battery failed by shorting and drew excessive current through the resistor, either burning it open or changing its value). For higher reliability, the battery may be replaced more often than once every four years. Hospitals, for example, replace rechargeable back-up batteries in their equipment annually.

Like many synthesized microprocessor-controlled solid state receivers, the 6790 cannot be used with a nearby loop antenna for MW band DXing because of RFI emitted by the 6790. The level of RFI emitted by the 6790 in the MW band is greater than the level of RFI emitted in the MW band by the NRD-525. Perhaps the 6790 RFI levels could be reduced to an acceptable level by mounting the 6790 inside a well-shielded cabinet, or by shielding the microprocessor board. I have not tried either.

The PC boards in the 6790 are fairly easy to remove and replace. Removal usually involves disconnecting a few cables and removing a few screws. The 6790 maintenance manual seems to have complete and thorough instructions for removing all PC boards. For example, replacement of the nickel cadmium battery was routine because removal and replacement of the microprocessor board was routine.

How does the 6790 stack up against other top DX receivers, like the R-390A and NRD-525? I hate to say it, but the 6790 comes in third, with the R-390A still my number one choice, followed closely by the NRD-525. If the 6790 was free of close-in reciprocal mixing spurs, and was a little more sensitive, it would be right in there with the other two. Unfortunately, it is not. The slight insensitivity of the 6790 would be relatively easy to fix with a high dynamic range, tuned, transformer feedback preselector. It remains to be seen if the close-in reciprocal mixing spurs can be reduced or eliminated.

Addendum 10 VI 94

Elimination of the close-in reciprocal mixing spurs was something of an ordeal. I had considerable assistance in the form of advice about how to proceed with trying to isolate the spurs from two very helpful RACAL employees. However, all of their helpful and appreciated advice led to what seemed to be dead ends. The 6790 1st and 2nd LO's were eliminated as possible sources of the spurs by operating the 6790 with external oscillators. (This required me to fabricate some adapter cables using SMB connectors, which was not an easy task.) Next, I attempted to isolate the spurs to a particular place in the 6790 by conventional trouble shooting methods (my own idea), and again I reached dead ends. Finally, out of desperation, I went at every board in the 6790 with "freeze spray" while sitting on one of the close-in spurs with the BFO on (so that I could hear even the slightest change in spur frequency). A slight change in spur frequency (a few 10's of Hz at most) led me to the hermetically sealed 5 MHz master crystal oscillator with built-in crystal

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oven. The 5 MHz output is divided by 5 to 1 MHz which is used throughout the 6790 as a reference. The 1 MHz reference is also output at a BNC plug on the rear panel. I connected the 1 MHz output through a 20 dB attenuator to an R-390A and tuned around 1 MHz. The close-in spurs were found at the same offsets as on the 6790. I removed the 5 MHz master oscillator and powered it stand-alone on my work bench with +12 VDC. The spurs were found near 5 MHz at the same offset as on the 6790. An "internal/external" slide switch on the rear panel permits the internal 5 MHz master oscillator to be disabled and an external 1 MHz source to be used. I operated my 6790 with a high spectral purity external 1 MHz oscillator and found no close-in reciprocal mixing spurs. A new 5 MHz oscillator was ordered from RACAL ($240 plus shipping), installed in my 6790, and there now appear to be no close-in reciprocal mixing spurs of the kind described at the beginning of the article. The RA6790/GM does, of course, have a few weak spurs here and there. And if you happen to make a reciprocal mixing measurement near one of these spurs, it will appear to be a reciprocal mixing spur. In addition, there do appear to be a few irregular weak reciprocal mixing spurs. To eliminate the fixed internal spurs from a reciprocal mixing measurement, one should do two reciprocal mixing measurements at two different frequencies. The weak fixed internal spurs can be found by tuning around with BFO on and no antenna connected. For my 6790, these internal spurs are at 1.000, 4.000, 4.500, 4.900, 5.000, 5.100, 6.825, 7.000, 7.00084, 7.100, 8.000, 8.00097, 8.300 MHz, and so on. Except for the 1.000 and 5.000 MHz spurs, these internal spurs are typically about 3 dB above the -121 dBm noise floor of my 6790 in a 6 KHz BW. They should not be observed in actual listening situations below, say, 5 MHz where man-made and atmospheric noise are high.

While fiddling around with my 6790, I had noticed that my 3.24 KHz BW filter (RACAL part # 08413, McCoy part # 164B67) had considerable leakage on the high side. I replaced it with an NTK CLF-D2K N311A ceramic filter mounted on an adapter board like the Collins torsion filters discussed above. Good-bye filter leakage. These ceramic filters are available from Kiwa Electronics, 612 South 14th Avenue, Yakima, WA 98902, tel. (509) 453-5492 for about $70. You will have to fabricate the adapter board yourself, unless Sherwood Engineering has an adapter board available by the time you read this. Bob Sherwood told me that he was planning to make some adapter boards for the 6790, but I don't know if his boards will accept Collins torsion filters or CLF-D2K N311A ceramic filters. The CLF-D2K N311A ceramic filters I measured typically have stopband attenuation in excess of 86 dB in the 400-500 KHz frequency range, with "notches" in excess of 100 dB close-in. When these filters are cascaded with the 40.455 MHz IF cryatal filters in the 6790, overall stopband attenuation is in excess of 100 dB. My flakey 3.24 KHz BW 6790 filter apparently is not unique. Bob Sherwood mentioned a 6790 with a 6.8 KHz BW filter which appeared the have a BW of about 10.3 KHz. Evidently there can be considerable variation from one 6790 filter to another.

Because I had been working on and succeeded in improving the inadequate Drake R8 50 KHz IF image rejection from about 80 dB to almost 100 dB, I was naturally inclined to examine the RA6790/GM 455 KHz IF image rejection. With a stock A3 mixer board, 455 KHz image rejection was about 114 dB, which is substantially greater than any other receiver with a 455 KHz IF that I have measured, and, of course, exceptionally outstanding. With a modified A3 board which I had implemented for some of my trouble shooting, the 455 KHz IF image rejection was greater than the limits of my measurement equipment, in excess of 126 dB.

Repairing or modifying RA6790/GM PC boards is not easy because most, if not all, PC board holes are plated through, and many of the leads fit tightly in any case.. I had to develop new techniques to remove components without damaging the PC board. Unless you are an expert at PC board work, don't even try to work on a 6790.

After my success at trouble shooting and eliminating the close-in reciprocal mixing spurs, it is unclear to me whether the problem is as widespread as I had been led to believe. The fellow who sold me the 6790 assured me that close-in reciprocal mixing spurs were normal for the 6790, and since he was in the process of selling about 50 of them, I assumed he would know. But then the first 6790 he shipped me had a bad A2 1st mixer board, and a bad A7 1st LO board, which required me to return the 6790 to him for repairs.

I was a bit surprised to find that he had painted the A2 cover plate mounting screws and the A7 cover plate mounting screw day-glow orange when I received the repaired 6790. It was easy enough to remove the paint with a mild solvent because the paint was hardly dry. Perhaps there are other 6790's with close-in reciprocal mixing spurs due to bad 5 MHz crystal oscillators, but it seems unusual that a surplus dealer should have 50+ of them. In any case, I was never told by anyone at RACAL that the close-in reciprocal mixing spurs were normal, and, in fact, was told just the opposite, namely that the close-in spurs were not normal for 6790's. They were right. And the surplus dealer was wrong. A more plausible explanation for the spur situation which I encountered is that the surplus dealer was not knowledheable enough about RA6790/GM's to check it out properly. This prompts me to advise anyone thinking about buying a surplus 6790 the familiar "caveat emptor." On the other hand, it is also possible that there are significant numbers of RA6790/GM's with defective 5 MHz crystal oscillators, and, thus, close-in reciprocal mixing spurs like I experienced. That remains to be seen.

Based on my experiences, the 6790 was not intended to be repaired at the component level (except for the 455 KHz filters, which are plug-in). In other words, it appears that the 6790 was meant to be repaired by replacing PC boards. As I mentioned above, the manual does not have the detailed data, like stage gains, active device operating voltages and resistances, and so on which are required to trouble shoot at the component level, and the plated-through-tight-lead-fit makes component level board repairs difficult. Board prices vary from about $600 at the low end to several thousand dollars at the high end, depending on the board, so repair-by-board-changing is probably not an acceptable option for most hobbyists. Prices of individual parts can also vary wildly. For example, the USB filter (part # 08410) currently is $260 (+ S&H), but the matching LSB filter (part # 08409) is $700 (+ S&H), and both prices are subject to change. Since many of the 6790's which came on the surplus market recently were missing one or more filters, no surplus dealer (to the best of my knowledge) will sell you an individual 6790 filter, and so you are stuck with RACAL's current price for the filter you want (or you can merely live without it).

Back to the question of how the 6790 stacks up against other top DX receivers like the R-390A and NRD-525, I still vote 390A/525/6790 for 1/2/3, mainly because of the slight insensitivity of the 6790 compared to the other two. While I am reasonably sure a carefully designed tuned preamp will fix the 6790 sensitivity, that remains to be seen. But I don't expect to see a solid state microprocessor controlled PLL receiver as spur-free and with as low LO noise as the 390A in my lifetime. And it is tough to beat the combination of good intercepts, tracked tuned front end, ease of use, small size, light weight, and overall good performance (after a few simple mods are done) of the 525. I don't regret buying the 6790 even after having to "go to school" on it. Some people like fine music, or fine food, or fine cars, or fine houses, to name a few. I like fine receivers, and the attention to detail of design and construction place the 6790 in a category by itself. I did not buy it to use as a DXing receiver, but rather to learn more about top end receivers and especially to learn more about intermodulation distortion and perhaps to use the 6790 as part of my ultralinear intermodulation distortion measurement system. I must say, however, the 6790 audio quality in AM mode is exceptionally good, due, in part, I presume, to the AM synchronous detector, and the hang AGC in medium and slow release modes. In AM mode, detection is always (and only) by AM synchronous detection. Operation of the AM synchronous detector is completely transparent to the user (as it should be): it never loses lock and there is never a growl or any other evidence of the AM synchronous detector. For this reason alone I will probably use the 6790 for some of my listening.